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A MANAGEMENT SURVEY BY THE NAVAL OFFICERS IN THE MANAGEMENT ENGINEERING PROGRAM

87

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CHAPTER XI - MANUFACTURING

11.1 Manufacturing - General

11.1.1 Background. Scintilla Division of Bendix Aviation Corporation is located at Sidney, New York, a village in a rural section of Central New York in the western foothills of the Catskill Mountains.

The Division was originally Scintilla Magneto Co. Inc., established in May 1921 when the Scintilla Magneto was introduced to American markets from its switzerland origin. Manufacturing began in Sidney in 1925, and in 1929 the Division became a subsidiary of Bendix followed in 1939 by its designation as a Division of Bendix. The Scintilla Magneto was so good it captured 95% of the magneto market and still represents a considerable portion of the Division's annual sales volume. The pre-eminence of the magneto was due in all probability to the unsurpassed quality standards maintained by Scintilla. This emphasis on quality has been carried forward to the present day with respect to all products manufactured.

Although still important, the magneto is slowly giving way to many other products. In fact, so wide is the variety of customer requirements that the present Scintilla policy is that of a "job shop" that produces only on receipt of a customer order. Scintilla designs and manufactures complete ignition systems for missiles, jet engines, gas turbines, and aircraft piston engines. Various electronic devices for such systems are also produced by the division. In addition, quality ignition systems are produced for automotive, stationary, and marine engines. Fuel injection pumps, nozzles, and nozzle holders are manufactured for diesel engines. And since 1947, in a steadily growing electrical plug-in-connector market, Scintilla has become a volume producer of these units for all types of service. Present products can be grouped into five categories as follows:

1. Mechanical	Ceramics
	Air Pressure Pumps
	Governors
	Service Tools
	Manufacturing Tools and Gages

2.	Electro-Mechanical	Battery Ignition Timers Dist. Assy. Heads, Fingers Switches Magnetos
3.	Electronic	Jet Ignition Equipment Ignition Analyzers
4.	Hydraulic	Fuel Pumps Nozzle Holders Spray Tips Nozzles
5.	Electrical	Relays and Panels Vibrators Filters Ignition Coils Ignition Leads Jet Ignition Plugs and Primers Harnesses and Manifolds Electrical Connectors

Such a wide variety of products has resulted in the development of a correspondingly wide variety of manufacturing facilities and skills. The below listed operations and processes categorize the present Scintilla manufacturing "job shop" activities.

General Machining - Ferrous, Non-Ferrous, Non-Metallic
Precision Honing
Automatics and Turning
Tube Bending and Sheetmetal Fabrication
Heat Treating and Nitriding
Sand Blasting, Vapor Blasting, Metal Spraying
Dichromating
Painting
Soldering
Brazing - Induction, Flame, Silver
Welding - Spot, Resistance, Inert Gas Fusion
Coil and Condenser Winding
Impregnation
Ceramic Manufacture
Die Casting
Plastic Molding
Tool and Gage Making
Assembly - Mechanical, Electrical, Electronic
Plating - Gold, Silver, Nickel, Chrome, Cadmium, Tin, Copper, Zinc, Brass, Black Oxide, Anodize Parko Lubrite.

To provide the requisite personnel skills for these various operations and processes, Scintilla draws on the labor force of Sidney and from a commuting radius as far as fifty miles. Being the only large manufacturing concern in the area Scintilla has a primary interest in maintaining a stable, satisfied labor force so as to keep the labor pool intact.

The end result of the manufacturing process is an annual sales volume of an estimated $42,000,000, broken down into product categories as follows:

Aircraft Magnetos, Distributors, Heads & Fingers	$3,500,000
Aircraft Harnesses, Leads, Cable Assemblies	6,500,000
Aircraft Coils, Switches, Filters	2,500,000
Ignition Analyzers and Equipment	500,000
Jet Ignition Equipment and Plugs	6,500,000
Spare Parts, Service Tools, Repair Sales	5,000,000
Ordnance, Industrial, Auto, Crankshaft, & H Magnetos	4,000,000
Fuel Injection Units and Parts	2,500,000
Electrical Connectors	9,000,000
Miscellaneous	2,000,000
	$42,000,000

These sales represent an extremely wide variation in types, sizes and other unique characteristics within each product category. For instance in electrical connectors alone there are over 60,000 different variations involved in one year's sales.

The customer market for Scintilla is principally either government or primary government contractors. There is at present an attempt to try and capture more of a competitive commercial market so as to reduce dependence on government contracts.

The following pictures portray various aspects of Scintilla, Scintilla products, and manufacturing.

11.1.2 Study Approach. To begin, it is suggested that a sales order results when the following criteria have been satisfied: the customer can get what he wants; the customer can get it when he wants it; the customer can get as many as he wants; and he can get it at the price he is willing to pay. These customer criteria, for any supplier, including Scintilla, should be formally evaluated to obtain optimum

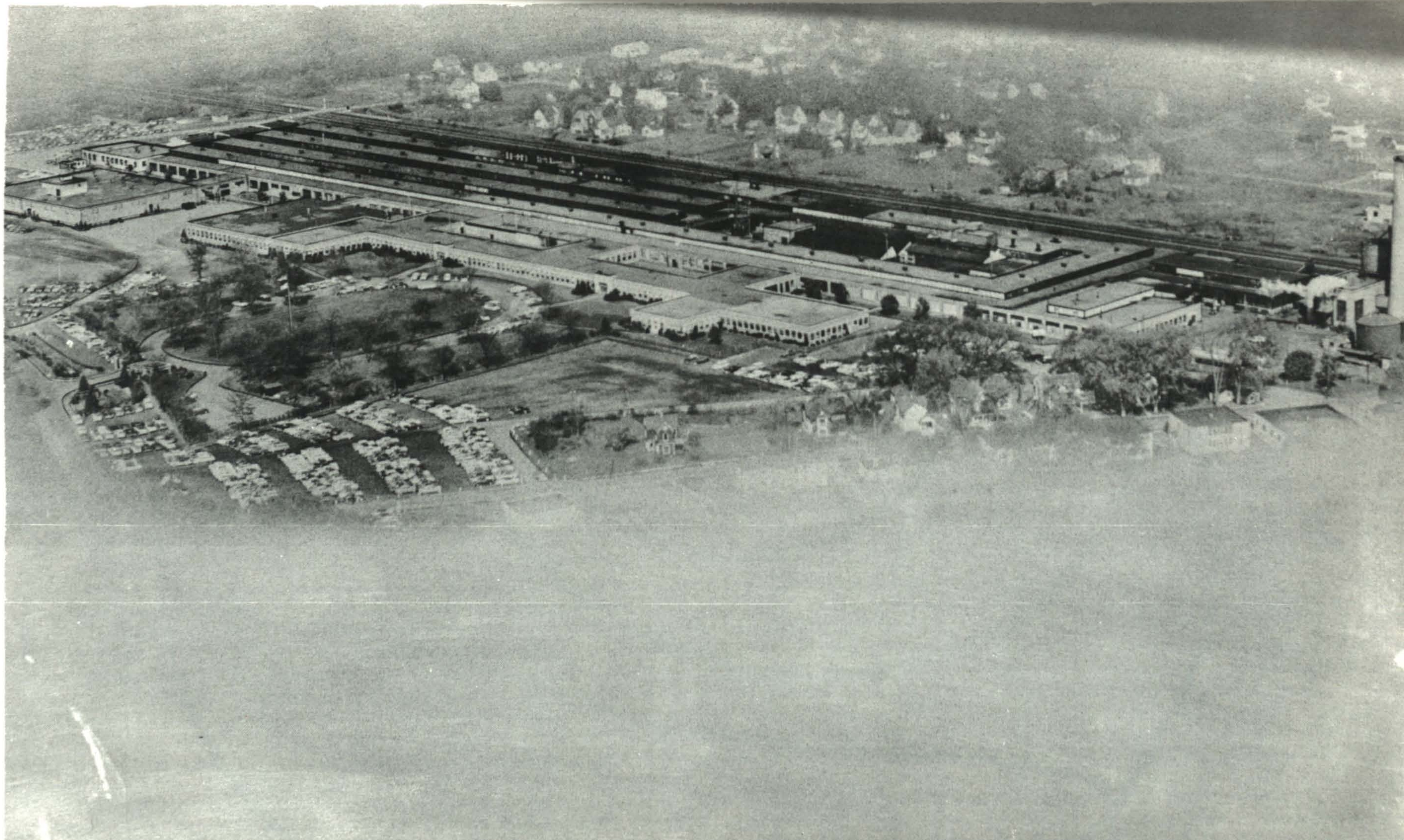
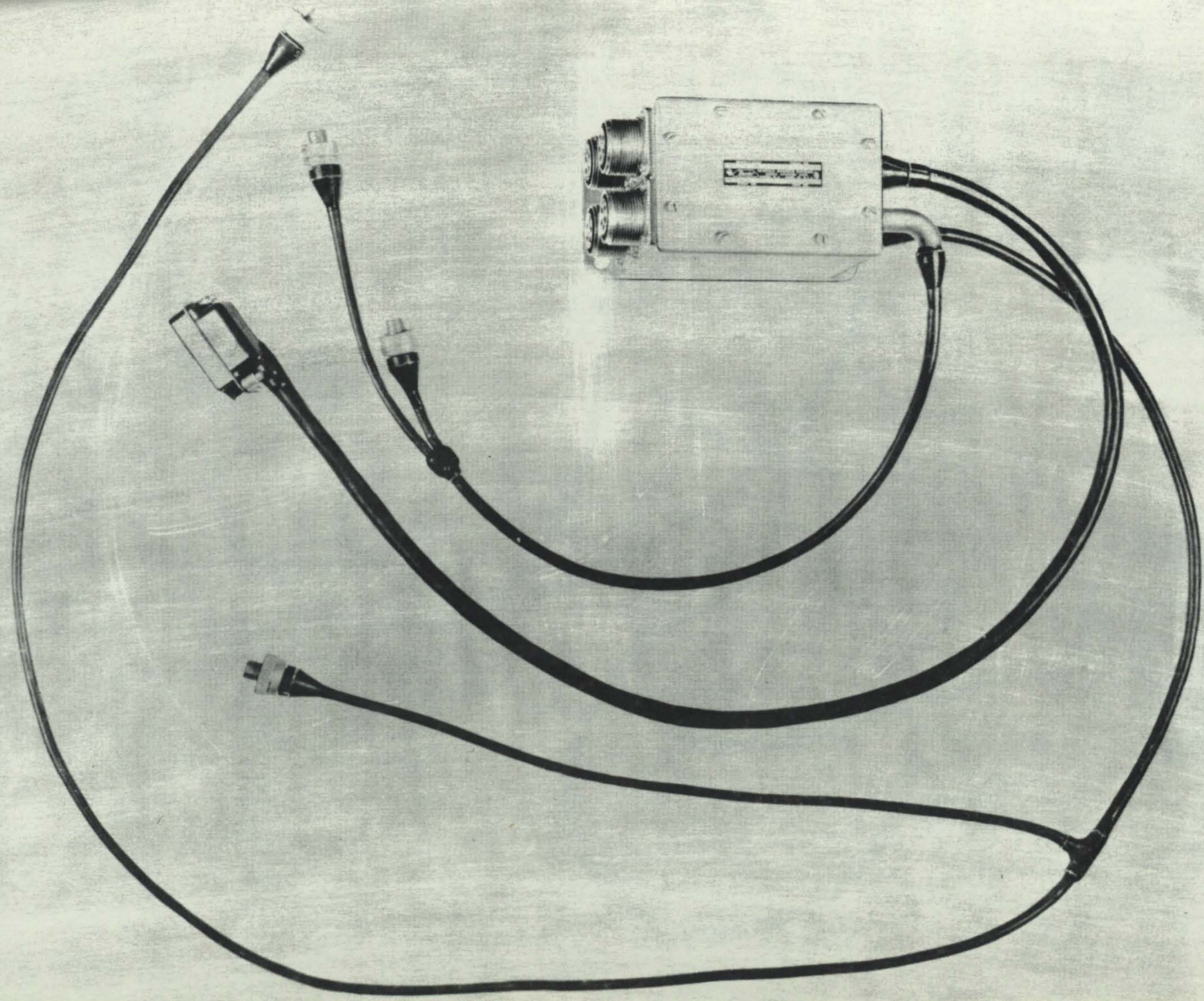
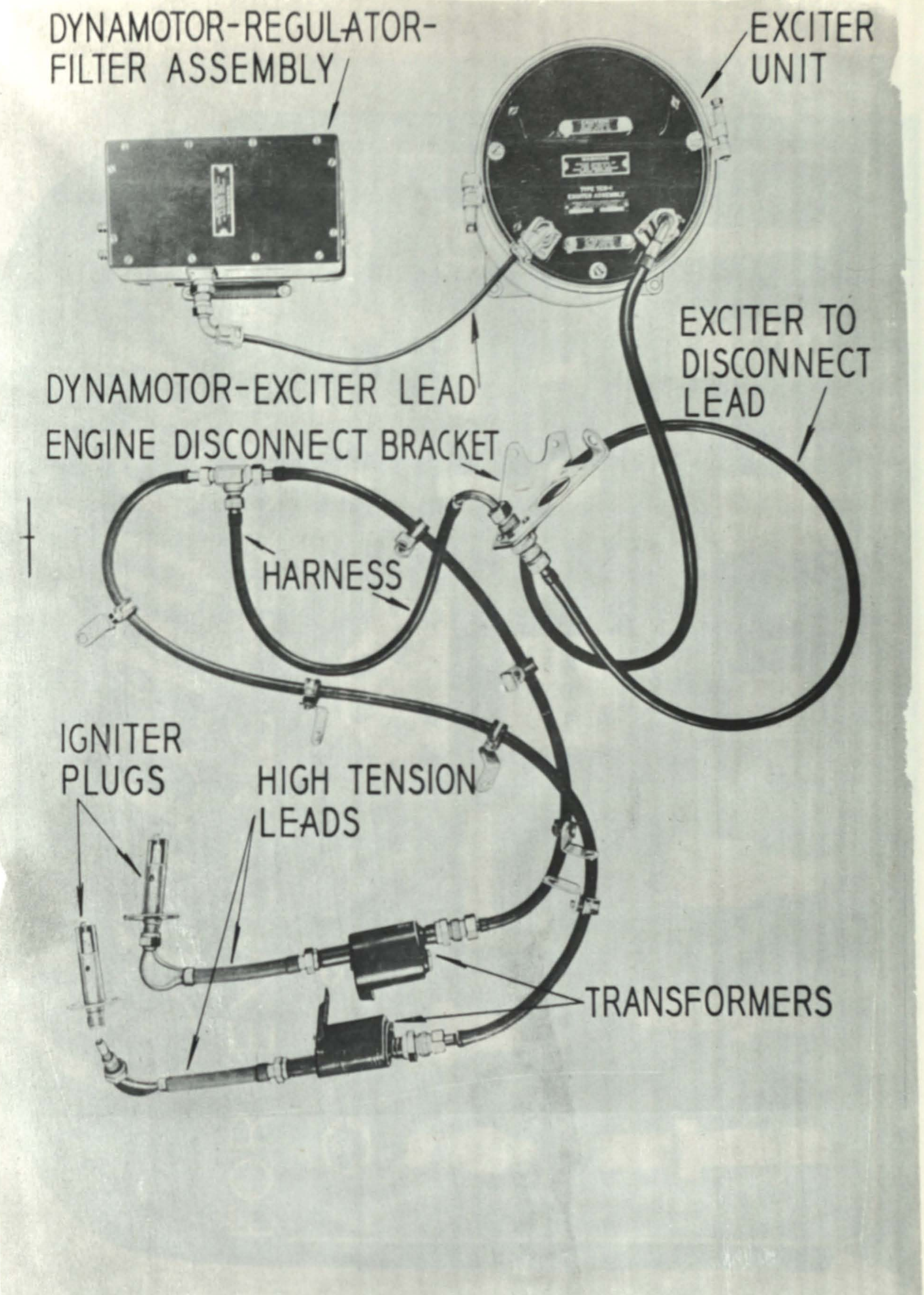


FIG. 1. SCINTILLA DIVISION, SIDNEY, NEW YORK

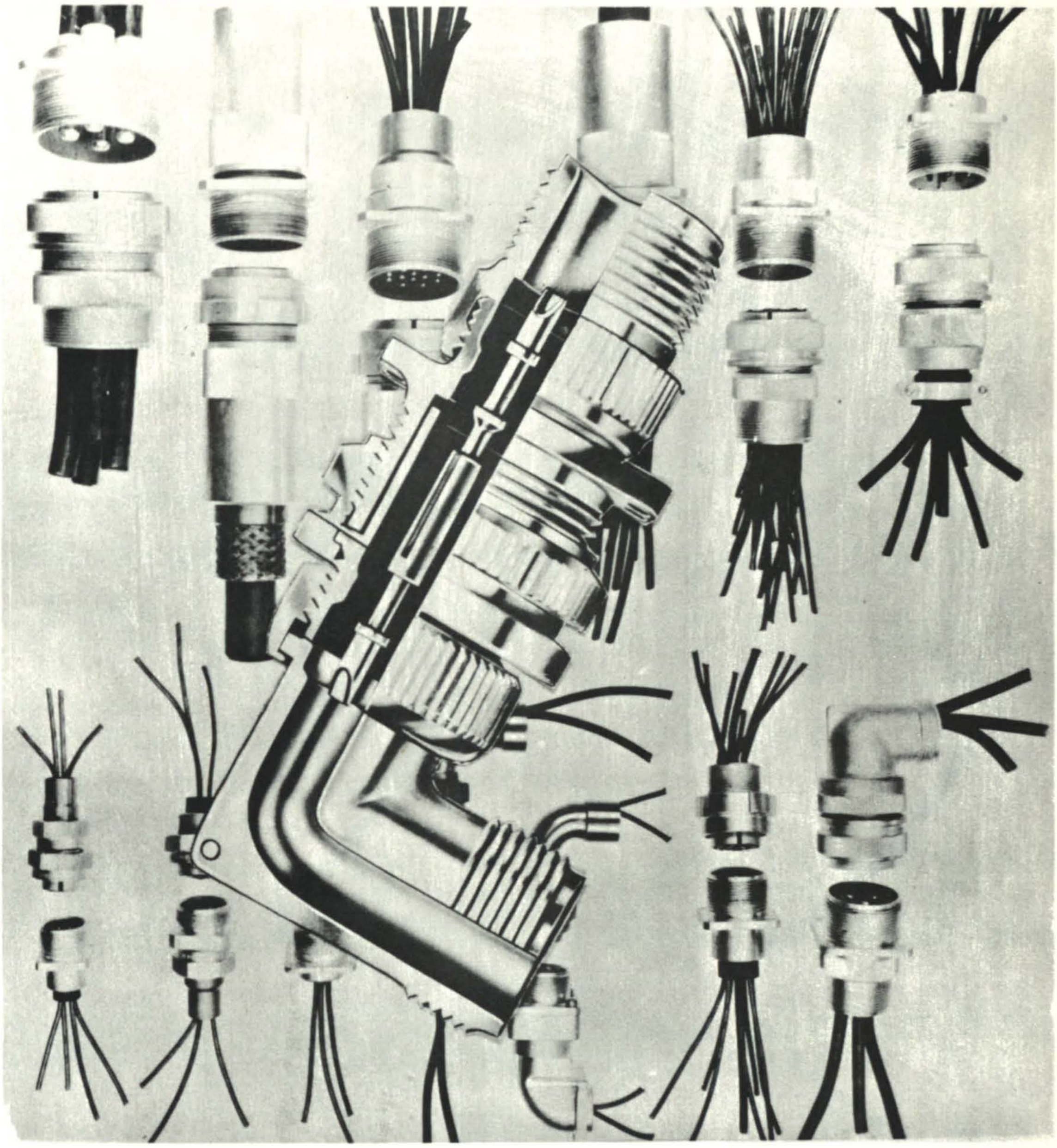


18069 SCINSEAL WIRING HARNESS

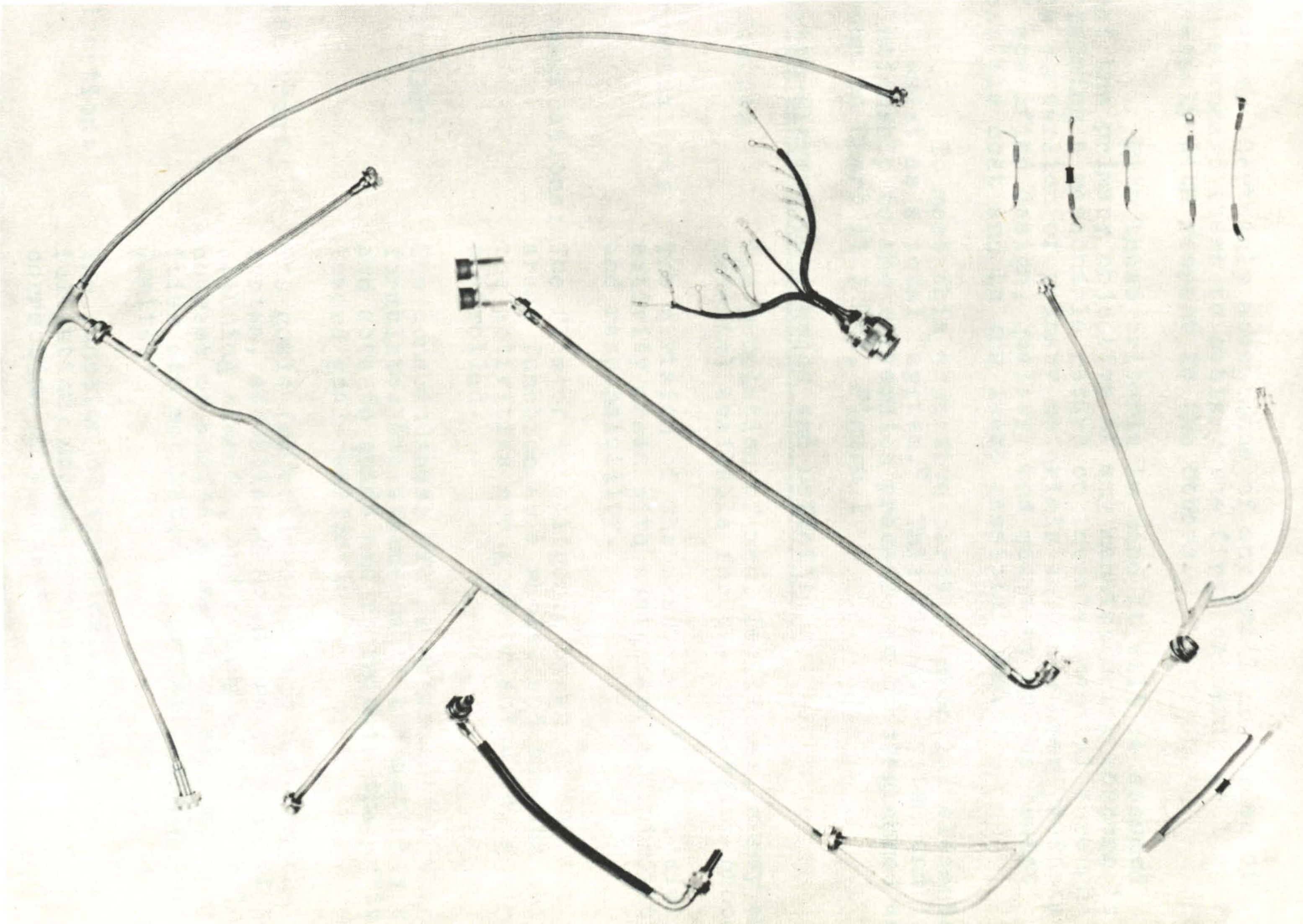


8316 JET IGNITION SYSTEM - TYPE TEN-1

15671 **CERAMIC PARTS**



9895 ELECTRICAL CONNECTORS



15806 WIRING HARNESSES AND LEADS

balance. Certainly acceptance of any small lot order of non-standard items to satisfy the first criteria will operate adversely with respect to the others.

With these criteria in mind it will be assumed that the primary objective of any manufacturing concern is obtaining a reasonable return on invested capital through the conversion of primary materials into customer products of specified design, quality, and quantity at the lowest possible cost and in the least possible time.

To meet this objective certain essential elements must exist as a total "system." This element-system and its relationship to the conversion process can be diagrammed as shown on Chart 11.1.2-1, Figure 1.

<u>System-Element Categories and Definitions</u>

Resources: The population of men, facilities, money and material available for the conversion process.

Organization: The division of the resources into specialized activity areas with assignment of authority and responsibility.

Communications: The flow of intelligence by which the activity areas function as a whole, and through which the activities are goal-oriented and goal-controlled.

Planning: The consciousness of the organization which formulates the standards of the activity areas, and acts to guide and coordinate the activities toward goal-realization.

Standards: The goals (objectives) of any unit in the system, established as an end product of the planning element, and acting as the elected courses of action along which the unit activities are motivated to proceed within certain limits.

Direction: The function of applying authority in the initiation, delegation, supervision, and correction of activity.

Operations: The directed functional activities which actually "do" the planned activity.

MANUFACTURING SYSTEM

ELEMENTS AND EFFECTIVENESS CRITERIA

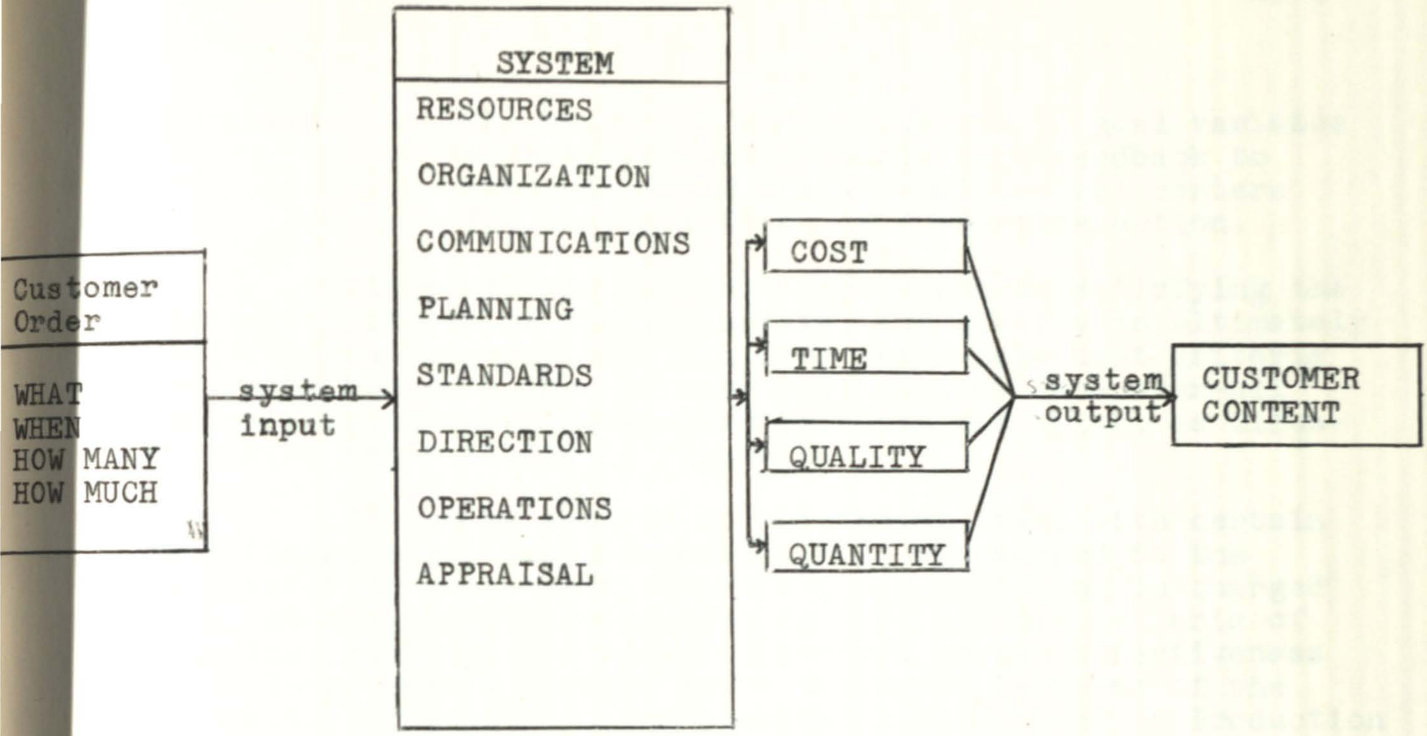


FIGURE 1

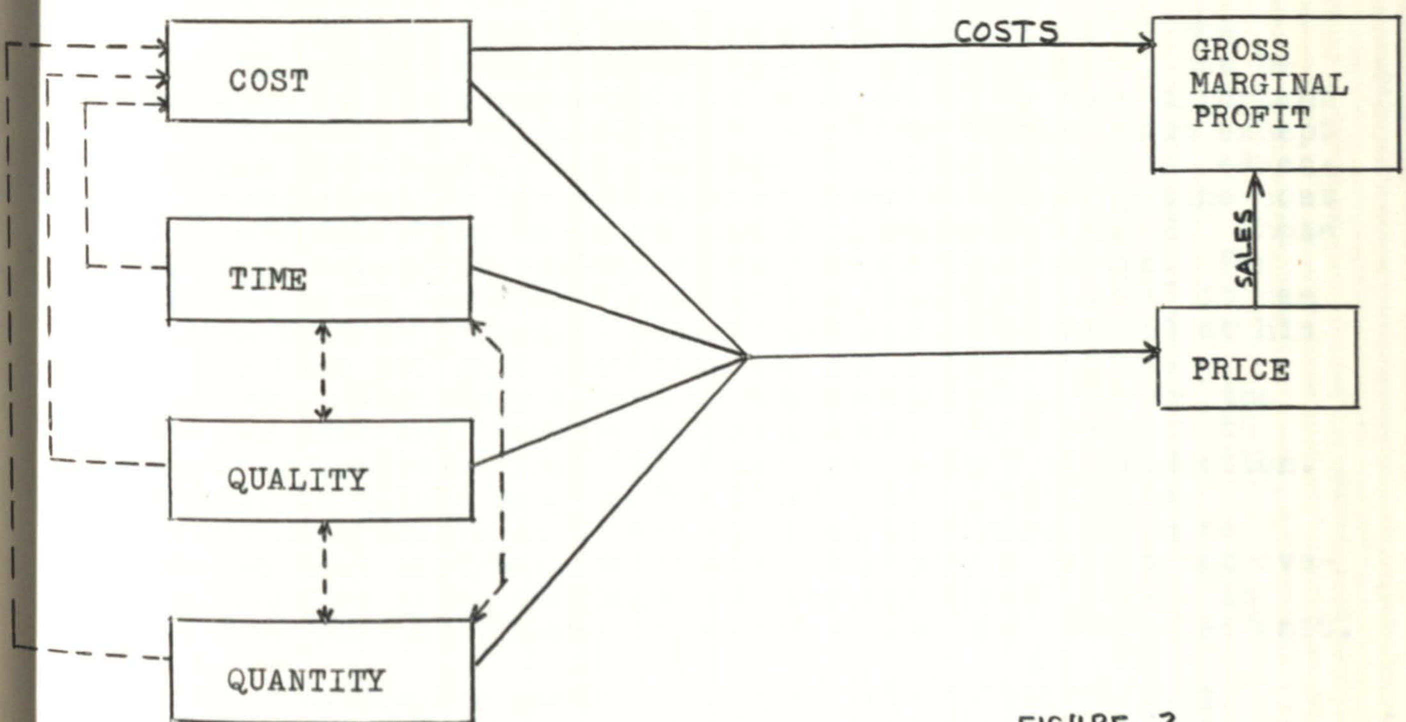


FIGURE 2

CHART 11.1.2-1

Appraisal: The detection and evaluation of goal variance with subsequent communication feedback to management and operational control centers for the initiation of corrective action.

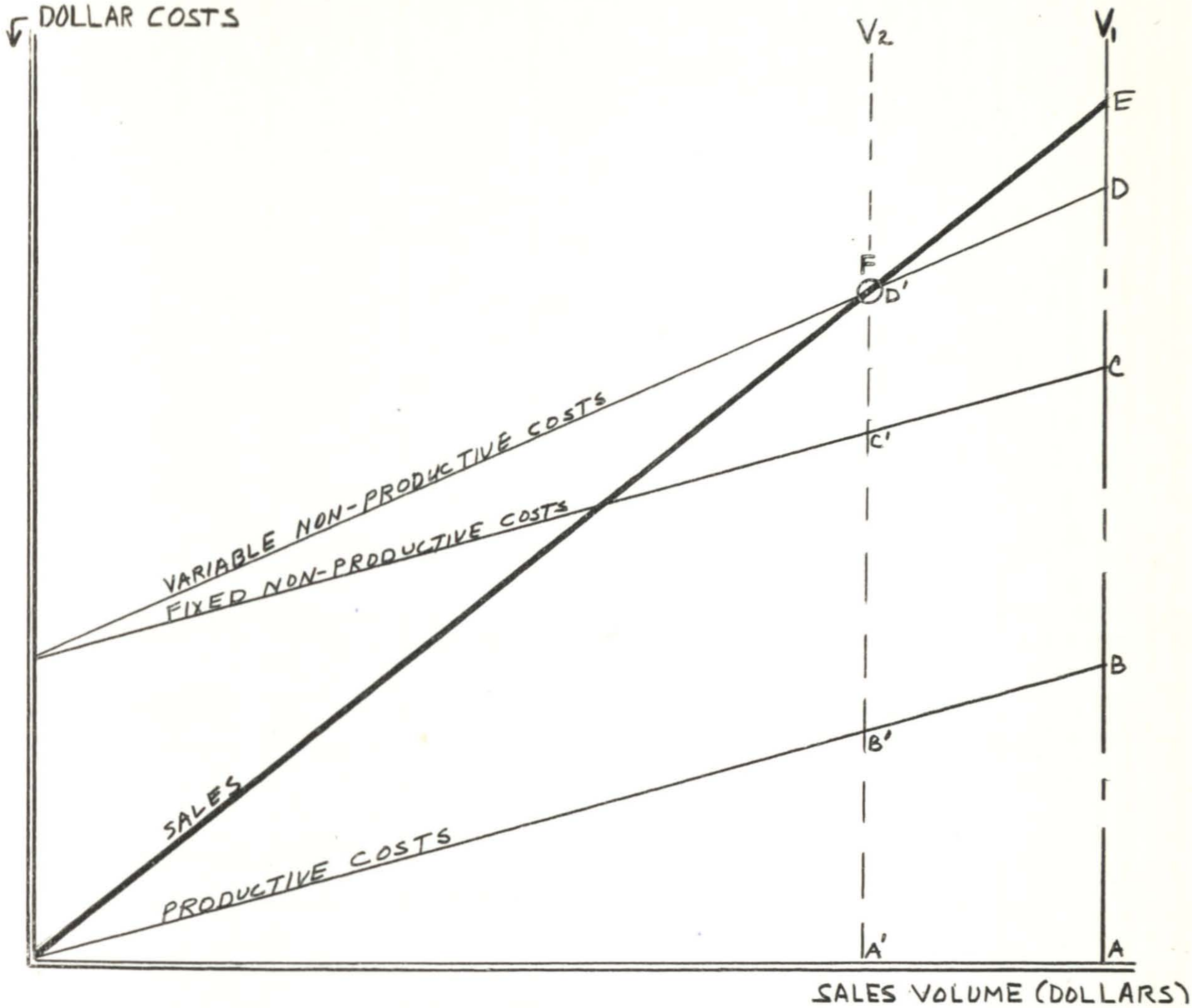
Since all the system effort spent in satisfying the customer criteria of time, quantity, and quality is ultimately reflected in the cost, and all four inter-dependent criteria determine how much the customer will pay, we have over-all system effectiveness determined by costs and sales, as illustrated on Chart 11.1.2-1, Figure 2.

It can be assumed at this point that, with certain exceptions, costs are generated within or charged to the manufacturing department. Further, manufacturing is charged with the responsibility of meeting the customer criteria of quantity, quality, and time. Therefore system effectiveness is in large part a measure to be evaluated in terms of the manufacturing activity, and specifically in terms of Production Efficiency which can be illustrated by the Volume-Cost-Profit Chart, shown on Chart 11.1.2-2. In reference to the chart, since productive costs are fixed and non-reducible, any increase in productive efficiency will reflect a decrease in non-productive costs further reflected as an increase in system effectiveness.

It can also be seen under the conditions of the chart that gross margin of the system (effectiveness) can be increased by an increase in unit sale price, or more important by an increase in volume (profit cannot be talked about except in terms of volume). The increase in volume becomes an essential consideration if attention is given to quantity-time-cost relationships shown on Chart 11.1.2-3, Figures 1 and 2. These functions represent typical established relationships. For instance if we consider Figure 1 as a "learning curve" it can be seen that as a worker becomes more and more skilled at his job the time per unit decreases and his output (volume) increases. Similarly a methods improvement will reduce the time per unit and increase volume output. With respect to Figure 2, consider first the fixed cost aspect of production. That is, as volume goes up the fixed costs (facilities, service departments etc.) are absorbed over more and more units so that cost/unit decreases. Further, a design improvement, such as using standardized components will result in less time per unit, hence increased volume and lower cost/unit.

Since the manufacturing department has primary control over time and cost standards, and has primary respon-

VOLUME - COST - PROFIT CHART



Productive Costs represent useful output and are those non-reducible costs of material present in a given end product of the conversion process together with the man and machine evaluated costs directly applied as useful work on it. These costs represent the output of the conversion system, and on the above chart equal AB at volume V_1.

Input Costs consist of the total costs generated in the system toward production of the end product, and equal AD at volume V_1, A'D' at V_2.

Productive Efficiency is the ratio between output and total input, and at volume V_1 equals AB divided by AD.

Gross Margin, or Gross Profit, is the margin remaining after subtracting total production costs (AD) from total sales (AE), at volume V_1.

Break-Even Point is that Sales Volume (V_2 above) where total Sales is exactly equal to total production costs, represented by point F. Above this volume there will be a marginal profit and below this point there will be a marginal loss.

PRODUCTION VOLUME FUNCTIONS

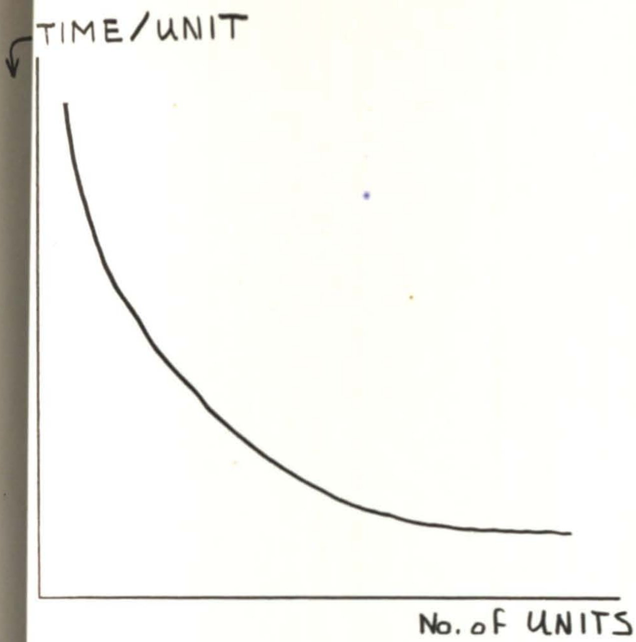


FIGURE 1

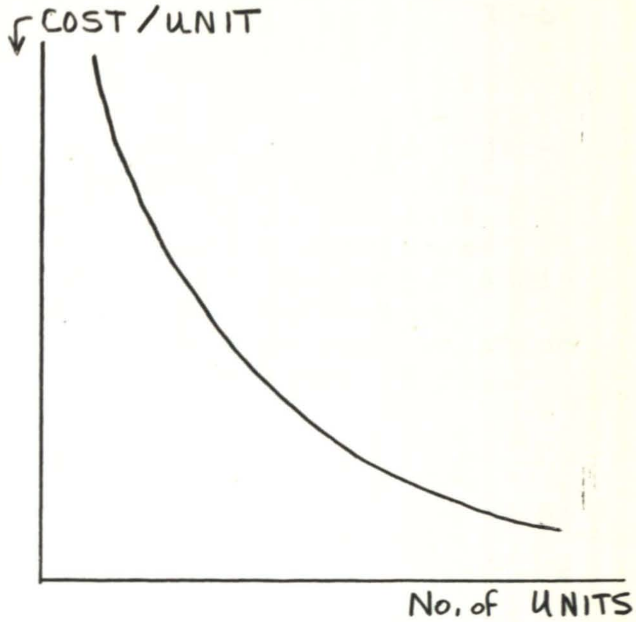


FIGURE 2

VARIANCE CHART

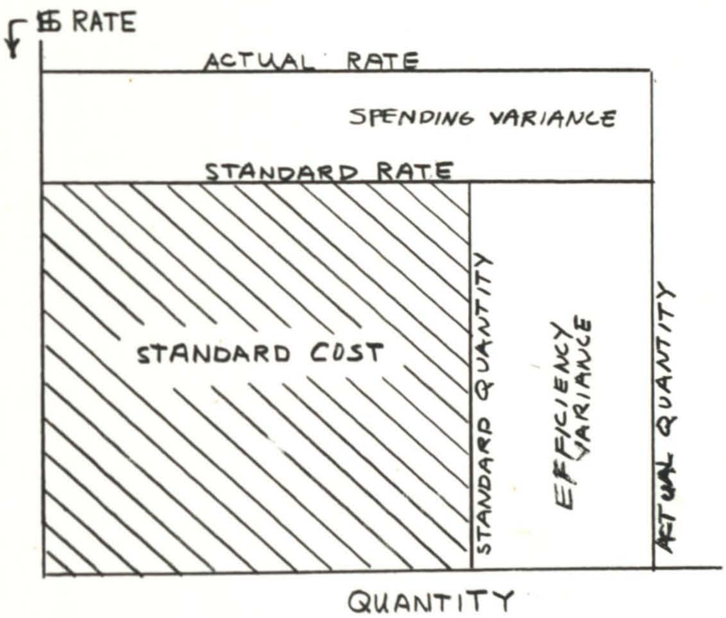


FIGURE 3

Spending Variance = (Actual Rate-Standard Rate) X (Actual Quantity).

Efficiency Variance = (Actual Quantity-Standard Quantity) X (Std Rate).

Total Variance = Spending Variance plus Efficiency Variance.

sibility for adhering to quality standards, it is the objective of this study group to become familiar with all the system elements, to determine their parameters, and make such recommendations for their revision as are considered sound with respect to improving production efficiency. Additional evaluation will be made on the basis of variance analysis, that is, what is the actual performance in relation to what it should or could be. A typical variance chart is illustrated by Chart 11.1.2-3, Figure 3.

Data collection will predominantly involve the sampling technique due not only to the immensity of the total data and the non-availability in many cases of requisite summarizations, but due to the desirability in some instances of checking the data for reliability and validity. The sampling technique (also called at times "Ratio-Delay" and "Frequency Study") is discussed in the "Industrial Engineering Handbook" by H. B. Maynard and published by McGraw Hill Book Co., First Edition, 1956. Refer to chapter 5 of Section 3.

It was initially determined that Scintilla manufacturing was too big, too complex--and time too limited--to study all the organizational elements, all the procedures, all the systems, all the methods, or all the products. Therefore the above mentioned analysis tools, along with sampling studies were to be used to determine areas of weakness in the system as a whole related to the primary standards of cost, time, quality, and quantity. Then, applying the technique of the "exception principle" these weaknesses were to be used as guide posts in checking back through the manufacturing system to find the cause--and possible improvements.

Basic cost and sales data used throughout this report are primarily inferred estimates. They were generated by sampling techniques based on the principle that by sampling a result a statistical inference can be made about the cause. It was not the purpose of the study group to delve into the actual cost and profit structure of Scintilla and, more importantly not to report it. Therefore certain data has been arbitrarily modified. However, existing <u>relative</u> structures were stringently maintained to indicate significant areas which this group feels that Scintilla could profitably investigate further. A brief discussion of Statistical Analysis is presented in Chart 11.1.2-4. For a more detailed discussion see any text on Statistical Quality Control. Scintilla's own Quality Control Manual is considered an excellent source.

STATISTICAL ANALYSIS

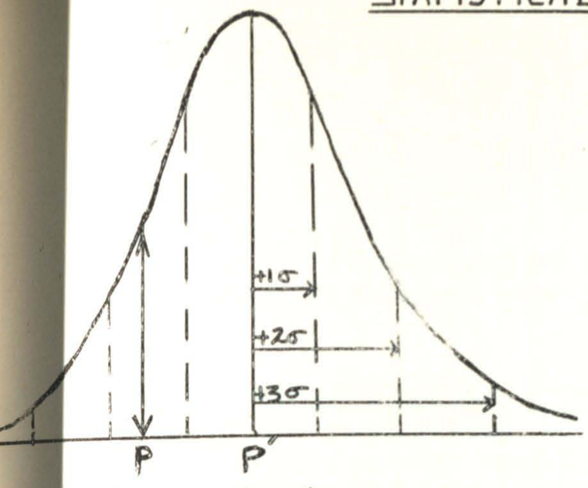


FIGURE 1

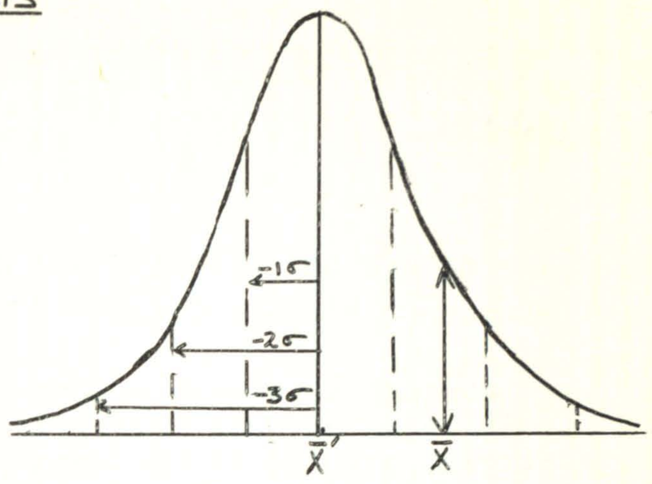


FIGURE 2

If a universe is sampled, and plotted as a frequency distribution, it sustains certain characteristics. In the ideal situation we get a "normal" distribution shown in figures 1 and 2. In figure 1 the distribution is in terms of discreet data, such as percent of occurrence of a certain element, where p' is the universe mean, and p is a typical sample percentage. In figure 2 the distribution is continuous data, where $\bar{X}'$ is the universe mean and $\bar{X}$ is a typical sample mean. σ represents the **standard deviation**, or error, of the mean, where $\pm\sigma$ encloses 68% of the area (possibilities) under the curve; $\pm 2\sigma$ encloses 95%; and $\pm 3\sigma$ 99.7%.

For sampling purposes this means that we may not get a p (sample percent) equal to p' (universe mean), in that a sample could fall anywhere along the distribution within $\pm 3\sigma$ limits. The acceptable tolerance, and the possibility of being wrong in the sampling observations are related through the standard deviation.

Figure 1. $\sigma = \sqrt{\frac{p(1-p)}{N}}$ Where p is the percent occurrence of the element sought, expressed as a decimal, and N is the total number of observations.

Figure 2. $\sigma = \sqrt{\frac{\Sigma f x^2}{\Sigma f} - \left(\frac{\Sigma f x}{\Sigma f}\right)^2}$ Where X is the numerical value of any observed occurrence and f is the number of times that particular value was observed in the total series of observations.

This means that for any sample the tolerance limits are given by σ and the accuracy of the sampled data is given by σ divided by p. In the statistical sampling studies of this report, tolerance limits will be taken at 95%, meaning that 95 times out of 100 the observed occurence (p or $\bar{X}$), $\pm 2\sigma$, will include the true universe mean.

One further note, for the above relationships to be held valid, total observations must be greater than 30, and preferably greater than 100, so that the sample standard deviation is equivalent to the universe standard deviation.

Presentation will be in the order of the system elements discussed previously.

11.2 Manufacturing - Resources. System resources include the total population of money, facilities, men and material available for the manufacturing conversion of primary materials into sale products.

11.2.1 Facilities

11.2.1.1 Plant. Scintilla Division has 98.3 acres of real estate of which 35 acres are now occupied. The plant itself contains 538,070 square feet of floor space, with an additional leased capacity of 31,884 square feet. Of this total, 42.6% is assigned to productive manufacturing. (See Chart 11.2.1-1 for detailed data on floor space allocation.) In relation to this plant floor space allocation, the plant flow diagram under the "Operations" section, is a print of the general plant layout by departmental activities.

The plant is fenced and further protected by a guard force, alarm system, and fire protection systems. Transportation facilities include railroad, trucking, and a municipal airport from which two company owned aircraft are operated. Utilities include electric power, which is 100% purchased, coal and gas fuels, and water from both the municipal system and a plant deep-well. The 33,000 square feet in the electronics building is air conditioned.

11.2.1.2 New Construction. In addition to the present plant a new series of plant additions are being constructed. This construction will take place in the form of four "cells" in sequence over the next few years, the first cell to be completed by this June. The new additions are primarily for the purpose of housing an integrated manufacturing center for the expanding electrical plug-in-connectors. Each cell will represent about 20,000 additional square feet of which about 60% will be productive manufacturing floor space.

11.2.1.3 Machinery and Equipment. Capital assets of Scintilla Division are estimated to be about $5,000,000 of which approximately 35% is government owned. Government owned equipment, if used for commercial application is rented at a negotiated rate. Present government rental amounts to about $50,000 per year. Other rental costs are incurred in the form of data processing equipment at the rate of about $65,000 per year.

FLOOR SPACE ALLOCATION-Square Feet

No. Bldg.	Name Bldg.	Sales & Service	Manuf (Prod)	Manuf (Non-Prod)	Acct.& Admin	Services	Eng.	Total
1,2	Guard					768		768
5	Gas Filler					511		511
6	Lumber Shed					7383		7383
7	Boiler House					3194		3194
8	Carpenter & Receiving			8577		6900		15477
9	Insp,Assy,Plating,Mould-ing,Painting,Tumbling		55267			2400		57667
10,AB	Mfg,Shipping,Oil Storage	3200	96065	31244		1959	7730	140198
11,A	Mfg,Office,ToolRoom,Stock			58887	1500	4650		65037
11B,C	Manufacturing		46329					46329
11D,E	Die Cast,Store,Stock,Eng			27712		2170	9665	39547
12	Engineering						2100	2100
16	Garage					2096		2096
17	Well					239		239
19	Old Guard House					109		109
20	Cafeteria					12545		12545
21	Boiler House					624		624
22	Eng. Lab						8516	8516
Dock	---					777		777
01,A	Engineering			2800	126	2755	37822	43503
01B	Offices	2809		5090	9764	6587	1580	25830
01D,E	Offices	9522		3121		615		13258
01C	Engineering						4616	4616
23	Personnel & Ceramics		11796			2700		14496
24	Electronics		32621			629		33250
Leased		3267			5500	23117 (storage)		31884
Total		18798	242078	137431	16890	82728	72029	569954
Percent		3.2	42.6	24.3	3.0	14.5	12.6	100.

Chart 11.2.1-1

A partial list of machines and equipment available for wide-variety manufacture include 195 lathes, 196 grinding machines, 77 punch presses, 32 gear cutters, 460 various borers, buffers, benders, die-casters, tappers, shearers, rivetters, etc., 20 units for sheetmetal parts fabrication, 124 units for plastic molding, 33 units for ceramic parts manufacturer, and 130 units for producing coils, condensers, relays, etc. Of this equipment, the manufacturing department has owned-machine-and-equipment facilities estimated at a present value of $1,800,000 with an average life of 6 years. A detailed breakdown of these facilities, by department and by machine categories is to be found on Chart 11.2.1-4. The breakdown further indicates the Scintilla operation (machine) code assigned each type and the corresponding load (efficiency) factor applied for mobilization planning, and also the estimated annual depreciation rate.

In addition, some new equipment has already been purchased, with more on order, for the new plant addition.

It should be noted that a considerable number of machines and equipment are not assigned to the manufacturing department in that Engineering maintains its own experimental shop, Sales manufactures its own small service tools, and the tool room has a considerable number for making tools and gages.

11.2.2 Men. Scintilla Division employs 4,684 persons of which 2,592 are in an indirect labor classification at an estimated annual payroll of $11,530,000, and 2092 are direct labor manufacturing department personnel at an estimated annual payroll of $8,350,000. Charts 11.2.2-1 and 11.2.2-2 detail these two categories by departmental assignment. About 30% of the employees are female.

The manufacturing department uses a wage-incentive system based on piece rate with a guaranteed base. Average base pay is $1.65/hour. Not all direct labor, such as setup men, etc. are on incentive. Of those that are, 23% of the time is at base rate due to jobs not being rated, machine setup, etc. The incentive workers earn on the average (including straight time) 127% base. Total % direct labor hours spent on straight time, including non-incentive workers, is 40%.

Direct labor accounts for a large proportion of product costs in that total facility costs approximate $960,000 while direct labor is estimated at $8,350,000. Direct labor,

MANUFACTURING DEPT. MACHINE & EQUIPMENT DATA (INFERRED)

MACHINE	OPER CODE	LOAD FACTOR	26	27	28	29	30	31	32	33	34	36	37	38	39	40	41	42	43	44	47	48	49	TOTAL	AVG. ORIG UNIT COST	Total Orig Cost	Present Book Value*	*Annual Dep Rate
			MANUFACTURING DEPARTMENTS																									
Turret Millers	03	1.5				1					1											1		3	$ 1100	$ 3300	$ 1320	$ 330
Cutter Grinders	05	1.2						5			3								1					9	500	4500	1800	450
SHAPERS	06	1.5									1													1	2100	2100	840	210
Drill Presses	10	1.2		1	1	21	7	18	2	1	7	3	2	4	10	4	2	1	2	1	3	11	3	104	1400	145500	58000	14550
MLTPL Dr Presses	11	1.2				6	1	1							1	5	3					2	1	20	1700	34000	13600	3400
Tappers	14	1.2	1			5	3	2			5				2	3					1	6		28	2100	58900	23550	5890
Winders	15	1.1												79						2				81	1200	97100	38850	9710
Arbor Presses	17	1.1		4		4	1	5	3		5	2	13	15	1	3	4	18	4	4	2	26		113	50	5650	2260	565
Swagers	20	1.2															3				3			6	1300	7800	3120	780
Punch Presses	21	1.3		24			1		1		5	5				2	7		2	1		17	1	66	3700	244000	97500	24400
Benders	22	1.3		2		1					3											1		7	2200	15400	6150	1540
Moulding Presses	24	.9										24	73			1					1	3		102	1900	193800	77500	19380
Auto Millers	31	1.3				7	7	6		1	3			1	2	8		1			1	10		47	1400	65700	26300	6570
Hand Millers	32	1.1				5	8	5			2			1	2	1			1			6		31	600	18600	7440	1860
Spline Millers	33	1.3				3		1								1								5	1500	7500	3000	750
Vertical Millers	34	1.3				3	1	2			8					1						2		17	2500	42500	17000	4250
Thread Millers	35	1.3				3	3				1											13	1	21	4700	98900	39800	9890
Profilers	36	1.3		1		8									1	2								12	3100	37200	14900	3720
Broachers	37	1.2					2									1	1					3		7	2300	16100	6450	1610
Cyl. Grinders	40	1.2					9	10		2	2				1	1	1		1		1	4		32	5000	160000	64000	16000
Int.-Grinders	41	1.1					2	6			1													9	4400	39600	15800	3960
Sur. Face Grinders	42	1.2				1	3	5		1	3				2	2								17	1400	23800	9500	2380
Thread Grinders	43	1.3	1				1	1																3	900	2700	1080	270
Cam Grinders	44	1.1					1	2		6														9	12500	112500	45000	11250
Sanders	45	1.0	4	1	3	5	3	6	8	1	3	2	1	2	5	3	1	1	4		2	5	1	61	100	6100	2400	610
Lappers	46	1.2				2	1	17		2					2							1		25	400	10000	4000	1000
Borematics	49	1.7				17	1	1							1	2	2							24	2600	62400	25000	6240
Auto Lathes	50	1.8			23	2	4								3							2		34	7900	268500	107000	26850
Turret Lathes	51	1.5	1		25	1	3			3					3	1						16		53	6500	344500	137500	34450
Hand-Screw	52	1.5	9		11		1	6		1	1				1	1			1			11		43	3100	133500	53400	13350
Auto-Screw	53	1.5	28																			26		54	7700	416000	166500	41600
Auto-Mltpl Spindle	54	1.8	25																			17		42	16300	685000	274000	68500
Engine Lathe	55	1.5	2	2	1		2	14		1	7			1	1		1		8	1		5		46	500	23000	9200	2300
Gear Hobbers	60	1.2					8			3						1								12	1500	18000	7200	1800
Gear Shapers	61	1.2								3												8		11	1800	19800	7920	1980
Gear Generator	62	1.2					2																	2	2500	5000	2000	500
Gear Finishers	63	1.2					1																	1	2300	2300	920	230
Engravers	66	1.1					2	2			1			1	3		2	1			2	5		19	1100	20900	8350	2090
Rivetters	67	1.2		6					1					4	1	1	3			1				17	300	5100	2040	510
Shearers	68	1.5		1							2		1	1										5	1600	8000	3200	800
Buffers	71	1.0		1					5								1			1	3	3		14	300	4200	1680	420
EQUIPMENT																												
Ceramic Equip	12																		37					37	3100	114600	45800	11460
Paint Equip	18								8											3				11	200	2200	880	220
Insp. Equip	23		4	3	6	8	12	26	20		6	2	2	16		3	2	13	14	6	1	5		149	400	59600	23850	5960
OVENS	25			1		1	1	1	13			1	25	14	1			4	9	36	7	2		116	1100	127900	51100	12790
Furnaces	28								39			18		2					8	1				68	2100	142900	57100	14290
Plating Tanks	30								141					1							1			143	600	85800	34300	8580
SAWS	69			1				1	1		2	2	1	1					2	1	2	1		15	200	3000	1200	300
Misc. Small Mach	70		2	2	1	5	2	2	5		6		6	6		1	2	5	3			14		62	600	37200	14900	3720
Vapor Blasters	72								11						2				1		1	2		17	1700	28900	11580	2890
Test Equip.	73		1				3	5	1					1		1		40		2	3	1		58	1700	98700	39500	9870
Tumblers	74			1					17				2				1					1		22	1400	30800	12350	3080
Solder & Weld	75						1		21		2		2	4				1		5	2	5	1	44	2800	123200	49300	12320
Impregnators	77													4						10				14	8900	124500	49800	12450
Degrease & Wash	78							2	3				1				2	1		5	2	4		20	400	8000	3200	800
TOTALS			78	51	71	109	97	152	300	25	80	59	128	158	45	49	38	86	98	80	38	289	8	1989		$ 4,437,700	$ 1,776,000	$ 443,770
TOTAL DEPARTMENTAL ORIGINAL EQUIPMENT AND MACHINE COSTS			$ 631,322	102,892	377,843	172,926	174,884	233,780	475,250	116,364	82,049	365,876	223,403	131,345	36,817	74,829	63,939	96,929	175,737	165,868	32,505	799,669	10,827	$ 4,545,054				
* DEPARTMENTAL ANNUAL DEPRECIATION COSTS			$ 63,130	10,290	37,780	17,290	17,490	23,380	47,520	11,640	8,200	36,590	22,340	13,130	3,680	7,480	6,390	9,690	17,570	16,590	3,250	79,970	1,080	$ 454,510				
* TOTAL DEPARTMENTAL PRESENT EQUIPMENT AND MACHINE BOOK VALUE			$ 252,500	41,100	151,000	68,700	69,500	93,400	190,000	46,400	32,800	146,000	89,200	52,500	14,700	29,900	25,600	38,700	70,200	66,250	13,000	319,000	4,320	$ 1,815,000				

* Depreciation computed at 10% straight line Rate.

* Book value computed at average equipment life of six years.

CHART 11.2.1-4

INFERRED INDIRECT LABOR DATA

DEPARTMENT NUMBER	DEPARTMENT NAME	ASSUMED BASE MONTHLY PAY	NUMBER OF PERSONNEL	GROSS MONTHLY PAYROLL
1	Exec.Admin.	800	13	$ 10,400
2	Exec.Mfg.	800	14	11,200
3	Shop Super.	600	18	10,800
4	Purchasing	370	26	9,600
5	Prod.Eng.	500	50	25,000
6	Prod.Offices	370	114	42,000
7	Stores	370	80	29,400
8	Tool Eng.	500	39	19,500
9	Mould Design	500	9	4,500
10	Tool Cribs	350	34	11,900
11	Tool Room	350	214	74,500
12	Maintenance	350	67	23,300
13	Truckers	350	126	43,800
14	Guards	350	29	10,100
15	Boiler Room	350	9	3,100
16	Receiving	350	18	6,200
17	Prod.Stds.	350	36	12,500
18	Salvage	350	3	1,100
70	Accounting	350	98	34,000
72	Office Serv.	350	25	8,700
73	Payroll	350	25	8,700
74	Timekeeping	350	31	10,800
75	A.I.M.P.	600	5	3,000
80	Sales	350	148	51,500
81	Shipping	350	116	40,400
82	Chauffeurs,etc.	350	12	4,200
83	Sales Service	350	17	5,900
87	Service Office	350	107	39,400
88	Service Repair	350	20	7,000
90	Engineering	500	213	106,500
91	Research Lab	500	140	70,000
92	Experimental	500	121	60,500
94	Personnel	350	23	8,100
95	Medical	350	9	3,100
98	Tabulating	350	19	6,600
99	Inspection	350	500	177,000
100	Quality Cont.	500	64	32,000
TOTAL MONTHLY			2592	$1,025,000
TOTAL ANNUALLY				$11,530,000

CHART 11.2.2-1

INFERRED DIRECT LABOR DATA

DEPARTMENT NUMBER	DEPARTMENT NAME	ASSUME BASE MONTHLY PAY	NUMBER OF PERSONNEL	GROSS MONTHLY PAYROLL
25	Trainees	300	125	$ 37,500
26	Automatics	360	112	40,100
27	Punch Press	360	68	24,300
28	Lathes	360	129	46,100
29	Lt.Metal Mach.	360	89	31,900
30	Steel Mach	360	67	23,900
31	Fuel Pump	360	97	34,700
32	Processing	360	162	57,900
33	Cam & Gear	360	31	11,100
34	Sundry	360	102	36,500
36	Die Cast	360	43	15,400
37	Moulding	360	70	25,100
38	Coil	360	174	62,300
39	Mould Mach.	360	36	12,800
40	Commercial	360	34	12,200
41	K&H Magnetos	360	21	7,500
42	Assembly	360	74	26,500
43	Ceramics	360	25	9,000
44	Plastics	360	67	24,000
47	Harnesses	360	106	38,000
48	Elec. Connectors	360	448	160,500
49	Ignition,Plugs	360	12	4,300
TOTAL MONTHLY			2092	$ 741,000
TOTAL ANNUALLY				$8,350,000

Monthly Base Computed as follows:

$2.01 Avg. Hourly Wage x 41.4 Hrs/week x 4.33 Week/month

Annual period assumed to be 12 months less 3 weeks vacation and leave = 11.25 months.

Chart 11.2.2-2

excluding allowances, is that amount directly costed to the product. In addition to this, each direct labor hour earns certain "allowances" such as vacation pay, overtime, etc., that are charged to overhead burden expense. Costs by product categories, as percent of sale price, are as follows:

Product Category	% Sale Price of D.L. Excluding Allowances	% Sale Price of D.L. Including Allowances
Electrical Connectors	14.76	22.60
Harnesses, Leads, Cable Assy.	10.06	15.40
Jet Ignition Equip. & Plugs	11.65	17.85
Spares, Tools, Serv. Repairs	7.80	11.90
Industrial Mags	15.88	24.30
Aircraft Mags	13.58	20.75
Fuel Injection Units & Parts	19.15	29.30
Coils, Switches, Filters	12.00	18.40
Ignition Analyzers & Equip.	10.23	15.70
Miscellaneous	17.05	26.10

11.2.3 Material. An inventory of an estimated $3,500,000 is maintained which is primarily work in process. There is no finished goods inventory, as such. Some completed work is on the shelves as stock spares or as units completed ahead of scheduled shipping date. Raw material inventory is maintained at minimum level related to orders-on hand, (some raw material is accumulated ahead of orders on the basis of advance releases predicated on a "firm" short-run forecast).

Direct material, like direct labor, constitutes a considerable part of the product cost. Annual material costs are estimated at about $11,000,000 annually at the present level of production. Of this amount, about 6% is material work-scrap cost and about 7% is product rejection-scrap cost. An active salvage section functions to regain some of this loss.

The following tabulation indicates the material cost by product category as a function of the sale price.

Product Category	% Sale Price of Direct Material
Electrical Connectors	22.71
Harnesses, Leads, Cable Assys.	26.42
Jet Ignition Equip. & Plugs	26.40
Spares, Tools, Service Repair	27.06
Ind., Ord., Auto, H Mags, etc.	30.35
Aircraft Magnetos	18.66
Fuel Injection Units & Parts	8.53
Coils, Switches, Filters	30.00
Ignition Analyzers & Equip.	34.67
Miscellaneous	26.15

11.3 Organization. The division of the resources into specialized activity areas with assignment of authority and responsibility.

11.3.1 General. The need for an organization is created when the top executive of any activity has more than he can efficiently do himself. He delegates certain functions to specialists who manage the delegated activities. One such function is planning. This group believes that if all other recommendations fail to become incorporated, the modification of the Division's organizational structure is mandatory, particularly to place the necessary emphasis on the planning function and to bring the objectives of the Division into dynamic perspective. With the right man in the job, with the job responsibilities clearly defined, and with the incumbent holding requisite authority it is axiomatic that the responsibilities will be discharged with a high degree of efficiency. Thus, a reorganization must be paralled with an organization manual setting forth job descriptions as carefully as possible, and further paralled with the most critical placement of personnel.

11.3.2 Present Organization. The present manufacturing organization is discussed in Chapter I, Organization, down through the intermediate levels of supervision. Levels and functions below this are covered in individual sections within this Chapter. Therefore, no additional present organizational analysis will be attempted here.

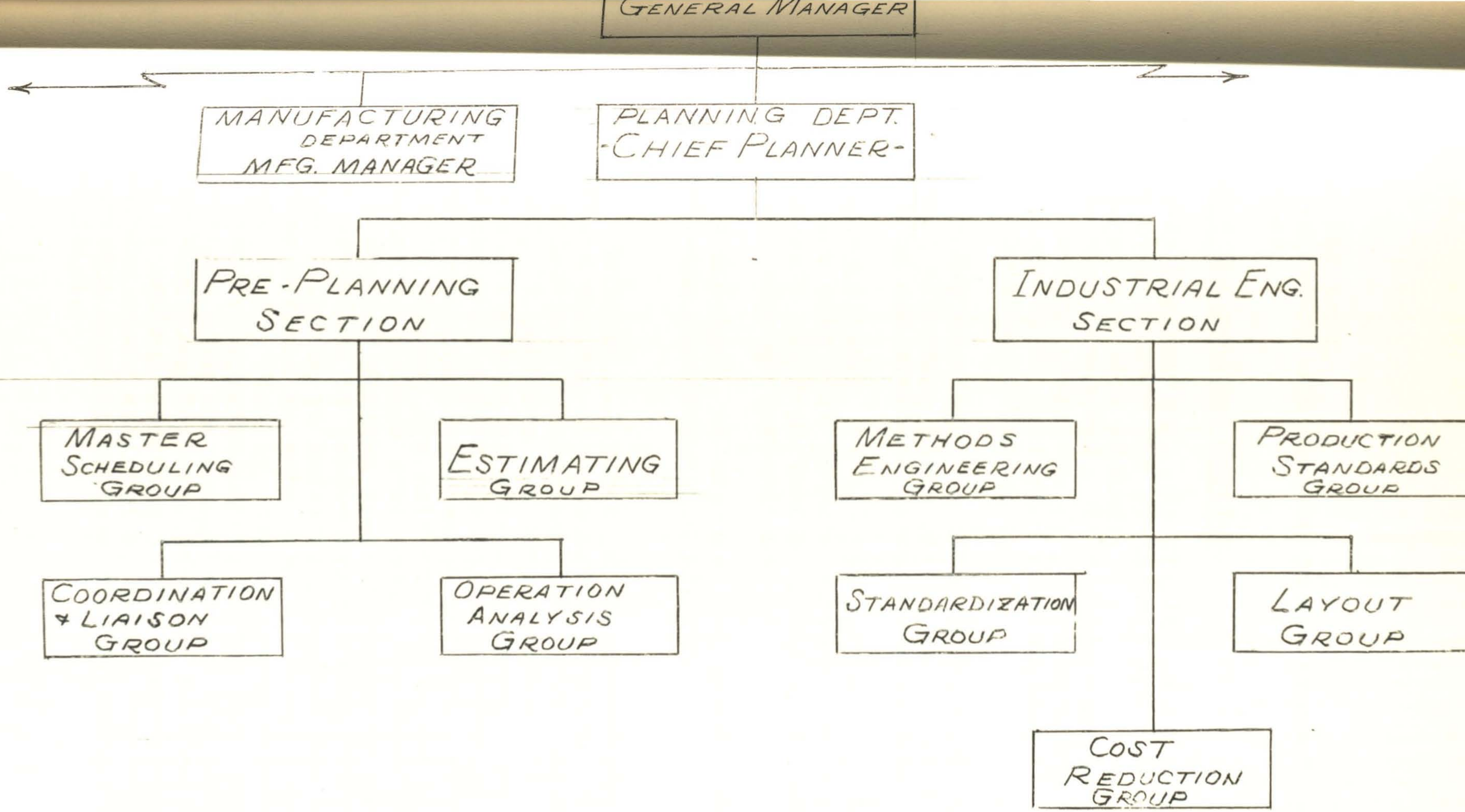
11.3.3 <u>Proposed Organization</u>. The General Manager's authority stems from the parent company who expects him to return a reasonable profit. In order to ensure continuous performance he must plan ahead. Here a choice exists. He can do the work himself or he can charge each of his subordinates to do their respective planning wherein he then co-ordinates the planning activities between them. This is the present concept.

We submit that each of these major subordinates, i.e., Sales, Engineering, Manufacturing, etc., inherently do not at all times treat the best interest of the company objectively. Desires of Sales and Manufacturing are historically divergent. Their planning consequently may be prejudiced. Periodic, major issues should of course be co-ordinated by the General Manager. But a continuing, high-level, long-range, responsibly charged function should exist to provide such an objective co-ordinated plan on a routine basis. It is therefore proposed that a position be established to function as the Chief Planner as head of a Planning Department for the Division to operate directly under the General Manager, on equal level with the present Departmental Managers. As discussed in subsequent sections, this department studies the Division's objectives, advises the General Manager, and through the General Manager's authority issues plans that may affect all departments to ensure that the objectives will be met. These plans must be based on standards, consequently included under the Planning Department is the function of Industrial Engineering.

Chart 11.3-1 portrays the recommended organization of the Planning Department.

<u>Pre-Planning Section</u>

1. Evaluation of present and future Scintilla requirements.
2. Forecasting of requirements with regard to mobilization.
3. Evaluation and forecasting of capital expenditures and flow.
4. Evaluation of the economic situation with regard to products, facilities and materials.
5. Development of master schedules and quotas for all departments.
6. Initiation, development and analysis of pilot-runs when necessary.
7. Estimating (in all its broad applications), and routine quote service.



PLANNING DEPARTMENT
ORGANIZATION

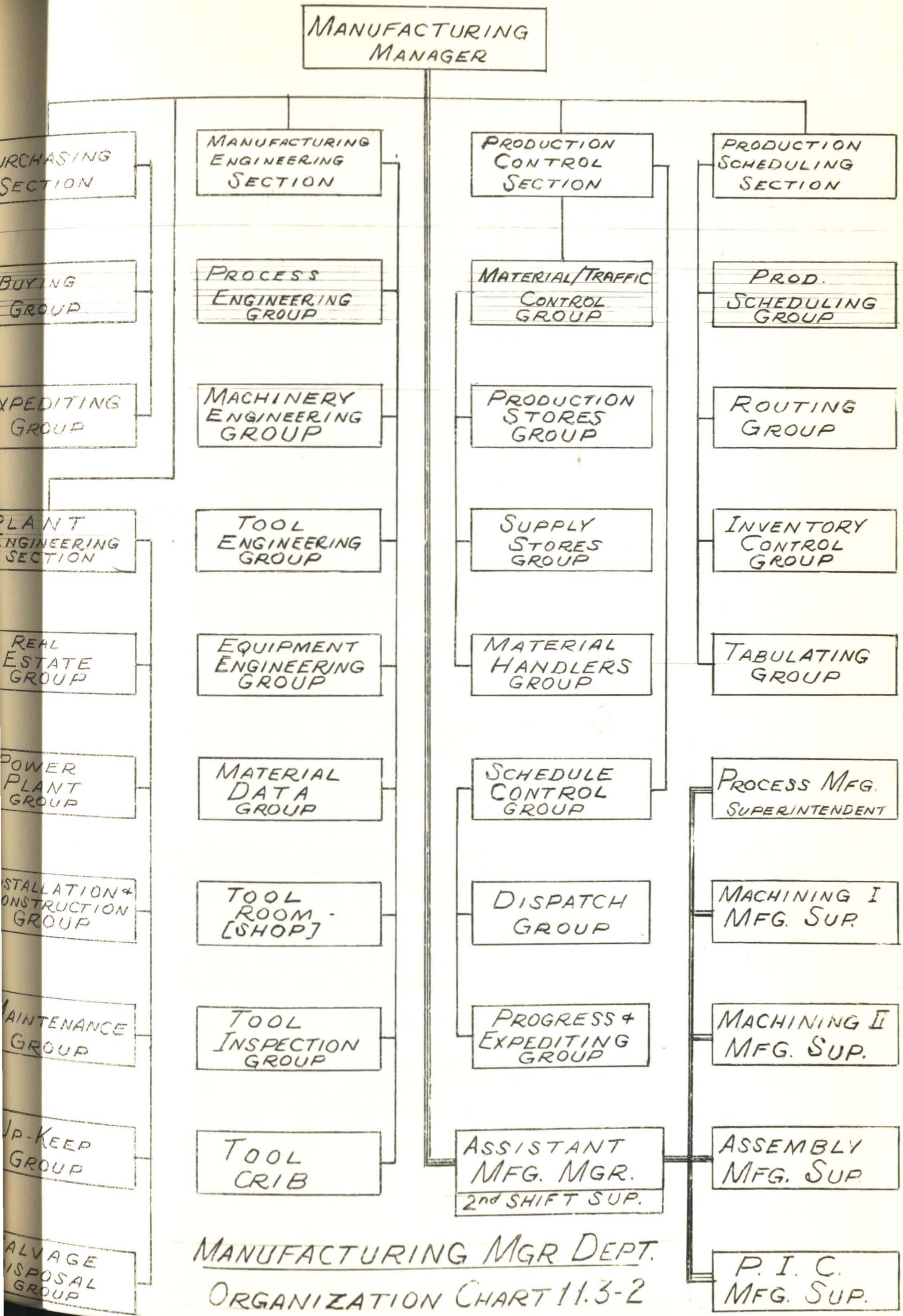
CHART 11.3-1

8. Cost Analysis.
9. Co-ordination and Liaison on new products and engineering changes.

Industrial Engineering Section

1. Methods Engineering. To utilize every proven technique in a co-ordinated and systematic approach to the problem of improving work methods.
2. Production Standards. To develop and install economic and accurate standards of performance for all possible functions to be performed in achieving the objectives of the Scintilla Division.
3. Layout Engineering. To maintain current data on all factors affecting plant layout and to plan and co-ordinate existing and proposed layout arrangements.
4. Standardization. To develop and install criteria or policies that will promote uniform practices and conditions with all departments of the plant and permit their control through comparisons.
5. Cost Reduction. To organize and guide a continuing plant-wide cost reduction program.

Chart 11.3-2 portrays the recommended revised organization for the Manufacturing (Factory) Manager. Under this organization, Purchasing will not be discussed since essentially it performs the same function and retains the same job descriptions as presently exist. The Plant Engineer, although somewhat modified retains essentially the same functions and responsibilities as at present. Modifications that do vary from present are self obvious in the block-titles and will not be further discussed. The Manufacturing Engineer (Master Mechanic) retains present functions and job description with the exception of long-range planning activities and those activities relating to Industrial Engineering and will therefore not be defined in more detail. Present duties are analyzed in Section 11.5. Finally, the Assistant Manufacturing Manager and the Factory Superintendents in the line organization remain unchanged with the exception that one additional Manufacturing Machining Superintendent is recommended to reduce the span of control existing in the present organization. The two remaining staff activities, namely Production Scheduling and Production Control include the following functional responsibilities:



MANUFACTURING MGR DEPT.

ORGANIZATION CHART 11.3-2

Production Scheduling Section. The principal objective of this section is to produce a departmental work station loading schedule to carry out as efficiently as possible the master unit manufacturing and assembly schedules developed by the Planning Department. The section consists of four groups: Production Scheduling, Routing, Inventory Control, and Tabulating organized as shown on Chart 11.3-2. Significant functions of the Production Scheduling Section are outlined below.

1. Determines net requirements for components necessary to complete master schedules.
2. Classifies net requirements by means of a priority classification system based on criteria that will maximize earnings potential commensurate with other Scintilla objectives.
3. Authorizes the use of raw materials and finished parts in support of the manufacturing and assembly schedules.
4. Incorporates into the scheduling procedure manufacturing and assembly operation process sequences, and determines "build" times using engineered time standards.
5. Develops and issues departmental work station load schedules in the form of job tickets, cards, or other appropriate means.
6. Provides tabulating and/or computing services for departments, section, and groups engaged in executing and controlling production activities.

Production Control Section. The essential activity of this section is that of execution and control of the departmental schedules developed by the Production Scheduling Section. The section consists of two groups: Material/Traffic Control and Schedule Control organized as shown on Chart 11.3-2. In support of the overall objective, the Production Control Section accomplishes the following:

1. Stores, issues, and physically accounts for raw materials and finished components necessary in direct support of production schedules.
2. Stores, issues, control and physically accounts for miscellaneous production supplies.

3. Moves production components and materials from and to storage areas; intra and inter-department movement of materials in accordance with the requirements of the departmental work station loading schedule.
4. Issues in proper sequence the promulgated manufacturing and assembly schedules via departmental dispatchers working in cooperation with the foremen.
5. Progresses the successful fulfillment of schedules; signals non-compliance with scheduled activities; accomplishes necessary expediting work.

11.4 Communications. The flow of intelligence by which the organized activity areas function as a whole and through which the activities are goal-oriented and goal-controlled.

Discussion

The basic concept of communications as used herein is as applied to "control communications", although other aspects with regard to employee morale, routine administrative procedures, etc., through the wide range of communication applications in the transfer of any type intelligence are of equal importance to the smooth functioning of any organization. Control communications can only be discussed as a "system". Control cannot be an individual function except as a responsibility at the highest levels of management, where the function by definition is to plan and control. After delegation of responsibilities from these top levels, the various activities must be linked, co-ordinated, and directed through control systems.

Chart 11.4-1, figure 1, representa a simple loop with first order feedback. A certain goal (standard) is set as the input, which in turn operates the drive mechanism (B) which causes a resultant action (C). The actual output characteristic of (C), which may be different from the set goal, is fed back from (C) to (A) and any error is detected and applied to the drive mechanism control at (D) to reduce the output error. A simple system such as this includes all the elements comprising the remainder of the manufacturing section in this report, namely: planned standards (goals), direction, operations, and appraisal, which can then be analyzed in terms of a conventional communication closed

SIMPLE COMMUNICATION LOOP ANALYSIS

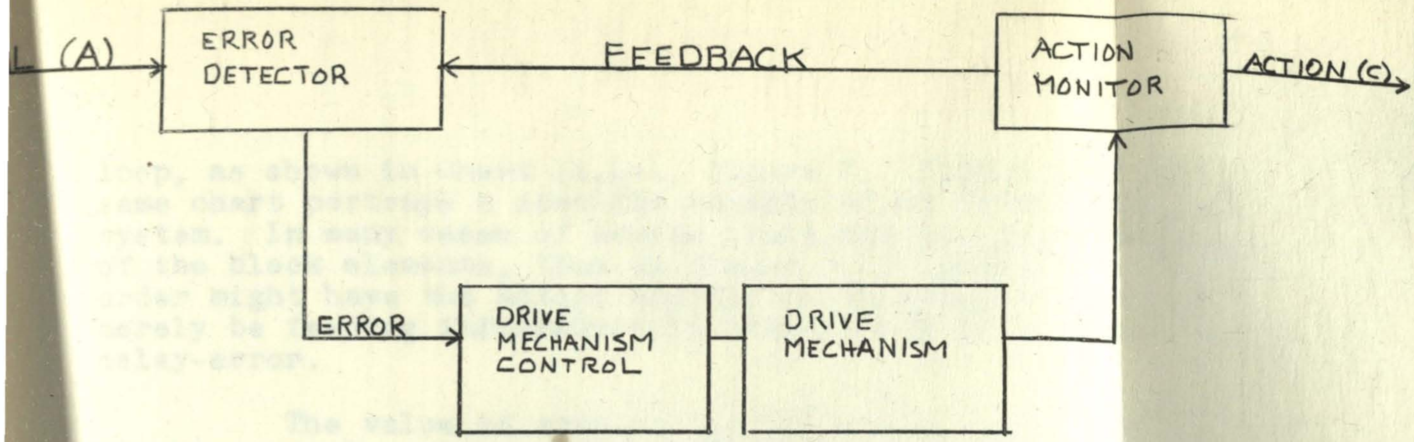


FIGURE 1

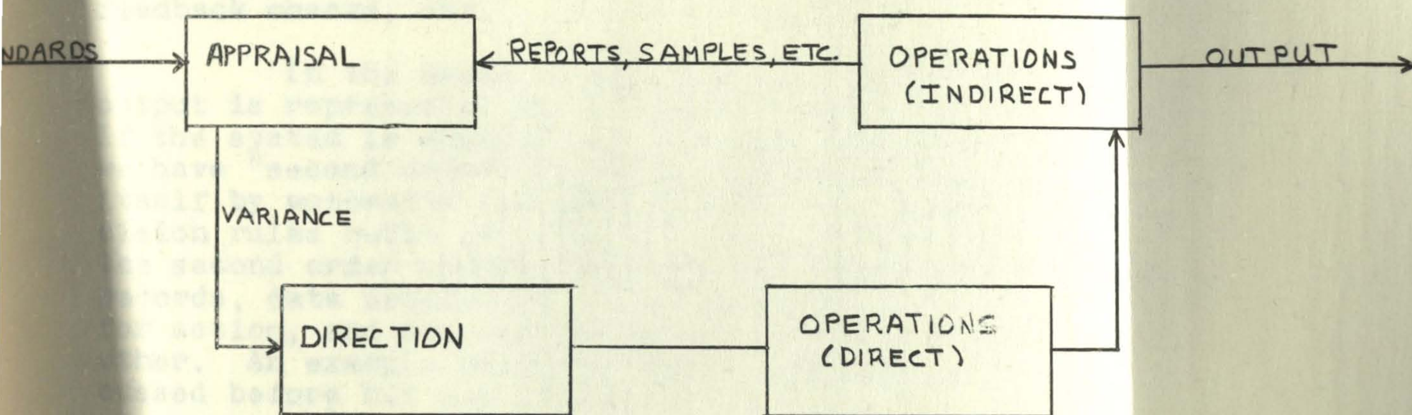


FIGURE 2

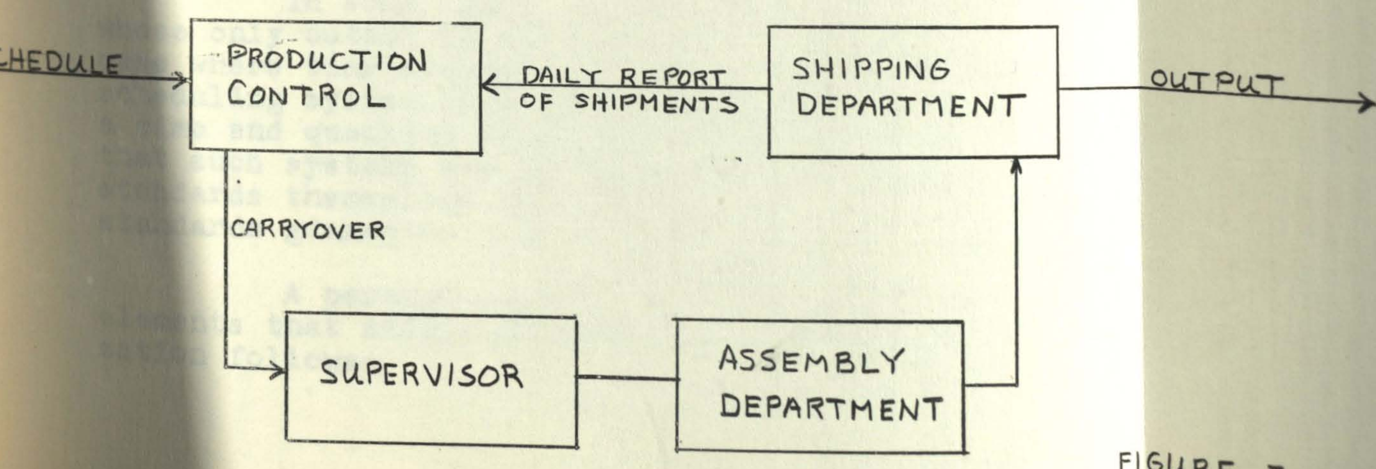


FIGURE 3

loop, as shown in Chart 11.4-1, figure 2. Figure 3 of the same chart portrays a specific example of an order scheduling system. In many cases of course there may be a combination of the block elements, thus in figure 3, a system on a single order might have the action monitor as an expediter who would merely be feeding information to himself and detecting the delay-error.

The value of such an analysis lies in the fact that if the control communication system does not exist for any investigated activity, then that activity is not properly monitored. The efficiency of any feedback loop can give the sensitivity and effectiveness of the monitoring that does exist and, further, of particular interest are evaluation of critical points for stability, error reduction, time lags, feedback checks, etc.

In the above simple case, the goal control mechanism output is represented as the input to the first order systèm. If the system is enlarged to include this goal-changing device we have "second order" feedback, where the system can control itself by automatic changing of its standards based on decision rules built into the system. This implies that within the second order system there is a memory reservoir (files, records, data processing, etc), several alternatives prepared for action, and the rules set up for selecting one or the other. An example would be the order scheduling system discussed before but now including the schedulers themselves.

Still further, the system can be enlarged to where it includes reflective decision making (formulating new courses of action and new decision rules and procedures) we have a third order feedback system which approaches most industrial or human organizations. An example of such a system is shown on Chart 11.4-2.

In some cases, an input may be a goal into a system whose only output is another goal or standard. This is the case where time standards are, or should be, inputs to the scheduling system where the output is another standard, i.e., a time and quantity schedule. It cannot be overemphasized that such systems are as important as activity output since standards themselves must be evaluated and controlled. Poor standards guarantee poor performance.

A partial summary of the various systems and their elements that should be present in a manufacturing organization follows:

THIRD ORDER COMMUNICATION SYSTEM - (ORDER PROCESSING @ SCINTILLA)

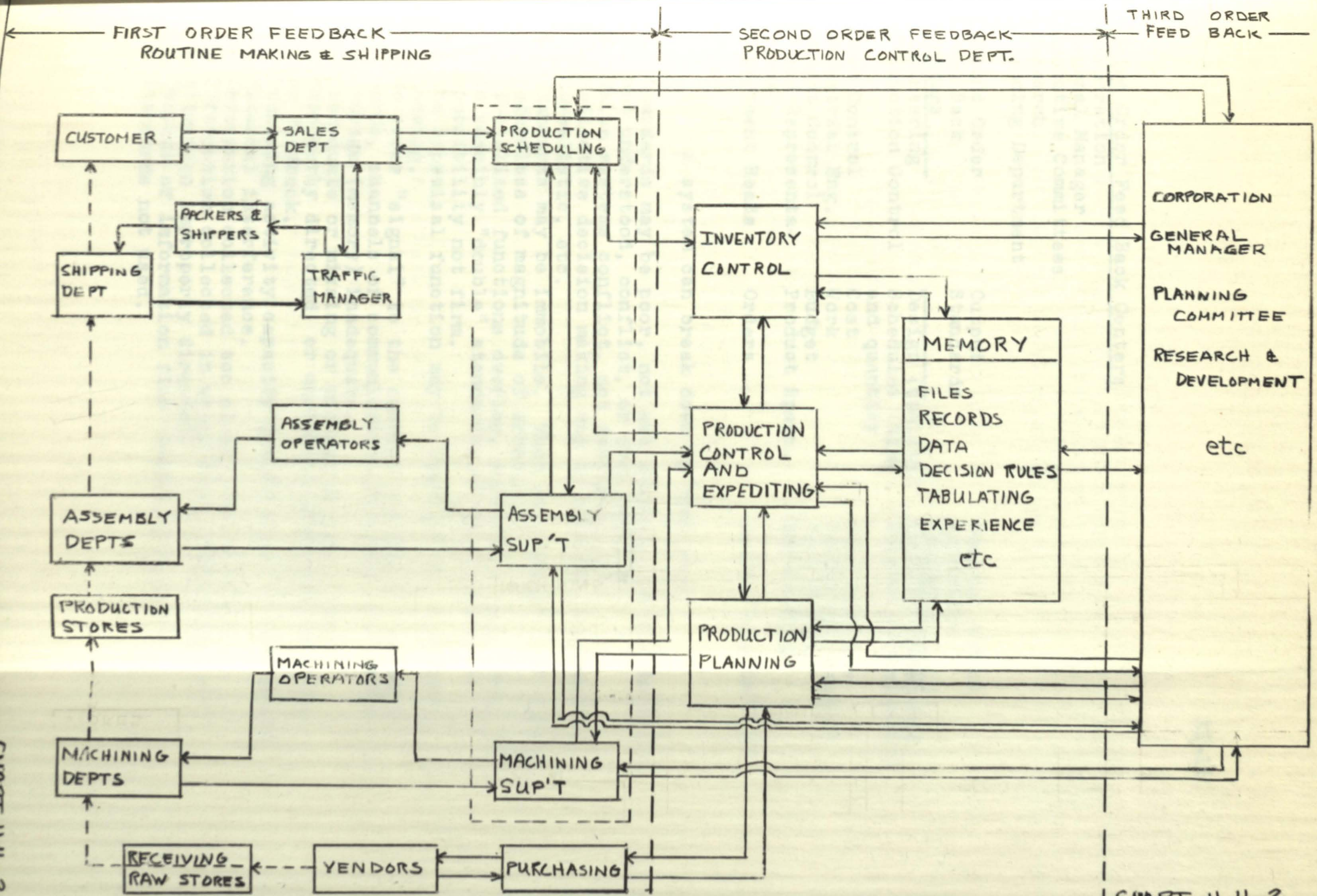


CHART 11.4-2

CHART 11.4-2

Third Order Feed Back Centers
Corporation
General Manager
Executive Committees
Research
Planning Department

Second Order Feed Back Centers	Output Standards	Monitor and/or Appraisal Centers
Engineering	Design (quality)	Quality Inspectors
Production Control	Schedules (time and quantity	Expediters/inventory
Cost Control	Cost	Cost Analysis
Industrial Eng.	Work	Production Control
Budget Control	Budget	Cost Control
Field Representatives	Product Specs.	Engineering
Department Heads	Orders	Assts/"reports" back

A system can break down in many ways:

1. Standards may be poor, not set properly, poorly defined, not understood, conflict, or even lacking.
2. Value systems conflict, not realistic, etc.
3. Reflective decision making may be missing, inadequate, unrealistic, etc.
4. Standards may be immobile. That is, incapable of change regardless of magnitude of error.
5. Specialized functions overlap, duplicate, etc., resulting in possibly "double" standards, or no standards if responsibility not firm.
6. The appraisal function may be ineffective, inadequate, or lacking.
7. No error "signal" to the control mechanism. In other words, channels of communication missing, overloaded, etc.
8. Storage (memory) inadequate.
9. Inadequate or missing or misused decision rules.
10. Improperly directed, or unstable, producing activity.
11. No feedback.
12. Producing activity capacity insufficient, or too great.
13. External interference.
14. Information collected too slowly, or too fast.
15. Information collected in wrong form, cumbersome, etc.
16. Attention improperly directed.
17. Content of information flow changed improperly.
18. Standards not used.

Examples of each of these possibilities are cited below. Numbers correspond to similar numbers in the foregoing paragraph. In most cases the examples relate to specific cases felt to exist at Scintilla, although no explanation is attempted here since subsequent sections of the report develop and analyze the situations.

1. Work methods not standardized or specified on most incentive operations.
2. In-Process inventory at high level. Policy of producing only to firm order creates long manufacturing cycle time with resultant high in-process inventory.
3. No long-range planning department or fixed responsibility for this function except by committee.
4. Time standards loose in many cases but employee relation considerations prohibit tightening to any great degree.
5. Work methods responsibility (in broadest aspects) duplicated amongst Methods Department, Time Study Department, Plant Engineer, Layout Department, etc. Also, the time standard on a lathe job in the lathe department may be different than the exact lathe job in the connector department.
6. There is no appraisal of schedule performance on intermediate departments on a Production Contract, unless the job is so late that "expediting" is necessitated by proximity to the completion date.
7. If a Quality Defect is not detected until final inspection, it may have lost its identity with a particular operator so that the "casual" point is not informed of the error, or corrected. Further, under the present cost center system, individual foremen do not receive a variance signal on specific jobs or types of expense.
8. Machine loading only on critical operations due to the complexity of the information involved.
9. Supervisors have no "job priorities" to work with. The general decision rule of which job goes next, unless modified by expediting action, is which one has been on the floor longest.
10. Low manpower and machine utilization.
11. No feedback for appraisal of time standards except when specifically requested and/or incentive operator earnings exceed 150% of base pay and/or method change instituted.
12. Insufficient machine capacity in a bottleneck operation.
13. Normal order processing system continuously disrupted by interjection of hot jobs, rework, etc.
14. Foremen do not receive Contract Status report until middle of producing monthly period.

15. Cost data collected by "Product Center" rather than by supervisory responsibility center for control.
16. Most supervisors attention directed primarily to meeting monthly "billing" instead of most economic production.
17. Appraisal tends always to find error of supervision rather than possible error in standard.
18. Time standards not used for scheduling except in critical operations.

It is recommended that as the remainder of the manufacturing department report is read, deficiencies indicated such as late order deliveries, scrap and rework, low utilization, low efficiency, etc., be used as entry points into a communication analysis to see where and why the system went "out of control", and from this analysis to determine the procedures necessary to establish standard performance under proper standards. In this respect, many deficiencies will involve second order feedback where the standards themselves need to be critically evaluated.

In the last analysis, a combination of many communication loops results in a "procedure system". Such a system is illustrated by Chart 11.4-3, which, in part, shows the administrative procedures involved prior to receipt of a firm order. A chart of this kind developed through detailed study can be invaluable in aiding organizational and procedural analysis.

11.5 Planning (and Control). The consciousness of the organization which formulates the standards of the activity areas, and acts to guide and co-ordinate the activities toward goal-realization in accordance with the basic objectives of the organization.

11.5.1 General. Two basic types of standards are set by the planning process; the goals are standards as are the courses of action chosen to realize those goals. Planning results ultimately in the corresponding control functions. Thus we see the two primary tools of management -- standards and controls. Both are interdependent and complementary, both stem from planning. In the industrial manufacturing sense there are, further, two levels of planning; the highest called pre-planning, the second is production scheduling, normally called Production Planning, but herein differentiated

COMMUNICATION PROCEDURE SYSTEM

(PARTIAL BEFORE-FIRM-ORDER FLOW OF INTELLIGENCE)

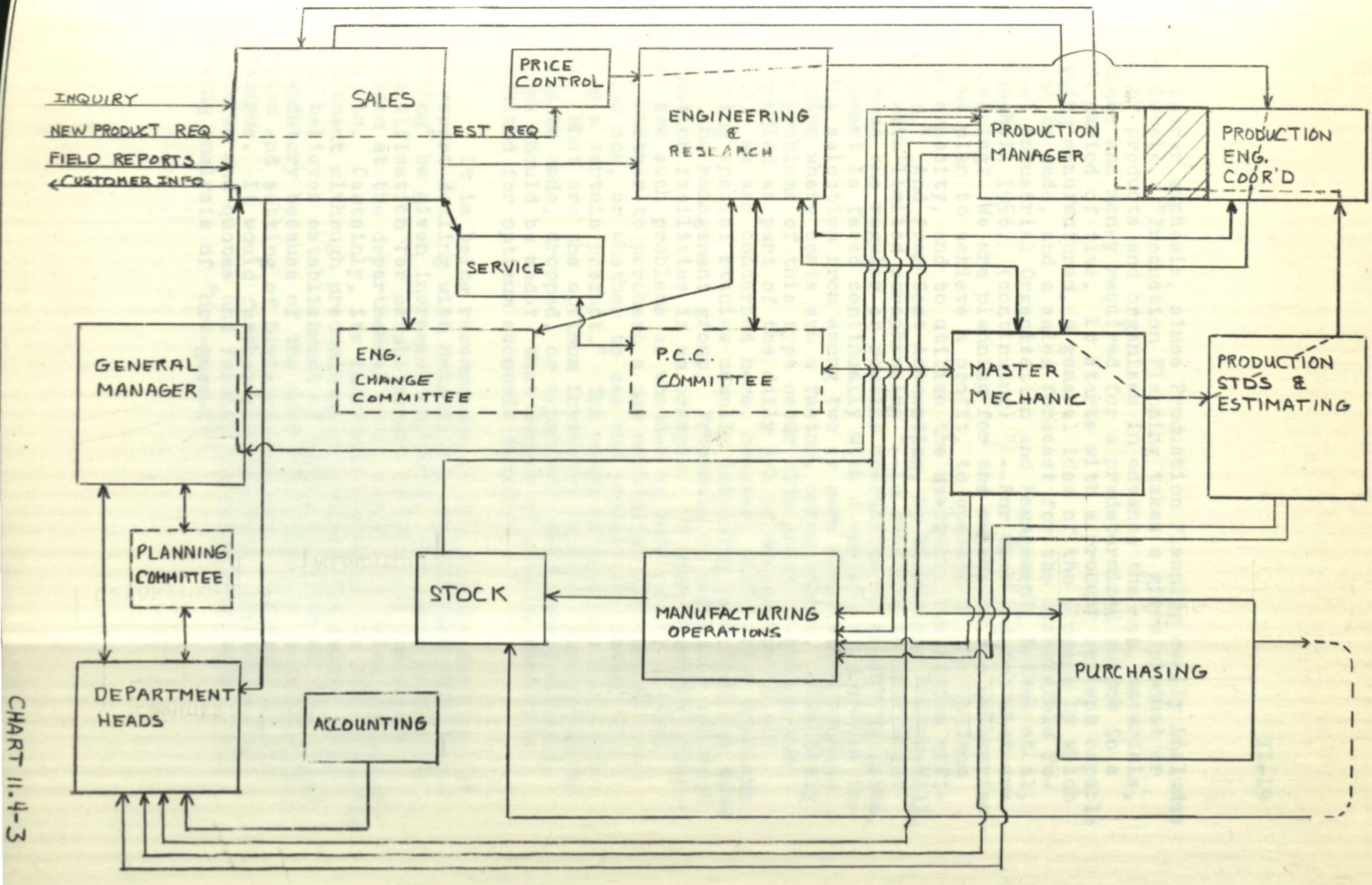


CHART 11.4-3

for clearer emphasis, since Production Planning really includes both levels. "Production Planning takes a given product or line of products and organizes in advance the men, materials, machines and money required for a predetermined output in a given period of time. It starts with a product concept capable of being manufactured, a general idea of the process by which it can be made, and a sales forecast for the discernible future--" Industrial Organization and Management, Bethel et al, McGraw-Hill 1956. (continuing) " --For whom and for what are we planning? We are planning for the owners of the enterprise when we plan to achieve a profit, to operate at the optimum plant capacity, and to utilize the available facilities efficiently." And from Cost Accounting, by Nickerson, McGraw-Hill, 1954, with limited paraphrasing "--In addition to what might be termed the regular or routine operations of producing goods, management is faced continually with a variety of problems involving selection from among two or more alternative courses of action where costs are a factor, among others. Relatively minor problems of this type occur with great frequency and are handled as part of the daily job of management at all levels. We are concerned here, however, with larger problems requiring special studies usually involving more than one member of the management group. Proposals to expand or contract production facilities is an example. Of more frequent occurrence are such problems as whether to make or buy a given part, whether to purchase a new machine or continue to use the old one, or whether to use one process or another in making a certain product." The range of problems is limitless. What are the optimum inventory levels? What products should be made, dropped, or expanded? What organizational changes should be made? What degree of quality should be maintained for optimum economic benefit?

It is being recommended in the various sections of this report dealing with Scintilla's organization that "preplanning" be given increased emphasis. The above paragraph is justification for establishment of this all important function at the departmental level along with Sales, Engineering, etc. Certainly, its functions transcend the Manufacturing Department although predominantly involved therewith. This group believes establishment of such a function at this level is mandatory because of the need for increased co-ordination, liaison and setting of Division-wide goals, objectives, and standards. It would further plan projects, develop master schedules and quotas and furnish top management with a continuing analysis of "how-goes-it".

Production Scheduling, the second planning level, takes the master strategy from the higher level as it is applicable to the manufacturing department, and keeping in mind the basic objectives of the Division, develops the tactics to ensure successful adherence to the strategy. Tactics include development of standards of performance (schedules) for the Manufacturing Department showing work task quantities and starting and completion times through the most economic correlation of production facilities as required by the overall plan. The hardward of Production Scheduling, as the reorganization is envisioned, is routing, inventory control, and tabulation. Inventory control is meant here to mean only requirement determination (not buying, not handling, and not level determination).

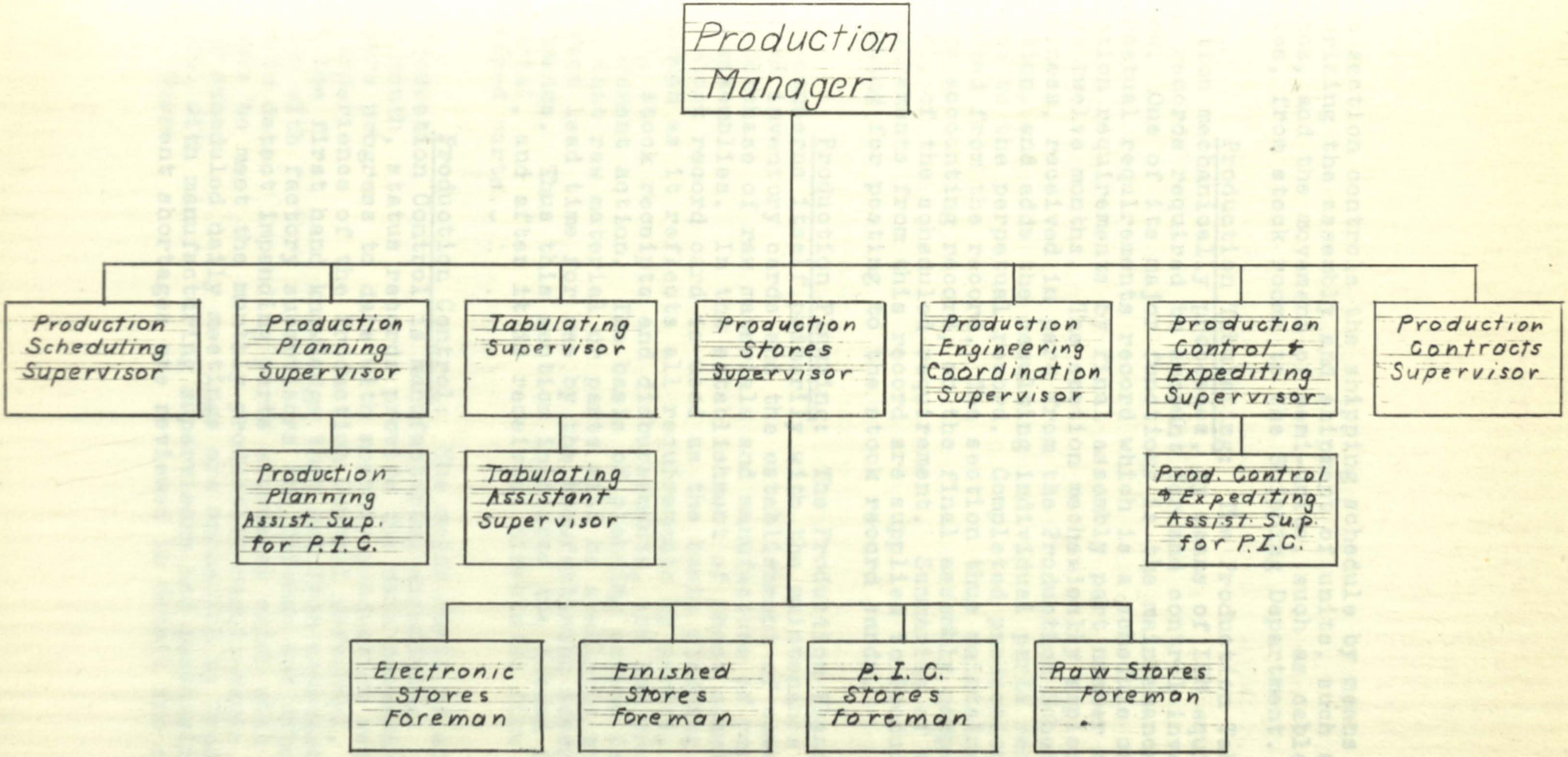
The following sub-sections present the various planning and control activities of the Scintilla Manufacturing Department, namely the Production Manager and the Master Mechanic. Presentation includes discussion of the present functions, analysis, and recommendations.

11.5.2 <u>Production Department</u>.

11.5.2.1 <u>Functions and Organization of the Department</u>. The Production Department employs approximately 215 persons and is organized as illustrated on Fig. 5.2.1-1. The Production Manager reports to the Factory Manager and performs for him, broadly speaking, the functions of master scheduling and schedule control, material planning and analysis, inventory custody and control, and manufacturing expediting.

11.5.2.1.1 <u>Functions and Responsibilities of Departmental Sections</u>. To carry out the above broad responsibilities, the department is divided into seven sections. Their detailed functions are briefly as follows:

<u>Production Scheduling</u>: The Production Scheduling section has as its primary function the development and maintenance of the master unit and semi-unit schedule records and controls. The section serves as the liaison agency between the Sales Department and the Production on matters pertaining to customer orders, delivery dates, and the scheduling of units and semi-units. Upon receipt of customer inquiries, delivery dates are developed based on plant loading and material availability. In addition to effecting master scheduling



Production Manager
Production Scheduling Supervisor
Production Planning Supervisor
Tabulating Supervisor
Production Stores Supervisor
Production Engineering Coordination Supervisor
Production Control + Expediting Supervisor
Production Contracts Supervisor
Production Planning Assist. Sup. for P.I.C.
Tabulating Assistant Supervisor
Prod. Control + Expediting Assist. Sup. for P.I.C.
Electronic Stores Foreman
Finished Stores Foreman
P.I.C. Stores Foreman
Raw Stores Foreman

Figure 5.2.1-1

the section controls the shipping schedule by means of authorizing the assembly and shipment of units, such as magnetos, and the movement of semi-units, such as cable assemblies, from stock rooms to the Shipping Department.

Production Tabulating: The Production Tabulating section mechanically processes, by means of IBM equipment, the records required to account for and control inventory flow. One of its major functions is the maintenance of the perpetual requirements record which is a schedule of production requirements by final assembly part number over the next twelve months. The section mechanically explodes new business, received in part from the Production Schedules section, and adds the resulting individual parts requirements to the perpetual record. Completed production is subtracted from the record. The section thus maintains the basic accounting record, on the final assembly component level, of the scheduled requirement. Summaries of the parts requirements from this record are supplied to Production Planning for posting to the stock record cards.

Production Planning: The Production Planning section concerns itself primarily with the maintenance of detailed inventory cards and the establishment of commitments for purchase of raw materials and manufacture of parts and sub-assemblies. In the establishment of these commitments the stock record card is used as the basic planning record, inasmuch as it reflects all requirements by period, stock level, stock receipts and disbursements, and any previous procurement action. The basis of planning action is to insure that raw material or parts will be available at the correct lead time for use by the Manufacturing Assembly Departments. Thus this section initiates the demand for raw material, and after it is received, directs its flow into finished parts.

Production Control: The major field of activity of Production Control is manufacturing expediting. During each month, status records provide the data necessary to compare progress to date with monthly production requirements. The experience of the Production Control personnel, together with the first hand knowledge they get from constant consultation with factory supervisors and foremen and others allows them to detect impending parts shortages which will cause failure to meet the monthly production requirements. Regularly scheduled daily meetings are sponsored by Production Control with manufacturing supervisors and purchasing personnel. Current shortages are reviewed in detail and specific action is decided upon and delivery promises made. Thus the basic function of Production Control is one of following the schedule and insuring that any parts or material which threaten to interfere with schedule progress receive the Manufacturing or Purchasing Department's attention.

Production Engineering Co-ordination: The major functions of Production Engineering Co-ordination deal with the areas of new projects and engineering changes to established products. Upon receipt of a customer request concerning a new project, this section quotes delivery dates. Upon receipt of the customer's firm order for the new item, necessary steps are taken to expedite the new item into manufacturing. In some cases where the time allowed for delivery by the customer on a new item is too short to allow regular manufacturing processing, Production Engineering Co-ordination takes over the manufacturing planning of the item. This entails complete material planning and the issuance of the Manufacturing Work Order authorizing fabrication. This section participates fully in the engineering change procedure, including consideration of the original change proposal, investigative action, and the establishment of the effective point of the design change.

Production Contracts: The basic function of Production Contracts is to account for the number of parts produced on individual manufacturing work orders, or "contracts", and "close" the contracts upon completion. Representatives of the section are stationed adjacent to the stock rooms to which finished parts are returned and note quantities of parts to be applied to contracts. Listings of finished contracts are returned to the Tabulating section for reduction of the outstanding contracts tabulation.

Production Stores: Production Stores is responsible for the storage of all raw material, sub-assemblies, and "mother" parts until required by the Manufacturing Department, and for accounting, allocation and dispatching of this material.

11.5.2.1.2 Functions Receiving Particular Cognizance of Production Manager. There are certain functions to which the Production Manager gives particular attention along with the general responsibilities associated with being head of the department. Ranking foremost among these functions is the control of inventory. Inasmuch as the division and the company are highly cognizant of inventory costs and invested capital this is a primary responsibility. Since the purchasing of raw material or other inventory influences division profit, policy determination in this area is also important. The Production Manager is involved personally in the development of new products and in the accompanying co-ordination between departments. The schedule progress is followed in a general way, keeping touch with orders which may require special attention. Cognizance is maintained of about 80% of the scheduled delivery dates developed by subordinates. The Production Manager, by maintaining cognizance of the deliveries promised by subordinates, serves as the co-ordinator between the four sections within the Production Department which are engaged in placing load on plant capacity in one degree or another.

11.5.2.1.3 Discussion of Organization. It is recognized that there is no standard production department applicable to different kinds of industries. Further, methods installed in any production department must be built along functional lines and must be definitely adapted to the particular plant in which they will be used. Production Planning and Control are generally thought of as facilitation services to manufacturing, having as their function the relieving of the superintendent of manufacturing of non-operating responsibilities and removing from the foreman the burden of preliminary planning, follow-up, and recording duties. These are certain functions and duties which must be carried out by some agency in an organization engaged in manufacturing. Whether the functions are carried out in a production department or elsewhere depends on the particular plant.

By way of analysis, a comparison was made of the functions carried out in the Production Department at Scintilla to those set forth in a standard authority ("Production Handbook"; Alford & Bangs, Ronald Press, 1956) as service functions, the majority of which are best handled in a production department. Those indicated by an "X" are noted as being in departments other than Production at Scintilla.

1. Job planning.
2. Production orders and forms preparation and issuing: work orders, time cards, move orders, materials issue slips, etc.
3. Stores record ledgers.

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1. Job planning.
2. Production orders and forms preparation and issuing: work orders, time cards, move orders, materials issue slips, etc.
3. Stores record ledgers.

4. Purchase requisitioning to:
   a. Replenish stores regularly carried.
   b. Obtain special items bought outside.

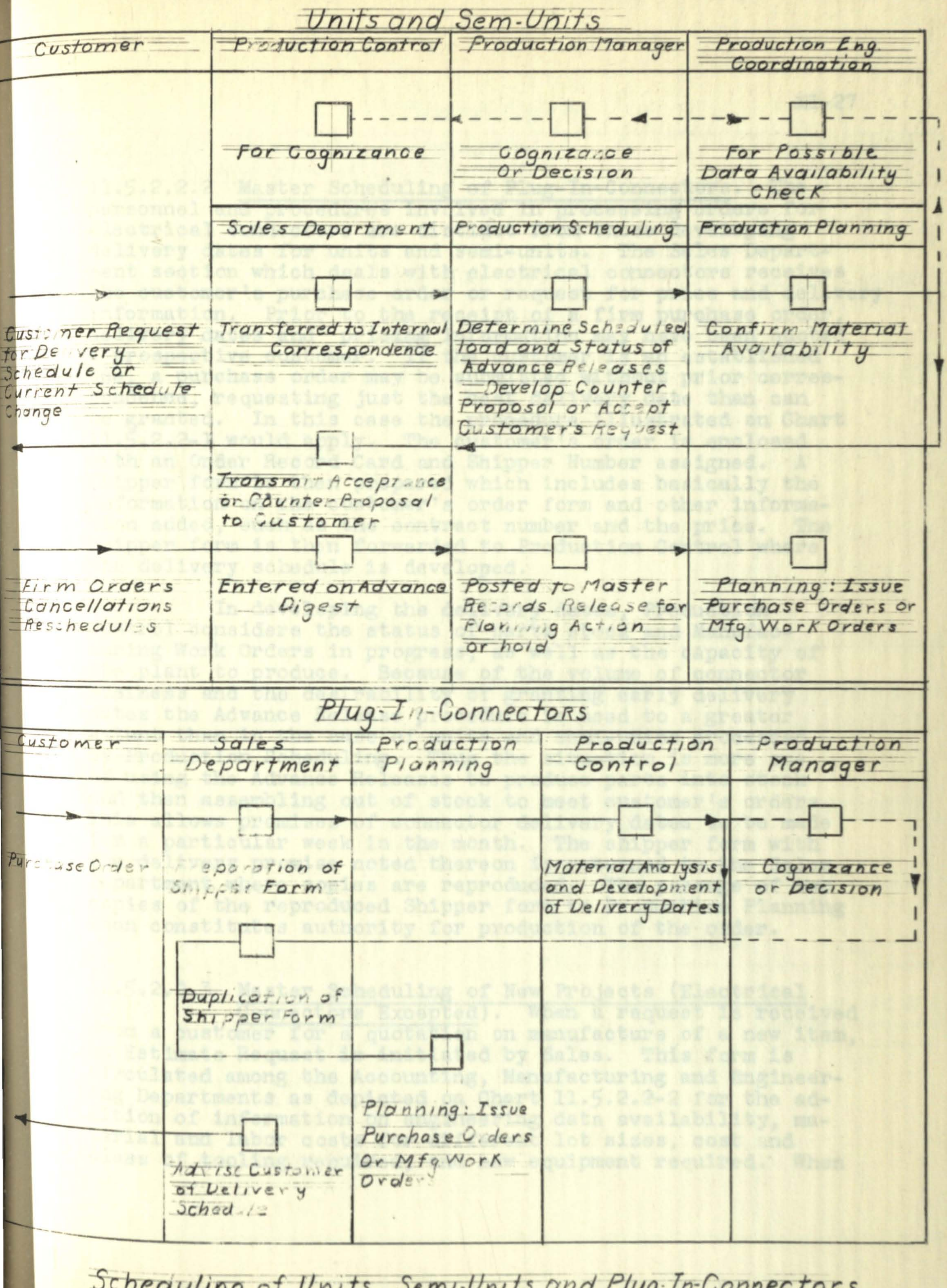
X 5. Methods engineering, operation analysis, etc.
X 6. Operation lists and route sheets.
X 7. Tooling for jobs.
X 8. Time and motion study.
X 9. Instruction cards.
X 10. Wage rate setting.
11. Work scheduling.
X 12. Machine loading.
13. Work dispatching.
14. Storeroom operation.
X 15. Tool crib operation.
16. Finished stock control.
X 17. Receiving.
X 18. Inspection of incoming materials for quantity and condition.
X 19. Shipping.
X 20. Job Estimating (for quotations).
21 Production records.
X 22. Standardization of operations, routing -- in co-ordination with other departments -- of tools, materials, etc.
X 23. Internal transportation.
24. Expediting of manufactured items and purchased items.
25. Subcontracting control.
X 26. Idle machine analysis.

Combination of these additional functions with those already carried by the department was considered impractical, however, because of the size and make-up of the Scintilla Division. The recommended organization structure set down in other sections of this report essentially divides the above listed functions among four activities: Planning Department, Manufacturing Engineer, Production Schedules, and Production Control. Relative to Production Department functions, as presently thought of, the proposed organization is tendered as a division of functions into a long-range planning function: The Pre-planning section under the Planning Department; a short-range planning function: Production Scheduling; and a control function: Production Control. The division was made to assign definite responsibility in those areas.

11.5.2.2 Master Scheduling. There are foursections within the Production Department which make delivery date promises and thus accomplish master scheduling. These are: Production Schedules for units and semi-units; Production Control for Plug-in-connectors; Production Engineering Co-ordination for new projects; and Production Planning for spare parts requirements.

11.5.2.2.1 Master Scheduling of Units and Semi-units; Established Products. The initial correspondence with any outside concern requesting information is received by the Sales Department. The most common procedure for the established product is the submission by the customer of a request for certain delivery dates and a price quotation. The flow of this paperworkis illustrated on Chart 11.5.2.2-1. This request involving units or semi-units is passed on to Production Scheduling for processing. The division between the categories of units and semi-units has become somewhat arbitrary as Scintilla has expanded its product lines. Generally speaking, a unit is an expensive, complex item, such as a magneto, and a semi-unit is a simpler, less expensive item, such as a cable assembly. Production Scheduling examines the requested delivery dates and quantities to see if they can be met conveniently considering plant loading. In making the determination, the request is referred to Production Planning for checking material availability, and possibly to Production Engineering Co-ordination if there is a question of engineering data availability, which might be the case if an engineering change were in process. If the request is for a critical order size or delivery date, it will be referred to the Production Manager for final decision. Also in this event, the request would very likely be routed to Production Control to be noted as a candidate for expediting. The method of determining whether a requested delivery date can be met is based largely on the knowledge of past performance of the plant in producing the item. The load already scheduled for a given period, for an item, is examined in the Master Requirement Record. If there appears to be more capacity, considering what the plant has done in the past, an additional amount can be scheduled. If management so decides, however, an overload may be scheduled intentionally. A portion of the overload or all of it may be sub-contracted from Production Scheduling to the Montrose Division, depending on the need of that division for work. Otherwise the overload is expected to be absorbed by the Manufacturing Department by hiring more workers or requesting sub-contracting at the component level. Another factor which has a bearing on the delivery date which can be granted a customer is the amount of "Advance Releases" which have been made for certain items. This is a procedure used to enable shorter delivery times and approaches producing to stock. The Sales Department estimates what the business from some items should be, based on past sales volume and the estimates of the field personnel in contact with the customers. There are three degrees of the releases authorized by Management and originated by the Sales Department: (1) procuring of material and finished purchased parts; (2) procuring of material and fabrication of parts; and (3) completely manufacturing units. The degree of surety of forthcoming firm business determines the type of release authorized. An effort is made to issue these releases at a time when the plant can conveniently absorb the load. Record Books of Advance Releases are maintained by Production Scheduling so that the balance available for application against customer orders is known at all times. Thus, in accepting a customer's requested delivery date or developing a counter proposal in Production Scheduling, the Record Books of Advance Releases must be consulted as well as the Master Requirement Record. The Sales Department is advised of the date by which the customer must have in his order to avoid alteration of the promised delivery schedule. After this preliminary paperwork has run its course and a schedule of delivery dates has been agreed upon, master scheduling has been accomplished. Further steps are keyed to the delivery date, by month only, promised to the customer.

The customer's firm order reflecting the agreed-upon delivery dates is entered by the Sales Department on the Advance Digest of New Orders, Increases, Cancellations, and Revisions which is issued daily by Sales. Items entered on this document are considered as authorized for manufacture. Production Scheduling receives the Advance Digest and enters the firm requirements in their master records. The orders received for a week are accumulated to take advantage of combining small orders with other orders or with the Advance Releases originated by the Sales Department. If the delivery date on a small order is not pressing, it may be held back longer in hope of combining it with a larger order later. The week's compilation of orders are then passed to Production Planning on the Weekly Release for Planning Action, commonly known as the IBM Supplement. This form, separated into units and semi-units shows the quantity and promised delivery dates of items over the next twelve months.



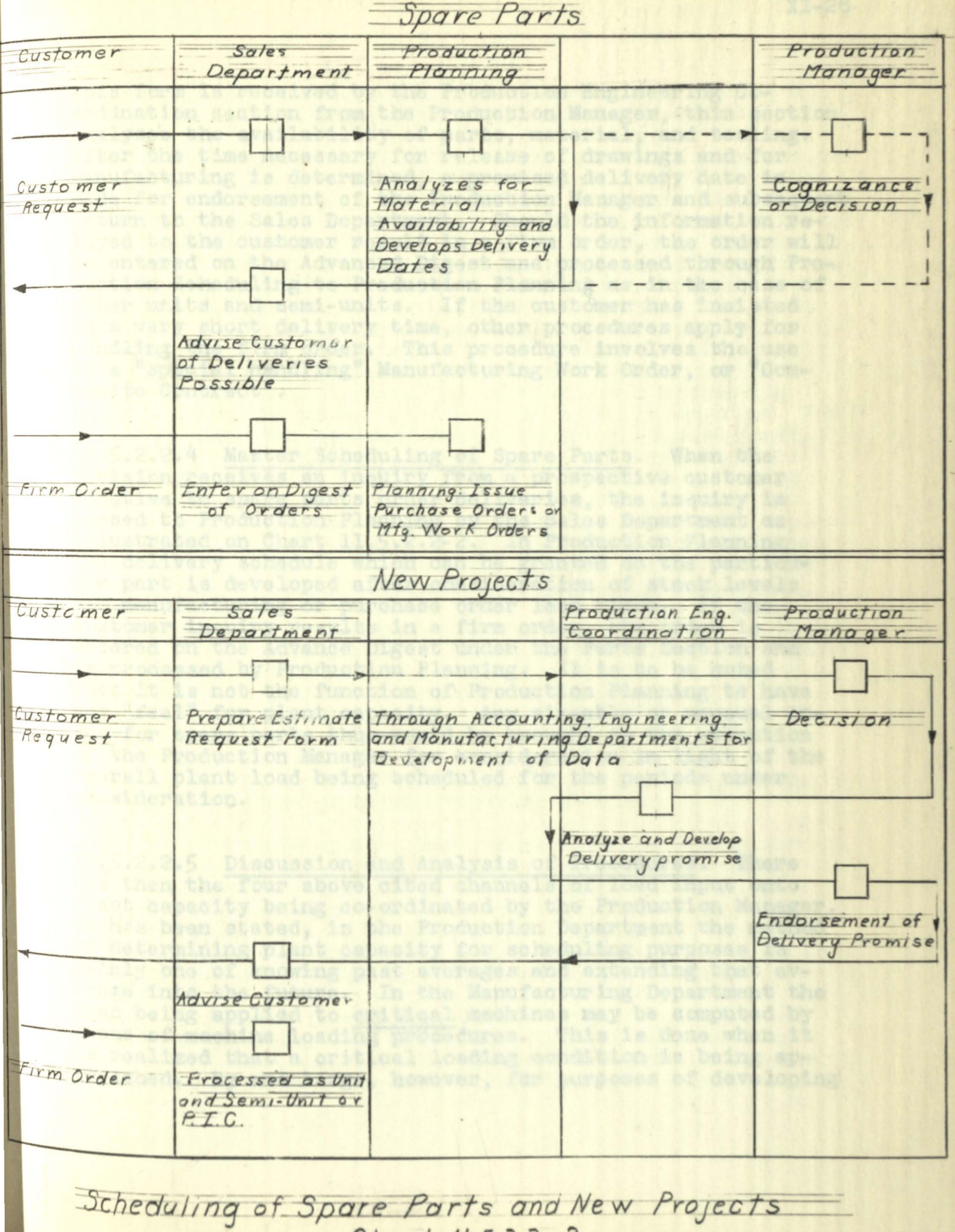
Scheduling of Units, Semi-Units and Plug-In-Connectors

Chart 11.5.2.2-1

11.5.2.2.2 Master Scheduling of Plug-In-Connectors. The personnel and procedures involved in processing orders for electrical connectors are distinct from those developing delivery dates for units and semi-units. The Sales Department section which deals with electrical connectors receives the customer's purchase order or request for price and delivery information. Prior to the receipt of a firm purchase order, delivery dates and pricing information may have been quoted a prospective customer. If the customer is an established one, a purchase order may be submitted without prior correspondence, requesting just the best delivery date than can be granted. In this case the procedure illustrated on Chart 11.5.2.2-1 would apply. The customer's order is enclosed with an Order Record Card and Shipper Number assigned. A Shipper form is then prepared which includes basically the information on the customer's order form and other information added, such as the contract number and the price. The Shipper form is then forwarded to Production Control where the delivery schedule is developed.

In developing the delivery dates, Production Control considers the status of parts stock and Manufacturing Work Orders in progress, as well as the capacity of the plant to produce. Because of the volume of connector business and the desirability of granting early delivery dates the Advance Release procedure is used to a greater extent than in the case of units and semi-units processed by Production Scheduling. Thus the situation is more one of using the Advance Releases to produce parts into stock and then assembling out of stock to meet customer's orders. This allows promises of connector delivery dates to be made for a particular week in the month. The shipper form with the delivery promise noted thereon is returned to the Sales Department where copies are reproduced. The passage of two copies of the reproduced Shipper form to Production Planning then constitutes authority for production of the order.

11.5.2.2.3 Master Scheduling of New Projects (Electrical Connectors Excepted). When a request is received from a customer for a quotation on manufacture of a new item, an Estimate Request is initiated by Sales. This form is circulated among the Accounting, Manufacturing and Engineering Departments as depicted on Chart 11.5.2.2-2 for the addition of information on engineering data availability, material and labor costs for different lot sizes, cost and class of tooling required, and new equipment required. When



Scheduling of Spare Parts and New Projects
Chart 11.5.2.2.-2

this form is received by the Production Engineering Co-ordination section from the Production Manager, this section analyzes the availability of parts, material, and tooling. After the time necessary for release of drawings and for manufacturing is determined, a promised delivery date is made for endorsement of the Production Manager and subsequent return to the Sales Department. Should the information relayed to the customer result in a firm order, the order will be entered on the Advanced Digest and processed through Production Scheduling to Production Planning as in the case of other units and semi-units. If the customer has insisted on a very short delivery time, other procedures apply for handling the firm order. This procedure involves the use of a "special handling" Manufacturing Work Order, or "Composite Contract".

11.5.2.2.4 Master Scheduling of Spare Parts. When the Division receives an inquiry from a prospective customer relative to spare parts order deliveries, the inquiry is passed to Production Planning by the Sales Department as illustrated on Chart 11.5.2.2-2. In Production Planning the delivery schedule which can be granted on the particular part is developed after consideration of stock levels and manufacturing or purchase order lead times. If the customer inquiry results in a firm order, the order is entered on the Advance Digest under the Parts Section and is processed by Production Planning. It is to be noted that it is not the function of Production Planning to have any "feel" for plant capacity. Any sizeable or unusual order for spare parts thus would be brought to the attention of the Production Manager for consideration in light of the overall plant load being scheduled for the periods under consideration.

11.5.2.2.5 Discussion and Analysis of Procedures. There are then the four above cited channels of load input onto plant capacity being co-ordinated by the Production Manager. As has been stated, in the Production Department the method of determining plant capacity for scheduling purposes is mainly one of knowing past averages and extending that average into the future. In the Manufacturing Department the load being applied to critical machines may be computed by means of machine loading procedures. This is done when it is realized that a critical loading condition is being approached. By and large, however, for purposes of developing delivery dates, the method of determining plant loading and thus being able to judge when more load can be applied, is based on the knowledge that in the past the plant has produced a certain number of given items in a month. In a state of stabilized product mix it is recognized that this method would be quite effective. The effects of competition between products going over common machines would have been reflected in the stabilized averages. It is felt, however, that in an era of new product development, increased competition for machine capacity invalidates past performance averages. It is felt that this inability to determine accurately the plant loading can result in inexact scheduling for any given month. The procedures followed in the event of an overload, namely subcontracting of end parts requirements, and hiring additional workers will relieve the overload, but a time lag occurs before the proper action to be taken is apparent. For example, since the Contract Status Report is issued monthly and is the only complete picture of end part requirements extending beyond the next thirty days, a month's planning time could conveivably be lost between issues. Then subsequent to recognition of an overload, the foreman or supervisor must initiate action to subcontract the work. Figure 11.5.2.3-1, discussed at greater length in a later section, was developed from an examination of parts subcontracting purchase orders to the Auburn Spark Plug Company. Of the forty-eight orders analyzed, 40% requested delivery in twenty days or less. Approximately 30% requested delivery in twelve days or less. This indicates that the foreman on some occasions has very little warning that he is going to be unable to meet his commitments. The time lag likewise reduces the advance planning time available for building up the work force. Thus it is felt that overloading and the attendant time lag before acrion is taken can be contributing to the present percentage of missed delivery promises.

It would appear that a more accurate system for determining available plant capacity at normal operating level for any period would prevent schedule overloading. Or, perhaps more important from the viewpoint of the division it would indicate at that point the degree of overload being scheduled so that steps could immediately be taken to plan for increasing the work force or subcontracting.

It is believed that such a system would have to involve translating each order into type of machine time in the different departments, and assembly time in the assembly departments if desired. This time would then be applied to the department time leaving a balance available. The total machine time available would be reduced by such factors as average down time. After the capacity of the normal operating force had been reached, further scheduling could be translated into additional man power required. After full machine capacity had been reached in certain areas, additional scheduling of work for those areas could be flagged for subcontracting. The following advantages would accrue from such a system:

A. Timely cognizance of need for subcontracting semi-units to the Montrose Division.
B. Timely cognizance of need for subcontracting of end parts.
C. Timely cognizance of need to build up labor force.
D. Accurate information on plant loading would be available for aiding decision making on requests for schedule revisions and step-ups.
E. Accurate information on when overtime would be required to meet a customer's rush delivery date would be available, thus providing a more accurate basis for placing premium prices on rush orders.
F. Accurate information on plant loading would allow Sales Depaartment to time Advance Releases to level production if feasible.

The presently used type of tabulating equipment could be employed to develop this type of loading information. Supposedly, since a load computed by tabulating equipment would be based on the standard time for each operation in the manufacturing process, it would be more detailed and accurate than the statistical procedure outlined in Section 11.9.2 for developing a plant load determination device. The statistically developed load analysis device would be particularly adaptable to sales forecasts for planning action where the degree of accuracy required for scheduling would not be needed. The accuracy attainable by employing tabulating equipment to maintain a running plant load would, of course, be expensive. It would not be necessary, however, to maintain the running load on all types of machines or departments, but only those considered as "controlling bottlenecks", or those where labor requirements were critical. Neither would it be necessary to run the load constantly on all scheduled periods. Thumb rules could be established such as are presently in use to determine when a point in the scheduled load is being reached where accurate information is necessary to make planning decisions. It would be up to management to decide whether having the above mentioned advantages would outweigh the costs of additional tabulating equipment and personnel. Establishment of firm layouts (manufacturing processes and sequences) would be necessary prior to adoption of the system. Also it is felt that a central agency for developing delivery dates on all products should be established. If a philosophy were adopted that master scheduling would be more exactly controlled, then it could only be done efficiently at one station.

It is recommended that the Division consider establishing a central scheduling agency and supplying that station with a running plant load as the normal operating level is being approached for any period to enable more exact scheduling and the timely development of information for planning purposes.

11.5.2.3 <u>Inventory Commitment and Control</u>. The requirements for manufacture in end product form developed by the various sections within the Production Department accrue at Production Planning by the previously described processes. The next step in the process is to reduce the scheduled items to an end parts requirement and plan the production or purchase of the end parts to have them ready at the proper time for assembly.

11.5.2.3.1 <u>Development of Subassembly and Part Requirements</u>.

To illustrate the working of the system the case of the Unit and Semi-Unit schedule input will be discussed. The Weekly Release for Planning Action received from Production Scheduling shows a week's accumulation of orders scheduled over the next twelve months. Planning interprets this document and assigns period numbers to the months' columns before passing it on to the tabulating section. The systems employed by the tabulating section are basically similar to those set forth in descriptive material on "IBM Accounting", published by the International Business Machines Corporation. The scheduled addition is exploded into final assembly components on a "first run" and incorporated with a Consolidated Requirement Record, known as the Schedule of Production Requirements. The record displays a consolidation of the individual parts required for the range of product models for each of the twelve succeeding periods. At this point any individual order loses its identity. From then on the system deals with quantities of end parts or sub-assemblies which will eventually be assembled to meet the delivery schedule. The record is "perpetual" inasmuch as scheduled requirements are added at intervals and completed production is subtracted.

The total requirements for each individual sub-assembly or part are prepared from this record and posted weekly to the Stock Record Cards which are maintained in Production Planning. One of these cards exists for each part number in the system. The card shows the balance in stock, receipts, disbursements, purchase order or manufacturing work order action, and the scheduled requirements, the latter again by periods. Information on the flow of parts into and out of stock rooms is passed to Tabulating on IBM cards, processed and posted daily to the cards. A group of cards is assigned to an analyst whose duty is to insure that the scheduled requirements are covered.

11.5.2.3.2 <u>Development of Purchasing and Manufacturing Schedule Information.</u> The summary postings effected weekly from the Schedule of Production Requirements to the Stock Record Cards is in the form of final assembly components. The period to which the posting is made on the card is still the month in which the final assembly component will be used. The analyst then must plan to insure that he has the required coverage for subassemblies and parts to be ready for use at the beginning of any assembly month. Shop Order Requisition cards are prepared for the subassemblies and parts which are manufactured at Scintilla, showing them as a requirement for the month preceding the assembly month. This is the first step in scheduling backward in time from the assembly month for component production. It is to be noted that the final assembly components are required just during the month and not at any particular time within the month. In other words, no detail scheduling within the month's period is done. The Shop Order Requisition cards are passed to tabulating for processing. The subassembly requirements are exploded into their end part requirements mechanically and manufacturing work orders are prepared concurrently to be used eventually as authorization for fabrication. The end part requirements resulting from the explosion of the subassemblies are transfer posted to their Stock Record Cards in Planning as a requirement for the same month as their "mother assemblies". If action is required by the analyst to insure coverage for these parts, a Shop Order Requisition Card will be prepared showing them as required during the month preceding. The requirement for parts to go into subassemblies is thus backed up one more month. The process in tabulating is repeated, resulting in manufacturing work orders for future use and postings to the material stock record cards. While this level by level analysis seems to consume time, it is justified since it prevents "pyramiding" inventories, or in other words, having an excess of component parts available, in both loose and assembled form. The system assures that no item is ordered unless requirements from a higher assembly stage make it necessary. The results of the explosion of subassemblies are known as "second run" parts. The parts which were end parts after the initial explosion arrive at the point of being a material requirement one step sooner. If material coverage is required by the analyst in Planning, such as in the case of a casting, a Purchase Order is initiated requesting delivery of the quantity needed no later than the month preceding the month in which the item will be needed. The appropriate purchasing lead time must be applied in determining when the Purchase Order must be initiated for processing by the Purchasing Department.

The analyst considers buying in economic lot sizes when initiating Purchase Orders. Particular advantage can be taken of buying in large quantities when a material is commonly used or a part is small and common to several products. Usage figures are maintained from past periods as an aid in extrapolating future requirements. The Schedule of Production Requirements is in large part exploded for twelve months ahead to enable material planning for that period. Likewise, consideration is given to manufacturing in economic lot sizes where possible. Management policy on inventory costs and obsolescence risks will not allow optimum lot size production in many instances. Since by and large, the division maintains the policy of producing to firm orders, there are numerous instances of manufacturing work orders which call for smaller lots than are efficient to manufacture. However, in the case of high usage, simple parts, lot sizes are optimized.

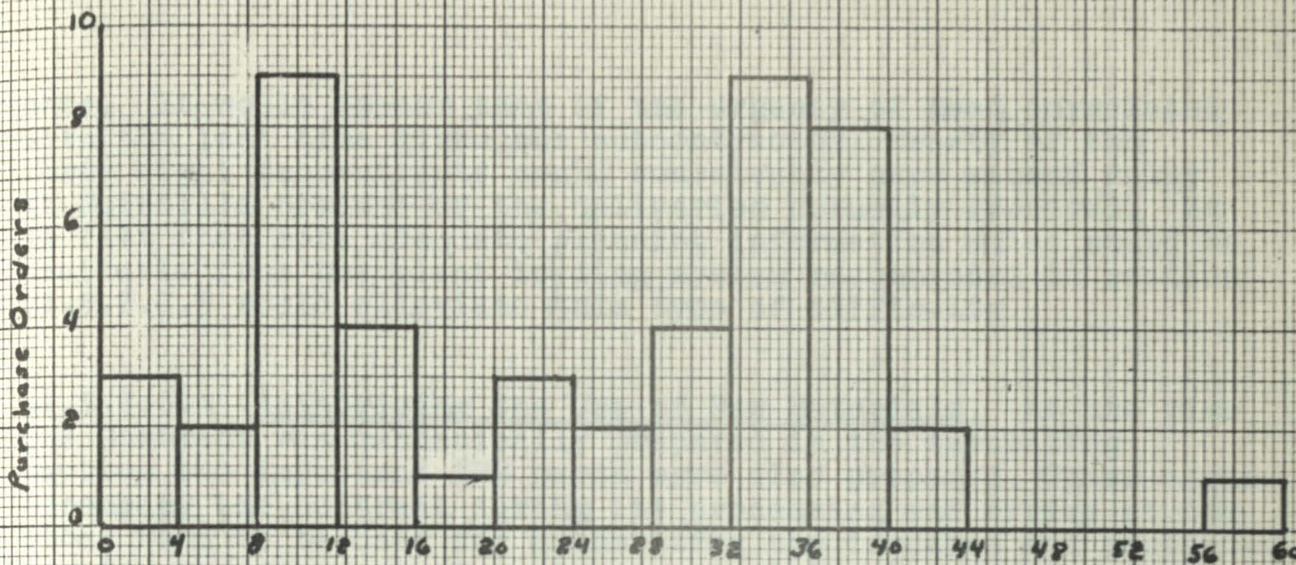
11.5.2.3.2.1. <u>Discussion of Scheduling Procedures</u>. It has been noted that detail scheduling within the month requirement period is not done. The foreman is cognizant of a group of manufacturing work orders which represent his work load for a month and is left more or less on his own to complete the work. It is well known that a detailed scheduling system is looked upon as being impractical at Scintilla. This attitude prevails because of the great variety and complexity of the products and the degree to which the schedule fluctuates because of changes in customer demands. Yet, certain undesirable features exist in the present system of scheduling. The foreman does his own work scheduling which was tentatively shown by a work sampling project to absorb around 30% of his time. This and other planning duties detract from the time that can be spent in supervision and training on the floor. Scrap and rework costs can generally be driven lower by more active supervision. Particularly at a time when the labor force is expanding could more supervision pay dividends in reduced scrap costs. It has been estimated in an other section of this report that a possible savings of $1,000,000 a year could be gained by increasing active supervision alone. This was computed as a possible accrual of driving the present 14% scrap and rework down to an estimated 10% inherent in machines and processes and decreasing the 22% observed Personal, Fatigue, and Delay time to the normal of 10%. To increase active supervision the foreman's planning and scheduling functions must be reduced and taken over by a staff agency.

The present system does not provide any positive way of progressing the jobs through the departments. Neither is there any system for designating the order or priority in which jobs are to be done. The foreman strives to minimize set-up time by running similar parts successively, but with the exception of the lead department, has no control over what jobs will arrive in his department at any given time during the month. A set-up for a job may have to be broken to get on to other work because a job requiring a part of the same set-up has not yet arrived. With the present system some parts get behind, requiring the expediters to enter the picture and exercise control. This in itself can be disrupting to efficient manufacture, for the parts being expedited occasionally require the breaking of a set-up in order that they may be run.

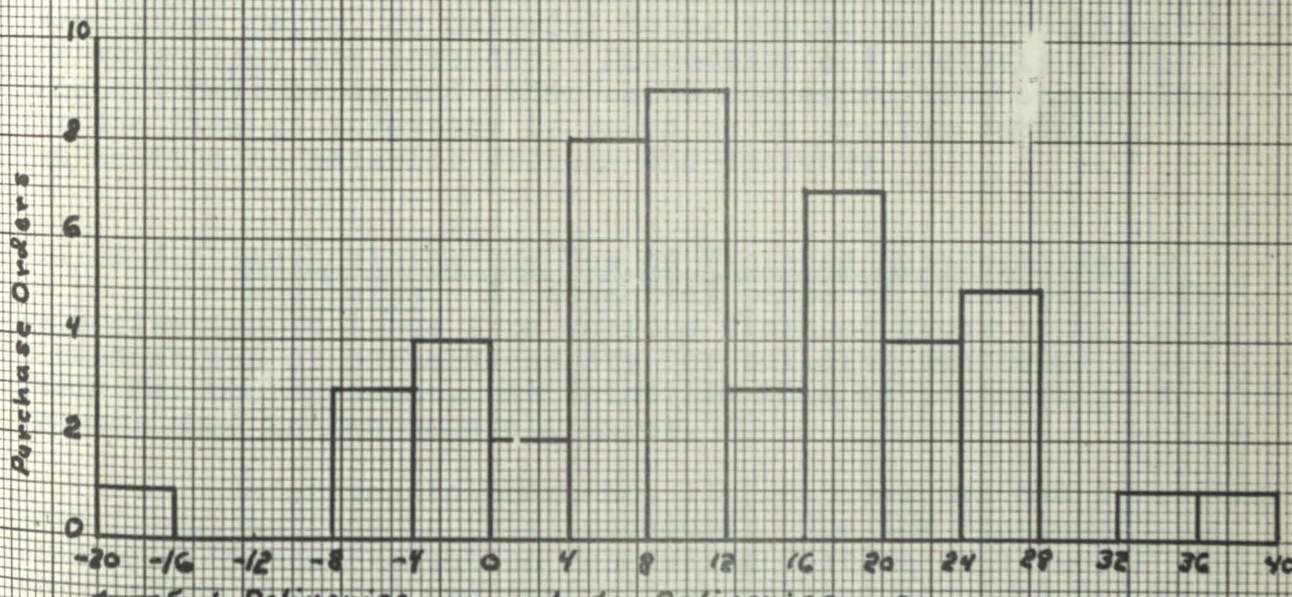
Therefore, against the present system which exhibits some failings, must be weighed the cost of a system which would provide greater control of the progressing of jobs through the plant. A system of detail scheduling to the departments by weekly periods would be a compromise between the present system and a system which actually assigned work to individual work stations. This would involve departmental loading by the week. In essence the work load would be metered through the plant by weekly periods. Necessary to realizing maximum manufacturing efficiency would be the adoption of a priority or contract sequencing system based on part similarity. Controlling the time period within which jobs should arrive at a department and designating the sequence in which they should be worked would result in both increased manufacturing efficiency and the controlled metering of the jobs through the plant. It is envisioned that a production control system to accomplish the above would of necessity involve mechanical aids. An adaptation of the International Business Machines Corporation system for detail operation scheduling could be considered. The IBM system although involving a great amount of machine time and considerable clerical effort does have the advantage of generating the necessary cards to operate the system. Such cards, to be used by a dispatching section, are material requisition cards, set-up cards, tool cards, move tickets, and operation cards. Because of Management policy of stressing customer service at Scintilla, any system set up to control production in an orderly manner would have to have an "exception channel" for "hot" jobs. It is believed however, that if a more strictly controlled production system were set up, excess machine capacity and manpower would be available for operating this channel in lieu of breaking in on other work. It is recommended therefore, that consideration be given to adopting such a detailed scheduling system in the future.

11.5.2.3.2.2 <u>Issuance of Manufacturing Work Orders</u>. As previously mentioned the manufacturing work orders, known as "Contracts", are prepared by mechanical process in Tabulating when the Shop Order Requisition cards are processed. Associated with each subassembly or part is a bill of materials which is in the form of IBM cards. The machine transcribes onto the Contract this bill of materials, the total number of the parts required, and the month for which they are required. It is necessary to bear in mind that the Shop Order Requisition card has designated the required month of manufacture, which was determined by the analyst to provide requirement coverage. After preparation the Contracts and cards are returned to the Planning section for filing until the appropriate time for their issuance. During the thirty days preceding the scheduled month the Contracts are issued to the stock room. The Contracts pass first to the Production Engineering Co-ordination section where the Route Sheet, an operation sequence sheet, is attached. The Contracts then go to the stock room where they await "release" by the foreman. Material may or may not be available for the work to be done on the Contract since Production Planning issues it without insuring that material is in stock. The reason for the procedure is to have the contract available when the material arrives, if it is late, and thus save the passage time from Planning to the stock room. However, the procedure results in the foreman having to keep track of contracts for which material is not available. This is another example of a function which it is believed should be performed for the foreman.

11.5.2.3.3 Capacity Planning at the Component Part Level. For planning purposes the foreman can check his file of accumulating contracts for the following months work. This, however, does not allow adequate time to take action should he find that the capacity of his work force is being exceeded. A longer range look is afforded by the Contract Status Report, which is a compilation of all current, backlog and future contracts which have been printed by the Tabulating section. With this report the foreman can look ahead to the second, third, and subsequent months beyond the current month. A situation can still arise in which an above normal schedule is developed between issues of the Contract Status Report and the foreman is caught with only a month to increase his work force or request subcontracting of some of his work. Figure 11.5.2.3-1 indicates that the present system will not afford adequate planning time in all cases. The figure depicts data developed from examination of parts subcontracting purchase orders to the Auburn Spark Plug Company. Sixty one orders had been initiated between 1 January 1957 and 29 April 1957. Of these, forty eight orders had been filled, which permitted a comparison of the actual delivery dates from the subcontractor to the requested delivery dates. Approximately thirty days had been stated as the normal lead time for orders to this subcontractor for small parts. This short lead time was allowable because the subcontractor had considerable unused machine capacity. This statement of the normal lead time was verified by the fact that 55% of the requested deliveries fell between twenty one and forty four days. However, it is notable that 40% of the orders requested deliveries in twenty days or less and 30% in twelve days or less. An analysis of the actual delivery date variance from the requested on the latter shows that they came in on an average of fourteen days late. The overall mean of the delivery date variances of this subcontractor was twelve days



Requested Deliveries In Days
Subcontracting, Auburn Spark Plug Company



Delivery Date Variance
Subcontracting, Auburn Spark Plug Company
Mean = 12 Days late

Figure 11.5.2.3-1

late. It would appear that if the urgency of need correlated with the lead time given the subcontractor, twenty of the forty eight subcontracts could conceivably have caused delay at Scintilla because of the deliveries actually received. It is felt that more adequate planning information which would be available from the plant loading system recommended in section 11.5.2.2.5 would alleviate this type of difficulty.

11.5.2.3.4 Authorizing the Use of Raw Materials. At the time the Contract was mechanically prepared in the tabulating section two important IBM cards were also prepared. These cards accompany the contract during its processing and arrive at the stock room to be used for authorizing the issuance and accounting for the movement of parts or material. The Holding Card is a card which authorizes the issuance of parts or material against a certain Contract. The card shows the quantity of an individual subassembly, part, or material required by a specific Contract and the assembly, subassembly, or part being made on the Contract. The Delivery Card is a card which is used to go with issues from the stockrooms and serves to identify the subassemblies, parts, or material being issued and the Contract for which they are intended. Discussion and analysis of the uses of these cards and other cards concerned with accounting for the flow of inventory is taken up in greater detail in the section on material storage and delivery.

11.5.2.3.5 Authorizing the Use of Finished Subassemblies and Parts. An essential phase of inventory is the authorization to issue from various finished stock rooms those subassemblies or parts necessary for building completed units ready for the customer. At Scintilla this authorization is accomplished in two general phases.

Referring to Chart No. 11.5.2.3.5-1, we can trace the significant actions in this procedure. The IBM Supplement developed by the Production Scheduling Section on a weekly basis and listing the unit and semiunit assemblies required for each of the next twelve months is sent each Friday to the Production Planning Section. At this point the unit assembly information is handled in a slightly different manner than that for the semi-units.

On the IBM Supplement sheets having unit assembly information, the calendar month of assembly is replaced by a

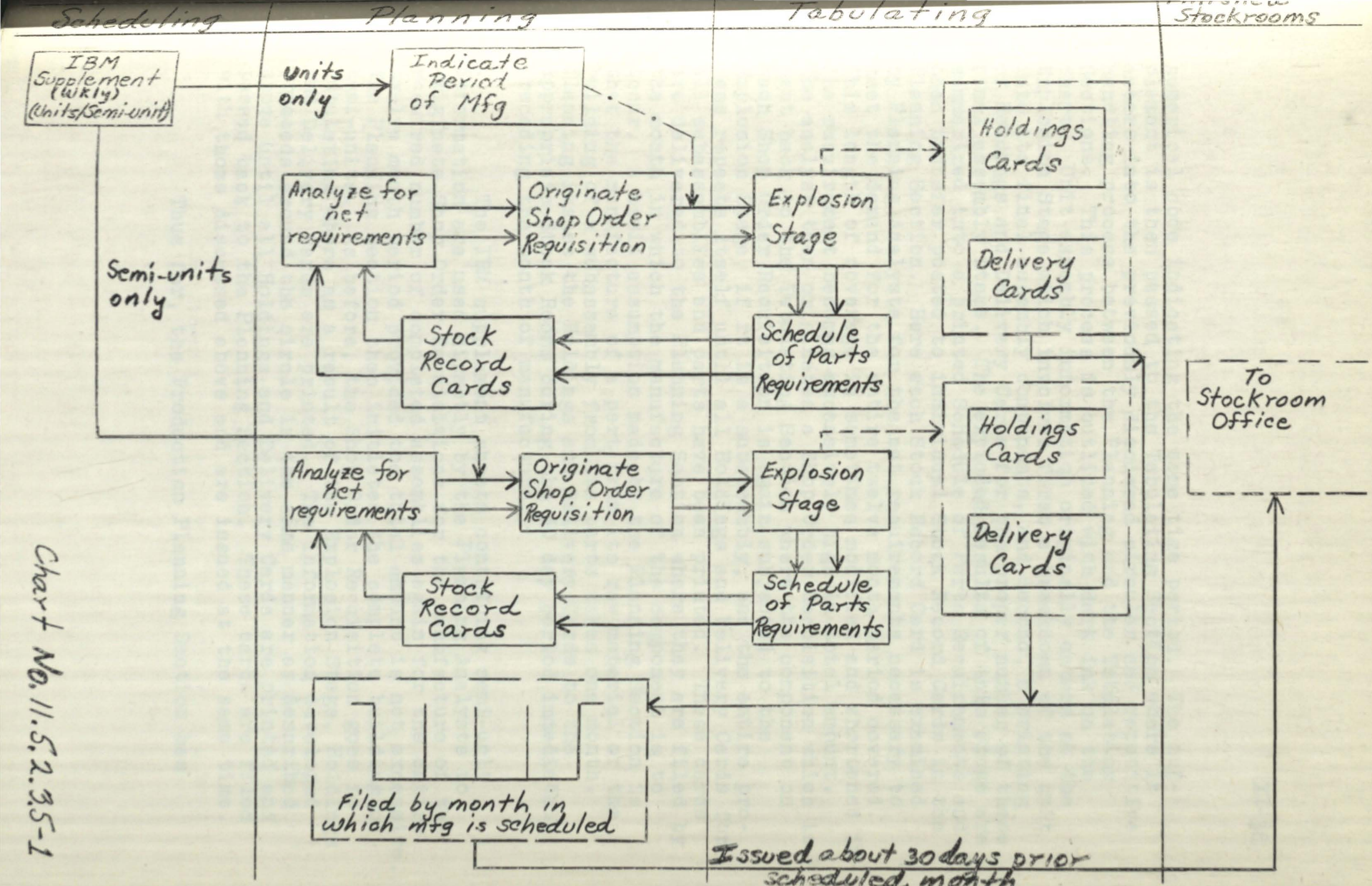


Chart No. 11.5.2.35-1

Authorizing the Use of Finished Subassemblies & Parts numerical code indicating the same time period. The supplement is then passed to the Tabulating Section where it enters into the previously discussed circular and repetitive handling process between the Planning and the Tabulating Sections. This process is outlined with dark ink on the chart. Unit assembly information originally enters at the Explosion Stage which involves first a breakdown of the unit into its final assembly components, and second, a printing of Holdings and Delivery Cards for the proper number of these final assembly items. The exploded results of this stage are summarized into a printed Schedule of Parts Requirements and then transfer posted to individual Stock Record Cards in the Planning Section. Here each Stock Record Card is examined by Planning Analysts for the net requirements necessary to meet the demand for the entire twelve month period covered. This length of coverage is sometimes modified and shortened if the requirement becomes excessively high in total amount. The analyst then originates a Shop Order Requisition which is sent back to the Tabulating Section where the component on each Shop Order Requisition is again subjected to the Explosion Stage, if it is a subassembly, and the entire process repeats itself until all Holdings and Delivery Cards for all subassemblies and parts have been printed. These cards are delivered to the Planning Section where they are filed by the month in which the manufacture of the component is to occur. A basic assumption made by the Planning Section is that the manufacture of a part from its raw material or the building of a subassembly from its parts takes one month. Planning issues the Holdings and Delivery Cards to the appropriate Stock Rooms during the 30 day period immediately preceding the month of manufacture.

The IBM supplement sheets containing semi-unit information are used directly by the Planning Analysts to originate Shop Order Requisitions for the manufacture of the required number of completed assemblies again for the entire twelve month period provided the total amount is not excessive. The Planning Section then initiates the complete building of semi-units. As before, the Shop Order Requisition goes to Tabulating where as a result of the Explosion Stage, Holdings and Delivery Cards are printed. The information developed proceeds around the circle in the same manner as described above until all Holdings and Delivery Cards are printed and passed back to the Planning Section. These cards are filed with those discussed above and are issued at the same time.

Thus far, the Production Planning Section has authorized the issuance of finished subassemblies and parts. As the month of promised delivery to customer approaches, a second phase of authorization procedure develops.

About 50 to 60 days prior to the month in which assembly of all units and semi-units is to be completed, the Production Scheduling Section issues two separate and distinct forms containing preliminary assembly information. The Preliminary Assembly Layout covers the unit assembly requirements for aircraft and commercial magnetos and for jet components while the Preliminary Holdings covers the required number of semi-units. The term "required" here denotes the number of units or semi-units which will be necessary to fulfill customer orders or management stocking instructions.

These issuances have two purposes: (1) to provide the basic information from which Holdings and Delivery Cards may be created for the final assembly components that go into unit assemblies, (2) to facilitate the preparation of the Monthly Shortage Analysis Report which is subsequently used for expediting.

Referring to Chart No. 11.5.2.3.5-2, the Preliminary Assembly Layout and the Preliminary Holdings are compiled from collation of the Master Unit Requirements Record and the Master Planning Record within the Production Scheduling Section by a hand typing and ditto process. Action copies of both reports proceed to the Tabulating Section. The Preliminary Assembly Layout is "exploded" into its final assembly components and Holdings and Delivery Cards for these components are printed. The Preliminary Holdings is used directly for the printing of Holdings Cards only which authorize the transfer of finished semi-units from Stock Rooms "C" and "E" to Stock Room "S" which in turn can move them along to the Shipping Dept. as desired. These Holdings and Delivery Cards are delivered to the appropriate stock rooms when their printing is completed but this process seems to take about two weeks. Copies of the Preliminary Assembly Layout and the Preliminary Holdings are sent to Production Planning, Production Control, and the Finished Stock Rooms. In retrospect, therefore, we see that both the Planning and the Scheduling Sections issue authorizations to use finished subassemblies and parts.

At the present time both the Preliminary Assembly Layout and the Preliminary Holdings are hand typed records.

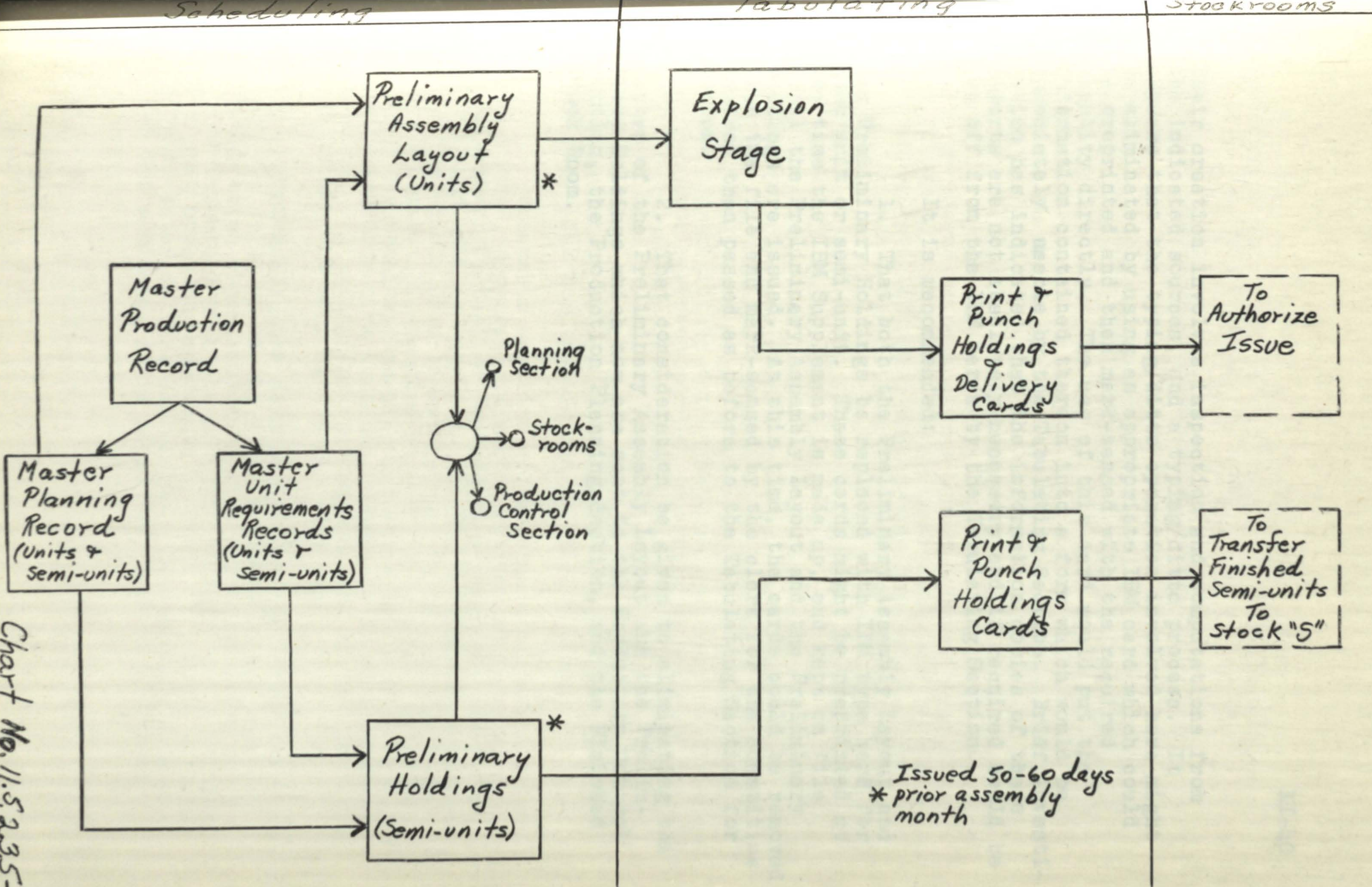


Chart No. 11.5.2.35-2

Authorizing the Use of Finished Subassemblies & Parts

Their creation involves inspection and computations from the indicated sources, and a typing/ditto process. It appears that the typing/ditto operation involved here might be eliminated by using an appropriate IBM card which could be preprinted and then mark-sensed with the required quantity directly. The use of this card would put the information contained thereon into a form which would be immediately usable by the Tabulating Section. Brief investigation has indicated that the information copies of these reports are not absolutely necessary and if required could be run off from the IBM cards by the Tabulating Section.

It is recommended:

1. That both the Preliminary Assembly Layout and the Preliminary Holdings be replaced with IBM type card for each unit or semi-unit. These cards might be preprinted at the time the IBM Supplement is made up, and kept on file until the Preliminary Assembly Layout and the Preliminary Holdings are issued. At this time, the cards could be removed from the file and mark-sensed by the clerk for the quantities desired then passed as before to the Tabulating Section for action.

2. That consideration be given to eliminating the copies of the Preliminary Assembly Layout and the Preliminary Holdings which now are sent to the Production Control Section, the Production Planning Section, and the Finished Stock Room.

11.5.2.3.6 Material Storage and Delivery.

11.5.2.3.6.1 Responsibility. Although this section deals mainly with the storage and delivery of material which is changed by the manufacturing process into end products, it is well to consider consumable supplies and associated material due to the similarity of functions involved.

Product material storage and delivery is the responsibility primarily of the Stores Unit but this responsibility is shared to some degree with the Spare Parts Stockroom (Stock "S") under the Sales Department, and Service Stockroom (Dept. 88) under the Service Department. The Stores Unit has responsibility for storage and delivery of all product material from the time of receipt as raw material or purchased parts until it is delivered to assembly departments or to the Sales Department. Stock "S" has the responsibility of storage and delivery of product material in the form of finished spare parts which have been released to the Sales Department or finished products which must be staged awaiting complete fulfillment of a customer's order. Service Stockroom has responsibility for storage and delivery of the stock of spare parts reserved for use in servicing products the customer has returned. Thus, product material is received by the Stores Unit, issued to Production Departments for processing into semi-units and unit, and then in the case of semi-units passes back through the Stores Unit to Stock "S" where a portion is further transferred to Service Stock.

Consumable supplies and associated material is ordered, stored, disbursed primarily by four storerooms: (1) Department 13 handles consumable production, janitorial, medical, and similar supplies; (2) The Maintenance Stockroom handles materials used in maintenance items; (3) The Tool Room, Department 11, handles production tools and materials required for machinery repair; (4) Stock "D" handles miscellaneous administrative supplies. There is no general flow of material among these storerooms due to the dissimilar nature of the material handled by each one.

Generally, the division of responsibility for storage and delivery of the diverse materials and supplies among the seven organizational units mentioned above appears satisfactory with the possible exception of a portion of the task presently performed by Stock "S", which will be considered later in this discussion. Disregarding this exception for a minute, it is noted that each of the above storage units gives direct support of a specific type to major organizational functions and four of the storerooms are responsible for ordering supplies and material from Purchasing. Under these conditions the present assignment of these storerooms to the major organizational functions they support provides sensitive and immediate response to the material needs of these functions and avoids unnecessary dependence of one function on another. The possibility of centralizing responsibility for storage and delivery of all or the majority of materials and supplies should not be overlooked, for direct monetary savings in storeroom operating costs are feasible. However, any centralizing must be primarily a physical one for potential savings are in the areas of personnel and possibly space. Such physical contralization, accompanied by a centralization of responsibility under a single organizational function, would raise questions of the efficiency of service by a central stockroom to the several disbursed functions, and the lessening of response to the demands of the several major functions served. Since this subject demands careful consideration of plant layout, personalities involved, materials handling, and other factors, it is suggested that a study be conducted to consider the possibilities of the situation in detail. Such a study is beyond the limited scope of this report and therefore no formal recommendations on the subject are made herein.

The remainder of this Material Storage and Delivery section will concentrate on the most active and largest storeroom organization, that of the Stores Unit.

11.5.2.3.6.2 <u>Stores Unit Organization and Layout</u>. The Stores Unit reports to the Production Manager and is composed of four storerooms each responsible for a specified type of material. Stock "CC" is the raw stores stockroom and is staffed by a foreman, 3 clerks, and 11 stockmen divided into 3 shifts. Stock "C" is the finished parts stockroom and is staffed by a foreman, 7 clerks and 14 stockmen divided into 2 shifts. Stock "E" is the electronic material stockroom and is staffed by a foreman, 2 clerks and 1 stockman on a 1-shift basis. The "PIC" stock is the plug-in connector stockroom and is staffed by a foreman, 7 clerks, and 27 stockmen divided into 2 shifts. To recap, the Stores Unit has a supervisor and secretary plus 76 other employees. Thus, the cost of this function in salaries per year is about $275,000.

The layout of the four stockrooms is based on the pattern of flow of production. Stock "CC" is adjacent to Receiving and is near the machining, casting and molding operations. Stock "C" is located in the heart of the departments that it receives parts from and disburses them to. Stock "E" is located adjacent to its largest customer, Department 38. "PIC" Stock is located adjacent to the plug-in connector assembly department, Department 48. This arrangement of stockrooms, of course, has the advantage of reducing material handling, but this advantage is gained at the cost of increased supervision, increased number of personnel required to operate the segregated stockrooms, and introduces the problem of co-ordinating the work of the stockrooms. Considering the fact that with the high volume of material presently being moved on the production floor, it only requires about 11 electric trucks with operators, it seems logical that savings from a physical centralization of these stockrooms would not be measurably decreased by the slight increase in material handling costs. Before considering possible improvements any further, it would be well to look at future plans for expansion in relation to stockroom service.

The production floor is presently in the shape of a long, narrow rectangle with a width to length ratio of about 6.5 to 1. Proposed expansion plans generally involve a continual increase in length while expansion in width is limited by the railroad on one side and office extension on the other. It would appear that as the length of the production area grows, the obvious increase in materials handling will dictate the establishment of additional stockrooms. Of course, this is not the only approach to the problem but it is one that can easily grow into being as the overall efficiency of operations becomes overshadowed by a localized problem. An evaluation is needed of the costs of interdepartment material handling as related to the costs of operating of the stockroom function under various different arrangements, the main one being a completely centralized stockroom. Even a cursory look at the possibilities is worthwhile.

It is questionable whether a centralized stockroom would be so much harder on the material handlers than at present. The following is a simple analysis of some of the primary sources of traffic going in and out of the stockrooms:

Disbursements

Destination (Department)	Stockrooms Making Shipments CC	C	PIC	E
27	X	X		X
31	X	X		
32	X		X	
38	X		X	X
42		X	X	X
47	X	X	X	X
48	X		X	
50		X	X	
83	X	X	X	X

Receipts

Received From	Stockroom Receiving Material CC	C	PIC	E
Receiving	X	X		X
27		X		X
32		X	X	X
36	X		X	
37		X	X	
38		X		X
39		X		X

Even though these are not complete listings of production departments sending to and receiving from the various stockrooms, it is apparent that many departments are doing business with several stockrooms causing long hauls by material handlers. Two departments receive material in decent quantities from all four stockrooms, 3 departments receive from 3 of the stockrooms, and 4 departments receive from 2 different stockrooms. Traffic from production departments to stockrooms follows a somewhat similar pattern. So from a material handling standpoint, possibly the separate stockrooms are not such a big savings over a central stockroom.

There appears to be no overwhelming reason why Receiving could not be shifted to a more central location, thereby facilitating the movement of Raw Stores. An access road behind the building is feasible as are unloading docks. There are no real critical reasons why the other stockroom could not then be consolidated forming a central stockroom and Receiving area somewhere near the center of the present building. Manpower required to operate the stores could be substantially reduced and material handling, both within the central stockroom and to many departments, could then be mechanized to some extent due to increased volume of traffic in the resulting consolidated traffic pattern. This mechanization of material handling would be undertaken only if savings would result which appears possible.

Therefore, it is recommended that a detailed study of the feasibility of a centralized stockroom to replace the present four in the Stores Unit be made with a view to effecting substantial savings in operating personnel.

Materials handling adjacent to and within the existing Stock "C" and "PIC" Stockrooms is high in volume as evidenced by the number of stockmen presently required. "PIC" Stock has 27 stockmen divided between 2 shifts and Stock "C has 14 stockmen divided between 2 shifts also. The items being moved are mainly in tote boxes. The present flow of this material, all being handled manually, is from production departments (1) to inspection stations adjacent to the stockrooms, then (2) to count stations, then (3) into the stockrooms. In the case of Stock "C" the material is placed in a waiting area until the clerks decide on its disposition, which can either be to the electric trucker's pickup station outside Stock "C", to Dept. 42 storeroom nearby, to the shelves, or combinations of these 3 alternatives after splitting. This procedure normally involves picking each tote box up and setting it down about 5 or 6 times, in a very short distance, from the time it leaves Inspection until it is disposed of in one of the above ways. It also involves a certain amount of waiting by the stockmen depending on volume at any one time, and about 50% of the walking done is empty-handed on the way to start another trip. Issues from the shelves involve a simpler, but again, repetitive manual task. In "PIC" Stock the procedure is generally the same with the main exception that incoming material goes directly into stock. It appears very probable that this manual system of repeatedly handling similar material in exactly the same traffic pattern could be completely mechanized with a substantial savings in personnel and a reduction in the present processing time. The general system proposed for Stock "C" is a roller conveyor, starting at the Inspection station, which feeds the material to a scale which is built in the conveyor so that material need not be handled on and off the scale. Assuming that the functions of the existing contract check station could be put on IBM machinery and incorporated with regular stock control, this conveyor scale could be adjacent to the stock control files. When the stock control clerk makes a disposition of the material the scale operator could switch the material on any of 3 branch conveyors, either to Department 42, to the shelves, to the electric trucker's station, or to any combination after he split the material on the scale. A similar but somewhat simpler arrangement could be made at "PIC" Stock by diverting the existing aisle around back of PIC Stock and alloting the existing aisle section to the stockroom. This would place the stockroom immediately adjacent to the counting station and the Department 48 with no separating aisle. Eliminating the manual transporting of material around the stockrooms will not eliminate the need for stockmen completely of course. A lesser number will still be required for filling orders from the shelves, inventory, and putting material in the shelves. Nevertheless, it is anticipated that the savings in stockmen required would be substantial.

Therefore, it is recommended that a mechanical material handling system for Stock "C" and "PIC" Stock be studied and, if feasible from an economic standpoint, be installed. This recommendation would also apply to a centralized stockroom if established.

11.5.2.3.6.3 <u>Functions of the Stores Unit</u>. The following are the primary functions of the Stores Unit:

1. To store all raw material, sub assemblies and mother parts until required by the manufacturing schedule.
2. To account for all material received from production department.
3. To allocate material to various competing requirements, based on rules set by Production Control.
4. To dispatch material to the proper production departments specified on holding cards.
5. To serve as a reporting check point for production control information.

The storage of material is performed in an efficient manner by the use of tote boxes placed on shelves. A location file is kept on all material in the storeroom shelves. The amount of material on the shelves is dependent on (1) the effectiveness of scheduling and production planning in having parts produced at the right time in the right amounts; (2) the amount of stock releases authorized by management; (3) the amount of material produced in advance of requirements under economical lot size policy; and (4) the effectiveness of production departments in producing amounts required from material authorized.

The accounting, allocating, dispatching, and reporting functions are accomplished by means of an IBM punched card system. The process works as follows. Contracts and assembly schedules are authorized by Production Planning and sent to the stockrooms together with holding cards and delivery cards. Only a contract must subsequently be released by the individual production department foreman whose department is the lead department on a contract. Upon activation of work, either by authorization of the assembly schedule or release of contracts by foremen, the holding and delivery cards are placed in the active stock control files behind the inventory card for the particular part required. There are three primary cards involved in the stock control system, the delivery card being relatively unimportant. The receipt card tells what material and how much was received by the stockroom and from what contract or purchase order it came. The inventory card tells how much of a certain material is on hand in the stockroom available for issue. The holding card is authorization to issue material and tells what specific material and the amount required on a specific contract and to which department it is to be sent. So, for example, on a contract requiring five different parts there are five holding cards in the stock control files, each one being located behind the inventory card for the particular part required. When a lot of parts are received, a receipt card is prepared and sent to the stock control file. There the clerks compare the part number and amount with holding card requirements, if any, and immediately dispatch the parts to the production department shown on the holding card. If there are no holding cards in the files for this part there is no current requirement on assembly schedules or contracts which have been released to date and the part is entered as an increase in stock on the inventory card. When new assembly schedules are authorized or new contracts released, the holding cards for parts required are checked against stock available on inventory cards prior to filing these new holding cards.

Every afternoon at 3:30 all cards which have shown action during the past 24 hours are sent to Tabulating where the inventory card is corrected to show the new quantity in stock, the holding cards are reduced to show requirements still remaining to be filled, and new delivery cards are prepared for each holding card which has not been completely filled. While these cards (minimum of 3 for each part received and disbursed and a minimum of 2 for each part which was either received or disbursed but not both) are in Tabulating all information required for various daily reports is extracted from them. This process is completed by 5 P.M. each day when all corrected cards are returned to the stockrooms.

The entire IBM stock control system is simple, fast, provides for the automatic detection of the majority of clerical errors, and all in all is an extremely efficient system. Scintilla is justifiably proud of this system.

The Stores Unit practices in making running inventories of parts is also commendable and helps to avoid critical shortages just when production departments require the parts. At any time any apparent discrepancy arises in the amount of material shown on the inventory cards, an immediate check is made of the material on the shelves and inventory records are corrected if necessary. Anytime the amount of stock of an item falls below a specified level, a physical count is made and checked with the inventory card. Stock counting of disbursements by subtracting the amount left on the shelves from the amount on inventory records is not permitted. Material being issued must actually be counted to avoid shorting production departments and introducing hard to detect errors into the stock control files. Random spot checks of stock are made periodically and a complete annual inventory is made at which time all inventory records are corrected. This system of stock checks is effective and results in a minimal amount of production trouble due to stock shortages.

Allocation procedures in the stockrooms are established and modified on occasion by Production Control. Basically, the system sets priorities in varying degrees on assembly schedules, contracts, and spare parts holdings. These priorities also depend in part on the due date of the particular schedule, contract, or spare parts. There is reason in this system based on the general importance to Scintilla of the various classes of work but the system is not without serious drawbacks. First, there is no assurance that such an automatic allocation system results in optimum utilization of parts available. With two requirements competing for the same part, the one requirement that prevails over the other may be in no position to use the part due to shortage of other parts with which it is to be assembled. Thus the system can result in several partially filled requirements where re-allocation would allow some work to proceed on schedule. Another drawback to the system is that it allocates parts only to "active" holding cards, those in the stock control file. These active cards are not necessarily the top priority requirements since there are contracts which for one reason or another have not been released by foremen and therefor have no active holding cards to be filled. As an example of what may occur, a part may come in and be disbursed to fill a spare parts requirement where it may sit on Stock "S" shelves for several months. A day or so after this disbursement is made, a current or even overdue contract may be released by a production department foreman and the parts will not be available. This can start a minor chain reaction of holdups right on through the assembly departments. Another drawback this system produces is the accumulation of excess stock on the production floor. When a contract is released, this is automatic authorization to send any parts required under this contract to the releasing department. There are some deviations from this rule in the case of "unit issue contracts" but these are a small percentage of the whole and do not mechanically fit into the normal allocation procedure. So, parts are sent to production departments to await accumulation of the required variety and the required amount of each variety. The use of valuable production floor space for this staging function is not economical and the crowding that results does not promote efficient operations. The "unit issue contracts" are another illustration of the drawbacks of the present allocation procedure. As the name implies, these contracts call for staging of the complete variety of parts required before disbursements are made to production departments. Due to this, they do not mechanically fit into the stock control file where single part numbers are the only consideration. As a consequence, "unit issue contracts" take second preference when parts are received even though the need for these contracts may be greater than other requirements which are filled first. It should be noted that the above comments do not apply to "PIC" Stock and that the present allocation procedure does work reasonably well.

Possibilities for improvement of the allocation procedures are two fold. First, before any requirement is filled, an analysis could be made to determine the optimum allocation of the parts available. This would obviously be a complex and repetitive system which would require additional personnel. A second approach to the problem is an indirect one and the most rewarding. It is simply to install an effective scheduling and production control system where manufacturing can be maintained on-schedule rather than 20% behind. Under such conditions parts would arrive on time and at specified times, within fairly narrow limits, and all requirements could be filled on schedule. Thus, there would be no allocations of a few parts among several requirements to be made since the right amount would arrive in time to fill requirements as they are set up. Reference is made to the section of this report dealing with "Control of Schedule Progress" for a discussion of the possibility of an improved scheduling and production control system.

One last point concerning the functions of the Stores Unit is worth considering. As mentioned earlier in this section, the Sales Stockroom, Stock "S", has several functions among which are the stocking of spare parts for future requirements and the physical filling of orders for these parts. The stocking function is identical to the stocking function performed by the Stores Unit except that the material in Stock "S" is reserved for filling customer spare parts orders. The order filling function of Stock "S" is identical to the allocation of parts function in the Stores Unit except that the Sales Department sets the allocation rules in Stock "S" and Production Control sets them in the Stores Unit. To perform its assigned functions, Stock "S" employs 1 foreman, 4 allocation clerks and 14 material handlers (stockmen). There appears to be substantial savings in personnel by physically combining the stocking and allocation functions of Stock "S" with the Stores unit leaving only a parts staging function to be performed by a small Sales unit or by the Shipping Department. Combining the stocking function would reduce the number of stockmen presently required to perform these functions at separate locations and would economize on storage space by making the utilization of space more flexible. Combining the allocation function would reduce the number of allocation clerks required and would incorporate the records and reporting system of Stock "S" into the regular stock control system. This could be accomplished easily by adding a different colored spare parts inventory card and order holding cards behind the regular stock inventory card. It is discouraging to find that this suggestion for improvement has been proposed in one form or another in the past but has not been studied thoroughly and objectively. Personal opinions have been taken as fact, personality differences have influenced consideration of the idea, and distrust by one another of various branches of the organization has overshadowed overall efficiency of the Scintilla Division as a unit. This statement of hearsay and opinion is injected only because it presents some of the existing attitudes and prejudices which must be overcome before an objective appraisal of the proposal can be made. Routine machine reporting of all transactions, routine inventories, physical segregation of stock, and other protective devices are either inherent in the proposed system or can be included and appreciable savings would still result.

Before concluding this part, it should be mentioned that for ease and simplicity of presentation, variations among the procedures of the four stockrooms of the Stores Unit have received little or no mention. The same basic system is used in all four stockrooms, the primary differences being in the "PIC" Stockroom by virtue of the nature of the product being processed in that stockroom. Plug-in connector manufacturing is faster and involves tighter schedules which materially affects the operations of the stockroom. Faster and a different type of service is required so that the basic stock control system has been modified to meet the demands of this unique product. However, with a few exceptions the above discussion of the stock control system applies to the PIC Stockroom.

In concluding this part it is recommended that the bulk of the functions of Stock "S" be combined with similar functions under the Stores Unit in order to effect reductions in personnel requirements.

11.5.2.3.6.4 <u>Reports Generated from Stock Control Data.</u>

The routine processing of materials and parts in and out of the stockrooms produces a wealth of information by virtue of having a mechanized system (IBM) capable of rapid processing of data. The information produced is primarily of a work progress nature which is extremely useful in production control work. The reports generated from processing the stockroom cards are depended on by Production Control personnel, manufacturing foremen, Production Planning and others for essential information upon which many decisions necessary for planning, executing and controlling production will be based. The primary reports produced are as follows:

1. Stock Receipts Report (weekly) lists the materials and parts received by stockroom during the past week.

2. Stockroom Inventory Reports (daily) show the amount of each item on hand in the stockrooms as of 3:30 P.M. each day and the date each item was last received or disbursed.

3. Stockroom Transaction Reports (daily) show all receipts, issue, losses, and gains for the day for each item that was involved in a transaction.

4. Production Planning Stock Card Postings show the transactions that affect the total amount of each part which is on order, the amount available in stock and the amount issued to manufacturing.

5. Contract Status Report (monthly) shows all authorized contracts, when they are scheduled for completion, the amount completed, and the amount still outstanding.

6. Shortage Report (monthly) is a listing of contracts and purchase orders due this month for meeting next month's semi-units and assembly schedule requirements.

7. Stock Spares Report (weekly) shows the holdings remaining to be filled for spare parts only.

8. Sub-Contract Report (weekly) shows what sub-contracts are overdue and when their scheduled delivery date was.

9. Other similar reports covering plug-in connector stock movement and authorized work.

The value of each individual report compared with its cost of preparation has not been calculated but it is fairly obvious that the information presented by these reports is of the type that is needed to properly conduct the complex manufacturing operation.

11.5.2.3.7 <u>In Process Inventory</u> Generally speaking, the volume of materials in various stages of manufacture and/or assembly is a function of all of the parameters indicated below.

1. Adequacy of the scheduling system at the operating level.

2. Procedures and methods of material handling.

3. Layout of production machinery.

4. Location of storerooms.

5. Company policies as to the number and type of finished stock items that are permitted.

We find that items 3 and 4 above are relatively unchangeable. Item 2, the procedures and methods for handling materials, appears to be simple and efficient.

Of the remaining items, adequacy of scheduling on the operating level, and the company policies on the amount of finished stock, the former by all tests has the greater influence. Regardless of whether company policies are good, bad, or indifferent, in process inventory is destined to be high if the system for scheduling production at the operating level is inadequate. Conversely, it can be assumed that when such inventory (in tote boxes) is high then the fault lies predominently with the operational scheduling system.

In regard to company policies on how much and what type of products can be built for finished shelf stocking, however, it can often happen that the efficiencies gained by some levelling of production with an increase in finished stock levels on repetitively produced items more than offsets the actual or potential losses due to finished stock becoming obsolete on the shelf. Increasing the amount of authorized finished stock makes for easier scheduling which in turn reduces the in process inventory.

As is common with most companies, Scintilla has periodic drives to reduce in process inventory. The very fact that these "drives" occur seems to indicate that there is no adequate control over such inventory and further that there exists no definite standard of in process inventory performance. While no detailed nor intensive investigation was made, it appears on, the basis of simple questioning that no one individual below the level of the Production Manager is now responsible for developing information as to the growth, value, cost, movement, and corrective control of in process inventory (in tote boxes).

It is recommended:

1. That some more adequate provision be made within the Manufacturing Department for delegating to a single individual responsibility for providing information as to the growth, value, and cost of In Process Inventory (in tote boxes), and for recommending to management ways and means to reduce these figures. A suggested procedure for developing some information about the inventory at regular intervals is outlined below.

a. Divide the entire productive area of the factory into a series of equal area grids.

b. Choose about 30 to 50 of these grid areas by a random selection process.

c. At days chosen at random during the month find for each of the selected grids the following:

(1) The total number of tote boxes in the grid

(2) The total value of the material in the tote boxes

(3) The total factory floor space occupied by the tote boxes

d. Calculate the mean for each of the items indicated in (c).

e. Use these calculated means to estimate the total number of tote boxes in use, the total value of the inventory in those tote boxes, and one of the costs of such inventory by multiplying the total floor area used by the productive cost per square foot of factory floor space.

2. That the optimum amount and value of In Process Inventory be established with the aid of a management consulting firm, and that this value be the standard of performance against which the current inventory

(in tote boxes) be measured. It would appear that this optimum inventory should be based upon the sales forecasts for various general product lines.

3. That a serious and detailed study be made of the relative value and cost of in-process inventory under a system of greater production into finished stock as compared to the present procedure. Such an investigation ought to study:

a. Possibilities of better scheduling on the operational level and therefore more rapid conversion of raw or purchased materials into finished products.

b. Costs of excessive fluctuations of production in terms of labor turnover, and direct labor costs for overtime and second or third shift personnel.

c. Possibilities for reducing scrap and rework costs under a better scheduling system.

d. Possible losses from obsolescence of finished stock while it is still unsold on the shelf.

4. That the growth of in-process inventory be recognized as an indication representative of inadequate scheduling on the level of the Shop Supervisor/Foreman.

11.5.2.3.8 <u>Expediting Purchase Orders</u> No study of the Purchasing Department was made because of the lack of time but it is presumed that some type of a tickler system is employed which signals that certain purchase orders are about to become or are actually overdue.

The Production Control Section through continuing analyses of its Weekly Shortage Reports develops information about critically needed materials and by memorandum requests the Purchasing Department to expedite procurement.

The actions taken by the Production Control Section described above are "after the fact". By the time the memoranda are sent it seems possible that the materials may already be holding up either manufacturing or assembly. The system of checks and balances desired here must uncover potentially critical items before the time at which production is delayed.

It is recommended that the contents of the memoranda initiated by the Production Control Section be analyzed by the Purchasing Department in order to:

a. Gain an insight into the specific character of the materials that repetitively cause production delays, and

b. Form a basis for more accurate estimates of purchasing lead time.

11.5.2.4 Scheduling of Manufacturing Facilities The scheduling activities thus far in the Production Manager's Department have resulted in the following information being placed in the hands of the Shop Supervisors and /or Foremen:

1. The Contract Status Report is published monthly and is a complete up-to-date summary of all outstanding Manufacturing Department manufacturing work orders. This report lists "contracts" which have been issued by the Planning Section and those "contracts" still in Planning Section files. The report is made both in composite form and is also broken down by departments. Each report contains listings of part number, manufacturing work order or "contract" number, the quantity of parts still to be made on this contract, the quantity made already on this contract, the month in which the parts are to be made, an indication of the lead department and the department responsible for insuring that the contract is completed.

2. Manufacturing Work Orders or "contracts" as they are called at Scintilla. These contracts actually authorize the performance of work. When issued by the Production Planning Section, the "contracts" are sent to the Production Engineering- Coordination Section where route sheets are appended to them. Following this, they are delivered to an office adjacent to the Stock Room most used by the department which has been designated as the "lead" department. Shop Supervisors and /or Foremen accomplish much of their contract releasing activity in these offices. For this reason, delivery of contracts is said to be made to stock rooms, but this is only for the convenience of the supervising personnel.

3. Daily IBM inventory reports on materials then available in all stock rooms. Of particular interest to manufacturing persons are the inventories of raw materials found in Stockroom "CC" and of finished parts found in Stockrooms "C" and "E".

Chart No. 11.5.2.4-1 outlines the manner in which Mfg Work Orders and the Contract Status Report are developed. Successive "explosion processes" followed by transfer postings have resulted in stock requirements appearing on individual part stock record cards. Each card is analyzed by a Planning Analyst who originates a Shop Order Requisition (IBM) card form whenever a net requirement is revealed. Shop Order Requisitions are delivered to the Tabulating Section where through a punching/printing process, one Mfg Work Order and one Mfg Work Order summary card are prepared for each Shop Order. The Mfg Work Orders are returned to the Planning Section where they are filed by the month in which the work is to be accomplished. During the 30 day period immediately preceding this month all of the "contracts" for the coming month are issued as previously described. The summary cards on Mfg Work Orders are retained in the Tabulating Section until the "contract" is terminated, and once each month the Contract Status Report is prepared from such cards as still remain the active file.

The general action taken at the Shop Supervisor/Foremen level upon receipt of the information discussed above varies since few routine procedures exist. Each individual department is left largely to its own devices in accomplishing the detailed work station scheduling required to complete the "contracts" issued to it.

A typical approach to this problem is described below for a lead department.

Each morning the foreman goes to the stockroom office and examines his file folder in which the office clerk has placed newly issued contracts. The folder also contains unreleased contracts. He checks on the availability of materials necessary to complete each contract by referring to the latest stockroom inventory reports. If no material is available, he usually notes this fact on the face of the contract and returns it to his folder. If materials are available, he must decide whether or not to release the work to his operators. This decision is made on the basis of the following information:

(1) expediters may have indicated the need for particular parts

(2) past experience singles out parts that have previously given trouble

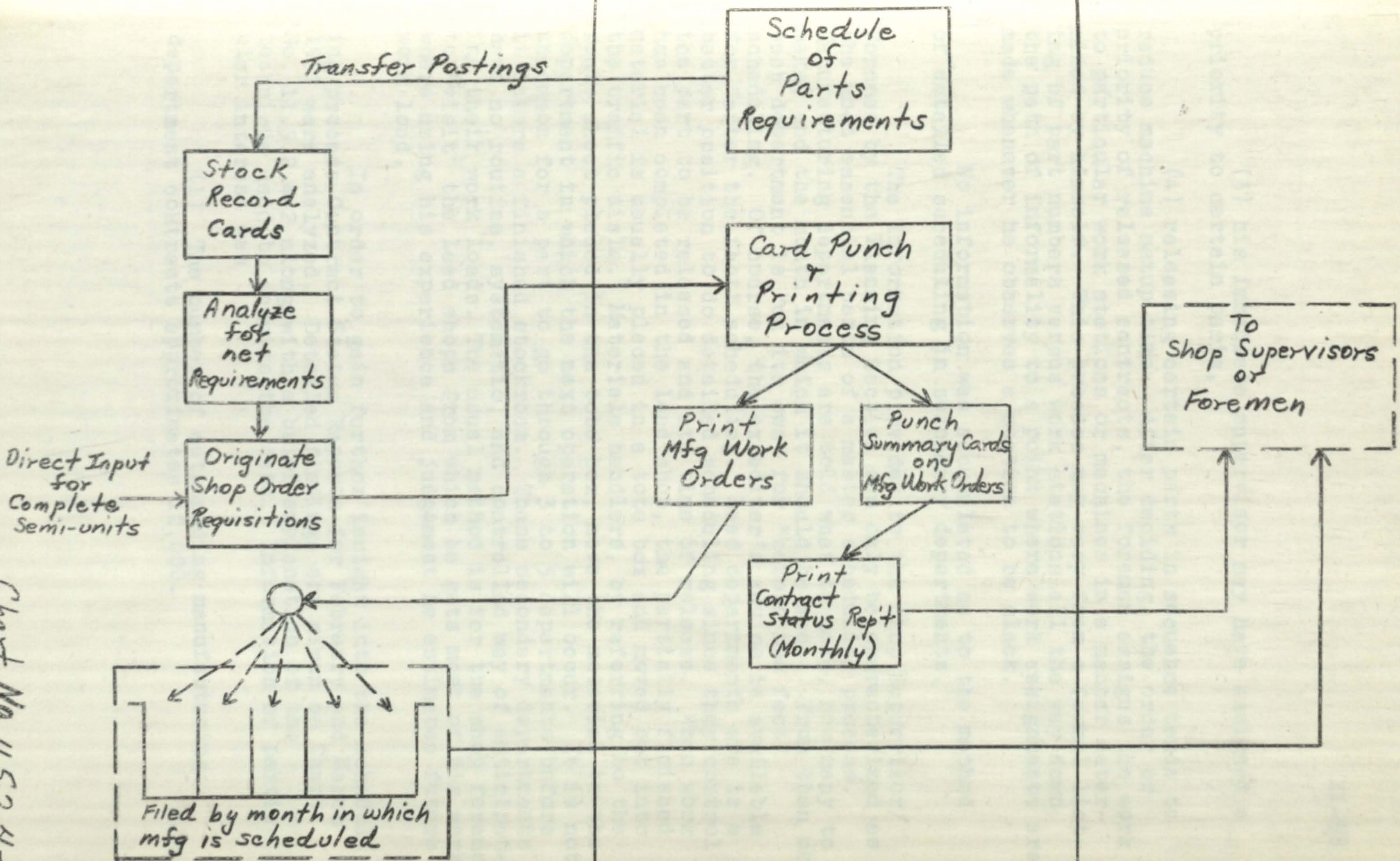


Chart No. 11.5.2.4-1

Scheduling of Manufacturing Dept. Facilities

(3) his immediate supervisor may have assigned a priority to certain parts,

(4) releasing certain parts in sequehce tends to reduce machine setup time. After deciding, the order or priority of released contracts, the foremen assigns the work to particular work stations or machines in a manner determined by himself. This process may vary from a formal listing of part numbers versus work stations all the way down the path of informality to a point where work assignments are made whenever he observes a station to be slack.

No information was accumulated as to the method of detailed scheduling in secondary departments.

The information provided to the Shop Supervisor/Foremen by the Planning Section can only be characterized as the most essential parts of a master scheduling process. Manufacturing departments are told what to make, how many to make, and the month in which it should be made. From then on, each department is "on its own" for "before the fact" scheduling. Of course, the expediter's advice is available for "after the fact" scheduling. Lead departments are in a better position to do detailed scheduling since they control the part to be released and its time of release. When work has been completed in the lead shop, the partially finished material is usually placed in a tote box and moved out into the traffic aisle. Materials handlers, by referring to the route sheet placed in the tote box, move the material to the department in which the next operation will occur. It is not uncommon for a part to go through 3 to 5 departments before it enters a finished stockroom. These secondary departments have no routine, systematic, and controlled way of anticipating their work loads. The usual method is for the shop foremen to "visit" the lead shops from which he gets most of his work where using his experience and judgement he estimates future work load.

In order to gain further insight into the scheduling process Contract Status Reports for February and March 1957 were analyzed. Detailed findings are given on Chart No. 11.5.2.4-2 along with a brief explanation of the technique used to acquire the data. Information of particular interest was

(1) The number of outstanding manufacturing department contracts approximates 12,000.

Mth/Year	7/6	8/6	9/6	10/6	11/6	12/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7	1/8	2/8	3/8	4/8	5/8	6/8	7/8
% contracts Scheduled	.092	.092	.46	1.75	3.49	5.23	10.1	16.6	20.4	15.0	8.35	5.14	4.31	2.75	2.66	1.19	.92	.46	.55	0	.183	0	.183	0	.183
No. contracts not completed on schedule	11	11	54	206	412	618	1192	1960	2410	1770	987	606	510	325	314	141	109	54	65	0	22	0	22	0	22
Total % not completed on schedule	←			37.81%				→																	
No. backlog contracts	←			4464				→																	
No. backlog plus current contracts	←			6874					→																
Est. No. contracts on floor	←			8644						→															

Report of February 1957 No. observations 1147

Mth/Year	7/6	8/6	9/6	10/6	11/6	12/6	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7	10/7	11/7	12/7	1/8	2/8	3/8	4/8	5/8	6/8	7/8
% contracts scheduled	.44	1.13	2.0	3.1	4.6	10.0	17.5	25.0	12.8	7.9	4.6	3.9	2.4	1.75	.87	.52	.61	.35	-	-	-	-	-	-	-
Total % not completed on schedule	←			38.77			→																		
No. contracts not completed on schedule	53	135	240	372	551	1199	2100	3000	1534	948	551	468	288	210	104	62	73	42							
No. backlog contracts	←			4650			→																		
No. backlog plus current contracts	←			7650				→																	
Est. No. contracts on floor	←			9184					→																

Chart No. 11.52.4-2

Note: For each Contract Status Report, 29 pages were chosen at random. On each page tabulations of the number of contracts with the same scheduled month were made. Overall totals for each month were then computed and the percent occurrence developed by dividing totals for each month by the total of all observations.

Analysis of Contract Status Reports

(2) Approximately 38% or about 4500 contracts are not fully completed as originally scheduled, but of these 84% or about 3700 have had some work done on them.

(3) Approximately 25% of all contracts in each of the reports concern work to be accomplished two or more months in the future.

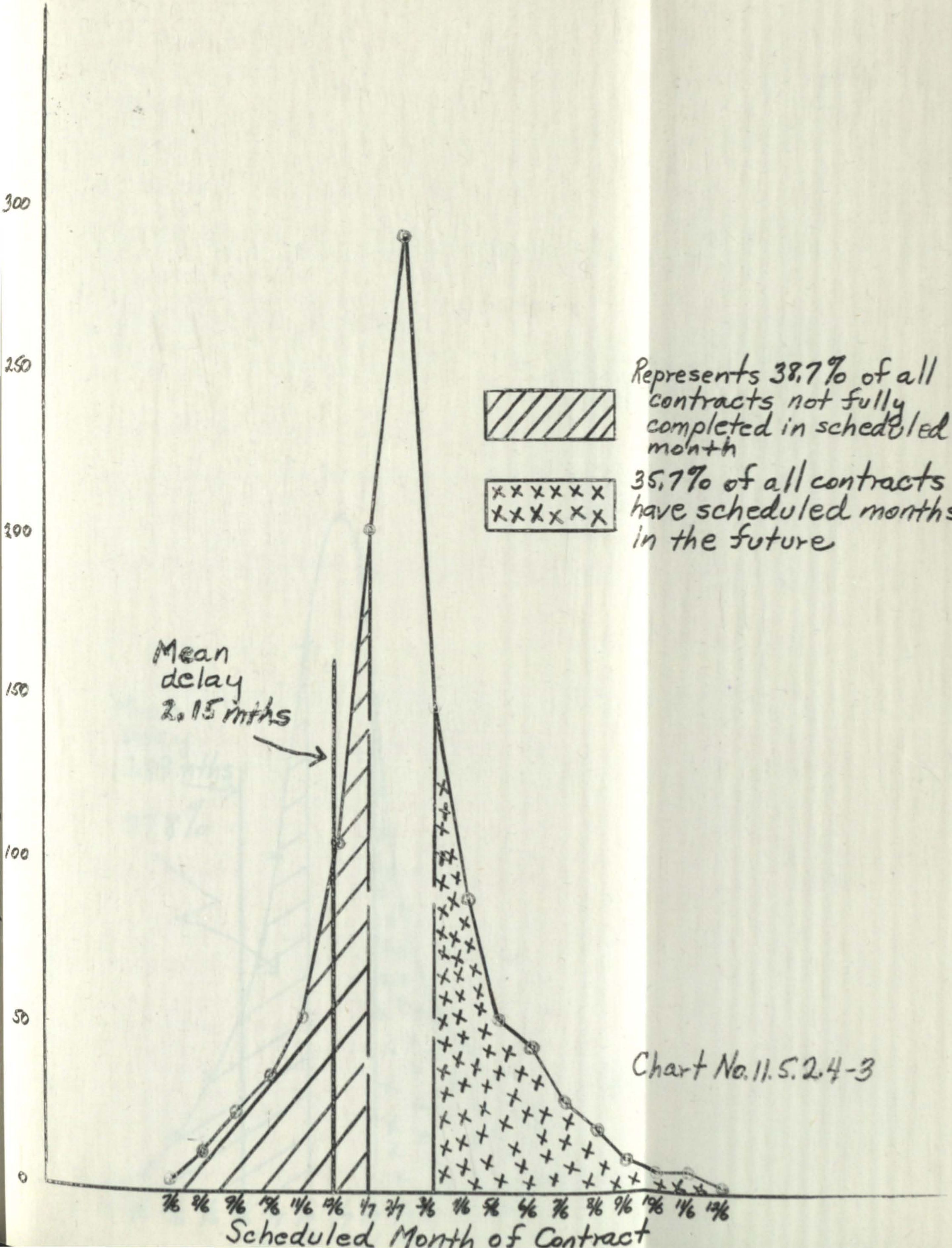
The average manufacturing time per contract was developed from the data on the chart as indicated below.

Estimated number of backlog plus current contracts in Feb. 1957	7650
Estimated number of backlog contracts in Mar. 1957	4464
Estimated number of contracts completed per month	3186
Estimated number of backlog plus current contracts in Mar. 1957	6874
Months to complete March backlog and current contracts	$\frac{6874}{3186}$ equals 2.15Mths.

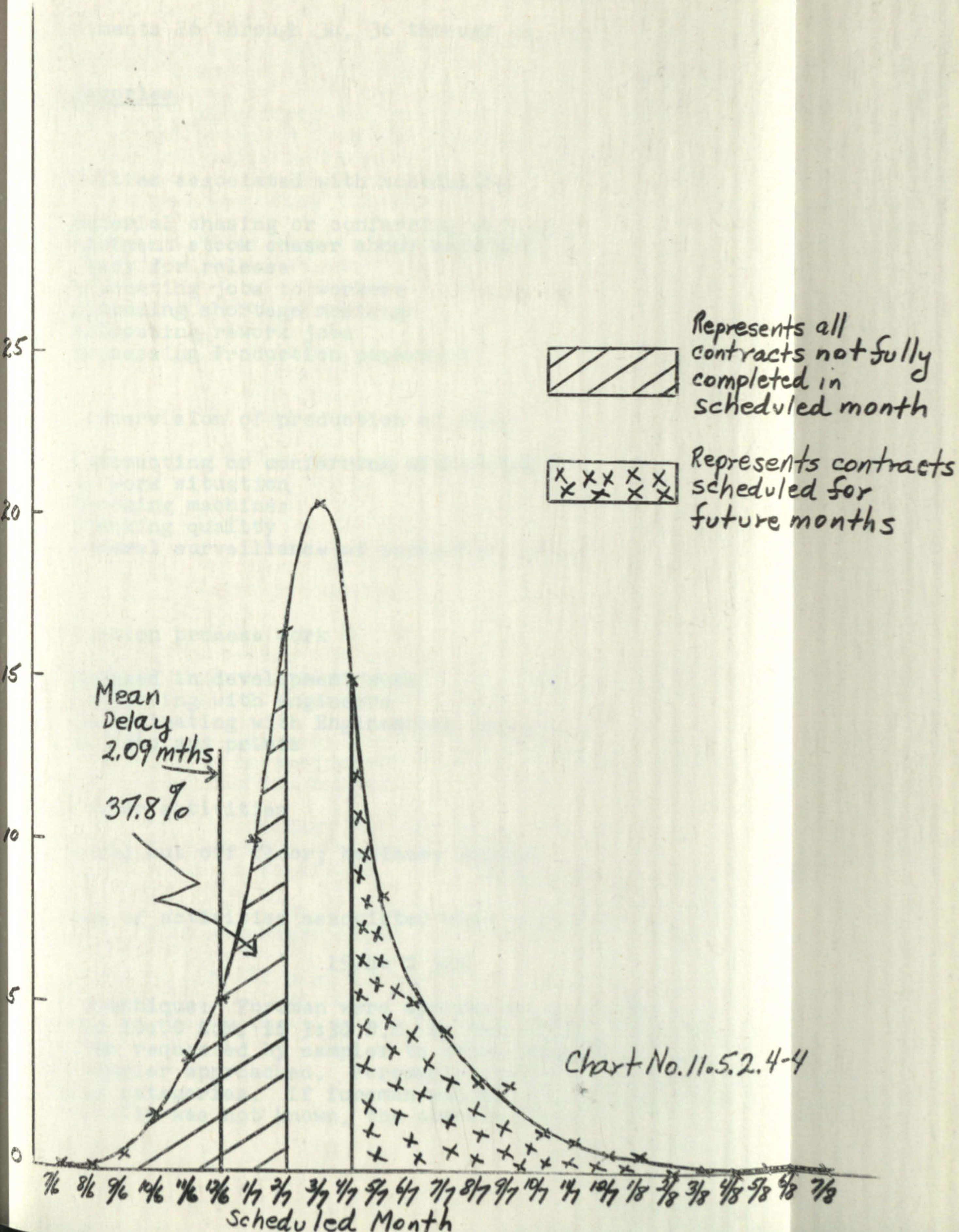
This delay of 2.15 months checks out closely with the mean time of delay calculated directly from the distribution of scheduled months shown in the individual Contract Status Reports. These delays were: in Feb. 1957, 2.15 mths; in Mar. 1957, 2.09 mths. Chart Nos. 11.5.2.4-3 and 11.5.2.4-4 show the distribution of scheduled months taken from sample data. Although these data are based upon only two samples, they seem to indicate that at the present time the average contract takes approximately 62 days to pass through the Manufacturing Department.

A work sampling survey was made on two successive Tuesdays in an attempt to determine the amount of time that the average foremen spent on scheduling activities. The detailed results are shown in Chart No. 11.5.2.4-5 of significance is that foremen appear, on the basis of these few samples, to spend approximately 32% of their working time in detailed scheduling activities. Such activities detract from their ability to supervise their operators on the production floor which is the generally accepted responsibility of first echelon supervision. That this inability to supervise continuously at work stations affects

Analysis of Contract Report dtd 18 FEB 1957



Analysis of Contract Status Report of March 1957



Results of Foreman Work Sampling

Departments 26 through 34, 36 through 44, and 47 through 49

rk Categories	Detailed Obs.	Total Obs.
Activities associated with scheduling		
A. Material chasing or conferring with department stock chaser about material ready for release	3	
B. Allocating jobs to workers	7	
C. Attending shortage meetings	1	
D. Allocating rework jobs	1	
E. Processing Production paperwork	3	
		15
All supervision of production of floor		
A. Instructing or conferring with workers on work situation	-	
B. Checking machines	-	
C. Checking quality	-	
D. General surveillance of production progress	-	
		11
Production process work		
A. Engaged in development work	3	
B. Conferring with engineers	1	
C. Co-ordinating with Engineering Department on data and prints	2	
		6
All other activities		9
At work, but off floor; business unknown		6
Total Observations:		47

rcentage of activities associated with scheduling observed:

15/46 = 32%

te on technique: Foremen were approached at random times during urs from 10:00 A.M. to 3:30 P.M. on two Tuesdays a week apart. reman was requested by sampler to state what work he was engaged in t time sampler approached. Foreman's stated activity was then fitted to above categories. If foreman was at work but not present and his act activity was not known, the observation was placed in category V.

production seems to be verified by the average scrap and rework figure of 14% of output. High scrap and rework in turn produces at least two important effects of its own. First, it interrupts the routine movement of partially completed products from one department to the next and, therefore, tends to increase overall manufacturing time, and second, it has a tendency to increase the volume of In Process Inventory (in tote boxes) for the same reasons.

In summary it appears that the present lack of systematic detailed scheduling from the Shop Supervisor/ Foremen level to the work station is the most significant factor contributing to:

(1) High volume of In Process (in tote boxes) Inventory.

(2) High scrap and rework costs.

(3) High percentage of manufacturing contracts not being fully completed as scheduled.

(4) An average contract life of about two months versus the planned life of one month.

It is recommended:

1. That a reputable management consulting firm be hired to revamp the scheduling system particularly at the Shop Supervisor/Foremen level. It would appear that some of the important characteristics of such a system should be:

(a) It must provide for the directed movement of materials between manufacturing departments in an orderly preplanned manner.

(b) It must aid and guide the Foremen in accomplishing work station loading by providing priority information on contracts.

(c) It must permit scheduling by both primary (lead) and secondary shops.

(d) It must preclude the possibility of scheduling the manufacture of a component for which either tools or materials are not known to be available.

(e) It must be simple to relate the scheduled load to the department and/or factory capacity to produce.

(f) It cannot be too radical a departure from the present system.

(g) It should be adaptable for use with the IBM Machine Accounting Installation.

(h) It must provide for pointing out those components or materials which are going to be delayed so that extra time or alternate facilities are utilized.

(i) It must be flexible enough to be interrupted by "emergency" jobs from time to time.

2. That the Contract Status Reports be made more useful to the Foremen and Shop Supervisors by either (a) eliminating therefrom all contracts which have not yet been issued by the Planning Section to the Manufacturing Department, or (b) separating the backlog/current contracts from the future contracts and publishing the future contracts in a separate report.

3. That the Production Planning Section study the average time for Manufacturing to complete a contract and utilize this time for planning purposes in lieu of the one month period now assumed.

4. That the Production Planning Section take action to check on the availability of tools and materials prior to the issuance of any contract to the Manufacturing Department. There seems to be no logical reason for a Foreman to have contracts in hand on which he cannot do work.

11.5.2.5 Scheduling of Assembly Department Facilities-About fifty to sixty days before the assembly month is to begin, the Production Scheduling Section prepares the necessary Assembly Department "contracts" using the Master Unit Requirements Record and the Master Planning Record as the sources of information. This process is accomplished simultaneously with the creation of the Preliminary Assembly Layout discussed under the section of this report dealing with the Authorization to Use Finished Subassemblies and Parts. The assembly contracts although prepared well in advance are held in the Scheduling Section for issue to the

Assembly Department about fifteen days before the beginning of the assembly month.

Referring to Chart No. 11.5.2.5-1, the next issuance occurs some seven to ten days prior to the assembly month in the form of the Preliminary Assembly Schedule. This "schedule" lists unit requirements for aircraft and commercial magnetos, and jet components only. Its purpose is to permit the Assembly Department to commence its work in advance of the scheduled assembly month if the current workload is slack.

At the beginning of the work month, the Assembly Schedule covering the same units as the Preliminary Schedule is issued. Small differences in quantities may occur between the two schedules otherwise they are alike.

As soon as possible following the Assembly Schedule, the Monthly Schedule listing the net requirements for units and semi-units is promulgated. This schedule shows the total requirements reduced by the number of units and semi-units actually on hand in various stages of completion. It also shows the quantity of each unit and/or semi-unit which must be "shipped" from the production departments to the Shipping Department or to Stockroom "S". Locally known as the monthly pink sheet, this schedule is the so called "bible" for unit and semi-unit production. When combined with the basic assembly contracts, it provides information as to the type of units and semi-units desired, the net quantity that must be produced, and the month in which these items are due.

There appears to be no essential difference between the Preliminary Assembly Schedule and the Assembly Schedule except minor changes in quantities of units required. Furthermore, since the Monthly Schedule is the working "bible" it would seem that the Assembly Schedule serves no important useful purpose and could be eliminated.

The similarity between the type of information made available to the Assembly Department for scheduling and the information given to the Manufacturing Department should be noted. Again, these procedures amount to master scheduling only. Shop Supervisors and/or Foremen are left once more to accomplish detailed work scheduling activities. On the average they spend as much of their

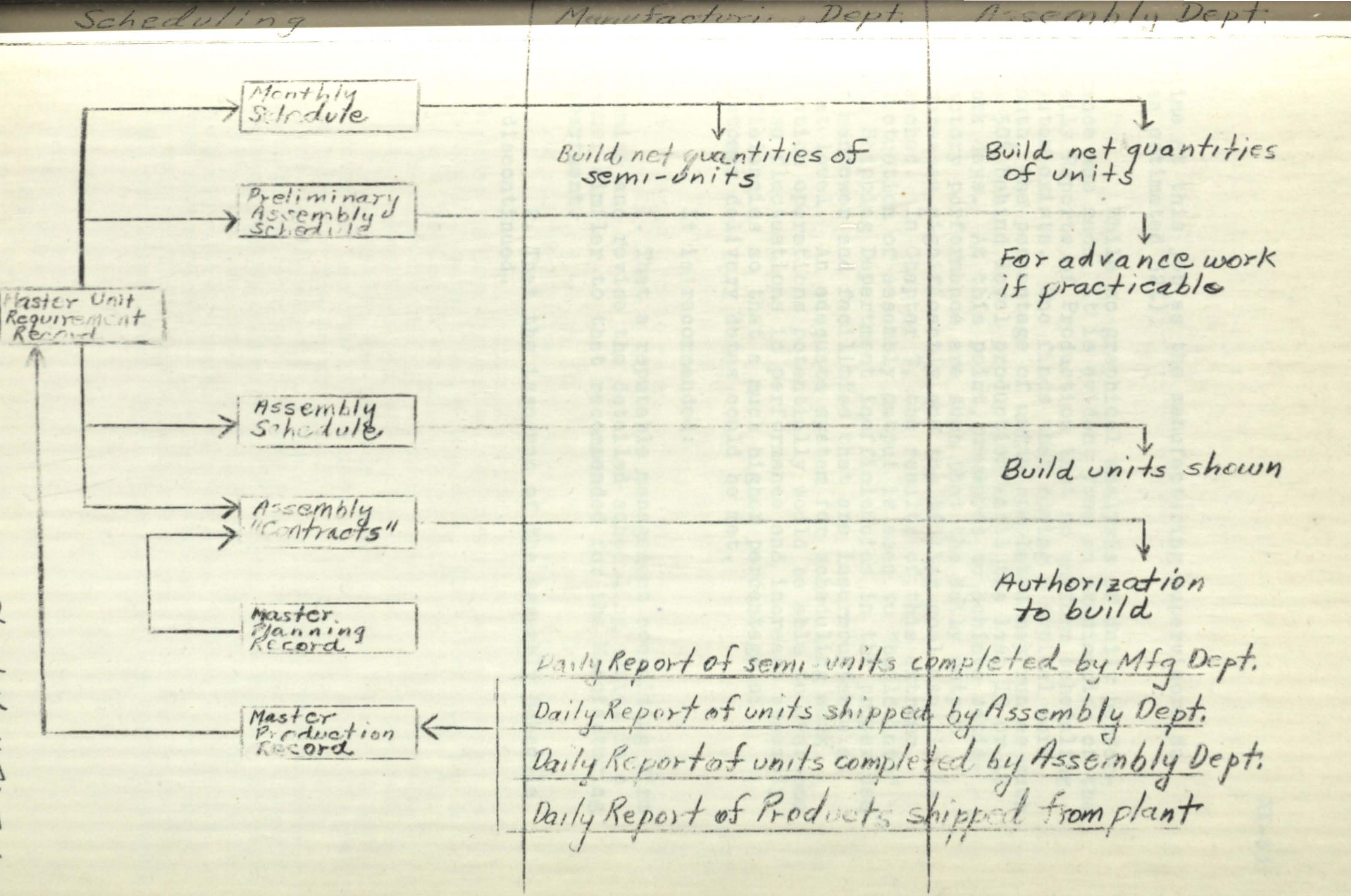


Chart No. 11.5.2.5-1

Scheduling of Assembly Facilities

time at this job as the manufacturing supervisors do (an estimated 32%).

While no graphical analysis of daily performance was made, it is evident from an examination of the Daily Reports of Production that no uniform scheduling system exists. One finds that during a typical work month, the percentage of units completed may run as much as 50% behind level production until the last 10 or 12 work days. At this point, pressures to achieve satisfactory performance are such that the daily output increases significantly and the billing goal usually is reached. In Chapter 7, the results of this extreme fluctuation of assembly output is seen to "build into" the Shipping Department inefficiencies in the proper use of manpower and facilities that are insurmountable at that level. An adequate system for scheduling work station operations potentially would be able to overcome these fluctuations in performance and increase assembly efficiencies so that a much higher percentage of customer delivery dates could be met.

It is recommended:

1. That a reputable management consulting firm examine and revise the detailed scheduling system in a manner similar to that recommended for the Manufacturing Department.

2. That the issuance of the Assembly Schedule be discontinued.

11.5.2.6 Control of Schedule Progress.

11.5.2.6.1 Responsibility. The responsibility for the timely execution of production schedules rests with the Production Control personnel and the manufacturing foremen. The foremen are vested with sole authority to issue orders to the operating personnel but in order to do this and effectively meet the production requirements, the foremen must depend on Production Control for essential information and advice. The reasons for this are mostly quite obvious since an individual foreman has little knowledge of the complexity of operations outside his own department which will have an effect on or be affected by, operations within his department. Production Control is the collection and interpretation center for this information which includes such data as urgency of various parts, availability of parts which will go into an assembly, work load on succeeding department, sub contract delays and lead times required, breakdown of a contract for a single part into requirements for several assemblies or spare parts and the urgency of each requirement, etc. It should be kept in mind that these decisions are made on individual parts or mother parts which often are only one of many going into a single final assembly and the "priority" of all parts going into such a final assembly can change radically when one key part becomes unavailable for any reason. With thousands of parts being manufactured, the decision making problem for individual parts becomes extremely complex and repetitive if optimum results are to be achieved.

Another factor that contributes to the foreman's dependence on Production Control for scheduling advice is the system of scheduling dates used. Each contract has a scheduled completion time which is indicated only by the month in which it is due, with the exception of electrical connector assemblies which have weekly scheduled completion dates. This system was adopted to allow flexibility in the manufacturing departments on setups, etc., and to allow some slack time for the accumulation of all parts that would be required for an assembly. These two features are desirable and should be retained in some form. However, the net result is that out of approximately 250 working days during the year, contracts are evaluated as "late" on only 12 days, the last working day of each month. On the other 238 days no exact measure of performance is possible under present procedures. It is true that the experience and judgment of the Production Control personnel gives them a "feel" as to the current status of production but this cannot be easily and constantly transmitted to foremen for use in decision making on scheduling matters. Thus, the foremen find themselves in the position of not knowing what their workload for the month is, since contracts are possessed only by the first department that will work on them, and they cannot plan very far ahead since they do not know when work from other departments will arrive. As a consequence, without advice of Production Control, foremen could only work on a first come, first worked-on basis with little or no regard to economical scheduling and relative urgency of contracts.

To summarize the subject of responsibility for execution of production schedules, the foremen have sole authority to say when and on what machines each contract will be done and they are held responsible for execution of the schedules, but they do not possess, nor are they routinely furnished with, the information required to perform this task. Production Control personnel possess this information but have neither the authority to make work assignments nor are they held responsible for meeting the schedules (except within fairly broad limits). This assignment of authority and responsibility appears misdirected as evidenced by the numerous progress meetings of foremen which are necessary, the high rate of late contracts, and the undesirable and unnecessary tension in a foreman's job due to being responsible for a task which the foreman cannot properly plan. It is strongly recommended that Production Control be given the responsibility and authority to execute production schedules and the foremen be freed to spend full time supervising his workers and planning the technical aspects of the work. Adoption of this recommendation would enable the only group which accumulates the complex of information affecting schedule performance to utilize this information for detailed scheduling, thus heading off trouble before it arises, rather than their present role of recommending to foremen the expediting of contracts already seriously in trouble.

11.5.2.6.2 Organization of Production Control. The Production Control organization consists of about 40 persons divided into six product groups such as Jet Units, Leads and Cables, Aircraft Magnetos, etc. Each product group is responsible for following the progress of components under its jurisdiction, making recommendations to foremen on priority of contracts for these components, making departures from normal parts allocation procedures in stockrooms, expediting the movement of material through Receiving, Inspection and on the production floor, and collecting material under terminated contracts which is on the production floor. It is well to keep in mind that the results being achieved by this section are costing about $200,000 per year in salaries.

The organization of this section into product groups has many advantages. The primary benefit is the familiarity of a group with its assigned products, the normal troubles they encounter in procurement, sub contracting and in production, and the location of specific parts on the production floor out of thousands being worked on. This organizational breakdown facilitates the analysis of current production of various products as units which is the form of all inquiries from Sales and others.

There appears to be three primary drawbacks to the present organizational breakdown: (1) Co-ordination of the expediting efforts from several product groups, directed at a single foreman who produces parts for all of these groups, is not provided for on a routine basis and is not effectively accomplished; (2) Evaluation by one group of the changes going on in product lines of other groups, with the consequent effect on production capacity used by several groups, is not easily performed due to lack of familiarity of these other product lines; (3) Expediting a product line often means that a single group is trying to keep track of and manipulate the numerous, complex and constantly changing factors affecting Purchasing, the majority of the production departments, and an assembly department. A single group trying to master an extensive operation of this complexity appears to be spreading manpower pretty thin unless they forego the idea of controling production and resort to "plugging each leak as it occurs". Discussion of each of these drawbacks follows:

Co-ordinating the expediting efforts of several groups which are directed at a single production foreman is an essential requirement especially from the foreman's point of view. How much help are these advisers to the foreman if they don't give him integrated advice on how best to get all products (i.e., contracts) through his department in the most efficient and timely way? The foreman is in no position to combine these various requirements into an integrated schedule for he lacks the essential information on operations outside his own department. At the same time the Production Control men are specialists in specific products and their interest and knowledge lies in their own product line. The result of this situation is that Production Control does not concentrate their efforts on getting the maximum overall production out of a department's facilities to the benefit of all products, but instead pushes contracts which are late today with little regard for the effect on overall production. With production running about 20% late constantly, it is easy to imagine the amount of continual "pushing" of foremen to get individual product line parts out. But no one in Production Control is evaluating each department as an individual unit of production to find out how each department can best be used to cut down the ever-present backlog of overdue contracts.

The next point, that of each product group having little knowledge of the effect on production of its product caused by changes in production of other products, exists for the same general reason as the disadvantage explained in the previous paragraph. Production Control personnel are evaluating progress of parts of specific products but are not trying to evaluate, in advance, the troubles various production facilities will encounter due to <u>combined</u> input of parts for <u>several</u> different products. Lacking such overall advanced planning of all parts going into each production unit the result is that a production unit must get into trouble and cause delays in progress of parts before attention is devoted to the bottleneck. Not being organized to perform such advanced planning, Production Control is seriously limited as to the amount of <u>preventive</u> action they can take.

Finally, following products completely through production from Purchasing to final assembly results in the expediters in each group trying to master a major portion of the production process and involves duplication of expediting effort in departments which are not devoted solely to one product line. This is a big assignment for the Production Control personnel for it does not simply involve recording progress and pushing the late contracts. It involves a great deal of minute and thorough planning in advance if production is to be effectivly controlled and not just followed. But the area to be covered is too great and control is split among groups whose products often are being processed in a single department. The result is trouble shooting after the trouble develops and too late to prevent it.

As mentioned at the beginning of this section, the present organizational breakdown of Production Control into product groups has many advantages and the sale of completed products is what pays the bills. Retention of this breakdown is recommended but changes in the duties of about one half of the personnel is required. The following general revision of the organization is recommended :

1. A Production Control man be assigned to each production department (or 2 men in some and 1 covering 2 departments, as dictated by conditions) who will be responsible for scheduling all work through the department and reporting progress of the work against the schedule. His progress reports and department schedules would go to the product groups in the Production Control office and to the Production Control men in succeeding departments. Thus a Production Control man would receive schedules showing him what work to expect and when.

2. A Production Control central office be composed of small product groups co-ordinated by a senior man, or small group, with an additional man as Sales Liaison man. The functions of the product groups would be to maintain <u>product</u> progress records and to compile integrated priority listings of all urgent products and those involved in competing for the same production facilities. The latter would be used for the guidance of the Production Control men assigned to production departments. The Sales Liaison is recommended to increase the response of production to customer needs and to more easily and readily refer such questions as choice of which deliveries will be later, back to Sales.

It is the opinion of the writer that this revised organization would require no more than the present 40 persons and would result in controlling production rather than present trouble shooting. In addition, much better progress records than are presently being produced will result. Each department would be a check point on progress, rather than the present system of using stockroom reports of receipt of completed contracts as the basis of progress records.

11.5.2.6.3 Schedules to Control. A schedule is commonly thought of as a single document, or board, or group of data in some assembled form which presents the complete plan of action for a specified length of time in the future, and which is used as a standard to compare with performance. Essentially Scintilla has a schedule that fits this description but it is difficult to state what one document or group of documents actually comprise the schedule. All contracts, taken as a group, which have been issued by Production Planning represent the schedule for sub assemblies and mother parts. Not too much emphasis is placed on these contracts as a schedule (about 20% are continually overdue) although production foremen work against delivery dates on contracts to some extent. A Contract Status report is prepared monthly showing progress on all contracts but is not timely enough to be used as a scheduling and control device. So, all contracts as a group do not exactly comprise "the schedule". A portion of all active work is extracted, that portion being the mother parts due in the current month plus sub assemblies going into these mother parts. This is tabulated on the monthly Shortage Analysis report prepared by Production Planning. This report then comprises the production schedule that must be met this month, but it by no means covers all active contracts such as sub assemblies required in future months which are being worked on now. In addition, it should be noted that the Monthly Shortage Analysis shows requirements only for the current assembly schedules plus spare parts and does not include parts in current contracts which are for future requirements. Such parts are involved due to cutbacks in assembly schedules, revised assembly schedules, economic lot sizes, etc., and do comprise part of current production goals since the due dates of the contracts they are under so specify. Thus, the Monthly Shortage Analysis is only a part of the total schedule. This concludes the listing of what could be considered as "schedules" for mother parts and sub assemblies. The remainder of the work, assembly operations, is covered by documents which are obviously complete schedules for this portion of the work. They are the Monthly Assembly Schedule covering units of finished products and the Monthly Holdings covering semi units. (It should be noted that assembly work on plug-in connectors is omitted from this discussion.) Thus, for Production Control there exists three documents which comprise an incomplete schedule against which they work: the Monthly Shortage Analysis, the Monthly Assembly Schedule, and the Monthly Holdings. No criticism of the lack of one composite schedule is intended since each of the above documents generally covers separate production department groups.

The main criticism of this aspect of schedules is that no current schedule is maintained on contracts for sub assemblies (not mother parts) which have delivery months other than one month prior to the scheduled final assembly month of the finished units they will go into. Since a large portion of the total workload falls in this category, it is evident that production of these sub assemblies is not being followed much less controlled. The net result of this system of schedules from a Production Control standpoint is that even though units take three months or more to manufacture, progress is followed for only the last two (2) months, that of final assembly and the preceding month of manufacture and assembly of mother parts. On units that take say four (4) months to manufacture, the troubles that develop during the first two months will be ignored until the third month when it will probably either be too late to take effective corrective action or the expediting action taken will be of a "crash" nature adding to the confusion and disrupting regular work routines and plans.

Therefore, it is recommended that schedules of all current production be prepared and that Production Control direct their efforts over the total production, in any stage, which is currently scheduled. This recommendation is made in recognition of the fact that production and purchasing troubles will be spread in a random distribution over the total time required to produce a product, and that the sooner these troubles are spotted the easier corrective action will be, the smaller the disruptions to normal production will be, and the greater the success in meeting production goals will be.

Schedules, in the form of contracts, holdings, and assembly schedules presently specify only the month in which the part, assembly, etc., is due. As a consequence, 12 days of the year all work is evaluated as being either on-schedule or late. It is important to note that work is not evaluated as being ahead of schedule. What effect does such a scheduling procedure have on efforts to control production? Production can only be controlled if a plan of production is formulated for use as a continual guide in making everyday decisions and evaluating performance to date. Monthly schedules do furnish a goal to work toward but they are not of very much help in evaluating everyday performance, which must be done if production is to be controlled.

The present situation is generally as follows. Most contracts and assembly of units and semi units are allotted one month for accomplishment. Actual work on a contract, as an example, may only take a few days from the issuance of material from stock, performance of all operations and inspection, transportation and waiting time, and delivery of completed work to Stock "C". Nevertheless, in general all material needed anytime during the next month is scheduled for production anytime during the current month. Since the only due date the foremen have is the end of the month for all work, they must try to plan, from the limited information available, in such a way that they will meet the schedule or come as close to it as possible. This assignment of responsibility to the foreman is presently a matter of management policy even though the foremen have little or no information on purchasing delays, order and time of arrival of work from other departments, detailed requirements of man hours and equipment for the entire month's workload, and other essential planning information. It is no wonder that the foreman's plans are, of necessity, short range and, in general, poor. This, of course, results in a natural tendency to work at a set rate during the month until it becomes obvious that the schedule won't be met. Then for the remainder of the month pressure increases in an effort to catch up.

As a simple example of another situation this system can and does produce, take two sub assemblies being made in department A, for inclusion the following month in two different mother parts, and two other sub assemblies being made in department B for inclusion in the same two mother parts. If one sub assembly from each department is late, then production of both mother parts can be delayed, whereas if each foreman were told in what general order to produce the sub assemblies, production of only one of the mother parts would be delayed. Due to the fact that an appreciable portion of production is constantly behind schedule, this situation is an important factor in causing shortages. It also adds to the level of in-process inventory, primarily in stockrooms, since a shortage of a single part causes a "pile up" of all the other parts that are going into the same mother part or assembly.

A summary of the production control problems caused by monthly scheduling is as follows:

1. On only 12 days out of the year can an evaluation of the current status of production or any part of it be made and progress accurately measured. Consequently, effective control between these monthly due dates is not attained.
2. Allocation of a month to perform a certain group of contracts is arbitrary and does not consider the actual manhour content of the work which may be less or, more often, greater than the 25 or so working days allotted.
3. Foremen are officially charged with planning the work although they do not process the requisite information to do such planning properly.
4. Due to incomplete planning it is late in the month before poor progress rates become apparent and unnecessary pressure is then applied in an effort to meet the end of the month due date on the majority of production.

5. Lack of a co-ordinated plan among departments producing sub assemblies causes delays in subsequent stages of production by producing the wrong sub assemblies at the wrong time.

This list of problems is probably not unique with Scintilla but would be found to a greater or lesser degree in any large job shop. The problem of setting up a workable schedule for complex job shop conditions and then controlling the production so as to conform to the schedule has not, in the writer's opinion, been satisfactorily solved to date, textbook writers not withstanding. The problem is to set up an <u>optimum</u> and workable schedule, in terms of the company's objectives, and not just a workable schedule, and then to control production in such a manner that optimum results are achieved. Among methods of scheduling and controlling such a job shop are the following with probably a few more which differ in detail only:

1. Man hour and machine hour scheduling with "control" being done basically by re-scheduling the work when progress wanders too far from the existing schedule.

2. Periodic load schedule (such as monthly) where at the beginning of every period the production "hopper" is filled with an amount of work which experience has shown can generally be produced. Control is generally in the nature of stock chasing late parts with little consideration of troubles being generated in other parts.

3. "Make-span" scheduling of parts with control being exercised through a set of "optimum decision rules" used for dispatching.

With the present craze for utilizing electronic computers, attempts have been made to mechanize all of these methods but without any great degree of success to date, at least for complex job shops.

For such a shop as Scintilla, the first of the above methods is impractical from a time, cost and accuracy standpoint. That isnot to say that such a system could not be used by generalizing here, padding times there and making other compromises that would encourage inefficiency in the shop. The second method is the one presently used. From the amount of late work at all stages of production and the amount of production control effort on the part of management, foremen and Production Control it is obvious that this method is not extremely effective.

The third method in some respects is believed to be relatively new and quite promising. A paper on this method, "Operations Research in Production Control" by A. Vazsonyi of the Ramo-Woolridge Corporation is strongly recommended since it deals with the progress of adapting this method to a job shop quite similar to Scintilla. Mr. Vazsonyi's original objective was not to derive a new method of scheduling and production control but to apply large scale electronic data processors to the existing production control problem. In attacking this problem he strayed from the original objective, out of necessity, and has come up with the basis of a new and improved scheduling and production control method which also is a first step in setting the problem up for solution by electronic computers.

The scheduling phase of this method is based on calculating the "make-span" of the various parts from actual experience in producing them. Working backward from delivery dates these "make-spans" are plotted and a basic schedule is produced which is not so sensitive that upsets will destroy it since it is based on average conditions in the shop. The production control phase of this method utilizes the basic schedule to determine "in dates" and "out dates" for parts, from which priorities of various parts are determined whenever a foreman must pick from several waiting lots. The production control phase of the method is designed to continually keep the flow of production on an optimum basis. Of course the management of each company must specify what factors are to be considered in determining what an "optimum" flow of production is.

The description of this third method of scheduling and production control is extremely simplified as presented here and only a thorough study of Mr. Vazsonyi's report could properly present its possibilities. However, it has the following advantages:

1. It provides a schedule against which progress of work can be evaluated at any time to determine present status of production.

2. Any contract can be evaluated to determine its status in relation to its due date.

3. Parts are produced only at the time they are needed not ahead or behind schedule.

4. Utilization of "decision rules" by foremen insures that the flow of work on the production floor is continually in an optimum condition.

5. Constant scheduling by foremen based on incomplete information is eliminated.

6. The need for co-ordination to insure timely arrival of all parts going into a unit is automatically accomplished by the use of the "decision rules" unless conditions beyond the control of foremen arise such as purchasing delays.

Therefore, it is recommended that scheduling and production control be based on "make-spans" and automatic control be exercised through the development and use of "optimum decision rules" similar to the system being developed by the Ramo-Wooldridge Corporation. In passing it is understood that Mr. Vazsonyi is presenting a second progress report on the installation of this system sometime in May.

11.5.2.6.4 Production Control Reports. The information on Production Control reports comes primarily from two sources. various stockroom transaction reports and verbal information from foremen. The reports are:

1. Daily Parts Shortage Reports. These reports, one on each primary product line and one on spare parts, are based on the production requirements listed on the monthly Shortage Analysis from Production Planning. These reports are published weekly thus the term "Daily" in their title is misleading. Some information, mainly on mother parts, is posted to these reports daily from the daily stock transaction reports. Since the stock transactions reports list parts which have been completed, they are a good current source of requirements filled to date but they do not give any information on progress of production prior to completion of contracts. Status of sub assembly parts are posted to these reports weekly from the Stock Receipts Report. Weekly meetings of foremen are held for each product line at which time information on where all parts presently are and their status is gathered and entered on these reports.

2. Critical Items Reports. These reports are prepared daily on each product line from information on the Daily Shortage Reports and from information gathered directly from the foremen. These reports list the items which are badly needed in the next stage of production. They list the part, the total amount required, the amount delivered yesterday, amount delivered to date, and the location and status of the parts on the production floor.

These reports are sent to production foreman and supervisors for information and action and are used by the Production Control men to record the progress of production and items which should be expedited. The primary value of these reports is to highlight items which are critical. The Daily (weekly) Parts Shortage Reports are not too meaningful early in the month when the "Short" column is almost identical with the "Required" column, and they do not show which items are behind schedule until fairly late in the month when corrective action is the most difficult due to pressure to get out everything at once. These faults do not arise from the reports themselves but from the system of scheduling all "due dates" for the end of the month. Unless there is a specified daily or at least weekly production goal no meaningful evaluation of production progress can be made from these reports except near the end of the month.

The only serious criticism which can be made of the reports themselves is the fact that they do not cover all production going on during the month but only that portion that will be assembled into finished units and semi-units next month plus spare parts required this month. Thus, although other work has a current due date and must meet this date in order not to cause future trouble, no evaluation of the progress of this work is made until it is already overdue.

Therefore, it is recommended that progress reports (shortage reports) be made on all production in order that production troubles can at least be detected during the month they develop. Until this is done, a major source of delays will continue undetected.

11.5.2.6.5 Controlling Production. With production constantly 20% behind schedule, it is difficult to consider that production is being controlled. The plan of production is not only not being achieved, but no progress is being made in approaching achievement. Two possibilities present themselves. First, possibly the plan is unrealistic and impossible of achievement. Second, possibly attempts to control production are not effective. It is assumed that a single month's schedule, less the carryover of overdue work from the previous month, is realistic since production does not appear to be droppong further and further behind schedule. One reason for perpetuating this condition as explained to the writer was to keep pressure on production. It is questionable whether this is an effective stimulus for people to do their best, in fact it could be considered as having adverse effects on morale, quality and costs. The average incentive bonus being earned by workers does not substantiate the claim of this being an effective stimulus. Nevertheless, since this constant carryover does exist, it is difficult to evaluate the effectiveness of Production Control. They are primarily attempting to control the production of mother parts. Sub-assemblies are for the most part already late when they first appear on Production Control Reports and their efforts in the assembly departments are primarily to get the parts required by the foremen of these departments. There is no convenient yardstick to measure their effectiveness in controlling production because it cannot be stated with certainty, one way or the other, whether the schedules are good, meaning attainable with efficient use of men and facilities, or bad, meaning either unattainable due to overloading of available capacity or too easily attained due to underloading.

Production Control personnel do their controlling by (1)advice and suggestions to foremen on what work to perform in what sequence, (2) by allocation of parts in the stockroom for most effective utilization of production, and (3) by expediting the movement of material through Receiving, Inspection and on the production floor. The first means employed, that of advising foremen, is the most important and is potentially a very effective means of achieving controlled production. However, since efforts directed at foremen are in the form of advice and in every instance must be "sold" it is a delicate arrangement where personality conflicts could easily destroy the effectiveness of the Production Control men. In addition, it is easy to see that Production Control men can readily "sell" their recommendations where it is fairly obvious to the foreman involved that the situation is really critical and will probably result in the foreman getting a fair share of the "chewing" from superiors. This is the case with present stock chasing of late parts. But if production were to be controlled by heading off critical conditions long before they arose, and in departments far removed from those where the trouble would finally become apparent, it is questionable whether Production Control advice would be as readily accepted.

The second and third means used to control production, the allocation of parts and expediting movement of material, are presently effective but both could become complex procedures should the purchasing and delivery situation suddenly become critical for some reason. Allocation procedures especially should be kept under continual study to improve the effectiveness of production.

Recommendations which would facilitate more effective control of production have already been stated under previous headings of this section.

11.5.2.7 Sentiments of Foremen Rather late in the project period it was decided that direct interviewing of foremen might uncover some significant information concerning production scheduling and other related matters. Unfortunately the time limitations permitted the completion of only three interviews out of a possible total of about 40.

Pertinent comments from this relatively small sample are outlined below:

1. Question. About how many hours per week do you spend checking stockroom files for releaseable contracts, checking material and tool availability prior to release of contracts, attending Shortage Meetings, and assigning priorities to contracts after release?

Summary of Comments The average number of hours reported in answer was 6 hours per week or about 15% of the work time. Two of the foremen indicated that they did not regularly attend Shortage Meetings, and one reported that he did not receive copies of Stockroom inventory reports.

2. Question What would be the effect on your work scheduling activities if you were to receive a Contract Status Report in the form shown below instead of in its present form?

Dept---

Scheduled Completion Date Mth/Wk	Part Number	Contract Number	Quantity To Make	Estimated Production Hrs Per 100	Cumulative Work Hours This Report
3/19	10-52502	384250	675	9.2	62
3/19	10-64901	396821	5200	7.0	426
3/19	10-82106	417245	1200	5.0	486

Summery of Comments One department which did considerable lead work expressed strong interest in such a report which indicated that it was his practice to compute essentially the same information in order to estimate manpower and machine capacity requirements. Another foreman appeared disinterested in the proposed format stating that whenever he needed such information, the present Contract Status Report was sufficient. The remaining foremen indicated that he never received the Contract Status Report but the proposed format would help him, if it constituted a schedule of work.

3. Question If you had sufficient time to devote to any problem in your department, what area would you attack first?

Summary of Comments All foremen reported that the reduction of scrap and rework is their single biggest and most continuous problem. One indicated that some work fails to pass bench inspection because the Routing and Layout Sheets are not correct. It was not uncommon to find 3 or 4 mistakes each week in these instructions, many of which the foreman did not find until after being informed that a production lot was not up to specifications. Another secondary problem in one department was one of on-the-job training of new workers. This foreman said that he could have such workers up to average output much faster if he could devote more of his time to their training instead of leaving them largely on their own or under the supervision of several experienced workers.

4. Question How do you go about scheduling work for your operators?

Summary of Comments One assembly department foreman used the Monthly Schedule (Pink Sheet) as a basis modified by his own judgment with priorty of assembly set by his supervisor. Another said that he depends almost entirely upon the Weekly Shortage Reports promulgated by the Production Control Section. He reported that he normally handles the oldest contract appearing on these reports first unless the expediters have indicated something different. This same department stated that competition among expediters for machinery caused him frequent difficulty. The third foreman met with his Shop Supervisor who gave him a listing of parts he was to work on in order of priority. The foremen generally assigned work to operators personally or via group leaders.

5. Question Do you accomplish anything similar to machine loading procedures in your department?

Summary of Comments Two foremen reported that they did not. One of these apparently had no idea of what "machine loading" involved. The remaining foreman had moved a step toward formal machine loading techniques in that he calculated from the Contract Status Report and production standards how many hours it would take to complete all the work of his department. In estimating his capacity, he used a flat 20% for downtime. By comparing the two machine hour figures, he could see whether or not Contract Status work could be completed.

6. Question What does the Roving Floor Inspector do in your department?

Summary of Comments All foremen reported that their Floor Inspectors checked first new parts off machines for specifications and regularly signed operator piece rate cards. Two foremen had a generally poor opinion of floor inspection. One stated that such a procedure tended to make the operators quantity conscious since only sample inspections were made and most parts were accepted. The other foreman indicated that the floor inspectors were not doing a proper job and that furthermore the machine operators were being paid already for an inspection operation. The last foreman felt that floor inspection was necessary and that if the operators had to do this type of inspection, additional equipment would be needed. All agreed that some substitute inspection procedure would be necessary if the Roving Floor Inspectors were discontinued.

7. Question What do you do with the Daily Inspection Report? (Daily listing of items failing inspection)

Summary of Comments Two foremen stated that they used such information to council and guide their operators. The other foreman did not receive this report but received the inspection report on high cost items which is published bi-weekly. He stated that the information on this issuance was "cold turkey" by the time it got to him and was of only general interest.

Conclusions Although these interviews covered only about 8% of the total number of foremen, important trends and attitudes have appeared. Analysis of the comments has yielded the following pertinent conclusions:

1. A more usable format for the Contract Status Report would be helpful to foremen.

2. Problems of particular interest to foremen in order of priority are:

a. Reduction of scrap and rework

b. Mistakes in routing and layout instructions.

c. On-the-job training (Assembly Dept.)

3. The procedures used in each department for work scheduling involve different numbers and levels of personnel, different information sources and varying amounts of personal judgment.

4. There is a general unawareness at the foreman level at the concept of "machine loading", what it seeks to accomplish, and various ways it can be done.

5. Although mixed sentiments exist about the efficiency of floor inspection, the consensus of opinion is that these procedures are not now achieving their purpose of insuring satisfactory product quality at each work station. In many cases, the company seems to be paying for floor inspection service which it is not actually receiving.

6. The Daily Report of Inspection is very helpful to foremen in counciling and guiding the operators but is not being received by all departments.

It is recommended:

1. That the format of the Contract Status Report be changed to make it more useful to foremen for schedule planning purposes.

2. That operator production standards be modified if inspection is not actually being accomplished.

3. That foremen training include the following subjects:

a. Procedures to reduce and control scrap and rework.

b. Development and execution of on-the-job training programs.

c. Methods and procedures useful for work station scheduling.

4. That the Daily Report of Inspection be sent to every department.

11.5.2.8 Summary of Recommendations

Master Scheduling

1. That one section in the Production Department having cognizance of overall plant capacity be established to receive customer orders and develop delivery schedules.

2. That in coordination with the single section established to develop delivery schedules a plant loading analysis be conducted periodically in order to allow the section to do the following:

a. Schedule more exactly

b. Advise the Manufacturing Department of the exact overload in terms of machine hours that were being scheduled for any period compared to an established normal employment level.

c. Advise the manufacturing Department and other appropriate departments or sections that the schedule being developed will require subcontracting of a certain amount of machine time.

d. Accurately judge when overtime will be required to provide a more exact basis for placing premium prices on rush orders.

Inventory Commitment

1. That both the Preliminary Assembly Layout and the Preliminary Holdings be replaced with IBM type cards, one card for each unit or semi-unit. These cards might be preprinted at the time the IBM Supplement is made up and kept on file until the Preliminary Assembly Layout and the Preliminary Holdings are issued.

2. That consideration be given to eliminating the copies of the Preliminary Assembly Layout and the Preliminary Holdings which now are sent to the Production Control Section, the Production Planning Section, and the Finished Stockrooms.

3. That some more adequate provision be made within the Manufacturing Department for delegating to a single individual the responsibility for providing information as to the growth, value, and cost of In Process Inventory (in tote boxes), and for recommending to Top Management ways and means to reduce these findings. It is suggested that the Chief Planner be assigned this responsibility.

4. That a serious and detailed study be made of the relative value and cost of in process inventory under a policy of greater production into finished stock, and that the beneficial effects of such a procedure be weighed against the present policy of little or no finished stock inventory.

5. That the Purchasing Department analyze the material shortage memoranda issued by the Production Control Section weekly in order to avoid repetitious delays of similar material, and to form a basis for more accurate estimates of purchasing lead time.

6. That the optimum amount of In Process Inventory be established with the help of a management consulting firm and that this be the standard of performance to which the Manufacturing Department should conform.

<u>Scheduling of Manufacturing and Assembly Facilities</u>

1. That the issuance of the Assembly Schedule by the Production Scheduling Section be discontinued.

2. That a reputable management consulting firm be hired to revamp the scheduling system particularly at the Shop Supervisor/Foremen level. It would appear that some of the important characteristics of such a system might be:

   a. It must provide for the directed movement of materials between the manufacturing departments in an orderly preplanned manner.

   b. It must aid and guide the Foremen in accomplishing work station loading by providing priority information.

c. It must permit scheduling by both primary (lead) and secondary shops.

d. It must preclude the possibility insofar as is possible the scheduling of the manufacture of components for which either tools or materials are not known to be available.

e. It must be simple to relate the scheduled load to the department and/or factory capacity to produce.

f. It cannot be too radical a departure from the present system.

g. It must be adaptable for use with the IBM machine Accounting Installation.

h. It must provide for pointing out those components or materials which are going to be delayed so that extra time or alternate facilities are utilized.

i. It must be flexible enough to be interrupted by "emergency" jobs from time to time.

*3. That the Contract Status Reports be made more useful to the Shop Supervisors and Foremen by eliminating therefrom all contracts which have not yet beem issued by the Production Planning Section.

*As a first step toward such a system, we feel that the development and publication of a weekly "contract" workload by department should be commenced as soon as possible.

4. That periodic analyses of the Contract Status Reports be made similar to the manner described to check on the average manufacturing delay and the growth of contract backlog.

5. That the Production Planning Section study the average time for the Manufacturing Department to complete a contract and utilize this time for planning purposes in lieu of the one month delay now assumed.

6. That the Production Planning Section take action to check on the availability of tools and materials prior to the issuance of any contract to the Manufacturing Department

7. That the amount of time spent by the Foremen in scheduling activities be reduced.

Sentiments of Foremen

1. That production time standards now applied to operators be revised for inspection procedures which operators are not accomplishing.

2. That foremen training include the following subjects:

a. Procedures for reducing and controlling scrap and rework.

b. Development and execution of on-the-job training programs.

c. Methods and procedures useful for work station scheduling.

3. That the Daily Report of Inspection be sent to every department.

Miscellaneous

1. That the Shop Supervisors and the Foremen be commended for the outstanding job they are doing in fulfilling the master schedules as they are now prepared.

11.5.3 Plant Engineer. Due to insufficient time in which to inquire fully into the functions of the Plant Engineer, this section of the report will be confined to a discussion of only a few topics.

The Plant Engineer is charged with the maintenance and operation of the plant utility systems, the maintenance of the building and service equipment, minor maintenance of production machinery, plant layout, and the accomplishment of alterations to the plant and relocation of equipment.

The maintenance systems employed are up-to-date but not wastefully elaborate. Inspection schedules are maintained on most service equipment and inspection cycles are based on experience in past maintenance of this equipment. Scheduled maintenance is employed where recurring maintenance in the past has demonstrated a need for such regular service. Large maintenance jobs are undertaken by plant forces if the job can be spread out over an extended period of time, present and anticipated workloads permit a steady progress rate on the job, or where production operations dictate job conditions which would either be unacceptable to an outside contractor or would cause an excessive price for the job if awarded to outside contractors. Maintenance work is farmed out to local area contractors if special skills or equipment are required, if this is the most economical way to do the job, or where present workload dictates the contracting of the work. It appears that the policy on maintenance of production machinery is primarily one of breakdown maintenance. Even though this is generally frowned on, without an economic evaluation of the policy in operation, no criticism is justified.

The plant layout function in this office is presently absorbed in the new extentions to the plant. Unless plant layout conditions are continually re-evaluated there is a danger that gradual alteration and expansion will promote overall inefficiency in the plant. Product changes, sales volume changes, process changes, small expansions and localized alterations and rearrangements can all affect the materials handling function, stockroom locations, locations of particular machinery, and types of operation (ie production line vs. process setup). It is easy to have changes so gradual and planning confined to apparently isolated functions that the need for large scale modifications escapes notice as the planning personnel get accustomed to present operations being laid out in the same way it has been for years. To provide the continual review of layout that is desirable, it is recommended that a plant layout review committee be established, with representation from a good cross section of the organization, and be assigned the responsibility of detecting and evaluating all changes affecting plant layout. Meetings would be infrequent and because of this, and the inherent nature of the problem, guide lines from management must be specific and comprehensive or the committee will become ineffective.

The only remaining area considered for improvement in this office is the area of performance standards. There are two considerations here. The first is the performance standard set for this unit of the organization by the accounting office. At present this standard is limited to the cost of labor which is calculated on a meaningless basis. It does not give any measurement whatsoever of the effectiveness with which the maintenance force is utilized. In addition there is no standard for material consumed. Therefore, it is recommended that performance standards for the Plant Engineer be established by Accounting on a meaningful basis.

The other consideration of performance standards is in the nature of work standards for maintenance employees. Although somewhat difficult in large plants it appears that the setting of work standards for maintenance work at Scintilla could be done with fairly complete coverage due to the repetitiveness of the majority of maintenance work performed. By setting such standards a continual measure of performance would be available and opportunities to improve the efficiency of maintenance work would become apparent. Therefore, it is recommended that work standards be developed for maintenance and that they be used to gage and improve performance. No recommendation pro or con is made concerning the use of incentive pay with these standards.

11.5.4 <u>MASTER MECHANIC:</u>

11.5.4.1 <u>General Function.</u> The Master Mechanic Department (sometimes referred to as the Production Engineering Department) is responsible for providing the tools, equipment facilities and process instructions to manufacture any product developed by the Engineering Department and/or required by the company's sales force for the customer.

11.5.4.2 <u>Discussion.</u> In essence this department plans the method by which the product will reach the shipping room door, by:

1st. Deciding how the product is to be made in conformance with design. (Includes coordination with engineering to establish design for ease and economy of manufacturing.)

2nd. Making up manufacturing layout process sheets. (Layout Department)

3rd. Deciding requirements for tools and machines and responsible for their design, construction or purchase. (Designed in the tool design section, constructed in the tool room, or procured, if necessary, through the equipment engineering section.)

4th. Making test runs on intricate, specialized machines through the methods engineering department. (Not all tool go through the methods engineering department - just those machines that are highly complicated.)

As outlined above the decision as to what kind of tools and how many to make rests with the master mechanic who categorizes those tools into four different types as follows:

1. Pre-Production tools or short life tools, for limited production, where the design is not settled and changes are very apt to be heavy. Short tool life is expected, and a comparatively high part price for the unit is acceptable. Short delivery for tools and low tooling cost are of prime importance. Only limited tool drawings are provided.

2. Class 2 tools are still in low production quantities but required for a unit that is of a stabilized nature. Tools are better made than the above and more accurate.

3. Class 1, or high production tooling, where low unit cost, stabilized design, and long run tool life are optimized, and a tooling cycle of from four to six months is acceptable. Tools are designed to provide the best appearance and highest degree of accuracy. Gages and measuring instruments are provided so as to guarantee full compliance with blueprint tolerances and assure interchangeability.

4. Automatic tooling, which is actually only a high degree of mechanization, ushered in by the requirements for plug-in-connector pins and sockets, produced in extremely high volume.

The basic information as to productivity, urgency of delivery and long run outlook is given to the Production Engineering Department either in special explanatory meetings or, as is the case in most instances, through the Production Control Committee meeting. This meeting is attended by sales, Engineering, Production and Cost Estimating. It is at this meeting that the Master Mechanic Department is first informed of the amount of tooling money that it is expected to spend. Tool estimates then have to be prepared by the Cost Estimating Department in a relatively short time and, according to the Master Mechanic, often with only sketchy information or prints.

The Master Mechanic has an assistant who does everything possible to relieve the Master Mechanic of detail. As such he stands in his stead as chairman of the production control committee as well as the suggestion committee. He is also responsible for gathering facts on any situation in which the master mechanic might be interested or obligated to make a decision.

There are seven different sections that comprise the Production Engineering Department. They are:

Production Engineering - Liaison and Methods
Layout or Process Department
Tool Control
Tool and Mold Design
Toolroom and Tool Inspection
Tool Cribs

Production Engineering starts, fundamentally, with design. To avoid later bottlenecks and production or tooling difficulties, a PED man is assigned the Engineering Design Section in the form of the Production Engineering Liaison Engineer. He reports directly to the Master Mechanic and is responsible for consulting with project engineers to advise them on manufacturing capabilities. As such his functions in Engineering Design are purely advisory, reporting back to the Master Mechanic for opinion or decision if the problem is in the manufacturing realm.

The methods engineering group are responsible for the development of new methods applicable to intricate machines. They are responsible for ascertaining that equipment does function as required prior to being released to manufacturing thus deciding the basic method of operation. Little effort if any is expended, however, on the improvement of methods on existing processes or machinery.

The Layout or Process Department is responsible for establishing manufacturing procedures. The sequence of operations as well as the machines to be used is decided upon. Thus manufacturing layouts (process sheets) are made up so that the manufacturing department may proceed with the productive operations and will be provided with the necessary tools and equipment. The Layout Department must review engineering designs for comments to ascertain their present capability for economical manufacture. Based on Layout recommendations the Master Mechanic would make the decision as to the desireability of buying or building the necessary machinery. (P.P.C. does not delve into designs to the extent that they can determine the capability of the individual machines, so that this function becomes a prime responsibility of the Layout Department.) They are also responsible for revision of layout because of engineering design changes. Additional duties are commenting on new designs and dimensioning, filling out material control sheets, writing operation sheets and originating tool requests.

Tool control coordinates the procurement of tools and gages required for production. When a specific tool is required by layout, tool control acts to prepare a design contract (on a standard form) with the necessary information together with an estimation of costs. The cost estimation acts as a "safety valve" to prevent tool design from going "overboard". The design contract is then sent to tool design giving that group the basic data with a delivery date. Tool Design takes over to sketch and design the requested tools, gages, fixtures, molds and test equipment. After Design the "contract" is returned to Tool Control with the sketches. Tool Control then sends it to the Tool Room to be made or through Purchasing for procurement.

The Tool Room is a completely equipped machine shop staffed with tool makers, tool maker machinists and associated equipment. In all approximately 210 people are so employed, with about 50% of their time utilized by tool upkeep.

Tool inspection is responsible for checking all tools for conformance to blueprint specifications in the case of both new tools and those coming from the floor for periodic inspection.

IFACTURE of a PRODUCT: - PRESENT SYSTEM WITH COMMENTS -

GINAL IDEA USUALLY IN FORM OF A MEMO FROM SALES - NO SPECIFIC FORM.

(2) To PRODUCT DESIGN FOR ANALYSIS WHICH SENDS IT TO:
- a. MATERIALS LAB. FOR TEST of (1) STRENGTH (2) GALVANIC ACTION
- b. RESEARCH FOR (1) CIRCUITRY (2) BREADBOARD (3) COMPONENT DIVISION

(AT THIS POINT THE PROPOSED PLANNING DEPARTMENT SHOULD BE INCLUDED FOR ANALYSIS OF MFG. PROBLEMS & PLANT CABABILITY.)

(3) To DESIGNER → To EXPERIMENTAL SHOP FOR
- a. PROTOTYPE

To TEST LAB. FOR
- a. QUALIFICATION TEST

To CUSTOMER

(TOOL DESIGN, MFG. ENGR. DEPT., SHOULD BE INCLUDED HERE TO FACILITATE PRODUCTION.) - AS A FUNCTION OF PLANNING DEPT. LIAISON -

(4) To DRAFTING FOR
- a. DETAIL DRAWINGS b. Assemblies c. Installations

(5) To STANDARDS FOR
- a. SPECIFICATIONS
- b. TECHNICAL WRITING
- c. CHECKING

} THAT STANDARD SCREWS HAVE BEEN USED, etc. { ENGINEERING STANDARDS MANUAL

(6) To ENGINEERING RECORDS FOR
- a. RELEASE → To SERVICE DEPARTMENT FOR
  - a. TECHNICAL PUBLICATIONS
  - b. SERVICE TOOLS
  - c. SPARE PARTS
  - d. TECHNICAL INVESTIGATION

(7) To MANUFACTURING FOR

LAYOUT
- a. product
- b. flow

METHODS
Improvement of Manufacture

TOOL DESIGN
- a. tools
- b. jigs
- c. fixtures

MOLD-DESIGN
- a. ceramic
- b. aluminum
- c. Plastic
- d. bakelite

BOTH OF THESE SHOULD HANDLED BY THE NEW PLANNING DEPT. PRIOR TO GOING TO Mfg.

(8) To PRODUCTION

[PRESENT P.C.C. SHEET CONTAINS NECESSARY INFORMATION ON AMOUNT ALLOTTED FOR MACHINE TOOLING, THE ANNUAL PRODUCTION FORECASTING, DESIGN NUMBER OF PART; WHO IT IS FOR, WHAT IT IS FOR, DESIRED DELIVERY AND ESTIMATED DELIVERY DATES.]

(9) To INSPECTION

(10) To CUSTOMER

SECTION 11.5.4.2

CHART - 1

The Tool Crib, as its name implies, is the storage point or locating activity for any and all tools. It is responsible for maintaining active and inactive storage and pertinent records for all tools used in production. The Tool Crib is not empowered to dispose of tools but may store them in inactive locations. They maintain sufficient tools of any type needed to satisfy production requirements. If an emergency situation arises (critical tool shortage) it initiates a request for more tools through Tool Control.

11.6 <u>Production Standards and Methods</u>

11.6.1 <u>General Discussion</u> Production Standards--All standards developed for the purpose of planning for production, for wage payment, and for control, including standards for working conditions, production methods, and all manufacturing expense.

Methods Engineering-- The technique that subjects each operation of a given piece of work to close analysis in order to eliminate every unnecessary element or operation and in order to approach the quickest and best method of performing each necessary element or operation. Work simplification, operation and process analysis, and time and motion study are a part of methods engineering.

In the Manufacturing Department of the Scintilla Division at the present time, responsibility for production standards and work methods is divided between the Production Standards and Estimating Manager, the Master Mechanic, and the Factory Superintendents. In other departments this area is the general responsibility of supervision.

Standards are the tools by which all accurate planning and control are made possible. Without reasonably accurate standards one cannot hope to make any sort of estimate or forecast. Once the plan is made, standards provide the means by which it is possible to analyze and control the progress of the plan toward its goal. Standards may be classed in three groups as: (1) product standards, (2) planning standards, (3) doing standards.

(1) Product standards are determined by product design which is based on the need of the consumer. Product design determines the assembly drawings, parts lists, parts drawings, and material lists. These in-turn provide standards in terms of size, appearance, strength, finish, etc.

(2) Planning standards provide standard processes, standard methods, standard work places, and standard times to complete the operations.

(3) Doing standards control when the operations are done. This is accomplished through scheduling.

All production must be scheduled in some manner. One way to schedule is to put the required work load in some central area and have the worker select a new job upon completion of his old job. Another way is to direct from some central location every movement of the product through its process. Most scheduling falls somewhere between these extremes. It is recommended that scheduling be performed at an organizational level higher than the operator, utilizing trained personnel and specialized techniques and criteria to encourage efficient and economical scheduling thorughout the plant.

11.6.2 <u>Production Standards and Estimating Department</u> The Production Standards and estimating Manager reports to the Factory Manager. His department of thirty-four salaried employees has two primary objectives which require most of the available man hours in the department:

(1) To estimate direct labor and material costs for parts, assemblies, and products.

(2) To establish and maintain the production labor incentive system.

Other objectives or functions of the department:

(3) To analyze work in progress inventory variances regarding direct labor actual and standard costs and to recommend appropriate action if the size of the variance is relatively large.

(4) To analyze operator method and work place as part of the time study requirement and to make recommendations for improvement to the methods department in order to achieve optimum productivity at the operator level.

(5) To coordinate with the accounting department for material and labor estimates, with the plant engineer for plant capacity, and with the Master Mechanic for method improvements, tooling costs and layout.

To accomplish these objectives the department has an annual budget of approximately $170,000 and it is divided into two sections, a Cost Estimating Section and a Time Study Section.

11.6.3 Cost Estimating Section. The principal function of the cost estimating section is to predict the direct labor and material cost to manufacture a part, an assembly, or a product, for the purpose of establishing a selling price. If an order is subsequently received for a product for which an estimate has been made, the labor and material data in the estimate becomes the standard against which actual costs are compared.

The Cost Estimating Section consists of a supervising engineer and a stenographer, two cost estimating engineers, three senior cost estimators, two cost analysts, and four senior cost clerks. The annual payroll of the section is approximately $65,000.

Man hour utilization within the Cost Estimating Section is as follows:

(1)	Standard Estimate Request Forms	55%
(2)	Memorandum Requests for Estimates	
(3)	Requests for Price and Delivery	10%
(4)	Engineering Requests for Estimate	
(5)	24 Hour Deadline Requests for price on Plug-In-Connectors	22%
(6)	Form Request for same information	
(7)	Standards for Cost Accounting	8%
(8)	Standards for Plug-In-Connectors	
(9)	Monthly Breakdown of Product Division No. 39, Plug-In-Connectors	3%
(0)	Engineering Changes	
(1)	Variation Memo-- Changes in Cost	2%

An Estimate Request (ER) Form is the usual method of instigating a cost estimate. The form originates in the Sales Department as the result of a customer's request for information or a price quotation. The form goes to the Engineering Department to develop a design and to the Factory Manager for a decision to quote or not to quote a price. The factory Manager considers practicality, potential, suitability, and present capacity when he screens the request.

- If the Factory Manager elects to quote a price, the estimate request, layout and drawings, parts lists, and bill of materials are delivered to the Production Standards and Estimating office, where it is logged in by number, customer, part name and number, and date. The Cost Estimating Supervisor then assigns the request to an analyst or engineer. It is customary in the section for one man to do all the computations required for the request unless it is unusually complicated.

A record is maintained in the Production Standards and Estimating Department of the direct labor and material costs on all contracts completed in recent years. If a cost estimate is required for a new product, the estimator selects comparable parts or processes from the file and after adjustment for current labor and material costs and after adding or deleting elements of labor and material as may be required to manufacture the new product, the complete estimate is produced.

Many estimates require a great deal of experience and judgment on the part of the estimator. The normal processing of an Estimate Request requires the assembly and integrating of such varied information as raw materials inventory, machine operation and sequence of operations, tooling estimates and labor rates and allowances. To gather the necessary information on which to base an estimate on a new product may require a week or more. The section is frequently called on however, to make estimates, particularly for plug-in-connectors, within twenty-four hours. Such requests disrupt the orderly flow of work through the section.

The cost estimating section is also charged with the responsibility for the preparation of economic break-even studies for new tool costs. This type of study analyzes, for example, the cost factors and expense savings features of a $1400 four cavity mold compared with a $250 single cavity mold. The usefulness of such an analysis depends more upon the accuracy of the sales forecast than upon the relative accuracy of the manufacturing costs itemized in the analysis. Although such studies have been little used by the Scintilla Division in past years, it appears that they would be valuable in a cost reduction program, especially if tied in with a review of production methods.

11.6.4 Time Study Section. The time study section of the Production Standards and Estimating Department consists of a Supervisor of Production Standards and fifteen subordinates. The subordinates are divided among four position classifications. There are three Standards Engineers, classification E-118; one Senior Time Study Engineer, classification S-503; four Time Study Engineers, classification S-502; and seven Junior Time Study Engineers, classification S-501. The men in this last classification are, in effect, trainees. Immediately one notices an apparent inbalance in the direction of the lower classifications. This is the result of two recent developments. Within the past year some six men have left this department; all of them experienced personnel. Also within the past year the senior classification of Standards Engineer was established. The result of these two factors is that three of the remaining experienced men have been promoted to the higher classification and that many new men have been introduced into this section to replace the losses. This leaves the middle two classifications undermanned. The desired organization would be an approximately even division of twelve men among the three lowest classifications. The cost to Scintilla Division for the salaries of these men is approximately $75,000 per year.

Two methods are used to determine production standards at Scintilla Division, and two types of standards are set. The two methods used are time study and standard data. The two types of standards are permanent and temporary. Approximately twenty thousand production standards are determined each year, and an average of eighty-five percent of all operations in the plant have standards set. The standards are used primarily to determine piece rates for incentive pay purposes. They are also used for cost estimating and to determine machine loading.

Time studies are initiated in several ways. When a job has been set up the operator punches a time clock indicating that he is commencing production time. At this point he commences to work on incentive if there is a rate set for the job. Therefore, the pay roll clerk determines from the rate book at his desk whether there is a rate set for the job. If no rate appears in the rate book, either the pay roll clerk or the operator (neither one is specifically responsible so far as I have determined) makes a note that there is an unrated job in progress at the work station involved. A specific time study engineer has responsibility for conducting studies in each department.

Sometimes he is called at the request of the operator when an unrated job is commenced. At other times he is called at the initiative of the pay roll clerk. And at other times he inquires at the pay roll clerk's desk to ascertain if any unrated jobs are in progress. In any event, the time study engineer does not usually see the manufacturing layout or the blue prints for a job until he arrives at the operator's position. His first step on the scene is to study the layouts, prints, and routing sheet. If the part in question is similar to another part, engineering will have made reference to that fact. If this is the case and the time study engineer is aware of a previous study of this operation on the similar part which can be applied to the part in question, he may use this rate from the previous part. If, however, there is no similar part, or if engineering neglects to make the notation of a similar part, or if the time study engineer feels that the similar part is not sufficiently similar for the rate for this particular operation to be applicable to the new part, then a time study will be conducted. On the Time Study Analysis form the time study engineer completes the identifying information. He then observes several cycles to determine the appropriate elements to time. He then times several cycles and assigns an effort rating. The standard procedure is to time ten cycles (except where the cycle is excessively long). The normal effort rating is 60. Normal performance is defined in the union contract as, "The rate at whcich the normal operator works consistently and represents an increase of twenty percent in the amount of standard minutes of work performed over and above standard performance." Aften ten cycles have been timed, using "snap-back" timing, the time study engineer selects the time which in his opinion is the correct time for each element. The time selected is the one which represents most nearly in the mind of the time study engineer the correct time for performing the element at the assigned performance rating. These selected times are adjusted by the effort rating to become the normal times for the elements of the operation. Allowances are added for material handling and loading the machine. These appear to be determined exclusively by the time study engineer's experience. Allowance is also included for gauging the finished piece where this is applicable. These allowances and the normal element times are summed and multiplied by 100 to give "normal minutes per 100 pieces". To this is added a minimum allowance of thirty percent; ten percent or more for personal, fatigue and special allowances and a twenty percent incentive opportunity allowance. In most of the standards no allowance is included for tool trouble because when this occurs the operator reports the fact to the foreman and is paid at his base rate. After the standard has been computed, the time study engineer completes the Advance Rate Notice in duplicate (triplicate for temporary rates) before he leaves the operator. After showing the rate to the operator, the time study engineer leaves one copy of the Advance Rate Notice with the pay roll clerk for insertion in the rate book at his desk; the second copy goes to the pay roll office, and the third copy (in the case of temporary rates) goes to the rate book in the production standards office.

The rate may be temporary under conditions set forth in the union contract, to wit: "(a) Wherein an alternate or added operation is involved. (b) On jobs running on a type or kind of machine other than the one designated on the Analysis Sheet. (c) Where the scarcity of material requires use of materials causing more difficult machining, although the balance of the specifications may remain the same. (d) Where the amount of material to be removed is excessive, thereby varying from the regular requirements. (e) Where the proper tooling is not available on a machine and a permanent standard cannot be set. (f) To cover first run conditions when new products are introduced requiring temporary tooling, speeds, feeds, setups, etc. (g) Where schedules necessitate the running of any job, which because of preceding conditions or Engineering Specifications or Standard Practices, are not in accordance with the Analysis Sheet. (h) When repair operations and special operations are all of a temporary nature and consequently apply only for the condition existing for a specific period of time. (i) 'One lot only' rates." All other rates must be permanent and since they are subject to only cursory review and must be shown to the operator immediately, the time study engineer has the final authority. It should be pointed out in connection with this that the time study engineers are almost all former operators so that they have more or less experience with Scintilla's system of rate setting before they begin to do it as time study engineers. One of the things which has impressed the author is the vast store of knowledge of the jobs under study which is possessed by the time study engineers. Permanent rates may be restudied only for changes or upon the demand of the operator, according to the union contract. The changes may be in "tools, equipment, methods, materials or design which justify revision of the Standard. Only those elements of the job affected by the change shall be altered."

The Scintilla Division has been conducting time studies for a good many years. In that time voluminous files of data have been compiled. These data are used for determining temporary standards in many departments and for determining most permanent standards in several departments. It is the opinion of the author that these data are an invaluable asset which is not being used to the maximum extent due to the terms of the union contract which states, "Time studies will be made by the Management for the purpose of establishing rate-of-production standards." This clause is interpreted to preclude the use of standard data for determining permanent incentive standards. If this clause were eliminated it is possible that standards in many departments could be determined more economically, and possibly more accurately than through the present system of time study. The use of standard data whereever possible might result in more complete coverage than the present system, The advantage resulting from increased coverage might persuade the union to accept the change. Performing a job which has no rate established deprives the worker of the incentive opportunity, and therefore it is to the worker's advantage to have as many jobs as possible rated.

Furthermore, the use of standard data could and should be applied to developing standards of performance in areas which are not presently covered by incentive standards and therefore have no standards. Such functions as inspection, set-up, tool making, and material handling occupy the time of a large number of employees and incur large increments of the total costs of products which are difficult to estimate because no standards of performance exist in these areas.

11.6.5 <u>Evaluation of Present Organization</u>. Production Standards and Estimating Department -- The present organization accomplishes the primary objectives of the department but the additional functions, methods improvement, the detailed analysis of variances, and the co-ordination of these areas with other departments, appears to receive relatively little attention, perhaps because similar functions exist as the responsibility of other departments.

Cost Estimating -- No recommendations are offered in regard to the performance of the cost estimating function. The refined computations and techniques employed by the section appear to exceed the accuracy of the contract records data from which the labor and materials costs are developed. This is particularly true in regard to labor costs.

Time Study -- The time study section does a good job of providing basic data for maintaining the production labor incentive system, and the accumulated time study records are an excellent source of historical labor cost data. The usefulness of the study for any purpose other than a fast estimate of wage payment is questioned for the following reasons:

1. Work methods are not standardized.
2. Many studies are taken shortly after work starts on the operation and before the operator has become efficient.
3. The time study value is equated by an unstandardized effort rating to give a wage level.

Such time study values are of limited use for planning, scheduling, or for actual-standard comparisons to insure that the full measure of labor purchased is rendered and effectively utilized.

11.6.6 Proposed Industrial Engineering Section.

11.6.61 Functions and Objectives. The Industrial Engineering Section is a staff service section within the Planning Department. The primary objectives of the section are to establish methods for controlling production costs and to develop programs for reducing those costs. The principal areas of responsibility are (1) Methods Engineering, (2) Production Standards, (3) Layout Engineering, (4) Standardization, and (5) Cost Reduction.

11.6.62 Methods Engineering. In the course of the investigation of methods analysis the opinion was expressed by the Production Standards and Estimating Manager that to say that ninety-five percent of all operations at Scintilla could be improved would be a conservative statement. This is not to say that this number could be economically improved. But surely, if ninety-five percent could be improved in some way then there must be a large number which could be improved sufficiently to warrant the expense involved in effecting the improvement. In an effort to find an operation which might serve as an example of this point, a visit was made to the plant floor in the company of an experienced time study engineer. After a cursory survey of several operations which were too complex to serve as a simple example, an assembly bench was reached. The first operator on that bench bench was engaged in assembly operation number 251 on part number 10-076372. This operation, as it was being performed, consisted of picking up a bracket and holding it with the left hand while the right hand picked up and placed on the bracket two straps, one at a time, and picked up and hand started two screws, one at a time. Then the right hand picked up a hand screw driver and made several turns to tighten each screw sufficiently to prevent the assembly from coming apart in shipment. The left hand then set the finished piece aside and picked up another bracket for the next piece. Subsequent investigation of this operation revealed the following facts: The purpose of the assembly is to hold an ignition harness in place on an engine. After assembly the piece is placed in an envelope to be shipped to the customer with the harness. The customer has to disassemble it in order to use it to mount the harness. Counting the lot which we observed, seventeen contracts for a total of four thousand four hundred and seventy-two pieces had been processed since February 1955. There was no piece rate set on the operation; it was often assigned as a fill-in operation by the group leader, to be done when the work load was slack. The per piece actual labor cost for the operation had varied from a low of $0.0220 to a high of $0.1165. There is a fixture available to hold the bracket while the straps and screws are being assembled to it two at a time. This bracket, which costs $39.45 to make, was not in use at the time of the observation.

The immediately obvious improvement was to eliminate the operation altogether by dropping the unassembled parts in the envelope to send to the customer. The time study engineer who was our guide expressed the opinion that the customer might specify that the parts must be assembled and gave several examples of reasons that might be sufficient causes for the customer to so specify. He could not say, however, if anyone along the line of preparation for the manufacture of this assembly might consider it his responsibility to contact the salesman and ask if this assembling is really necessary. Conceeding that the operation is required by the customer, improvements are still possible. Someone had already taken a step in that direction. The fact that the fixture which was designed to improve the job was not in use can only be explained by theorizing. A likely theory might be that the operator, knowing that there was no piece rate on the job, didn't bother to look up the correct method (the manufacturing layout was not in evidence at the work station) and the group leader and foreman were too busy with administrative detail elsewhere to be supervising the operator properly. Anyhow, this oversight could not be prevented by methods engineering of this particular product (though a scrutiny by methods engineers of the method of communicating the necessary information to the operator might be in order). Even if the fixture had been in use, the time study engineer estimated that an additional saving of 0.1 minutes per piece would result from a proposal to substitute a rachet type screw driver for the hand screw driver in use. One further refinement comes to mind which would probably not have affected any further saving in this case, but which would undoubtedly represent a long term saving. The work station involved in this example was an assembly bench. Many operations performed here require the use of a screw driver. The economy of supplying a power screw driver on a permanent, adjustable, overhead installation certainly deserves some consideration, not just at this work station but at allthe numerous assembly stations throughout the plant. The example presented here may not be very spectacular, but it illustrates three very basic faults of Scintilla's procedures. It shows: (1) the lack of systematic methods engineering; (2) inadequate supervision, and (3) the absence of any control or follow-up. Systematic methods engineering would have conducted the above analysis, and provided the optimum process and method; adequate supervision would have required the use of the method indicated by the manufacturing layout, and follow-up checks or controls would have noted the relatively large and apparently unjustified fluctuation in labor cost and provided a warning to take appropriate action.

There appears to be an adequate number of technically trained and experienced men for methods work in the Scintilla organization, but their efforts and abilities are not always obvious in the manufacturing department at the operator level. When a manufacturing layout is drawn up for an operation the entire work sequence must be carefully thought out and it requires a good man to do the job. Unfortunately, only the skeleton of this work effort is usually written into the layout. The "what" to do is spelled out but not the "how". It is recommended that the present manufacturing layout be modified to include a standard operations instruction sheet for each operation. This instruction sheet should include a standard work place layout when appropriate and a description of the standard method.

When a product is set up on the floor for the first time, it is likely that the methods engineer will be on hand to insure that the layout is followed and that the sequence of operations is satisfactory. On later production runs a new operator, in perhaps a different section than where the original production run was made, will do the work and his only instruction may be the abbreviated layout. In the absence of detailed instructions, the responsibility for the correct method is left to the individual operator or to his immediate superior. It may be seen that although a trained methods engineer developed the method, the benefit of his work may be partially lost.

When production orders are enlarged or repeat production runs are required, no system exists for a review and improvement of the method communsurate with the size of the order. If production is drastically increased however, or if the method in use results in a considerable variance from the cost estimate standard, the method will come to the attention of management.

The time study engineer may consider possible improvements of the method as he takes the required time study. It appears from a brief discussion with three time study men that they feel that they should not take time to make a methods study in cases where the need for improvement is not too obvious and the solution apparent. They also expressed the sentiment that by the time they could effect a methods change the job would probably be completed.

It is recommended that the responsibility for method development, method standardization, and methods improvement be charged to the chief industrial engineer. The divided responsibility that exists at present in this area appears to leave essential parts of the function undone. In particular, a program for reviewing and revising established methods is lacking.

11.6.63 Standardization. According to the standard definition, standardization is a management sponsored program to establish criteria or policies that will promote uniform practices and conditions within the company and permit their control through comparisons. It deals with such areas as work quality and quantity, working conditions, wage rates, and production methods.

At Scintilla standardization is not a planned program apparently because of a feeling that it is not too important in job shop production. A certain degree of standardization is achieved when all jobs of a certain type are routed to the same individual in the methods department, to the same time study man for a time study, and to the same section on the production floor. The method is usually adapted from the record of the last similar job and the cost estimate which becomes the cost standard for the job is also based on previous records. These records tend to standardize production procedures, but an organized program in this direction is necessary. The classification system proposed in Chapter VIII of this report is a step in the direction of standardized products.

11.6.64 Layout Engineering. In the present organization of the Scintilla Division the function of plant layout engineering is the responsibility of the plant engineer and its accomplishment is discussed elsewhere in this report. It is believed, however, that much could be gained by placing more emphasis on this function. The need for increased emphasis is aptly expressed by Mr. Richard Muther, a National Director of the Society for the Advancement of Management, "In today's competitive business we are looking for every avenue of cost saving. It is indeed regretable when we fail to get adequate built-in economies at the time we plan and install our layouts, for cost reduction - some of the best cost reduction - comes from adequate planning of the original layout." (26) It appears to the author that this emphasis may be lacking in the present Scintilla organization. When this study was commenced ground had just been broken for a new addition to the plant. During the course of the study widely divergent views concerning the use of this addition were expressed to various members of the study group by various members of the Scintilla staff, many of whom could be expected to have a vital interest in the planning of the addition. The implication of this apparent confusion to the author is that the planning and engineering of the original layout of this addition was not as thorough as it might have been.

In view of the fact that layout engineering and the process analysis aspect of methods engineering are so irrevocably interdependent, it is recommended that the chief industrial engineer be charged with the responsibility for plant layout engineering.

11.6.65 Cost Reduction. Directly related to allthe other functions of industrial engineering is the vital function of cost reduction. The present cost reduction program at Scintilla Division is similar to the present methods analysis program -- many people feel that they share the responsibility for it, but no one directs it or promotes it to any extent. The result is that everyone is too busy with his primary responsibility and there is a tendency to "Let George do it". About two years ago a cost reduction training program was conducted for some four hundred technical and supervisory personnel. As a part of the course, each trainee was required to complete a cost reduction proposal. Shortly after the completion of this course, interest in cost reduction as an organized program began to lag. It appears that the program is functioning far below its potential because it lacks direction, control, and day-to-day implementation.

It is recommended that the responsibility for the direction and co-ordination of the cost reduction program be charged to the chief industrial engineer. The technically trained men in all staff departments should be enlisted in the program and encouraged to make recommendations relating to their immediate responsibilities, to improving techniques and training, increasing productivity, eliminating unprofitable and expensive projects, and changing overall policies. It is further recommended that a refresher course be instituted and that following the formal course a vigorous promotion campaign be waged in conjunction with the promotion campaign recommended for methods analysis (see Section 11.6.67).

It might be well to include in this continuing program some means for discussion or exchange of cost control ideas among the men who should be in the best position to recommend changes -- the foremen. This might be accomplished by a device such as monthly conferences similar to the management conferences described in reference (28). Conference leaders for a program of this nature could be selected from the personnel in the industrial engineering section and trained with material on conference leadership already available in the training section of the industrial relations department.

It should be emphasized that cost reduction is not the same as cost control. Cost control is concerned with maintaining costs in accordance with established standards while cost reduction programs are aimed at pushing costs downward. The cost control program should have periodic progress reports and long and short range goals as part of a comprehensive plan.

11.6.66 Production Standards In reviewing the very limited look at the Scintilla Division system of determination of production standards there is one thing which stands out in the mind of the author - the absolute dependance on the judgment of the time study engineer. The author has already expressed the opinion that these individuals possess a vast knowledge of the work they are seeking to measure, nevertheless, it all boils down to the fact that this is not an objective measurement of production, but rather a rate setting procedure based on the judgment of the time study engineer. One might even go so far as to say that rates are determined from the standard data filed in each time study engineer's head. It may well be argued that this is true to some extent of any time study which employs performance rating. When all is said and done, the objective of any time study should be to determine a production standard such that it defines a fair amount of time to be allotted to the employee to perform a fair amount of work for the company. When such a standard is applied to piece rates, it results in a fair day's pay. Standards set by pure guess work would be satisfactory, if they accomplish this objective. It is true that there are a number of uses for production standards besides the determination of pay. These uses are all dependent upon the standards being such that worker performance can be consistently predicted in terms of the standards. It follows from this that where production standards are used as they are at Scintilla to predict a fair day's work for a fair day's pay a simple way to evaluate these production standards is in terms of the pay and the work performed.

According to the contract between the Scintilla Division and Sidney Lodge number 1529, International Association of Machinists, the standards are required to include a minimum allowance of ten per cent for personal requirements, normal job fatigue time, and special allowances. The fair day's work is therefore, defined as a maximum of ninety per cent productive effort. The contract further states that the standard must include a factor of twenty per cent which represents the incentive opportunity allowance. This defines the fair day's pay as the base-rate for the grade plus twenty per cent. In other words, an average man working at a normal pace for ninety per cent of the time should earn one hundred and twenty per cent of his base rate. Column five of chart 11.6-1 shows that the workers actually average 132.2 per cent of the base pay for the period they are working on incentive. The figures in columns one and two of Chart 11.6-1 are actual averages computed by the pay roll section for all incentive workers during the middle week of each month of 1956. Although these are not strictly random samples, they are probably close of the actual average levels for the months concerned. According to experts in the field of time study the production of a random group of workers will tend to be in a normal pattern. If these workers are paid on an incentive pay system, the distribution of pay should also tend to be a normal curve. Since there is nothing to indicate that the workers at Scintilla Division are not a normal group, this assumption will be made for the purposes of this analysis. (The selection of personnel employed has the effect of eliminating most of the group of workers who would be sub standard, and selection would therefore raise the average of the group selected slightly, but this effect is relatively insignificant for the purposes of this analysis.) According to Presgrave (27, Pg. 127) the range of distribution of production of workers on incentive is such that the most skilled worker produces about two and one quarter times as much as the least skilled worker. From Presgrave's curves one can deduce that where the average worker produces 132.2 percent of the standard sixteen percent of the workers in the group will produce in excess of 149 percent of the standard, two percent of the workers will produce in excess of 165 percent of the standard, and two percent of the workers will produce less than 99 percent of the standard. At Scintilla, however, this is not the case. A report is produced showing the names of individuals who produce in excess of 150 percent of the standard on any particular job. This report consistently shows the names of from two tenths to four tenths of one percent of the incentive employees. One wonders immediately why this is so. The answer lies in the use to which the report is put. The philosophy of the management is that any man who exceeds 150% of the standard has either improved the method (which automatically makes it eligible for retiming) or has created an unauthorizdd shortcut. The author is willing to conceed that this philosophy might be the case if the group's average production were at the level of 120%, but it appears unrealistic with the group average as high as it is. Make up time is paid on approximately one percent of the incentive hours. Although a part of this is undoubtedly attributable to trainees, it indicates that in spite of selection of employees there are a few who produce less than one hundred percent of standard which is in agreement with the normal distribution shown by Presgrave. The situation

Chart 11.6-1

AVERAGE INCENTIVE EARNINGS PER HOUR IN 1956

onth	Average Base Pay $/hr.	Average Earned Pay $/hr.	Less General Wage Increase Note 1	% Payoff Col 3 / Col 1	Adjusted % Payoff Note 2
an.	1.494	1.885	1.825	122.2	130.2
eb.	1.503	1.863	1.803	120.0	127.2
ar.	1.510	1.902	1.842	122.0	129.8
pr.	1.509	1.928	1.868	123.8	132.3
ay	1.510	1.925	1.865	123.5	131.9
une	1.513	1.924	1.864	123.2	131.5
uly	1.511	1.936	1.876	124.2	133.1
ug.	1.504	1.913	1.853	123.2	131.8
Sept.	1.508	1.969	1.909	126.6	136.4
Oct.	1.501	2.001	1.881	125.3	134.6
Nov.	1.502	1.971	1.851	123.2	131.8
Dec.	1.511	2.021	1.901	125.8	135.3
				Average	132.2

Note 1: The general wage increase is paid per hour worked rather than per hour earned and must be removed from the figures in column 2 in order to show an accurate comparison of columns 1 and 2. This amount is .06/hr. from Jan. to Sept. and .12/hr. for Oct. to Dec.

Note 2: The percent payoff shown in column 5 is the rate payoff for incentive time after the straight time, which is paid for at base rate, is deducted from the total time. This is the true payoff percent for the incentive jobs performed. The relationship between straight time and incentive time is shown in Chart 11.6-2.

Chart 11.6-2

UTILIZATION OF INCENTIVE EMPLOYEE'S TOTAL HOURS IN 1956

Period		Total Hours Incentive	PAID FOR AT DAY RATES TTA	Setup	Other	Total Day Rate
Jan-June	Hrs.	1,305,648.11	47,555.02	130,425.35	166,750.81	344,731.18
	%	100.00	3.64	9.99	12.77	26.40
July-Dec.	Hrs.	1,328,103.92	47,882.60	134,729.32	175,409.74	358,021.66
	%	100.00	3.61	10.14	13.21	26.96

at Scintilla appears to be such that the lower half of the production workers operate in an approximately normal manner, but the upper half produce at a rate which drops off precipitously as it approaches 150 per cent of standard. In other words, the above average workers have a marked tendency to restrict production. This leads to the conclusion that the company does not receive a fair day's work in return for a fair day's pay. This does not deny that the company only pays for the number of pieces which are made. But the fact remains, that if the curve at Scintilla were actually normal, or nearly so, the above average workers would work at a rate sufficient to compensate for the below average workers with the result that the average of the whole group would move even higher. This, of course, would result in a more economic use of facilities.

Two things should be noted at this point. First, the terms normal and average should not be confused. The author believes that in the absence of evidence to the contrary the employees at Scintilla should be classed as normal and therefore, their production pattern should tend to fit a normal curve. At the same time the group may be above average for this type of employees. Several times the author has been told that management personnel feel that Scintilla employees are above average and that this accounts for the fact that the group produces at the rate of 132.2 per cent of the standard rather than at the defined average of 120 per cent of the standard. The author finds no quarrel with this point of view, nor does the author argue with the concept that a fair day's pay may be in fact an average of 132.2 per cent of base rate. This may well be true if a fair day's work is given in return, but the above discussion implies that the latter condition is not the case.

Are there any facts to support this contention? The reader's attention is invited to section 11.8.22 of this report wherein is described the results of two day's random sampling throughout the plant. This sample is admittedly not absolutely random and there may well be some small inaccuracies in its results. But the results are so striking that they are at least worthy of a fair evaluation and further study along this line. The results show that the average employee throughout the plant was engaged in activity which should be classed as belonging in the ten percent personal allowance, fatigue time, and special allowances to the extent of 30% of his time. This does not appear to be a fair day's work. It could well be that a large part of this excess personal time is taken by employees who are earning in excess of 150% of standard while they are working, and who have no desire to be included on the weekly report of personnel earning in excess of 150%. The operators are well aware that management will either suspect them of unethical practices or seek to adjust the standard for every job which appears on this report. If I put myself in the position of an operator producing at the rate of about 155% of standard, I rather imagine that I would prefer to take home a bit less money in order to avoid having suspicion fall on me or to reduce the possibility that the standard might be scrutinized with the result that I could then earn only about 120 to 130% of standard with the same effort.

The author suggests that if Scintilla would like to test the contention of this section more thoroughly this could easily be done. A more elaborate sampling experiment could be done to test the study mentioned above. In addition, the pattern of production output could be determined by plotting a curve of a randomly selected sample of jobs showing the percent of base rate earned on incentive as the ordinate and the number of employees earning that percent as the abcissa. If this were done, it is felt that instead of the usual normal curve a skewed curve would result with a relatively normal tail on the low side, a mean of about 132 percent, a mode of about 138 percent, and a sharp decline to nearly zero by 150 percent.

It is the belief of the author that the report of earnings in excess of 150 percent is doing untold damage to the production level at Scintilla. It stifles any inclination on the part of the worker to improve his methods and it results in a lackadaisical attitude on the part of the above average worker which may even affect the whole organization. This attitude, plus the almost complete absence of effective operation analysis results in a total lack of interest in cost reduction through methods improvements. What is needed is a system of incentive for improvement on the plant floor. It is the opinion of the author that this can be accomplished through the use of measured day work with bonuses paid for bona fida methods improvements originating with the operators. It is recognized that many difficulties would be encountered in such a system, however, it is felt that the results would be worth the effort. The most important problems to be faced would be the negotiation of a different contract with the union, the freeing of first line supervisory personnel from their present excessive administrative burden in order that they can be effective foremen, and the adoption on the part of everyone from top management down of a genuine desire to seek out and effect improvements. Many suggestions appear elsewhere in this report concerning the administrative burden of the foremen. The desire for improvement might be fostered by guaranteeing a percentage of the first year's savings resulting from any improvement. This might result in some rather large bonus payments. It should be borne in mind, however, that the bonus is only a percentage of the savings and therefore, the larger the bonus, the larger the saving involved. Viewed in this light, no incentive bonus could be too large.

All of the above discussion of standards has been directed toward the present system of production standards which apply only to the direct labor at Scintilla Division. It should be noted that direct labor represents only about fifteen percent of the total cost of the products of Scintilla and only about forty-two percent of the employees. The other fifty-eight percent of the personnel are by and large uncontrolled in the sense that they have no standard of performance against which to be compared. This group includes the personnel of the Quality Control Department, the Tool Makers, the Engineering Department, and the myriad of other clerical, technical, professional, and sub-professional personnel. It is not the contention of this author that standards could be determined for all of these personnel economically. It is contended, however, that where standards could be determined readily they would be of great value in several ways. Accuracy of estimates of both cost and time would be improved. Studies of the economic advantage of possible alternative courses of action would be facilitated. The studies and analyses necessary to determine these standards would undoubtedly show areas where technical and professional personnel are performing more or less routine clerical functions which waste their valuable talent and time. The reduction of this type of work would not only increase efficiency, but would probably increase the morale of the technical and professional personnel.

"Yes, but," we have been told," such studies as this cost money." This is a cliche with which I could not disagree. But the American Bosch Corporation points our (11) that a saving of one dollar in costs is equivalent in their organization to the profit effected through an increase in sales of twenty dollars. How much does Scintilla spend annually to increase sales? Who can prove that return on this expenditure is twenty fold the return on the expenditure for such studies as the ones proposed? Examples of the kind of studies which can be conducted with a minimum of cost and without disruption of routine functions and which could be expected to bear considerable fruit are found in Chapter VIII of this report and in references 24 and 25 in the bibliography of this chapter. The article in Factory Management and Maintenance magazine is particularly commended for study as it represents one of the most easily understood and at the same time one of the most useful articles the author has yet seen on the subject of work sampling, or ratio delay.

11.6.67 Training Program. It should be pointed out that an industrial engineering section cannot effectively perform these functions unless it has the cooperation of all with whom it comes in contact. If top management is not willing to give a new idea a fair try, if middle management is not willing to give the new born method a fraternal push in the right direction with helpful suggestions and constructive criticism, if operators and foremen are not willing to expend a little conscientious effort to accomplish the job the new way, then this proposed industrial engineering section will die aborning, and the money, time, and effort required for its establishment would be best left unspent. It would be dangerous to assume that this cooperation will flow easily once a block is drawn on the organization chart and the description is entered in the organization manual. Human beings naturally fear and distrust something they do not understand. It should therefore be the first order of business for this new section to acquaint everyone, from top management down, with the objectives of industrial engineering and with its tools and techniques. Such an introduction could be both a promotion and a training program which, if properly presented, would allow both methods analysis and cost reduction principles a chance to gain acceptance on their own merits. Simultaneous with the training program there should be a plant-wide promotion of methods analysis and cost reduction with appropriate posters, a regular feature column in The Scintillator, and, as soon as possible, public recognition of successful improvement ideas proposed by personnel outside the industrial engineering section. Above all, there should be from the very outset a policy statement by the general manager guaranteeing that workers whose jobs are affected by methods improvements will be transferred to other jobs with at least equal pay and that individuals who effect cost reductions will share in the savings. Thereafter, this policy must be scrupulously adhered to. Any reduction in force possible through improved methods should be made by normal attrition. Commencing this program with anything less than a sincerely enthusiastic attitude at the top will certainly hamper its effectiveness.

11.6.7 Summary of Recommendations. It is recommended that:

1. That an industrial engineering section be established and assigned responsibility for:

1. Methods development and improvement.
2. Developing and installing economic and accurate production standards.
3. Plant layout engineering.
4. An organized program of standardization.
5. Organizing and guiding a cost reduction program.

2. That a comprehensive study be made of the effect of the present incentive wage plan on production and productive capacity. This study should analyze and compare the present incentive system with the possible advantages of a measured day work system including an incentive bonus for acceptable cost reduction recommendations.

3. That a cost reduction refresher training course be instituted, As a part of the program the principles of work simplification, production standards, and work measurement should be taught.

4. That the general manager issue a statement of policy to the effect that no employee will suffer a loss of wages as the result of the methods improvement and cost reduction program.

5. That emphasis be placed on studying the cost of operations by thorough method analysis rather than on the cost of the product, since the product costs are merely combinations of various operations costs, and cost control is best effected at the source of the cost.

6. That the use of economic break-even studies for new tool costs and for other capital expenditures be expanded. The preparation of such a study and the reduction of the various factors to specific values can be used to illustrate the cost of not taking certain actions as well as indicating the economic advantages of expenditures.

7. That production standards coverage be extended to as many areas of indirect labor as economically feasible including quality control, engineering, traffic, plant engineering and clerical jobs.

8. That consideration be given to the possible application of work sampling as an aid in setting production standards, particularly in the indirect labor areas.

9. That the manufacturing layout be expanded to include a standard operation instruction sheet for each operation showing a standard work place layout if appropriate and the standard method.

10. That the weekly report of personnel earnings in excess of 150% on any job be discontinued. Economically, it appears to the advantage of the Scintilla Division to encourage the highest production rate possible.

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11.7 Direction. The function of applying authority in the initiation, delegation, supervision, and correction of activity.

11.7.1 General

11.7.1.1 Responsibilities and Job Performance of Supervisory Personnel. The heirarchy of manufacturing management and supervision at Scintilla is from the Factory Manager at the top, to Asst. Factory Manager, to Manufacturing Superintendents, to Department Supervisors, to Foremen, to Group Leaders. As used herein, "supervisors" is intended to include this entire range of supervisory levels unless otherwise indicated. Basically, the supervisory personnel have four goals (standards) that determine the direction of their activity:

1. Design standards, established by Engineering, with performance appraised by Quality Control.
2. Schedule Standards, established by Production Planning and Sales, with performance appraised by Production Control expediters and inventory procedures. (Inherent in the schedule standards are work standards established by the methods department and measured by the time study department but that are not used by Production Planning in developing schedules.)
3. Quantity Standards. Same as 2 above.
4. Cost Standards, established by Cost Accounting, with performance appraised by Cost Accounting.

In general, this correlates with the stated responsibilities, given by the various supervisory and management personnel in interview, which can be summarized as: "--To organize and plan production in such a manner as to meet the billing schedule; to produce quality parts; to satisfy customers at lowest possible cost while making deliveries on time; to maintain good employee relations and abide by the union contract; to help provide new and better tooling on new parts and established parts for lowest manufacturing cost."

The first point to be considered is the excellence of the job responsibility elements held by supervisors. Certainly they are inclusive, and reflect the company's objectives through all levels of supervision. However, proper evaluation of these performance responsibilities seems to be elusive. For instance, costs are generated by and charged to products and cost centers in both actual and standard amounts at Scintilla. Supervisors have authority for incurring these costs, and in this connection are responsible for all employees working under their direction. Costs for effective control purposes, however, must be identifiable with people and accountable for by areas of responsibility. Yet in neither product costing nor present cost center allocation are costs firmly fixed to positions of supervision below the factory manager. It is recommended that cost centers be re-evaluated toward the end of departmental centers, particularly since with job-lot operation any particular product may transgress many departments, making supervisory cost control a function of arbitrary inference.

A further case in point is evaluation of billing performance. Since only the first department on a contract is scheduled for starting date, and only the last departments are in a position to be closely affected by the schedule completion date, the intermediate departments are seldom evaluated in this respect. They have no starting or completion dates assigned to be used as standards against which performance can be evaluated.

Even quality control, an extremely tight evaluation at Scintilla, appears such that at times neither the means nor the remedy are available for assignment of responsibility at the point of "cause."

Thus supervisory performance cannot be said to be closely controlled, or in most cases even in a position to be objectively measured. Adoption of departmental cost centers, along with detailed scheduling and a crib-inspection-dispatch system as elsewhere recommended would aid considerably in this respect.

It must be remembered that supervision, as such, does not "do." It is a function of seeing that persons under supervisory direction "do" a job in conformance with the established standards. Supervisory performance is a reflection of how well they get the people under them to so conform, particularly since in the last analysis all control must be exerted by the workers themselves. They are the only ones who can actually control quality and the time to do the work. From this it would then appear that optimum supervision is obtained with optimum actual worker direction. A last consideration then might be a reflection on whether the lower supervisory levels have too broad a responsibility. How much planning and organizing and administrative control should they be required to do and still have sufficient time for proper emphasis on quality and quantity which are functions of personnel contact, training, correction, leadership, discipline, motivation, etc.?

This study group would like to point to the Plant Performance section (11.8.2) as reflecting supervisory performance in this respect, since man and machine utilization, labor performance, and time performance are primarily the results of how the supervisors have managed the men and machines under their direction.

It has been said that "good standards are an aid to good performance--poor standards are a guarantee of poor performance." With respect to this statement, this report indicates that time (work) standards are too loose (see section 11.8) and that time (schedule) standards are not specific. Further, standards as used at Scintilla are primarily historical, burying within themselves an accumulation of the inefficiencies of past performance. And as already discussed, the standards are not used as specific guide lines of activity in many cases, such as standards that do not reflect "people accountability," i.e. product cost centers vice departmental supervisory centers, and master billing schedules vice departmental detail schedules. In effect the lower supervisory levels do not have definite firm standards to work from and the standards reflect what performance <u>was</u>, not what it could be, in both cases design standards excepted.

11.7.2 <u>Personnel</u>. Personnel administration and procedures are covered primarily under the chapter on Industrial Relations. Supervisory personnel are bound by the union contract and in this respect have no real control over worker motivation and performance on the basis of promotion or pay, since in-grade promotions and pay increases are granted automatically on a time basis if the workers keep their noses clean. There is a formal procedure laid down for merit rating but it is not used because most direct labor increases are of the automatic variety. When a man is to be selected for group leader or foreman a conference technique is utilized by the higher levels of supervision and management.

11.7.3 Procedures. Supervisory personnel do most of the routine day to day planning required in the manufacturing department, obtaining their basic data from the Contract Status Report, Monthly Assembly Schedules, Total Requirements Sheets, Delinquent Sheets, etc. From these specific daily work requirements are determined and assignments made, adjusted as necessary by any expediting action. Action is planned and coordinated primarily by the "eyeball" technique, that is, from experience, where the supervisors can look at the overall picture, determine problem areas, and take necessary action, assuming the non-problem areas will take care of themselves. Thus if a supervisor determines from a cursory examination of the monthly requirements that his department is overloaded, or should be on the basis of past performance, he may request rescheduling or subcontracting. In some cases he may informally coordinate his work with idle capacity in another department. The supervisors also determine their manpower requirements and request additional men as necessary. On the top level the Factory Manager has a thumb rule wherein he knows the percent of direct labor applied to any product price. By taking a monthly billing, he then multiplies by this percentage to get total direct labor dollars required, and dividing by the average operator earnings he knows approximately how many direct labor operators are required for any product. This thumb rule works well in practice, but what it does, as discussed above in relation to historical standards, is project past performance into the future. If in the past the work standards for a product were loose and too many workers were therefore utilized, then this number of workers becomes standard and in the future work will be "spread out" over an equal rate of excess numbers.

The "on-coming" workload from preceding departments is planning data any supervisor needs to know. He determines this load from an analysis of outstanding contracts, "looking around," and in general estimating from practical experience when a particular load will reach him after introduction into the system. When any particular operation becomes overloaded the responsible supervisor takes extra pains to schedule and coordinate that operation, going in most cases to actual machine loading procedures to obtain maximum utilization and output. This is presently the case in die-casting, plating, and other maximum capacity operations.

Some of the administrative devices used by supervisory personnel, as aids and guidance in their activity, for information, direction, reporting, control, and performance evaluation in addition to the basic planning documents previously listed are:

1. Layout
2. Rate Sheets
3. Production Contract Route Sheets
4. Design Specifications
5. Directive Memos
6. Weekly Scrap Report
7. Tool Repair Order
8. Daily Report of Production
9. Summary of "X" Contracts
10. Cost Analysis Sheets
11. Regulations Manual
12. Collective Bargaining Agreement
13. Cost Reduction Report
14. Regulations Manual
15. Foreman's Manual
16. Daily Parts Shortage
17. Daily Inspection Report
18. Set-Up Report
19. Industrial Relations Handbook
20. Change Request (Time Standard & Method)
21. Tool Request
22. Shortage Analysis
23. Assemblies on Order
24. Manufacturer's Instruction Books

In addition to these aids, a meeting is held daily by the Production Manager where production schedule deficiencies are brought to the supervisor's attention. With respect to the "Layout" mentioned above as an administrative aid, a consistent comment among supervisory personnel during interviews was "--the lack of cooperation from the Layout Department regarding getting layouts changed when they do not do the job for which they were intended. Requests for changes are processed so slowly that the same situation arises time after time."

Supervisory job descriptions, etc., are also discussed under the Organization chapter of this report.

11.7.4 Manufacturing Superintendents. At the beginning of this group's study there were four categories of Manufacturing Superintendents: A Manufacturing Machining Superintendent, a Manufacturing Assembly Superintendent, a Second Shift Superintendent, and a Manufacturing Processing Superintendent, actually the Assistant Factory Manager. Since the study was started a fifth category, the Plug-in-Connector Superintendent has been added.

Assistant Factory Manager - Process Superintendent. As assistant Factory Manager, this supervisory position has the responsibility for general assistance, and specific responsibility for supply stores, janitors, matrons, inside trucking, scrap disposal, and grounds maintenance. Under the revised organization it has been recommended that most of these functions be put under the Plant Engineer.

As Process Superintendent, this supervisory position has the responsibility for all manufacturing process departments and activities:

1. Production Process'es Chemist

2. Department 9--Mechanical Engineering Process Design, including molds, die cast dies, plastic dies, etc. About 75% of the activity is related to plug-in-connectors.

3. Department 32--Operational Process manufacturing including furnace brazing, steel blasting, welding, brazing, painting, tumbling, and plating. One interesting process developed in tumbling is for P.I.C. inserts where flashing in the past was trimmed by hand. They are now hard-chilled in dry ice and tumbled with wooden pellets. In plating, the Alumilite 225 process gives aluminum a surface hardness of 9, just under diamond hardness. The disadvantage is that these hard surfaces become cutting surfaces and tend to destroy themselves. Plating also includes gold, silver, nickel, chrome, cadmium, tin, copper, zinc, brass, black oxide, and parko-lubrite. This department has responsibility for its own maintenance of electrical temperature controls, etc. and further has jurisdiction over the Process Control Laboratory which controls plating thickness, etc.

4. Department 36--Die Casting. At present this department is at maximum capacity, principally loaded by connectors. It is on 3 shift operation and half day Saturdays. The die casting facilities are very modern and have served as a model for several other companies.

5. Department 37--Molding. The function here is primarily the molding of plastic and rubber inserts for electrical

connectors. The problem has been to reduce curing time in the molds to attain high volume production.

6. Department 43--Ceramics. This department is devoted to development and manufacture of a wide variety of complex ceramic parts in an expanding field of high temperature electronic applications. An example is the use of a ceramic base-socket for electronic tubes requiring high temperatures and physical strength.

Manufacturing Machining Superintendent. Responsibility of this supervisory position is primarily for machining departments, although some assembly is included, particularly in the case of "Product" departments, and also composite contracts wherein the products are practically hand made from raw stock to finished good by the lead department.

1. Department 26--Automatics (Gridleys, Browne and Sharpes). Used for high volume manufacture of precision parts, such as connector shells, fuel injection components, etc.

2. Department 27--Punch Press. These are routine punch press operations with the exception of the recent introduction of the pygmy connector, the shells for which are extruded on the large press.

3. Department 30--Steel Machining.
4. Department 33--Cam and Gear Machining
5. Department 28--Lathes
6. Department 29--Light Metal Machining
7. Department 39--Mold Machining
8. Department 40--Eng. Speed Magnetos
9. Department 31--Diesel Fuel Pumps
10. Department 48--Plug-in-Connectors
11. Department 49--Jet Spark Plugs
12. Department 34--Sundry

Manufacturing Assembly Superintendent. Responsibility of this supervisory position lies primarily in assembly of parts, components, and sub-assemblies, although some manufacturing and fabrication is involved.

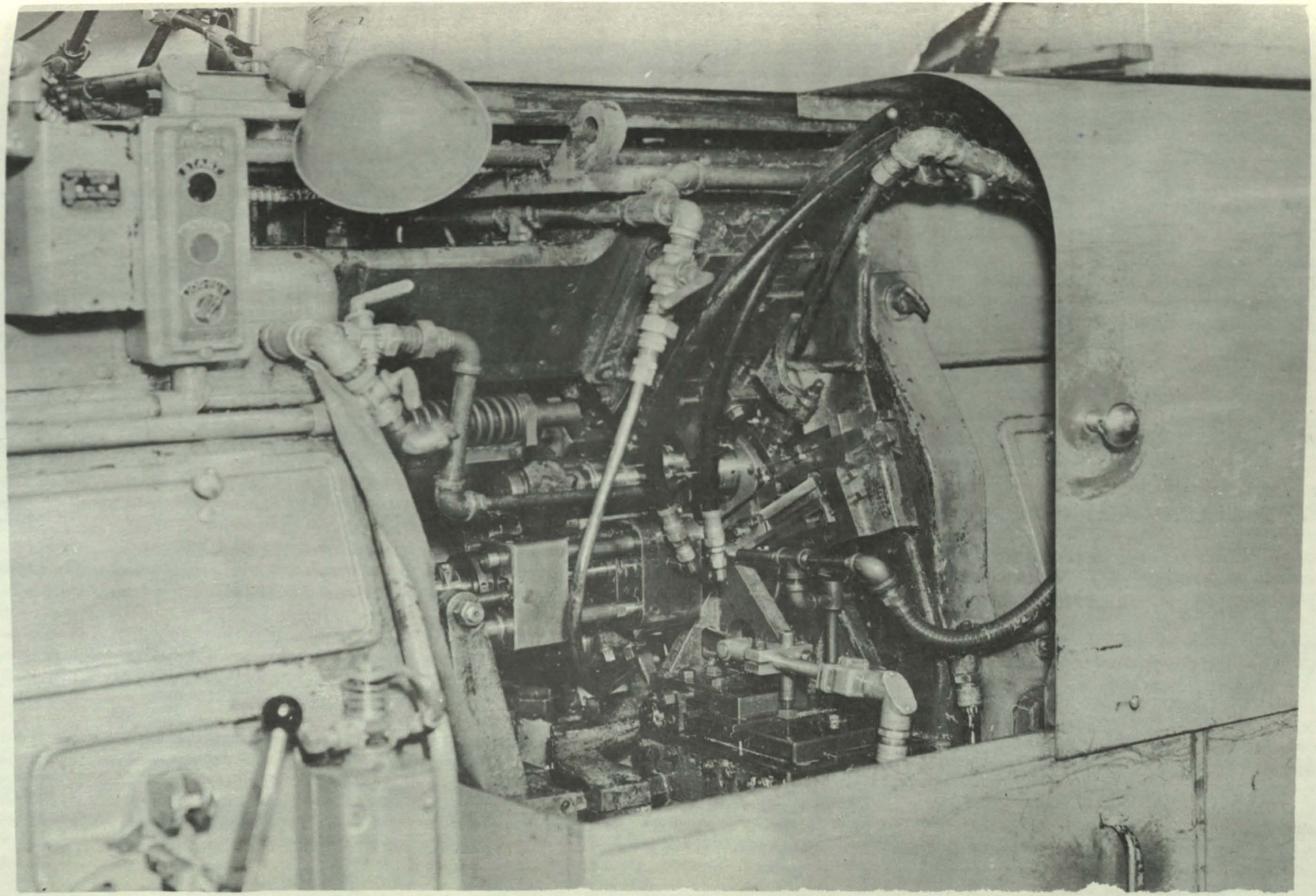
1. Department 42--Magneto Assembly
2. Department 38--Coils and Condensers
3. Department 41--K Magnetos
4. Department 44--Plastic Coils and Impregnating
5. Department 47--Tubular Harnesses

Second Shift Manufacturing Superintendent. This supervisory position is responsible to the Factory Manager for all second shift operations except those process operations falling under the Asst. Factory Mannager. He further is responsible for manufacturing operations on the third shift, excepting process operations.

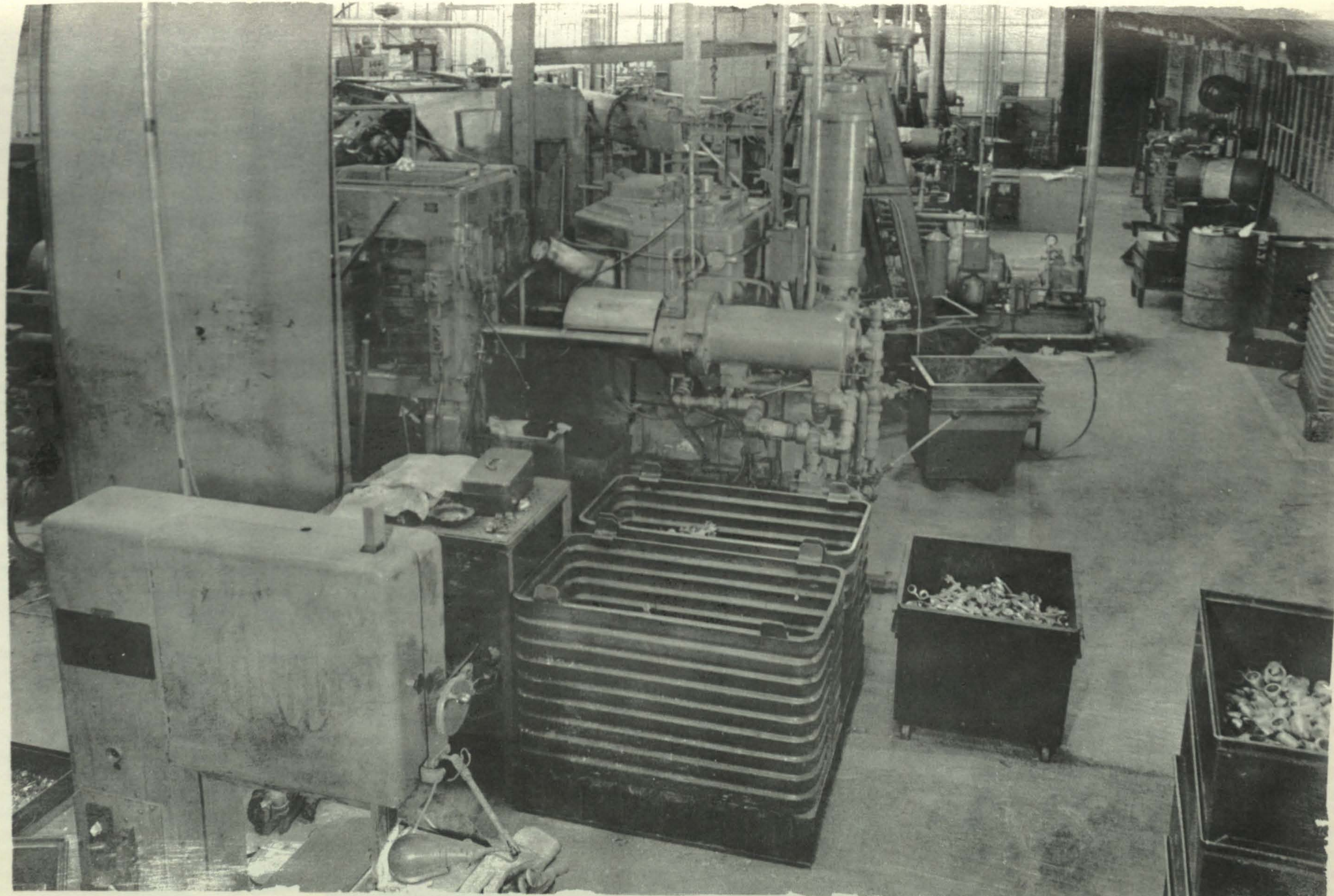
11.8 Operations. "Operations" is defined as the directed functional activities which actually "do" the planned activity. This section deals with how the men, machines, and materials are integrated to produce the product.

11.8.1 General.

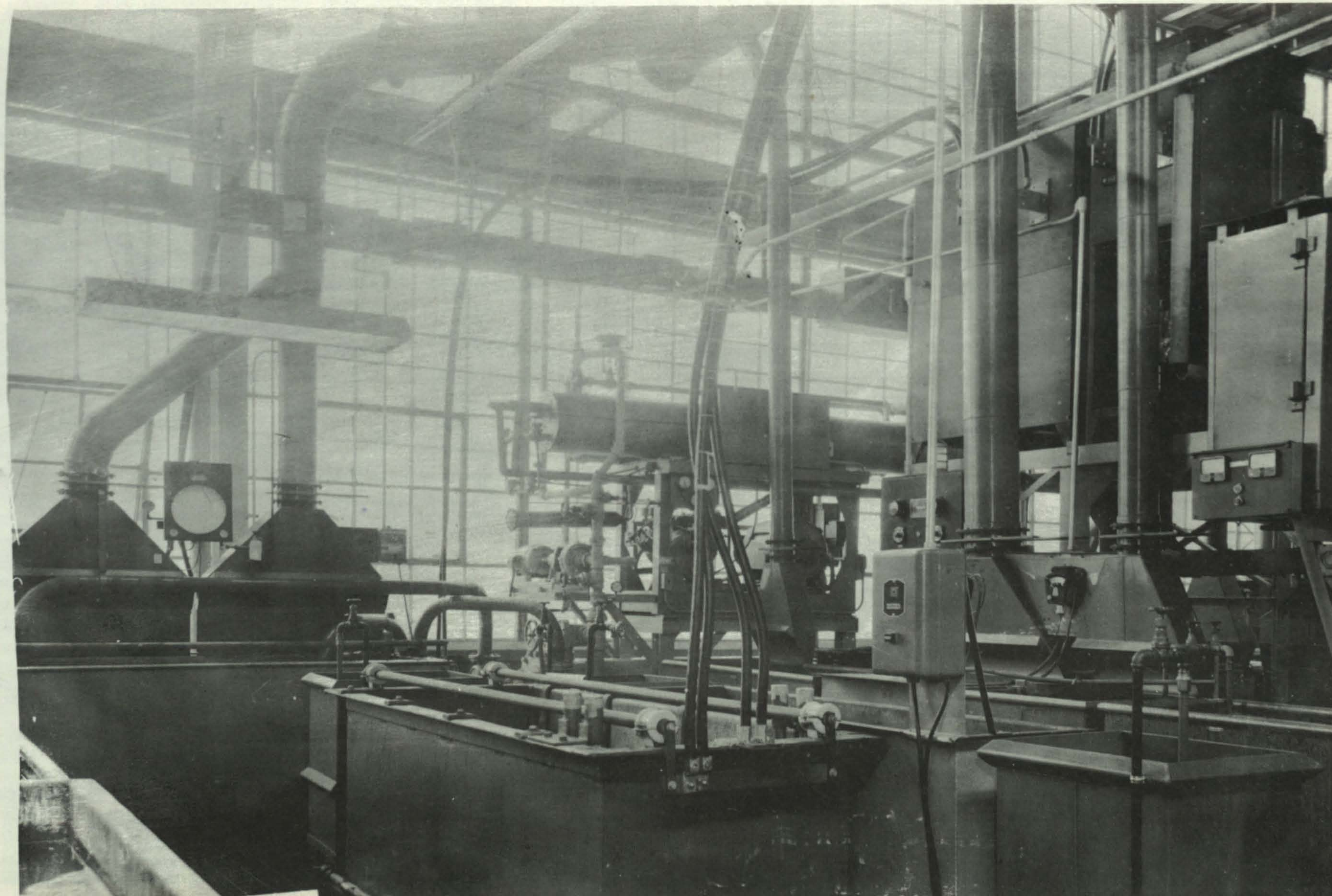
Manufacturing Concept. There are many ways that a producing plant can be organized, managed, and laid-out ranging from mass-production-lines to a true process layout where all similar machines are grouped into separate departments, i.e. a grinder department, lathe department, etc. Between these extremes lies a method of manufacture known as semi-serialized manufacture; serialized manufacture denotes production line techniques. "Industrial Organization and Management" by Bethel, et al, McGraw Hill, 1956, states "--this compromise provides a very advantageous arrangement devised by performing several operations on a single product within a department. Such an arrangement groups together the machines used in successive operations, possibly connecting them with conveyors (or transfer mechanisms). Or the manufacture may be serialized as far as possible except for a few operations requiring fixed, extremely heavy or very objectionable equipment which is then located centrally. The aim of any layout for semi-serialized manufacture is to decrease handling costs, lower the in-process material inventory, and obtain optimum capacity without seriously detracting from the flexibility of the machines--thus retaining the principal advantages of both serialized and job-lot manufacture. Semi-serialized manufacture establishes all possible production lines and then groups the balance of the machines by process. The production lines must be sufficiently flexible for the interrupted manufacture of a variety of products or types and sizes of the same basic products. Hence, to employ all equipment to optimum capacity, balanced production schedules must be maintained between sizes and quantities that can be manufactured at any one time on those lines or in the remaining machine groupings."



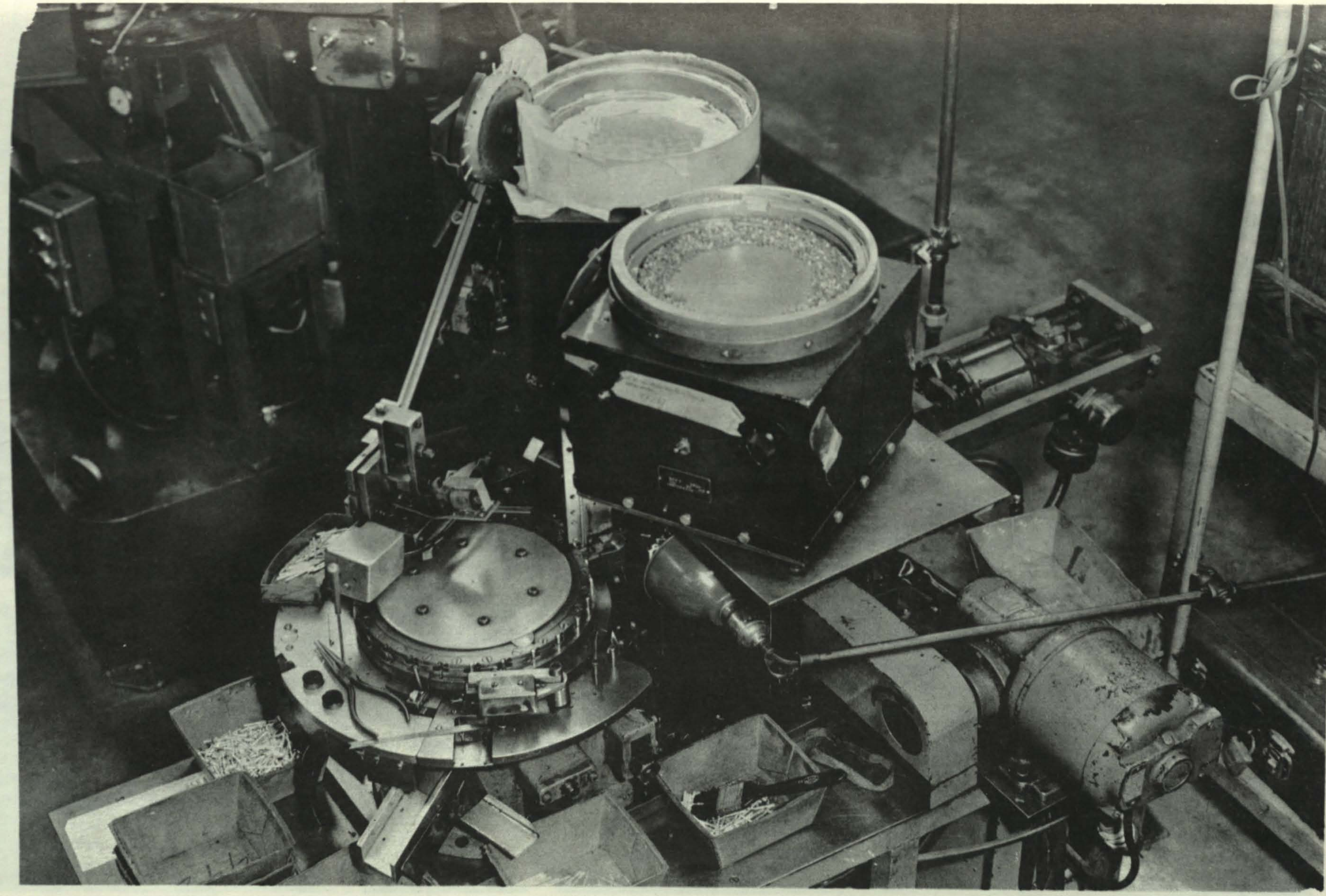
19346 GRIDLEY AUTOMATIC - TOOLING



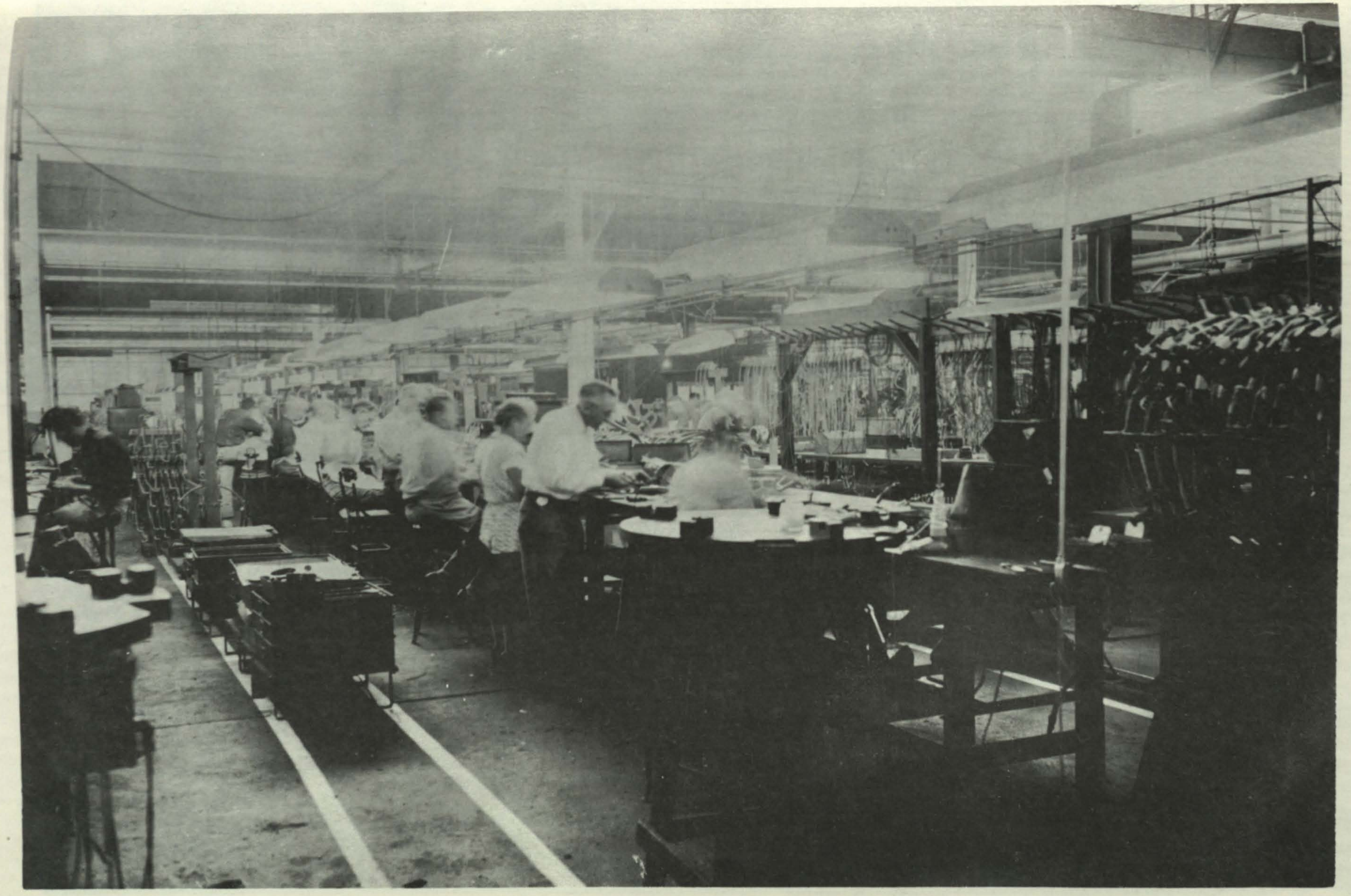
19344 DIECASTING MACHINES



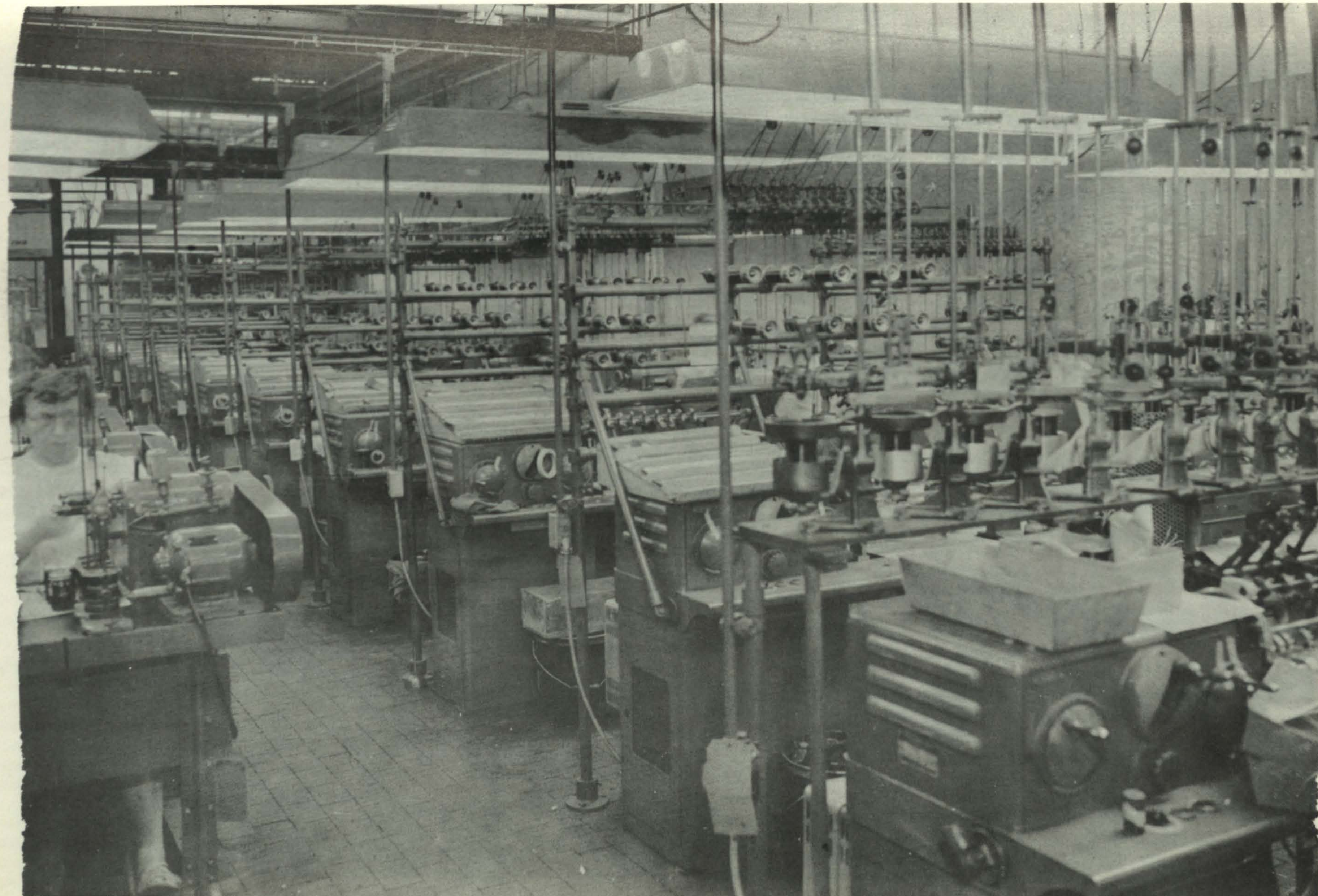
19128 ALUMILITE PLATING



19343 CLIP ASSEMBLY - CONNECTOR CONTACTS



18468 PARTIAL VIEW OF HARNESS ASSEMBLY (II)



COIL WINDING MACHINES - MULTIPLE

ELECTRONICS ASSEMBLY DEPT.

Scintilla is organized along these lines as shown by the departmental machine allocation tabulated on Chart 11.2.1-4. This is prima facie evidence that Scintilla has intuitively recognized that the volume of some products (and certainly of components of those products) warrant separation into specialized departments vice conventional process layout. This study group feels that this type of layout most aptly "fits" Scintilla. However, we also feel that the advantages have not been fully realized.

1. High volume items have not been segregated from low volume within product categories to facilitate production line techniques on the high volume items.

2. Material handling costs seem very high, i.e. $2,105,000 annually estimated.

3. In-process inventory also seems high, both in float, in floor space taken up, and in value, $3,500,000 estimated.

4. Machine utilization (of present capacity) appears low, at 39.3%.

Production line techniques, even within departments, should be incorporated when the time required to produce a single product approaches the time available. When the two times are equal, continuous production over any work-place, machine, combination, or sequence of operations is required and desired. Further, it should be remembered that it may be economically feasible to go to production lines even though continuous production of any one individual item cannot be sustained on an annual basis. Not only may much shorter periods prove sound provided the line is flexible enough to shift from one item to another, but within a series of items, manufacturing standardization (i.e. same sequence of operations with similar operation standards) may provide for continuous line operation on a variety of items. And still further, the entire production cycle need not be on a like base; that is, any part of the cycle may be separated out and put on a production line base. Connectors are the best example of a possibility for such treatment. This analysis is developed more fully in a subsequent section.

A classification system, and standardization (both product and manufacturing) with manufacturing sequencing, grouping by manufacturing, operations and/or tooling similarities, are the essential first steps toward full realization of the possibilities of semi-serialized manufacture, to ensure the most economic production of high volume items while retaining the essential job-lot concept of "making what the customer wants vice selling what the company makes."

Procedures. "Operations" really begin after the production contract has been issued to the inventory control points where they are picked up daily (if material available) by the supervisor, who may assign priority and tentative sequence schedule. The specific work is assigned to the group leaders who are in general responsible for obtaining the necessary tools, gages, material, etc. for the job from the various storerooms and cribs. The "Layout" (the designation given to Planning Records by Scintilla) is provided by the Layout Department under the Master Mechanic and in addition to including routing instructions, operation instructions, and design specifications, lists those tools, gages, and materials required for the job. Depending on the job and the department, the job may be set-up by a specially designated set-up man, or by an operator qualified and designated for both setup and operation. In some cases this procedure results in extended cycle times. For instance, where a setup/operator is responsible for more than one machine, each machine may be in a different part of its cycle, and if tool trouble or other manufacturing difficulty is encountered on the producing machine, the operator's attention must be directed to it. This extends the setup time on the down machine and results in a decrease in overall capacity utilization. It is recommended that more specifically designated setup men be assigned to the departments so effected. As discussed above and in other sections, the job assignment, (which tote box is selected for work next), is primarily a function of how long a contract has been outstanding unless expediting action has resulted in special emphasis. Supervisors make an attempt to relate the contracts by similarities but lack of standardization and classification, and insufficient monthly combining and scheduling of similar "groups" of products results in nearly random job mix, further resulting in maximum required setup times which aggravate the above situation.

After a machine has been setup, a "first run" is made during which quality control inspectors check the output and tooling deficiencies are determined. When the output is satisfactory the production run is started. The operators and operations are in general independent. That is, each operator works from and to a tote box, with no immediate transfer to the next operation. In most machining operations the operator must remove the pieces from a supply tote box and place them either on a pin-board or working tray. As they come off the machine they are inspected for overall quality by the operator in the ratio of about one in ten and placed on another pin-board. They are then counted by the operator and further transferred to a transfer tote box. If the next operation is within the same department, the above procedure is repeated. When any particular department has completed all the required operations and the pieces have gone through a bench inspection where they are certified for quality and quantity, the tote box is set straddling isle markers which is a signal for the truckers to "move" to the next department. The next department may or may not know that the work is on the way depending on how much checking the supervisor has done. When components have been completed, they are turned into stores for re-issue to assembly when required and/or when all components have been consolidated. All components go to Stores as an inventory check point before assembly and shipping.

Only the first operation on a contract is scheduled insofar as starting date is concerned and this is mere reflection that the contract has been issued and the work authorized. The Contract Status Report summarizes the contracts outstanding and specifies the first department and the lead department for each contract together with the issue date and the overall completion date of the contract. No intermediate operations are scheduled either for starting or completion dates except by expediting action. Thus work has a tendency to be delayed and lost sight of as the contract moves from department to department until it nears the end of the float period where the expediters start checking on progress and the department supervisors evaluate the work in relation to scheduled completion date of the contract. In any event, a contract-lot, represented by a tote box, may sit in a department for as long as 30 days before it is forced out by administrative procedures.

Manufacturing is centralized in one department insofar as is possible, as indicated by the semi-serialized production layout. Thus in many cases one department will produce a unit from raw stock to finished goods with the exception of certain process operations.

All of the above relates to standard production products, with Class 2 tooling. These are established products with complete sets of process sheets, which usually reflect product analysis and product design changes to optimize manufacture. Another manufacturing category is the Pre-Production products which are small lots of non-standard products that may or may not be repeat orders. Here the product design is accepted as released and the parts are produced with minimum new tooling on existing equipment. In addition, there are Composite Contracts, wherein normal production procedures are bypassed. Composite Contracts are issued on small lots of new products that are not expected to be repeated in any great quantity. Here, drawings are not checked, design specifications are not analyzed for optimum manufacture, and only the crudest tools are provided. The lead department practically hand makes the product from raw stock to completed unit. The question relating to PPL and Composite Contracts, and even in some cases to standard products, is at what volume and forecast requirement should Class 2 or better tooling be provided. A further problem is when to shift to high volume mechanized or automated type production. At present, only arbitrary limits have been established, such that in general for a contract over 1000 units, Class 2 tooling is utilized and, for contracts under 1000 units, Class 1 tooling is specified. Under the recommended revised organization, the pre-planning function of the Planning Department would determine the economic tool decision criteria.

A major problem in the "operation" area is scrap and rework, presently at about 14%. It is considered that there are four assignable causes:

1. Excessive setup and tear down resulting in a high rate of "new" runs. Once a machine has been brought under control on a new job the scrap and rework is considerably reduced. By increasing lot sizes, etc., a fewer number of "out of control" situations would exist.

2. Insufficient direct supervision and instruction, ranging from the operator not properly interpreting the manufacturing or design requirements to his lack of appreciation for what quality defects will constitute rejection criteria, such as tool marks, etc.

3. Insufficient pin-pointing of responsibility and attachment of penalties for bad work. In many cases the bad work is not detected until final inspection. Consequently, the job has lost its identity with the responsible operator.

4. Machine and tool limitations, particularly in high volume production of items with very small tolerances.

Some of the operations presently at or near maximum capacity and representing particular production problems are:

1. Die casting in which connectors represent about 60% of the load.
2. Alumiliting 225, in which connectors represent about one third of the load.
3. Furnaces (depending on type).
4. Molding
5. 125 ton punch press.
6. Department 26 automatic gridleys.

When necessary, Scintilla utilizes a 2nd and 3rd shift, and half day Saturdays, to overcome production bottlenecks, and beyond this sub-contracting is resorted to. In some instances sub-contracting is done routinely to maintain a supplier in an advantageous position for future requirements, particularly where complex tooling is involved.

<u>General Appraisal.</u> Scintilla accomplishes her production via the "float" method. This can be symbolized as a filtering process by which material is forced against the filter, the material trespasses the filter and finally emerges as the product. The material, while in the filter, is the float. The time taken to complete the filtering process is a function of:

1. The manner by which the material is introduced into the filter; i.e. whether force is exerted on the total input or whether each particular lot has force applied individually.

2. The relative resistance of the filter to passage of the various particles which in turn is a function of:

   a. The porosity of the filter, the number of passages and their size; i.e. the complexity and adequacy of the plant layout, manufacturing and processing quality, machine and manpower utilization.

   b. The attention that each particle receives during passage; i.e. whether each manufacturing operation is micro-scheduled vice macro-scheduled, dispatched and progressed.

In the case in point, Scintilla has chosen to treat her workload via the totalized concept. The float is added-to each month with the assumption that the "filtering" will be accomplished in sufficient time to meet the scheduled delivery date. That is to say, macro-scheduling only, with scorekeeping after-the-fact, is done. Schedules are issued monthly and represent the monthly billing. "Schedules," in this case, is a misnomer. Quotas is a more representative term. The individual departmental foremen (often delegated to the group leader or even an operator) is responsible for proper scheduling, in that he is responsible for meeting the monthly requirement.

Landy, in "Production Planning and Control", McGraw Hill, 1950, states, "--the concept that production control is a scorekeeping or statistical department is expensive and inefficient." For evidence of how expensive and efficient Scintilla's production control procedures are see the Plant Performance and Appraisal sections of this report. The only manufacturing activities observed to be under close control by higher management were those departments, or operations, that are producing near to full capacity. This follows, since to obtain full output close control including scheduling (time available versus time required) is necessary. The reason it is necessary is that inefficiencies are introduced otherwise; inefficiencies that cannot be afforded since capacity limits approach the "required" situation. Why is it not necessary to maintain close control over other than fully loaded operations? Are not the same troublesome inefficiencies introduced? Can they be afforded more readily than in the fully loaded situation? The answer given by the manufacturing management was a unanimous "YES!" This study group takes exception and suggests that Scintilla evaluate herself very closely in this respect.

Little modern materials handling techniques and equipment were observed. This is evidenced by the $2,105,000 total annual material handling cost cited in section 11.9.4.2. The total is contrasted to $10,000, the estimated annual depreciation cost of material handling equipment. Thus, material handling costs are composed primarily of wages (82%) and floor space allocation (13%). This floor space percentage represents storerooms only. Tote boxes holding in-process inventory consume an estimated 25% additional space within the productive manufacturing allocation. The primary reason for this large expense is Scintilla's use of the tote box method of handling, manufacturing, and scheduling. As discussed above, proper semi-serialized manufacturing procedures in many cases would route material directly from one operation to another, thus reducing the non-productive expenditure, clearing up a great deal of floor space holding tote boxes, reducing in-process inventory, reducing average production cycle times, and reducing the percent of products that are delivered late to the customer.

The group wishes to compliment Scintilla for the ingenious machines and tools designed and built to facricate and assemble certain connector components. The basic principle incorporated into these machines is recommended to Scintilla as a solution to many other problem areas. It is hoped that the next step will be taken; that of combining these excellent automated machines into one producing entity. It is suggested that, for instance, the output of the Gridley pin automatics could be fed directly into the automatic millers then to the tumbler. After batch transportation to plating and back, the output of the automated solder well filling machines could be fed directly into the automated clip assembly machine. Further, it is possible to locate the clip making machines near the clip assembly machine so that clips and sockets are both fed automatically and continuously to the clip assembly machine. The output of the clip assembly machines could be inspected for tension and size by the automatic machines after continuous transfer. It is suggested that Scintilla study this recommendation with a view toward setting up this completely integrated system in the plant addition under construction.

The idea of combining operations into one producing automated unit via transfer mechanisms to eliminate consecutive handling has literally thousands of applications throughout the plant and is particularly emportant, not only for machine application but also for method engineering of the human variety (work-place engineering and layout) since annual direct labor cost is estimated to be $8,350,000 while annual machine and equipment depreciation and rental costs are estimated at $960,000. Certainly machine emphasis is important from a capacity standpoint but engineering effort applied to human facilities is equally fundamental, not only for optimum capacity but for minimum cost. Observations of people and sampling of Methods Department Reports verify that the greater emphasis is on machines, machine tools, and processes.

11.8.2 Plant Performance

11.8.2.1 Man and Machine Utilization

General Discussion. One of the best indicators of productive efficiency is the utilization of available men and machines. This efficiency factor determines how much is actually gotten out of the establishment in relation to what is possible. To determine the utilization efficiency, statistical sampling of the manufacturing department men and machines was carried out on Tuesday, February 19, 1957 and Tuesday, March 26, 1957 with data obtained as per Chart 11.8.2.1-1, Figures 1 and 2. The procedure used was similar to that described in the "Industrial Engineering Handbook" by H. B. Maynard, Section 3, Chapter 5, except that observations were not limited to specific work stations and were confined to a period of the two Tuesdays. Observations were made by random walking up and down work station isles, marking the operator and/or machine activity at the immediate moment of arrival within arm's reach of any particular station. With respect to the personnel sampling, no attempt was made to pace the workers observed. The criteria for the activity classification "Producing" was simply that if the employee appeared to be constructively engaged he was so classified. Results were conservative. The employee may have been engaged in unauthorized production, been reworking a rejected piece, or may have been marking time waiting for the machine or process to finish although appearing busy. Thus in every case the employees actually on-the-floor were observed it is presumed that some were temporarily absent from production areas, in washrooms, storerooms, at tool cribs, etc. Inclusion of such persons in the total observations would decrease the "Producing" percentile.

In interview statements from the Production Manager and the Stores Foreman it was determined that there is no great fluctuation between daily production volumes, or even any significant seasonal fluctuations, except that Mondays are a little slow getting started, and Fridays are not completely "normal." This was further corroborated by a sampling check of daily completed production contracts. Thus the assumption is permitted that the Tuesdays the samples were taken satisfied the requirement for randomness insofar as having reasonable reliability within the generalized scope of this study. In any event it is felt that the results were conservative, in that the 19th and 26th were in the latter part of the months, and if fluctuation did occur, there would

STATISTICAL SAMPLING DATA OF MANUFACTURING ACTIVITIES UTILIZATION

MACHINE UTILIZATION

ACTIVITY CLASSIFICATION	NUMBER OF MACHINES OBSERVED BY DEPARTMENT										
	26	30	27	37	33 39	29	48	28 31	32	Total	%
Producing	66	50	14	80	28	40	164	74	16	542	.393
Non-Producing	72	84	58	70	78	114	168	180	24	838	.607
Maintenance	4	2	6	8	2	6	14	12	0	54	.039
Setup, Teardown	50	72	16	38	46	56	90	92	4	464	.336
Not assigned	0	0	8	6	14	26	6	28	12	100	.072
Out of material	0	6	6	14	4	6	18	12	2	68	.049
Adjust;Defective Tool	12	0	6	4	0	2	18	18	0	56	.041
Oper inspect product	0	0	0	0	4	0	6	6	2	18	.013
No operator	6	4	6	4	8	18	18	12	4	78	.056
TOTALS	138	134	72	150	106	154	332	254	40	1380	
Percent Utilization	.48	.37	.33	.53	.26	.26	.50	.29	.40	.393	

FIGURE 1

MANPOWER UTILIZATION

ACTIVITY CLASSIFICATION	NUMBER OF PERSONNEL OBSERVED BY DEPARTMENT										
	26 BS	26 GR	32	48	42	30	33	27	37	Total	%
Producing	16	10	0	314	70	38	16	14	24	502	.525
Non-Producing	14	26	4	256	34	20	24	34	44	456	.475
Setup, Teardown	4	8	0	28	0	2	4	6	2	54	.056
Admin. paper work	0	0	2	20	2	0	0	0	0	24	.025
Waiting for job	0	0	0	0	0	0	0	0	0	0	.000
Machine interference	0	8	2	24	0	4	2	0	26	66	.069
Mat'l delay&handl'g	4	0	0	20	4	0	0	4	6	38	.040
Tool Delay	0	0	0	4	0	4	2	0	0	10	.011
Machine Adjustment	2	0	0	14	0	0	0	2	4	22	.023
Inspecting own work	2	8	0	8	2	4	8	0	2	34	.036
Waiting for inspector	0	0	0	8	0	0	0	2	0	10	.011
Counting finished work	0	0	0	7	0	1	0	2	0	10	.011
Print/Spec Delay	2	0	0	6	10	4	2	2	0	26	.027
Being instructed	0	0	0	20	0	0	2	4	0	26	.027
Personal activity	0	2	0	96	16	2	4	12	4	136	.142
TOTALS	30	36	4	570	104	58	40	48	68	958	
Percent Utilization	.53	.28	.00	.55	.67	.66	.40	.29	.35	.525	

FIGURE 2

GRIDLEY UTILIZATION (Dept. 26)

	PRODUCING	MAINTENANCE	SETUP/TEARDOWN
No. of Observations	52	21	187
Percent Occurrence	.20	.08	.72

FIGURE 3

Chart 11.8.2.1-1

be an even greater utilization on these days than "normal" in view of Scintilla's monthly production billing schedule procedures.

Inasmuch as the Gridley automatics were stated to be a bottleneck operation in the manufacture of plug-in-connectors, these automatics were sampled at ten random intervals over a period of six consecutive Tuesdays to obtain a more detailed analysis of this operation. Data was obtained as per Chart 11.8.2.1-1, Figure 3. Since total observations were relatively small, the elemental breakdown was kept at a minimum, namely "Producing," "Maintenance," and "Setup/Teardown." Any machine either not producing or not down for maintenance was arbitrarily assumed to be within the setup-teardown cycle.

Machine Utilization Analysis.

Utilization, p, was 39.3%
Number of observations, N, was 1380
Standard deviation, sigma, was 1.31%
% possible error in p was .0131/.393, equal to 3.33%
95% tolerance limits were 36.7% to 41.9%

Meaning: On any random day, 95 times out of 100, the machine utilization will lie between 36.7% and 41.9%.

Further, since 14% of machine output is rejected scrap or rework, the true productive utilization is only (.393) - (.393 x .14), or (.393 - .055) equal to 33.8%.

Since machine and equipment annual depreciation costs are $885,000 (including government owned facilities), the various categories of machine activity can be grouped by the following types of costs:

Cost Type	Activity	%	Cost
1. Maintenance & Adjustment	Maintenance	3.9	$ 34,000
	Tool Trouble	4.1	36,000
2. Control	Operator Inspection	1.3	10,000
3. Material Handling	Out of Material	4.9	45,000
4. Non-Work	Not Assigned	7.2	64,000
	No Operator	5.6	59,000
5. Non-Productive Work	Setup/Teardown	33.6	298,000
	Scrap & Rework	5.5	49,000
6. Productive-Work	Producing	33.8	299,000

The significant item here is the Non-Productive Work category, particularly setup and teardown. Nearly as much machine time is spent on this as on productive output, indicating a possible need for manufacturing and/or product standardization in addition to detailed sequential scheduling wherein similar parts are scheduled in sequence. To do this of course, a classification system is essential for the determination of similarities.

Although utilization was only 39.3% it must be stated that this is not an area where substantial savings are possible with respect to overall costs, since machine and equipment costs are relatively insignificant compared to labor and material. However, where plant capacity, and hence sales volume, is limited by a machine bottleneck, as with the Gridley automatics, radical attempts should be made to improve the bottleneck conditions.

Gridley automatics utilization in department 26 was only 20%, with 8% maintenance, and 72% setup/teardown. The conclusion is obvious. To remove the bottleneck the following are some of the measures that could be resorted to; classification, standardization, sequential scheduling, increased lot sizes with production into inventory on a forecast basis, and product-line manufacture on high volume units. A full discussion of the Gridley problem is contained in sections 11.8.3 and 11.8.4. In addition it was noted in this respect that increasing the number of setup men in the department might be an immediate solution, in that down-machines were in excess of the number of set-up men, creating an "idle" condition resulting in a longer setup cycle than actually required.

<u>Manpower Utilization Analysis</u>

Utilization, p, was 52.5%
Number of observations, N, was 958
Standard deviation, sigma, was 1.62%
% possible error in p was .0162/.525, equal to 3.1%
95% tolerance limits were 49.3% to 55.7%

Meaning: On any random day, the manpower utilization, 95 times out of 100 will vary only between 49.3% and 55.7%.

Further, since 14% of the worker output is rejected scrap or rework, the true productive utilization becomes (.525) - (.525 x .14), or, (.525 - .074) equal to 45.1%.

Since the annual direct labor payroll has been estimated at $8,350,000 (including allowances), the activities can be broken down on the following cost basis for subsequent analysis:

Cost Type	Activity	%	Cost
1. Administrative	Paper Work	2.5	$ 215,000
2. Maintenance & Adjust.	Mach. Adjustment	2.3	192,000
	Tool Delay	1.1	92,000
3. Control	Print/Spec Delay	2.7	225,000
	Being Instructed	2.7	225,000
	Waiting for Inspection	1.1	92,000
	Inspecting Own Work	3.6	300,000
4. Material Handling	Counting Own Work	1.1	92,000
	Material Handling	4.0	334,000
5. Non-Work	Personal Delay	14.2	1,180,000
	Machine Interference	6.9	575,000
6. Non-Productive-Work	Setup/Teardown	5.6	468,000
	Scrap & Rework	7.4	618,000
7. Productive-Work	Producing	45.1	3,770,000

All of the activities other than productive work, totalling $4,580,000/year are significant enough to warrant close attention. In this respect, the following breakdown by cost "cause" is more beneficial.

Cost Cause	Activity	%	Cost
A. Methods	Material Handling	4.0	$ 334,000
	Machine Interference	6.9	575,000
B. Procedures	Inspecting Own Work	3.6	300,000
	Counting Own Work	1.1	92,000
	Administrative	2.5	215,000
C. Manufacturing Delays	Setup/Teardown	5.6	468,000
	Mach. Adjustment	2.3	192,000
D. Supervision	P.F.D.		
	Personal Delay	14.2	1,180,000
	Tool Delay	1.1	92,000
	Print/Spec Delay	2.7	225,000
	Wait for Inspector	1.1	92,000
	Being Instructed	2.7	225,000

The significant item here is "supervisory responsibility costs," wherin supervision is meant to include training, morale, discipline, leadership, direction, and corrective control action. It will be assumed that about one third of the scrap and rework is beyond operator control (inherent in machine or process), and further that 10% time allowance is expected (granted) for personal, fatigue, and delay. Costs reducible by increased supervision are then:

(11.8% plus 5.0%) x ($8,350,000) equal to $1,400,000.

It was determined in other sections of this study that a considerable portion of the supervisors' time was taken up by matters other than direct control of the workers. A way to gain increased supervision, aside from the desirability of an active supervisory training program, would be to take the planning, scheduling, loading, and other such responsibilities away from the supervisors, and put them in a planning section, leaving the extra time for real supervision of the workers themselves. Higher morale, more instruction and training, and tighter control over quality and worker activity through discipline and effective corrective action could well save in excess of $1,000,000/year.

Manufacturing delay costs, principally set up and tear down, can be considered in the same light as discussed under machine utilization. They are principally the result of complete job-shop operation with random selection of contract sequence and little consideration of economic lot sizes.

Procedure delay costs are just that. Operators inspect their own work even though it is processed through both a bench inspection and final inspection. Besides being duplication, the question can be raised whether the operator inspector really does any good, and in some cases whether it is done at all even though included as part of the time standard. In addition to inspection, operators also count their own work even though it is subsequently counted by both inspectors and stores personnel. Adminstrative production paper work is a function of the above items. In view of the duplication and overlap of effort, it is suggested that a procedure review be undertaken to release the workers from this activity. Inspection, counting, and paper work (including wage payment data) could all be accomplished by the bench inspectors and/or a dispatch section which is being recommended separately.

Methods delay costs involve work station inadequacies wherein the worker is not "loaded" and might well be running two or more machines, and in addition is probably handling material an excessive amount of the time, such as the Gridley operators who transfer shells from one tote box to another three different times before reaching the bench inspector. At other stations workers take material out of a tote box and put it on a pin-board, then off the pin-board to another pin-board, off the pin-board into a tote box, and out of this tote box to another larger tote box. With the risk of being redundant with regard to other sections of the report, it appears that great improvements can be made in the areas of "people." Little can be said about machines, for continual method study here has produced an efficiency and capacity probably unsurpassed in comparable industries. However, as stated previously, machine costs are insignificant compared to labor and relatively little has been done in motion and work station study. Tools are provided the workers but they are left to their own devices for the actual work methods. No standards as such as set. Operation instruction sheets prescribe "what" is to be done but not "how". There is duplication of responsibility between time study personnel and the methods department. With 21,000 time studies a year, the time study men can hardly be expected to conduct a thorough operation analysis before each study to ensure proper methods. Nor are the time studies such as to prescribe a standard method. There is no procedure for checking back on operations to see if and why methods have been improved by the operator except in cases of excessive earnings. Such studies are more important from a productivity standpoint than the setting of time standards merely as a basis for wage-payment.

11.8.2.2 Incentive Labor Performance

General Discussion. On Chart 11.8.2.2-1 the "Normally Expected" curve portrays the representative distribution of qualified workers performing under incentive conditions, the mean being at 125% of normal levelled effort on the Intermediate Task scale. Various performance scales are used for comparison with the Scintilla system, which corresponds to the Bedeaux for levelling purposes. For wage payment, Scintilla actually uses the Intermediate Task, although it is offset by 20% to provide for beginning incentive payment at 83% effort instead of 100% normal effort. In reference to the "normal" distribution on the chart, the range of Scintilla incentive earnings should be from base pay (100%) to 200%, with the average at 150%, corresponding to an average operator performance of 125%. Similarly it can be seen that about 70% of the incentive workers should be expected to earn between 132% and 168% of base.

Productivity can be defined as the ratio of actual output to normal output, and is a function of the time an operator produces (utilization), and the effort the operator expends while producing.

Let p equal productivity
Let u equal utilization
Let U equal utilization plus 10% PFD.
Let E equal performance effort.

Then: p equals U x E

"Normal" productivity will be assumed to be that of a normal operator working under normal conditions at normal pace (60B/100) for 90% of the time. Here p equals 1.00 x 1.00 equals 1.00. It will be further assumed that minimum effort is 83.3% of normal since this is the lower limit of the effort distribution, and that maximum utilization is 90% to give the operator his PFD allowance under all conditions. Thus, productivity above 100% is proportional to effort and below 83.3% is proportional to how much time out the worker takes over and above his allowance. Between these two limits productivity is interdependent on both utilization and effort.

The following analysis was made to determine what the incentive earnings actually are, and what is the actual productivity. Having determined these factors, to analyze labor cost and any labor cost variance.

Data

Average Direct Labor base pay rate equals $1.65/hour.
60% of Direct Labor hours are incentive hours (overall).
23% of Incentive Worker hours are on straight time.
Average annual hours/worker equal 2000.
Incentive worker earnings equal, on an overall average, 127% base pay.
"Normal" effort incentive worker earning rate equals $1.65 x 120%. That is, for 100% productivity a worker will earn 120% base, or $1.98/hour.
Number of direct labor workers equal 2092.
Number of equivalent direct labor workers on incentive equal 60% x 2092, or 1250.
Incentive Base equals (60B levelled time) plus 10% PFD plus 20% incentive opportunity.

Sampling studies of incentive work in conjunction with the total utilization analysis discussed previously, established that the time utilized on incentive work on time standard elements was 70% and the time spent on non-time standard elements was 30%, of which 10% was expected due to a 10% PFD allowance.

Although as previously stated, the average normally expected incentive earnings should be 150% of base pay, the present actual average at Scintilla is:

$$\frac{1.27 - (.23)(1.0)}{.77} = 1.35 = 135\% \text{ Base Pay} = 1.35 \times \$1.65 = \$2.225/\text{hour}.$$

Interview statements from supervisory personnel indicated an unofficial upper limit on overall earnings of incentive workers of about 150%. Earnings over this limit are subject to review. Then, incentive earnings at this overall level are:

$$\frac{1.50 - (.23)(1.0)}{.77} = 1.65 = 165\% \text{ Base Pay}$$

Similarly, a lower level of incentive earnings is established not only by a guaranteed base rate, but by a base rate equivalent of piece rate earnings on incentive, that is an operator cannot fall below the number of pieces required to make base rate without incurring supervisory action. These two limits, and the present average, give rise to a distribution of present Scintilla incentive earnings, shown on Chart 11.8.2.2-1.

Analysis. As discussed above, it should be expected that incentive time earnings would average 150%. Since they actually averaged only 135%, it would then be expected that effort was 112.5% from cross checking the scales on the chart. However, utilization was only 70%, giving rise to the assumption, since the workers were taking 20% more time out than allowed, that effort at the most would be normal, or 100%. This is conservative. Actually the workers would probably slow to a pace of 83.3% with standard allowance before increasing their time out to this extent. The conservative aspect of this assumption should be kept in mind throughout the remainder of this section. Present productivity can then be computed as:

$$p = U \times E = (.70 + .10) \times 1.0 = .80 = 80\%$$

And expected productivity can be computed as:

$$p = U \times E = (.90 + .10) \times 1.125 = 1.125 = 112.5\%$$

Actual present condition then is 135% base pay at 80% productivity compared to an expected present condition of 135% base pay at 112.5% and further compared to a "normal" condition of 150% base pay at 125% productivity.

Since piece rate essentially is payment for time <u>and</u> effort, the incentive pays on productivity, not effort alone. Incentive earnings therefore are as a percent of normal productivity, i.e. 100% productivity is equal to 120% base pay; 125% productivity is equal to 150% base pay, etc. It is obvious that as long as utilization is 90% (U equal to 100%) then productivity and hence pay is equivalent to the effort scale. In the present condition however, productivity is only 80% and at this point only base pay (guaranteed 100% at or below 83.3% productivity) is given.

Wages and labor cost relationships follow from the preceding:

Let W_e equal wages "Earned." That is the % of base pay equivalent to any level of productivity as related by the pay/effort scales of Chart 11.8.2.2-1. Present W_e equals 100% @ 80% productivity.

Let W_a equal wages "Actual." That is, what % of base pay is, or would be, paid under Scintilla conditions for any level of productivity, with the present condition being the base for computational off-set. Present W_a equals 135% @ 80% productivity.

Let L_e equal labor cost "expected," where labor cost is the cost per unit of production, and expected cost equals "Earned" wages divided by productivity. Present L_e equals 100/80 equals 125%.

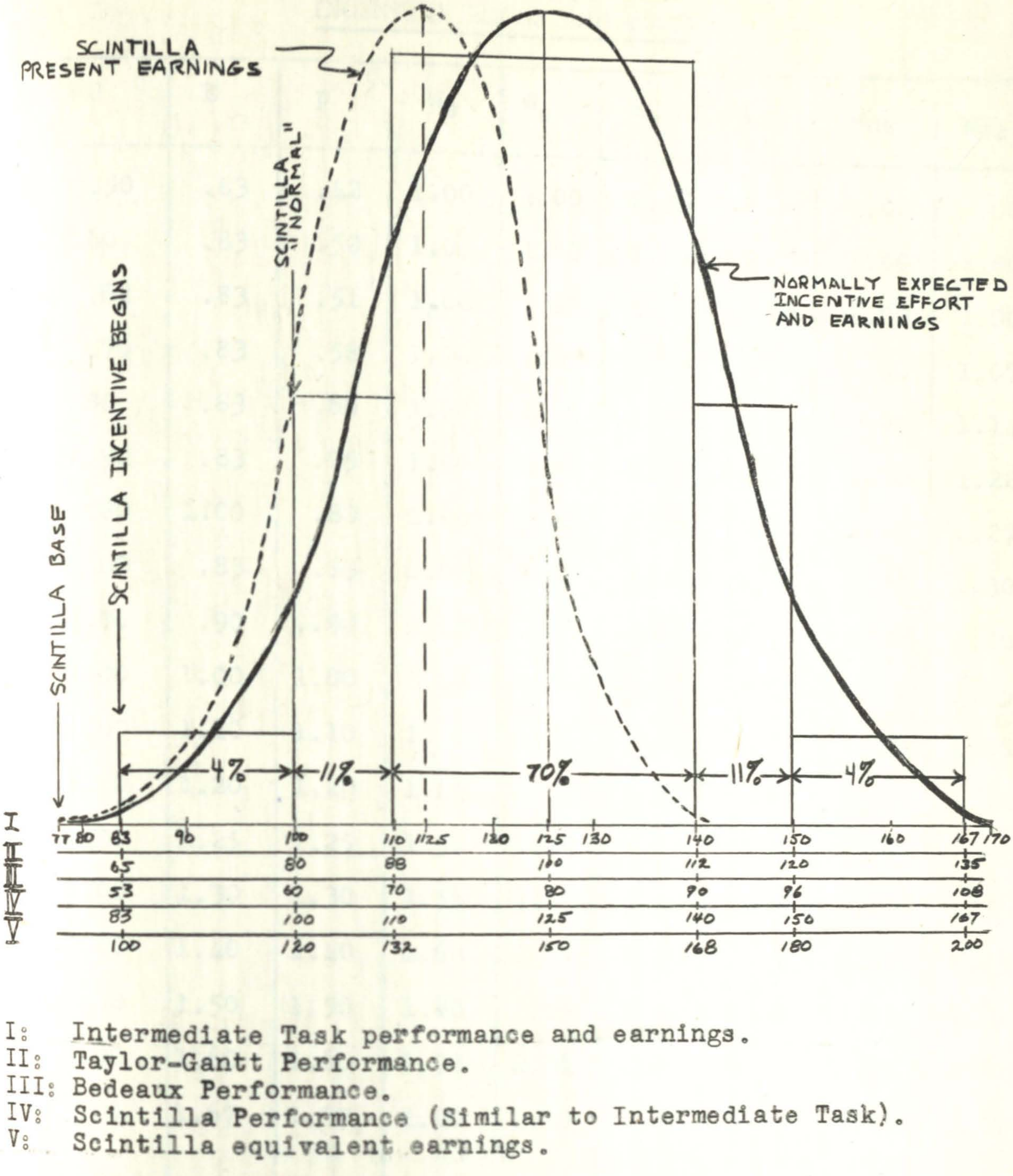
Let L_a equal labor cost "actual," which equals actual wages divided by productivity. Present L_a equals 135/80 equals 169%.

Let W_{oe} equal wages overall earned (straight time plus incentive): (.77 x W_e) plus (.23 x 1.00). Present W_{oe} equals 100% base pay.

Let W_{oa} equal wages overall actual, equals: (.77 x W_a) plus (.23 x 1.00). Present W_{oa} equals 127% base pay.

These relationships can be analyzed for any level of utilization, effort, and productivity. Chart 11.8.2.2-2 tabulates such an analysis, and Chart 11.8.2.2-3 portrays graphically the relationship between productivity, wages, and costs. The most significant feature of the latter chart is that it shows as productivity increases above 83.3% the wages increase rather

INCENTIVE PERFORMANCE-EARNING
NORMAL DISTRIBUTION



ale I: Intermediate Task performance and earnings.
ale II: Taylor-Gantt Performance.
ale III: Bedeaux Performance.
ale IV: Scintilla Performance (Similar to Intermediate Task).
ale V: Scintilla equivalent earnings.

A qualified worker, operating under normal conditions, e to the range of human ability of around 2:1, will perform tween the limits of 83 and 167 percent of normal on the inter-ediate task scale. The "normal" worker will perform at normal erformance, i.e., 100 under normal conditions, and at 125 under ncentive conditions if the incentive is strong enough (generally rom 120 to 135 percent of base pay). Under incentive conditions, 0% of all qualified operators will perform between 110% and 140% f normal, 11% between 100% and 110%, 11% between 140% and 150%, % between 83% and 100%, and 4% between 150% and 167%. An insig-ificant number of workers will perform at levels beyond these xtreme limits.

CHART 11.8.2.2-1

INCENTIVE WAGES AND COSTS

u	U	E	p	W_e	W_a	L_e	L_a	W_{oe}	W_{oa}
.40	.50	.83	.42	1.00	1.00	2.38	2.38	1.00	1.00
.50	.60	.83	.50	1.00	1.00	2.00	2.00	1.00	1.00
.52	.62	.83	.51	1.00	1.00	1.96	1.96	1.00	1.00
.60	.70	.83	.58	1.00	1.09	1.72	1.88	1.00	1.07
.70	.80	.83	.66	1.00	1.18	1.52	1.79	1.00	1.14
.80	.90	.83	.75	1.00	1.29	1.33	1.73	1.00	1.22
.70	.80	1.00	.80	1.00	1.35	1.25	1.69	1.00	1.27
.90	1.00	.83	.83	1.00	1.39	1.20	1.66	1.00	1.30
.90	1.00	.90	..90	1.08	1.47	1.20	1.63	1.06	1.36
.90	1.00	1.00	1.00	1.20	1.59	1.20	1.59	1.15	1.45
.90	1.00	1.10	1.10	1.32	1.71	1.20	1.55	1.25	1.55
.90	1.00	1.20	1.20	1.44	1.83	1.20	1.52	1.34	1.64
.90	1.00	1.25	1.25	1.50	1.89	1.20	1.51	1.39	1.69
.90	1.00	1.30	1.30	1.56	1.95	1.20	1.50	1.43	1.73
.90	1.00	1.40	1.40	1.68	2.07	1.20	1.48	1.52	1.83
.90	1.00	1.50	1.50	1.80	2.19	1.20	1.46	1.62	1.92
.90	1.00	1.60	1.60	1.92	2.31	1.20	1.44	1.71	2.01
.90	1.00	1.67	1.67	2.00	2.39	1.20	1.43	1.77	2.07

* u is percent absolute utilization. U is percent utilization with 10% PFD allowance. E is percent normal effort. p is percent normal productivity. W_e is wages earned in percent of base. W_a is wages actual in percent of base. L_e is percent of base pay, earned, of "labor cost." L_a is percent of base pay, actual, of "labor cost." W_{oe} is overall earned wages in percent of base of incentive operators including incentive time and straight time. W_{oa} is overall actual wages in percent of base.

CHART LL.8.2.2-2

INCENTIVE WAGE-COST-PRODUCTIVITY

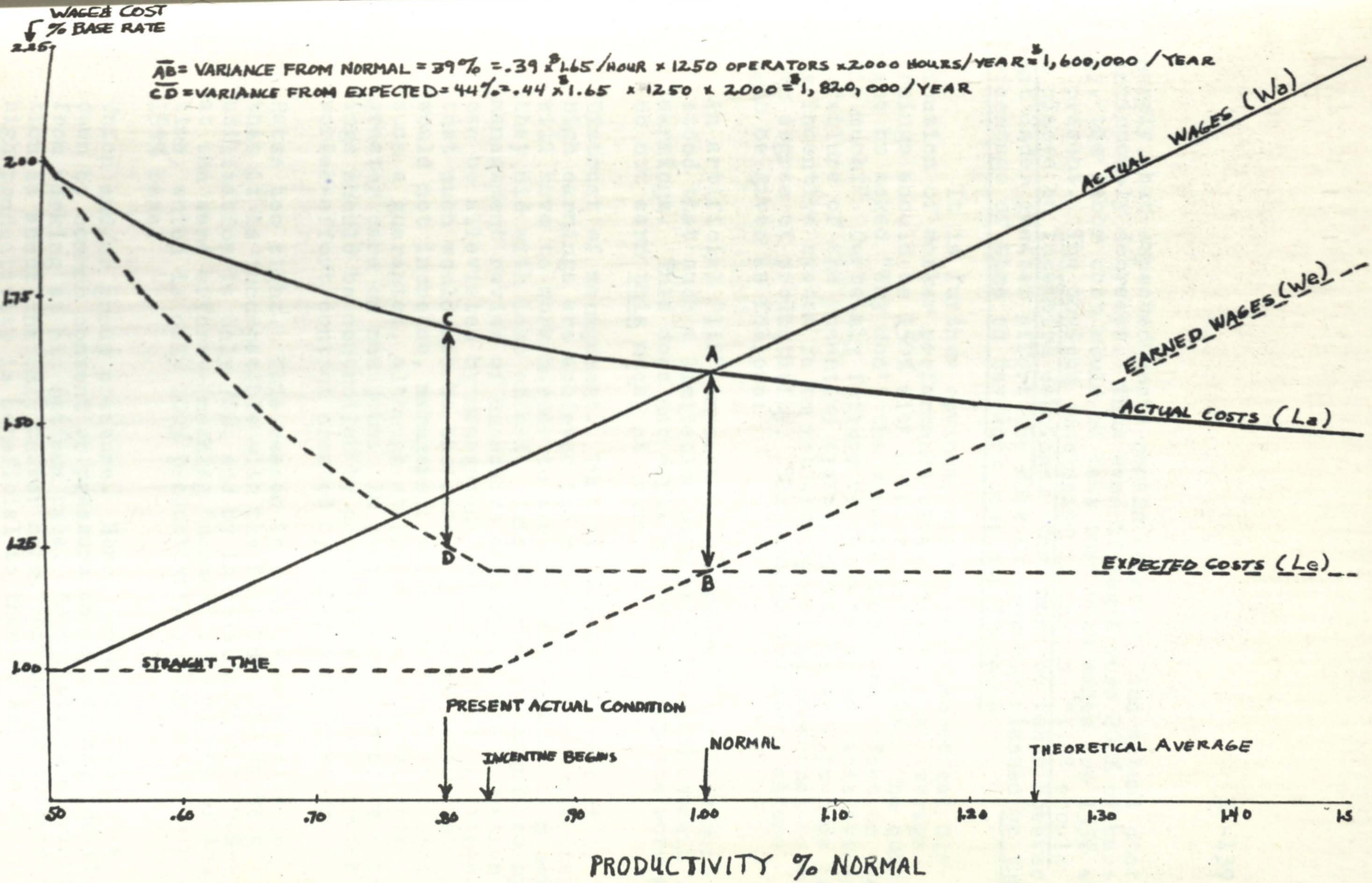


CHART 11.8.2.2-3

CHART 11.8.2.2-3

sharply, but expected costs remain constant, and actual costs continuously decrease. Thus even if wages were 200% of base pay, the labor cost would be less than when wages are 135% as at present. The obvious conclusion is that no "lid" should be placed on incentive earnings. Care must be taken however, that under greater effort the work is properly planned so that percentage of time on day work does not increase.

It is further obvious, due to the theoretical distribution of worker performance capabilities, that average earnings should be 150% with a labor cost of 120%. The question might be asked "Why don't the workers exert the effort to earn this much?" Certainly failure to do so is prima facie evidence of failure of the incentive system, since the sole purpose of any incentive system is to motivate operating personnel to a high degree of productivity. The reasons for such failure might be given as follows:

1. An artificial "lid" imposed by management. It is understood that such a limitation does exist at 150% overall earnings. This does not explain, however, why the workers do not earn this much, at least.

2. Distrust of management. That is, workers' fear that if high earnings are achieved the rates will be cut and they will have to work harder to earn the same amount of money they did with less effort. This distrust is magnified by management review of excessive earnings. This situation can be alleviated by management assurance, even guarantees, that such would not be the case. And since labor cost would not increase, management would not be forfeit from such a guarantee, although standard should be set with greater care on new jobs. In other words, incentive earnings should be controlled by good standards, not through worker-effort control created by management "pressure."

3. Rates too tight. This reason is considered invalid in that it is incompatible with the fact that the workers utilization is only 70%, and by increasing this to 90%--at the same effort--(meaning "normal" effort, 90% of the time, which is only 100% productivity), they could earn 159% base.

4. Union and/or group pressure. Here, jealousies and slowdown by common consent or pressure could keep any individual from working at his optimum pace. Proper attitude orientation is about the only answer here, showing the workers that high productivity is beneficial to them as well as to management.

5. Inability of the workers to project their own activity into a "Group Incentive" operation. Here, the faster workers may tend to pace themselves with the slower workers in order to not carry an unrewarding load. In fact they may fail to even see where increased effort on their part would improve the overall group performance and hence their own earnings. The solution here, although difficult, is more application of individual incentive.

6. Individuals primarily satisfied with what money they are earning, and since there is no distinction made for performance toward advancement under the existing union contract there just isn't any motivating force on the workers for greater effort. If this is so, the workers might just as well be paid at a straight time rate equivalent to present average incentive earnings and then motivated to higher productivity by a system of promotion-by-merit, or some other technique of non-monetary recognition.

7. Workers primarily craftsmen that are more interested in a "good job" than high production. This reason too is considered invalid, in that a person more interested in his work than in financial reward would show more than 70% utilization on the job.

8. Poor production scheduling and control such that the greater effort on incentive would result in a higher percentage of straight time activity with resultantly small increase in overall-earnings, making it relatively immaterial to the worker whether he does, or does not, exert maximum effort while on incentive work.

9. Inadequate planning, scheduling, supervision, and control, such that the worker is "forced" into considerable delay time waiting for prints, specs, tools, material, instruction, inspection, etc.

The real significance of the above analysis is that the time standards appear to be too "loose", in view of the present condition of 135% earnings at only 80% productivity. A possible reason for the standards being this loose is that they are set relatively early after a part goes into production, many times on the first run. Then, unless there is a method change, contract dictums prevent re-study, and even if there is a method change only the affected element can be re-studied. This applies to formal method changes instituted by management. However, as indicated by the "learning curve" of Chart 11.1.2-3,

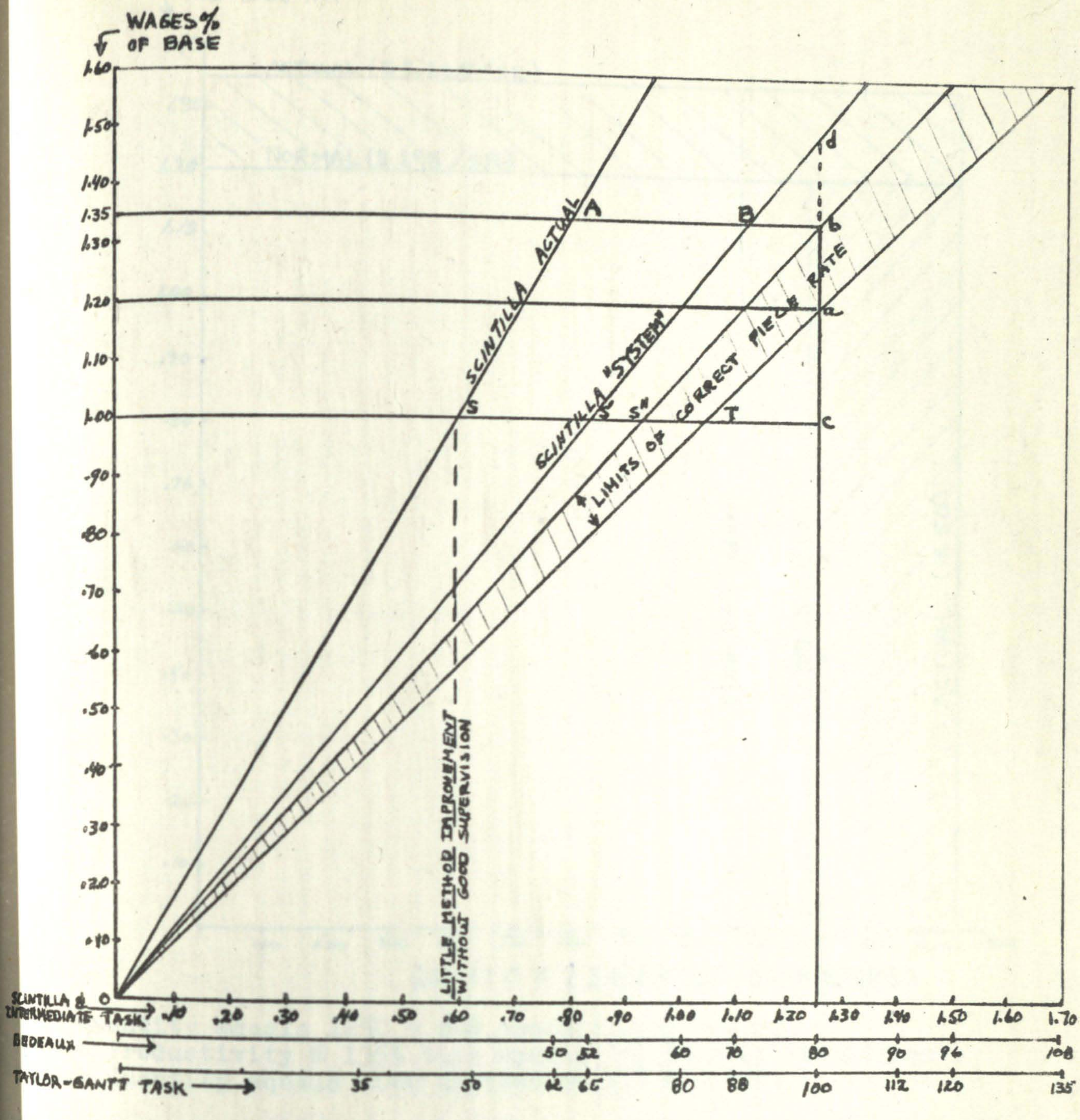
Figure 1, the operator after the first runs when the time study was made continues to reduce the time required per unit as a function of his familiarity and habit with the work. Also, there is probably a large amount of work simplification in motion patterns and the like adopted informally by the worker that in essence changes the "method." But these informal method changes are not evaluated by management except in the cases of excessive earnings, primarily because the motion patterns of the work station method were never standardized in the first place--only "measured" at inception. Thus standards might be tight or good when initially set, but they rapidly become loose due to learning and informal method changes.

Chart 11.8.2.2-4, taken from "Job Evaluation Methods," second edition, by C. W. Lytle, shows how a correct incentive rate should be set. On the Taylor-Gantt scale, locate the points 74 @ 100% base rate and 83.3 @ 100% base rate. Extend lines through these points to the origin. Lytle says "certainly all good piece rates should pass between these limits." Now on the chart the Scintilla "system" line is drawn by locating the point 100 (on intermediate task equivalent to a Taylor Task of 80) @ 120% base pay, and extending to the origin. It can be seen that the system as designed has too loose a task and too steep a pay slope. Finally, draw the "actual" condition line by locating the point 80 (80% productivity) on intermediate task @ 135% of base pay actual earnings, and extend to the origin. the pay slope is even steeper and the task even looser. In fact, at point S, where the line intersects the 100% base pay line, a vertical line to the abscissa gives a Taylor task of only .60. In this range, Lytle describes the condition as being without good supervision and with little method improvement. This correlates with what has been said before. Method study at Scintilla predominantly emphasizes machines with little attention to operator work simplification and standardization, and the supervisors have so many planning and control responsibilities that direct operator supervision is inadequate.

Variance Analysis. Chart 11.8.2.2-5 is nearly self explanatory, based on the premise of Chart 11.1.2-3, Figure 3. Costs are represented areas in the diagram. Thus normal costs would be 1000 operators x $1.98/hour. The basic data used in developing the chart is listed in the beginning of this section.

Under ideal conditions, the unfavorable spending variance would be balanced by a favorable efficiency variance, as shown by the difference between the expected quantity of 890 and the normal quantity of 1000. This is the concept of

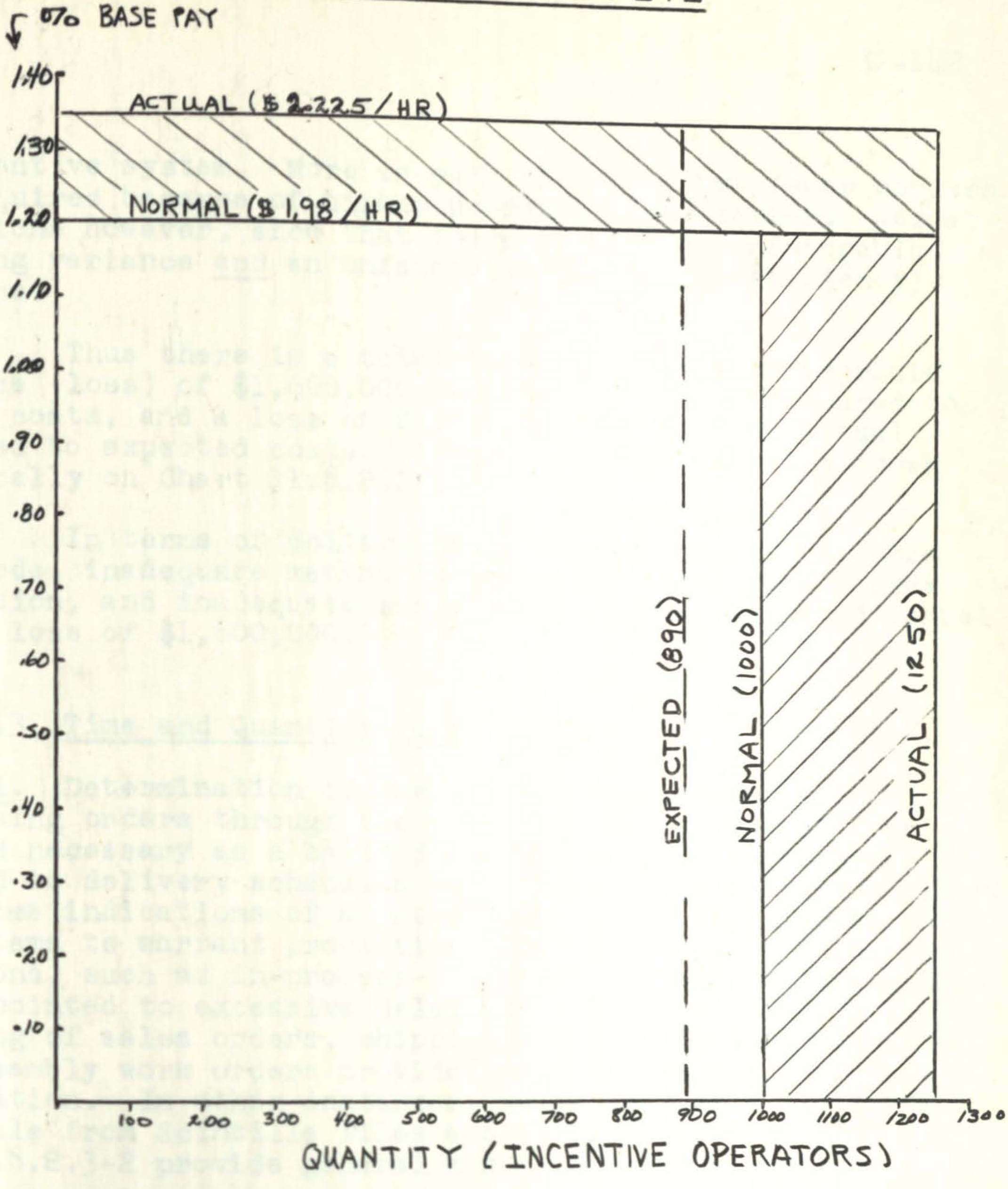
INCENTIVE LABOR PERFORMANCE



S"T	Standardized conditions and operations.
SS"	Unstandardized conditions and operations.
ab	Limits of correct piece rate.
bd	Scintilla increment over base (50% built in) to hold skilled operators at high task.
Point A:	Locator of actual present conditions(135%pay-80% productivity).
Point S:	Performance point indicative of little methods improvement and without good supervision under actual present conditions.

CHART 11.8.2.2-4

INCENTIVE LABOR VARIANCE ANALYSIS



Normal Quantity equals 1250 x 80% productivity = 1000.
Expected Productivity @ 135% base equals 112.5% (see tabulation).
Expected Quantity equals 1000 divided by 112.5 = 890.

Variance From Normal:
Spending Variance (2.225-1.98) x 1250 x 2000 = $610,000/year
Efficiency Variance (1250-1000) x 1.98 x 2000 = $990,000/year
Total Variance 610,000 plus 990,000 = $1,600,000/year

Variance from Expected:
Spending Variance (2.225-1.98) x 890 x 2000 = $ 430,000/year
Efficiency Variance (1250-890) x 1.98 x 2000 = $1,420,000/year
Total Variance 430,000 plus 1,420,000 = $1,850,000/year

CHART 11.8.2.2-5

an incentive system. More is paid per hour, but fewer workers are required because of higher production per worker. Actual conditions however, show that there is both an unfavorable spending variance and an unfavorable quantity (efficiency) variance.

Thus there is a total incentive labor unfavorable variance (loss) of $1,600,000 per year of actual compared to normal costs, and a loss of $1,850,000 per year of actual compared to expected costs. These variances are also shown graphically on Chart 11.8.2.2-3.

In terms of dollars then, the net result of loose standards, inadequare method improvement, inadequate worker motivation, and inadequate supervision, is an estimated annual dollar loss of $1,600,000.

11.8.2.3 Time and Quantity Performance

General. Determination of the statistical parameters of processing orders through the manufacturing system was considered necessary as a basis for evaluation of performance related to delivery schedules and production quantities. There were some indications of a production volume high enough on some items to warrant production line techniques. Other indications, such as in-process-inventory and manufacturing lead times pointed to excessive delay and idle time. Statistical sampling of sales orders, shipping data, production contracts, and assembly work orders provided much of the necessary information. In other instances, summarized data was already available from Scintilla files and records. Charts 11.8.2.3-1 and 11.8.2.3-2 provide general manufacturing information.

Performance. The data tabulated in Chart 11.8.2.3-3 and plotted as a frequency distribution on Chart 11.8.2.3-4 indicate that, of the three general categories of products, namely units, spares, and connectors, "units" take, on the average, the most time to process, which was to be expected. What was not expected was such a wide range of from one to over 10 months for each of the three categories. Further, connectors, relatively small and simple and relatively high volume as compared to units, have nearly the same average processing cycle time, i.e. 3.44 months for connectors and 3.90 months for units. As a follow up to this, Chart 11.8.2.3-5 tabulates the characteristics of order processing as to when an order was actually shipped compared to when delivery was promised. Note here that

SCINTILLA LEAD TIME CHART

PRODUCT CLASSIFICATION	PROCESSING CUSTOMER'S ORDER	MATERIAL PROCUREMENT	FABRICATING TIME ACCUMULATED	ASSEMBLE TEST AND SHIP UNITS	TOTAL LEAD TIME IN WEEKS
Aircraft & Commercial Mags except K & H	3-4	8-10	7-8	3-4	21-26
K and H Type Magnetos	3-4	8-10	2-4	3-4	16-22
Harnesses	3-4	8-10	6-8	3-4	20-26
Jet Ignition (Dynamotor)	3-4	20-24		2-3	25-31
Other Jet Ignition Units	3-4	16-20		3-4	22-28
Ignition Analyzers	3-4	8-10	4-6	3-4	18-24
Fuel Injection Units	3-4	8-10	7	3-4	21-25
Coils (cast housing)	3-4	6-8	7-8	3-4	19-24
Coils (tubular housing)	3-4	8-10	4-6	1-2	16-22
Ignition Analyzer Breaker	3-4	10-12	6-7	2-3	21-26
Vibrators	3-4	8-10	6-8	3-4	20-26
Switches (using castings)	3-4	6-8	6	3-4	18-22
Switches (all others)	3-4	4-6	6	1-2	14-18
Connectors	3-4		3-6	2-4	8-14

Chart 11.8.2.3-1

MANUFACTURING DATA

Order Processing Time thru Sales: Receipt Date to Digest Listing Date

Days	No. Orders
0	1
1	2
2	3
3	4
4	6
5	6
6	4
7	5
8	3
9	1

Mean = 4.75 Days

Engineering Processing Time (averaged from Production Engineering Coordination New Project reports) is about 64 days. Estimated percentages of orders that go thru Engineering (estimates from various sources) is about 10%, providing a mean estimated engineering process time of 6.4 days/order.

Average number of outstanding monthly contracts as determined from Contract Status sheets was about 12,000. Average number of contract releases and closures per month as determined from "Report of Contracts Released and Closed" was about 3,400. Thus the estimated total contract float on the floor at any one time in terms of months of orders outstanding equals 12,000/3,400 equals 3.53.

Mother Unit Standard Time Data for Connector Shells

Die Cast		Bar Stock	
Oper Code	Hrs/ 100	Oper	Hrs/ 100
24	.189	54	.435
27	.098	71	.030
74	.202	10	.796
52	.034	21	.377
35	.564	27	.367
27	.134	35	.220
45	.042	53	.330
78	.017	52	.251
30	.018	37	.365
Total	1.298		3.221

In reference to the chart at the left, the average shell mix is 60% die cast and 40% bar stock. Therefore average mother unit time equals 1.298 x .60 plus 3.221 x .40 = 2.0668 Hrs/100 = 1.24 min/pc.

Incentive Operators Performance Elements Determined in Conjunction with Utilization Sampling

Time Standard Elements	
Productive Work	55.2%
Machine Interference	7.2%
Material Handling	4.2%
Inspect Own Work	3.8%

Non Time Standard Elements	
Administrative	2.7%
Machine Adjustment	2.5%
Tool Delay	1.2%
Print/Spec Delay	2.9%
Instruction	2.9%
Wait for Inspection	1.2%
Counting Own Work	1.2%
Personal	15.0%

Chart 11.8.2.3-2

FREQUENCY DISTRIBUTIONS OF ORDER PROCESSING TIMES
AS DETERMINED BY
STATISTICAL SAMPLING OF ORDER/SHIPPING DATA

Month in which Shipped After Firm Order Receipt	P.I.C.		UNITS		SPARES		TOTAL	
	No. of First Shipments	No. of Last Shipments	No. of First Shipments	No. of Last Shipments	No. of First Shipments	No. of Last Shipments	No. of First Shipments	No. of Last Shipments
1	3	2	8	3	18	11	29	16
2	16	13	10	6	22	16	48	35
3	7	6	5	9	4	7	16	22
4	4	3	5	6	1	3	10	12
5	2	2	4	4	0	2	6	8
6	0	2	2	5	1	3	3	10
7	1	2	0	3	0	2	1	7
8	0	2	2	1	0	1	2	4
9	0	1	1	0	0	1	1	2
10	0	0	1	1	0	0	1	1
MEAN (months)	2.7	3.6	3.4	4.1	1.8	2.9	2.6	3.5

Month in which Shipped After Firm Order Receipt	SHIPMENTS (TOTAL)		
	P.I.C.	UNITS	SPARES
1	5	10	23
2	18	16	33
3	14	15	23
4	11	11	11
5	12	10	5
6	9	8	3
7	5	2	4
8	4	2	2
9	3	2	1
10	1	2	0
11	0	1	0
MEAN (months)	3.44	3.90	2.83

This means, for example, that on the average it can be expected the first shipment on any connector order will go out in 2.7 months and the last shipment in 3.6 months after receipt of the firm sales order. The overall mean for all connector order process times is 3.44 months.

Chart 11.8.2.3-3

FREQUENCY DISTRIBUTIONS OF ORDER PROCESSING TIMES

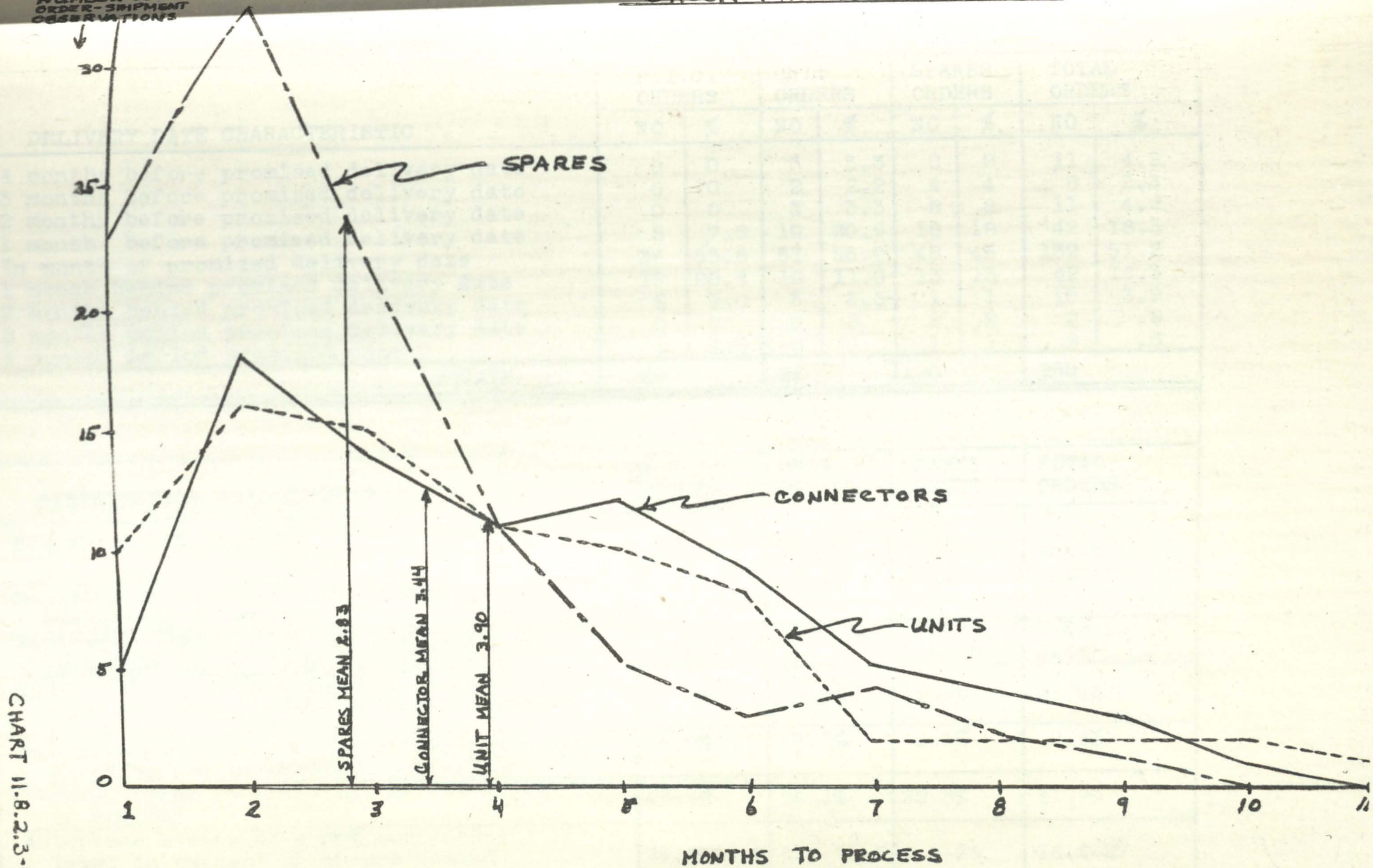


CHART 11.8.2.3-4

CHART 11.8.2.3-4

DISTRIBUTION OF PROMISED VS ACTUAL DELIVERY DATES AS DETERMINED BY STATISTICAL SAMPLING OF ORDERS AND SHIPMENTS

DELIVERY DATE CHARACTERISTIC	P.I.C. ORDERS		UNIT ORDERS		SPARES ORDERS		TOTAL ORDERS	
	NO	%	NO	%	NO	%	NO	%
4 months before promised delivery date	0	0	3	3.3	8	8	11	4.2
3 months before promised delivery date	0	0	2	2.2	4	4	6	2.3
2 months before promised delivery date	0	0	3	3.3	8	8	11	4.2
1 month before promised delivery date	5	7.5	19	20.9	18	18	42	16.3
In month of promised delivery date	36	53.6	51	56.0	45	45	132	51.2
1 month behind promised delivery date	19	28.4	10	11.0	13	13	42	16.3
2 months behind promised delivery date	6	9.0	3	3.3	1	1	10	3.9
3 months behind promised delivery date	0	0	0	0	2	2	2	.8
4 months behind promised date	1	1.5	0	0	1	1	2	.8
TOTALS	67		91		100		258	

DISTRIBUTION CHARACTERISTIC	P.I.C. ORDERS	UNIT ORDERS	SPARES ORDERS	TOTAL ORDERS
X(mean of the numerical distribution, in mos.)	.45 behind	.30 ahead	.53 ahead	.20 ahead
Standard Deviation of the numerical distribution, in months.	.985	1.05	1.57	1.34
Tolerance limits at a 95% confidence level in months ahead to months behind.	1.48 to 2.38	2.40 to 1.8	3.67 to 2.6	2.88 to 2.48
p(mean of percentage distribution in percent of orders behind promised delivery date)	38.8%	14.3%	17.0%	21.8%
Standard Deviation of the percentage distribution in absolute percentage	6.0%	3.7%	3.8%	2.6%
Percent error possible in "p" (accuracy of sample)	15.5%	26.4%	22.3%	11.9%
Tolerance limits at a 95% confidence level in percent of orders behind promised delivery.	26.8-51.0	6.9-21.7	9.0-25	16.6-27

Chart 11.8.2.3-5

connectors were the only general category that was, on the average, behind schedule, and by an amount of .45 months out of a total processing time of 3.44 months. If the scheduled date is considered as a "standard" of performance then in this category there was a 13.1% variation from standard. Taken percentage wise, 38.8% of all connector orders were behind schedule. This condition, plus the long processing cycle time, and considering the fact that connectors represent over 20% of the total sales volume and have a relatively high ratio of "direct costs," led to the decision to emphasize plug-in-connectors in the manufacturing study. Further data was collected on the basis of this decision.

Chart 11.8.2.3-6 shows a frequency distribution of P.I.C. delivery date variance, promised versus actual, the mean being .45 months behind schedule. This variance, in connection with the positive skewness of the distribution and the large range and deviation is interpreted to mean loose control, excessive processing difficulties, or promised delivery dates (estimates) that are not realistic or consistent with the performance standards. It is suggested that with tighter control, a distribution with a smaller deviation and without skewness would result, with a mean of zero months variance. This distribution is indicated by dotted lines as the "expected actual" on the same chart. A small percentage of orders would be late under these conditions. Another distribution, indicated by dotted lines as "desirable" portrays the conditions wherein only an insignificant number of orders would be behind schedule as a result of randome chance causes, and the small deviation is indicative of very close adherence to schedule dates. Charts 11.8.2.3-7 and 11.8.2.3-8 provide additional data relative to the manufacture and assembly of plug-in-connectors.

An abstract of the pertinent data related to the time and quantity performance of the plant is as follows:

1. Scintilla lead times vary from 16-22 weeks for K&H Magnetos to 25-31 weeks for jet ignition units with dynamotors, the average for all units being 20-25 weeks. Of this, 3-4 weeks is for material procurement, 6-7 weeks for accumulated fabrication time, and 3-4 weeks for assembly, test, and shipping.

2. Units, spares, and total orders are delivered ahead of schedule on the average, but 38.8% of the connector orders are behind schedule.

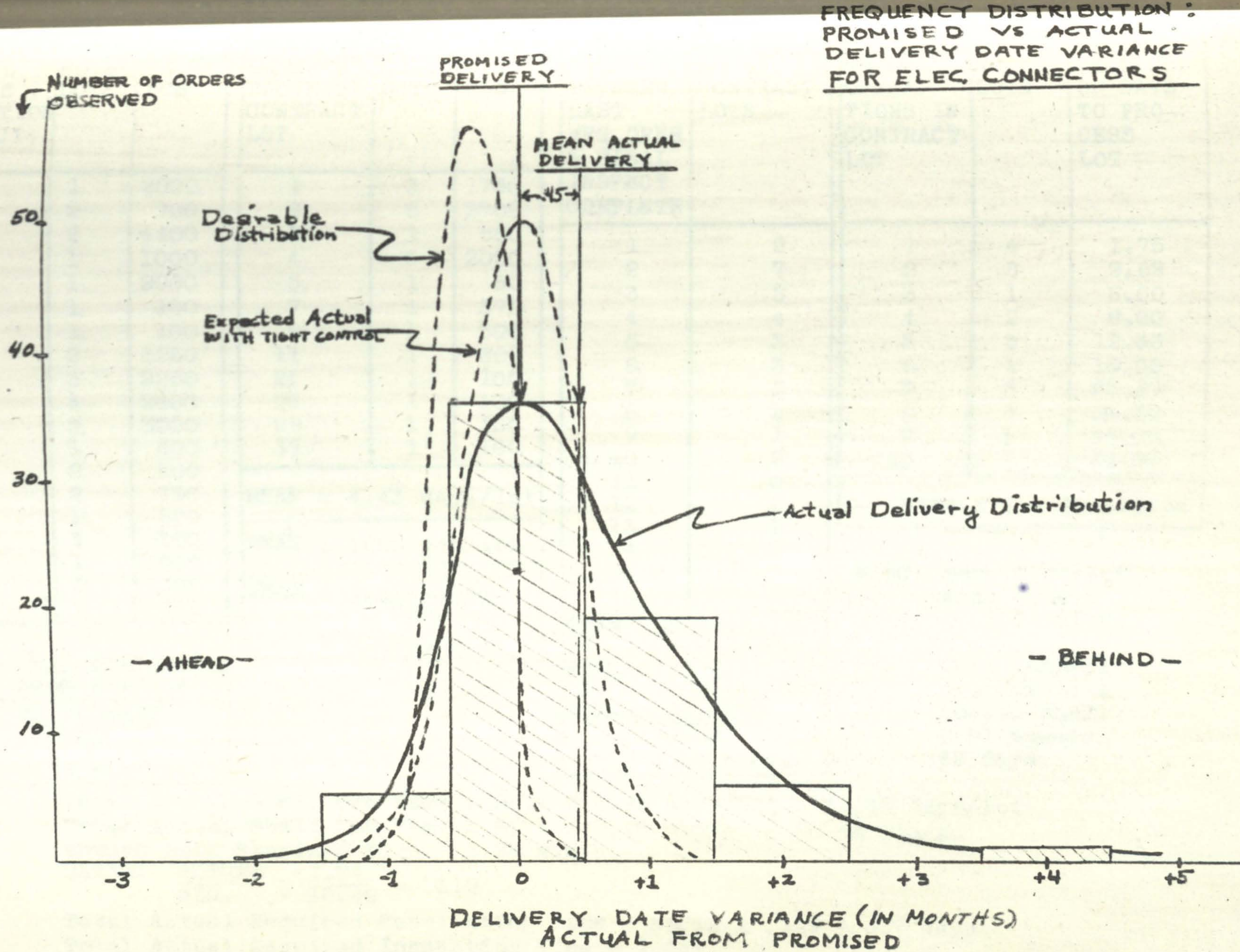


CHART 11.8.2.3-6

CHART 11.8.2.3-6

BASIC SHELL FABRICATION

DAYS TO PROCESS PRODUCTION CONTRACT-LOT	NO. of LOTS	NO. of PCS
2	1	2000
3	2	700
6	2	4400
10	1	1000
11	1	2000
22	1	100
26	1	100
30	2	1250
35	3	2250
37	4	2600
38	2	3000
39	1	500
40	2	500
42	2	750
46	1	500
51	1	100
55	1	1000
56	1	1000
59	1	1000

MEAN = 26.7 days/lot

MEAN = 2200 pcs/lot

MEAN = $\frac{26.7 \times 12 \times 60}{2200}$ = 8.74 min/pc.

SHELL MODIFICATION FABRICATION

DAYS TO PROCESS CONTRACT-LOT	NO. of LOTS	NO. of PCS
1	3	1750
2	5	2700
3	1	500
4	3	2000
5	1	50
7	1	370
9	1	500
11	1	300
21	1	100
26	1	100
29	1	100
31	1	100

MEAN = 4.43 days/lot

MEAN = 1900 pcs/lot

MEAN = $\frac{4.43 \times 12 \times 60}{1900}$ = 1.68 min/pc

INSPECTION

DAYS BETWEEN LAST MFG OPER & FINAL INSPECT COMPLETE	NO. of CONTRACT-LOTS
1	2
2	7
3	5
4	4
5	3
6	3
7	5
8	2
9	1
10	2
11	0
12	1
13	1
14	0
15	0
16	1

MEAN = 5.5 days/lot

MEAN = 2100 pcs/lot

MEAN = $\frac{5.5 \times 12 \times 60}{2100}$ = 1.89 min/pc

OPERATIONS PER CONTRACT

NO. of OPERATIONS IN CONTRACT-LOT	NO. of LOTS	MEAN NO. OF DAYS TO PROCESS LOT
1	4	1.75
2	8	2.62
3	1	5.00
4	2	8.00
5	3	12.33
6	1	16.00
7	3	23.67
8	3	30.00
9	5	35.00
10	1	38.00

MEAN = 4.9 Operation

MISC: Mean Contract size equals 10,300 units.

Mean Contract process time (basic shell fab) equals 42 days.

Total Actual Shell Fab Time = 26.7 + 4.43 days/lot = 31.13 days/lot
Total Actual Shell Fab Time = 8.74 + 1.68 min/pc = 10.42 min/pc
Mother Unit Standard Time = 1.24 min/pc
Ratio: $\frac{\text{ACTUAL}}{\text{STD.}} = \frac{1.24}{10.42} = .119$
Total Actual Required Fabricating Time = 31.13 x .119 = 3.7 days.
Total Actual Required Inspection Time = 1 day.

Chart 11.8.2.3-7

P.I.C. ASSEMBLY DATA
AS DETERMINED BY
STATISTICAL SAMPLING OF WORK ORDERS

DAYS FROM W.O. RELEASE TO ASSY. COMPLETION	NO. OF ORDERS
1	60
2	41
3	38
4	27
5	48
6	35
7	30
8	24
9	7
10	4
11	4
12	6
13	8
14	5
15	10
16	7
17	4
18	2
19	0
20	3
21	5
22	2
23	1
24	0
25	0

MEAN EQUALS 5.86 days, the number of days a work order is on the floor until assy. is completed.

DATE	NO. OF P.I.C. UNITS ASSEMBLED	NO. OF P.I.C. ORDERS COMPLETED
3/1/57	25,231	351
3/4/57	30,206	410
3/5/57	25,472	349
3/6/57	29,056	393
3/7/57	28,439	401
3/8/57	27,164	374
3/11/57	24,088	348

AVERAGE EQUALS 27,100 units/day

AVERAGE EQUALS 375 orders/day

AVERAGE EQUALS 72 units/order

NO. OF ORDERS IN "SETS" OF THE SAME UNIT	AVG. NO. OF SETS DAILY	TOTAL ORDERS REPRESENTING DUPLICATE (SIMILAR) UNITS
2	27	54
3	3	9
4	5	20
5	2	10
6	3	18
7	1	7
8	1	8
9	1	9
	TOTAL	135

% Duplication = 135/375 = 36%

RELEASES 1 MONTH BEFORE SCHED SHIP'T		RELEASES IN MONTH OF SCHED SHIP'T		RELEASES 1 MONTH AFTER SCHED SHIP'T		RELEASES 2 MONTHS AFTER SCHED SHIP'T		RELEASES 3 MONTHS AFTER SCHED SHIP'T	
NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
164	45.8	158	44.1	26	7.3	8	2.2	2	.6

Since those releases in the month of schedule shipment take an average of 5.86 days to complete, those issued within the last 6 days of the month are in effect released in month after scheduled shipment since they will not be completed in time. 6 days divided by 22 days times 44.1% equals 12.25%. Then total behind-schedule releases equal: 12.2 + 7.3 + 2.2 + .6 = 22.3%

MISC.

1. No. of persons assigned to assembly equal 155.
2. Min per piece = $\frac{155 \text{ operators} \times 8 \text{ hrs/oper} \times 60 \text{ min/hr}}{27,100}$ = 2.74
3. Avg. No. of persons per assy. line is 10.

Chart 11.8.2.3-8

3. The range of processing times, actual, is from 1 to 10 months for all products. Connector average is 3.44 months.

4. The range of delivery date variance (promised versus actual) for connectors is from 1 month ahead to 4 months behind schedule.

5. The average time a connector lot is "on the floor" is only 43 days (31 for component fabrication, 6 for assembly, and 6 for inspection) out of a total cycle time of 3.44 months, giving rise to the assumed probability that much of the delay time is external to actual manufacture and results from procedures and policies rather than manufacturing difficulties.

6. For the 43 days on the floor, the following conditions exist for the average lot of 2200 connectors:

   Required component fabrication time = 3.7 days
   Required inspection time = 1 day
   Required assembly time =

   $$\frac{2.74 \text{ min/pc} \times 2200 \text{ pcs}}{60 \text{ min/hr} \times 12 \text{ hrs/day} \times 10 \text{ oper/line}} = .84 \text{ days}$$

   Total required manufacturing time =
   $3.7 + 1.0 + .84 = 5.54$ days

   The interpretation here, of requiring only 5.54 days of actual working time out of a total available of 43 days, is that there is much delay between operations and sitting in tote boxes at the work stations waiting for processing. If true, it would be expected that there would be a high in-process-inventory. If this condition is assumed to be correspondent to products other than connectors, then it is in fact born out by the data showing 3.53 months of total contract "float" on the floor. In addition, the in-process-inventory has been estimated at three and a half million dollars.

7. Present average connector production is 27,100 per day.

8. About 22% of the connector assembly work orders are released to the floor after promised delivery date, in other words, already behind schedule.

9. There is a 36% "similarity" or duplication of assembly orders. That is, about every third order going through the assembly

line is a repeat of one that has already gone through that day. Interview statements from the foreman further indicated that these similar orders were not taken in sequence, rather that there was a complete "mix" of all orders, each being in its own box and put into the line independently of any other.

Delivery date variance then, appears to be a cumulative function. Too much time is spent in sales, planning, and procurement in processing of the order and more time than necessary is taken in actual manufacturing processing. Changes in policies and procedures can reduce idle-delay time in the former instance. A suggested procedure change is to have a "Master Scheduling" function under the Chief Planner which allocates time to all the various involved activities, before the order reaches the floor. A further change in policy is to increase the level of raw stores and hence reduce "procurement" time. The risk factor for raw material is not nearly so critical as for finished goods or components, and raw stores could justifiably be carried on a forecast basis, particularly if manufacturing cycle time were minimized.

In the second instance, excessive actual manufacturing time appears to be caused by inadequate scheduling and insufficient control. The fact is that control is not exerted until late in the cycle period under the procedure where expediters begin checking on a contract at a certain time interval from its scheduled completion. If excessive delay has occurred up to this point, no amount of expediting can correct the situation. The more operations necessary on a contract the more possibility for getting out of control. This is illustrated by the graph of Chart 11.8.2.3-9 which shows that there is a fairly linear relationship between time and number of operations up to three operations. From three to nine operations the curve becomes nearly exponential, indicating a geometric time interval for each successive operation. The interpretation is that no control is exerted in this area, that there is no positive dispatching between operations, or even any scheduled completion at each operation. At operation 9, the curve begins decreasing in slope, showing where the expediters appear to come into the picture and bring the operations back under control.

The solution is more detailed scheduling and more positive processing of the work. The question is how much more? A realistic solution would be a central scheduling activity, in conjunction with dispatching and progressing procedures that would schedule not only the contract itself, but each incremental

CONTRACT PROCESS TIME AS A FUNCTION OF THE NUMBER OF CONTRACT OPERATIONS, FOR P.I.C. SHELLS

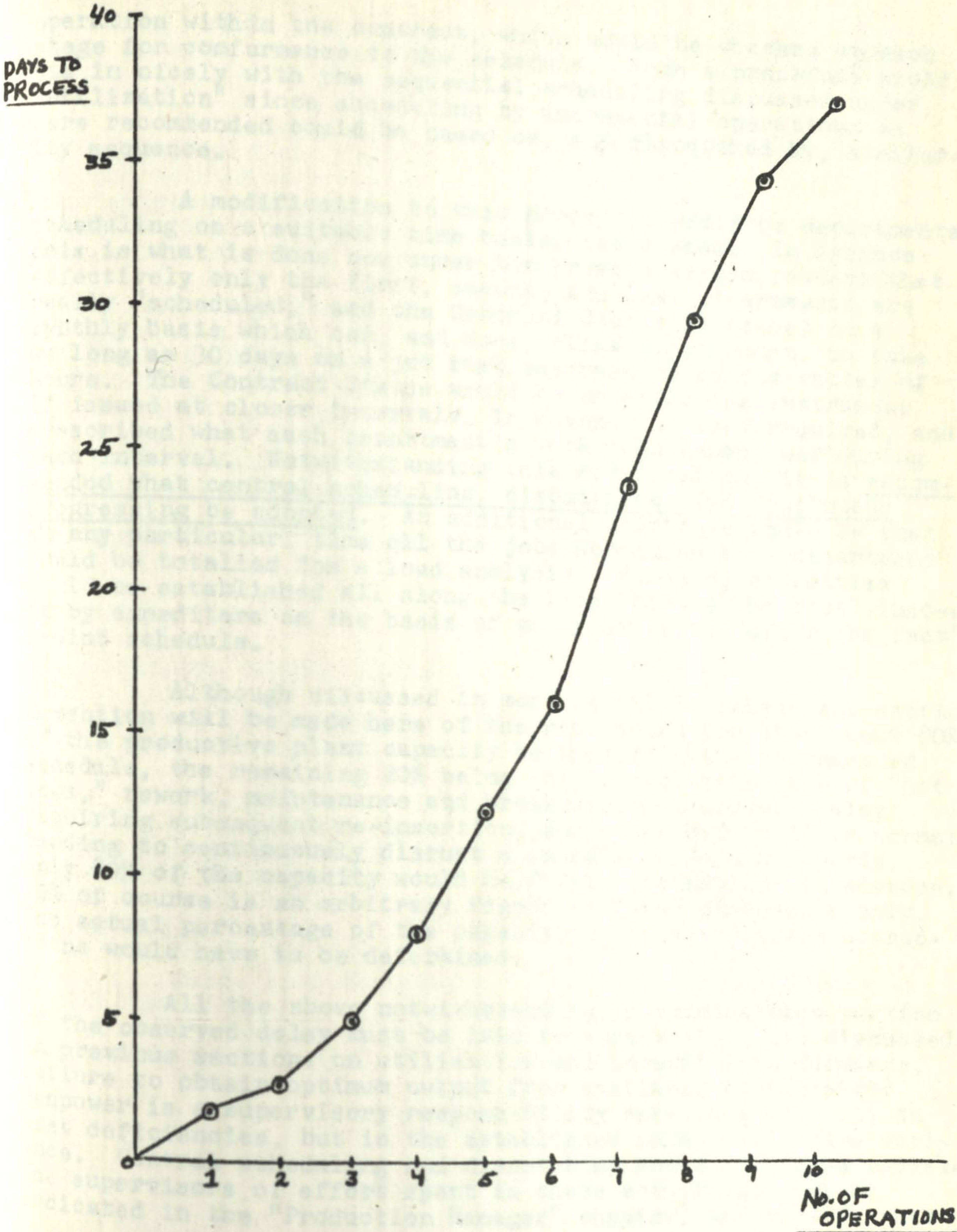


CHART 11.8.2.3-9

operation within the contract, which would be checked at each stage for comformance to the schedule. Such a procedure would tie in nicely with the sequential scheduling discussed under "utilization" since shceduling by incremental operations as here recommended could be based on, and dispatched by, similarity sequence.

A modification to this procedure would be departmental scheduling on a suitable time basis, say a week. In essence this is what is done now under the present system, except that effectively only the first, second, and last departments are really "scheduled," and the Contract Status is issued on a monthly basis which can, and does, allow a department to take as long as 30 days on a job that may require only a matter of hours. The Contract Status would be an effective instrument if issued at closer intervals, in advance of work required, and prescribed what each department's work requirement was during each interval. Notwithstanding this modification, it is recommended that central scheduling, dispatching, and continuous progressing be adopted. An additional advantage would be that at any particular time all the jobs scheduled to a department could be totalled for a load analysis. Further, priorities could be established all along the line "before the fact" instead of by expediters on the basis of an order being "after the fact" behind schedule.

Although discussed in more detail in subsequent sections, a mention will be made here of the recommendation that about 80% of the productive plant capacity be frozen to the recommended schedule, the remaining 20% being utilized to take care of "hot jobs," rework, maintenance and breakdown, procurement delay requiring subsequent re-insertion, and other difficulties normally tending to continuously disrupt a schedule. In other words, only 80% of the capacity would be firmly "scheduled" in advance. 20% of course is an arbitrary figure used for discussion only. The actual percentage of the capacity utilized by these disruptions would have to be determined.

All the above notwithstanding, a considerable portion of the observed delay must be laid to supervision. As discussed in previous sections on utilization and incentive performance, failure to obtain optimum output from available machines and manpower is a supervisory responsibility resulting not only in cost deficiencies, but in the established unfavorable time variance. Central scheduling and dispatching would of course relieve the supervisors of effort spent in these activities (32% as indicated in the "Production Manager" chapter) and provide them with more time for direct supervision. Positive progressing would provide a better check on the effectiveness of the supervision.

It is essential that work methods and work-place layout be standardized and that subsequent time standards developed thereon be actively used to plan and schedule rather than for wage payment alone as is the present case. Additionally these considerations would do much to reduce cycle time and minimize the number of orders completed after promised delivery date:

1. Methods improvement.

2. Product and/or manufacturing standardization with an adequate product classification system as the first step (see the Engineering chapter).

3. More consolidation of orders and increased lot-size to reduce set-up/tear-down and other indirect delays.

4. Separation of high-volume products from low volume products, as presently "mixed", and adoption of certain production line techniques (or semi-production line) for the high volume items in conjunction with 2 and 3 above.

5. Effective worker motivation.

6. A review of procedures toward reducing time presently taken by purely administrative processing of orders.

The importance of meeting delivery dates and of having short cycle times must again be emphasized. As pointed out in conjunction with product cost and quality, the time element and reliability of a supplier are prime considerations of customer relations, even influencing how much he is willing to pay for the product.

Aside from customer considerations, a large amount of capital is tied up in in-process-inventory. This inventory can be reduced in almost direct proportion to any reduction in manufacturing cycle time.

11.8.3 PLUG-IN-CONNECTORS, PRESENT PROCESS.

As noted throughout the manufacturing report, plug-in-connectors proved to be the Scintilla product that offered the greatest oportunity for beneficial results for both the investigating group and for the company. The present method of manufacture is presented through the use of the following flow diagrams and tables of data.

11.8.3.1 PROCESS FLOW CHART.

PROCESS OR OPERATION ANALYSIS CHART
PRODUCT PROCESS FLOW CHART

PROCESS: Manufacture of Electrical Connector — PRESENT METHOD

TIME Min.	DIST. Ft.	SHELL	O □ o ∇	O □ o ∇	INSERT	DIST. Ft.	Hrs. Min.
		In storage, bar stk			Raw rubber stock		
	87	Transport to the Gridleys, dept 26			Transport to cutting bench	450	
		Awaits set up (Oper. 541)			Cut material & weigh on scales		
.428		5 operation set-up to make shell			Awaits transfer to machine		
		Machine feed to tote box			To molding machine	18	
		Operator inspected			Awaits operation 241		
		Placed in 2nd tote box			Apply feed to part mold & catch card		
	20	Transferred to 3rd tote box			Remove bottom of mold to bench		
		Awaits completion			Assy two plates by hand		
	75	Transport to crib			Lube & blow dry as necessary		
		Stored in crib			Remove plate, assy mld.& slide to prs		
		Weighed			Assy 1 plate to mld & slide to prs		
		Placed in specific order in tote box			Rmve. card from pot w/hsd & t/a to tub		
		Awaits transport to dept 48.			Fold over & insert to pot, engage feed		
	930	Transport to dept. 48			Remains in mold predetermined tm.		
		Awaits machine time			Throw lever to drop pot mv. to bnch		
.20	5	To hammond buffer (Oper. 711)			Remove plate w/2hsd's & l/a		
		Awaits operator			Slide mold to stripper		
		Transfer stock to pin board			Transfered to tote box		
		Get pc. from pin board			Awaits completion of lot		

PRODUCT PROCESS FLOW CHART (CONT.) SHEET NO. 2

PROCESS: Manufacture of Electrical Connector — PRESENT METHOD

TIME Min.	DIST. Ft.	SHELL (Cont.)	O	□	o	∇	O	□	o	∇	INSERT (Cont.)	DIST. Ft.	Hrs. Min.
		Grease wheel flange									Transferred to inspection bench	20	
		Dispose of piece on pin board									Await inspection		
		Transfer to tote box & await handl.									Inspected		
	125	To Natco Semi-Automatic drill									Awaits transfer to tumbling		
.482		Awaits operator (Op. 111)									Transferred to tumbling (oper. 741)	30	
		Transfer to pin bd.									Awaits tumbling		
		Get piece from machine table									Tumbled in CO2 tumbler with wood		
		Load in jig - close with lever									Out of tumbler to tote box		
		Engage feed with button switch									Stored in tote box at tumbler		
		Drill four holes in flange									Transferred to burr bench	30	
		Pick up previous drilled piece									Stored at burr bench		
		Burr four holes-(by hand)									Transferred in small lots to bnch		
		Dispose of piece on pin board									Awaits oper. 271		
		Store on machine table									Shear off lip remaining aft.tumbl.		
	62	Transfer to dept Storage									To finished work chute		
.53		Awaits oper. 211									Stored at bench in tote box		
		To 8 station broach press									Transferred to Kahle Singe.mach.	25	
		Stored at machine									Awaits oper. 278		
		Pick up piece									Transferred to table by operator		
		Position in adaptor									Stored on table		
		Position adaptor in die, secure									To machine - singed		
		Apply oil to 8 punches with brush									To finished work chute		
		Trip pedal - 1st broach release									Stored in tote box until full		
		Lever index die to next broach									Transfer tote box to cure rack	20	
		Release lever, return die to next									Awaits oper. 281		
		Swing lever, remove adaptor from die									Cured in LN homo furnace		
		Remove piece from adaptor									Transferred to tote box		
		Transfer to pin bd									Stored in tote box		

PRODUCT PROCESS FLOW CHART (CONT.) SHEET NO. 3

PROCESS: Manufacture of Electrical Connector — PRESENT METHOD

TIME	DIST. Ft.	SHELL (Cont.)	INSERT (Cont.)	DIST. Ft.	Hrs. Min.
		Awaits completion of lot	To inspection bench	37	
		Transfer to tote box	Inspected		
		Stored in tote box	Transferred to assy - dept.48	875	
		* * * Alternate method* * *	SOCKET		
		To Fellows Shaper	In storage - stock		
		Awaits oper. 211	Transport to Nat. Acme Gridleys 48	800	
		Transfer to pin board	Awaits set up - Oper. 541		
		Awaits completion of transfer	5 operation set-up to make socket		
		Get piece from pin board	Machine feed to tote box		
		Screw pc in threaded loading ring	Operator inspected		
		Start machine cut key to depth	Placed in second tote box		
		Stop machine (automatic)	Awaits completion		
		Unload piece from fixture	Transport to Mill	40	
		Dispose of piece to pin board	Awaits mach. time		
		piece stored on pin board	Place in machine hopper-auto.mill		
		Transfer piece to tote box	Mill radius (auto) Oper. 311		
		Stored in tote box	To tote box		
		* * * * * * * * * * * * *	Awaits completion of lot		
	75	Transfer to burr bench	Transfered to Tumbler	30	
.30		Awaits oper. 271	Awaits machine time		
		Transfer to pin board	Tumbled Op. 741		
		Awaits completion of transfer	Transferred to Inspection	10	
		Get piece from pin board	Inspected		
		Remove broach ring from ID, hand file	Trans. to Circo degrease equip.	20	
		Position piece on bench	Awaits mach.time		
		Burr large and small keys	Degreased		
		Dispose of piece to pin board	Trans. to dept. 32 - plating	160	
		Awaits completion of lot	Awaits mach time		

PROCESS: Manufacture of Electrical Connector — PRESENT METHOD

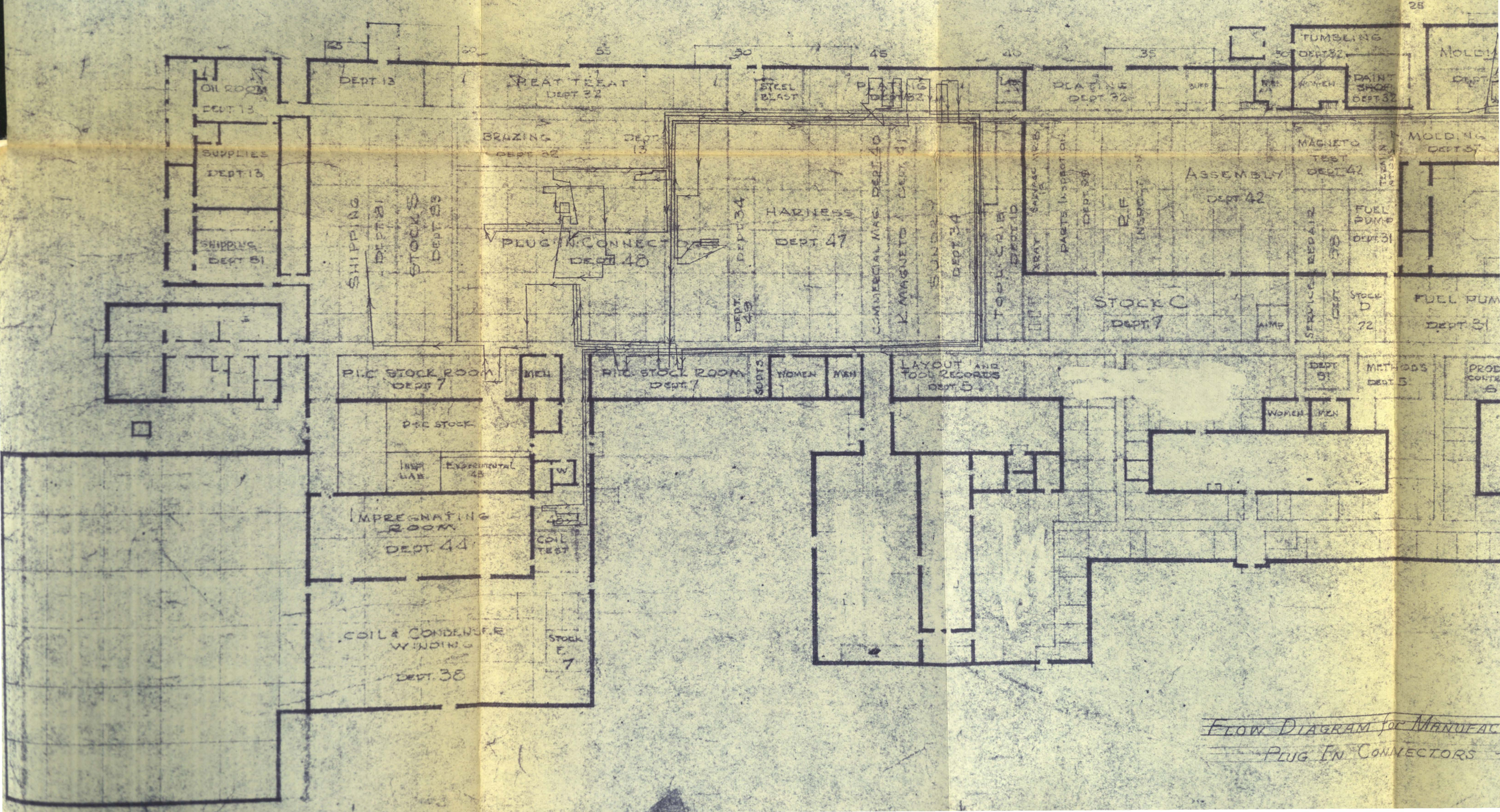
...E Min.	DIST. Ft.	SHELL (Cont.)	O □ o ∇	O □ o ∇	SOCKET (Cont.)	DIST. Ft.	Hrs. Min.
		Operator make visual inspection			Plate Oper. 301		
		Transfer to tote box			Awaits completion of lot.		
		Stored at bench awaiting transfer			Bake Oper. 251		
	35	Transfer to Cridan			Awaits completion of lot		
24		Awaits operation 351			Transport to 48A	600	
		Place box on machine tray			Fill solder op. Awaits mach.time		
		Get two pieces from box			Fill solder well Oper. 751		
		Load on arbor, one on each end			Awaits completion of lot.		
		Transfer arbor to machine			Transport to 32	600	
		Position load on mach.bring up TS			Awaits mach. time		
		Engage machine & generate thread			Clean Op. 303		
		Pick up arbor wth 2 previous pieces			Awaits completion of lot		
		Unload, transfer to pin board			Inspected		
		Awaits completion of lot			Transport to 48A	600	
		Transfer from pin board to tote box			Awaits mach. time		
		Store on tote box			Assemble & crimp spring clip Op.171		
	110	Transfer to Brown & Sharpe auto.ch.			Awaits completion		
,81		Store at B&S auto chucker(op 531)			Transport to 32	600	
		Get piece from tote box			Awaits mach.time		
		Load in threaded adaptor			Chromate Oper.306		
		Load in chuck and lock			Awaits completion of the lot		
		Engage machine (machine time 15s)			Final Inspection		
		Pick up previous pc & unload			Transport to stock	500	
		Transfer to pin board			Awaits assembly		
		Reverse adaptor with partial fin. engage machine to finish piece			PIN - SAME AS SOCKET WITH EXCEPTION OF SPRING CLIP.		
		Store on pin bd. until lot finished					
		Transfer to tote box					

PRODUCT PROCESS FLOW CHART (CONT.) SHEET NO. 5

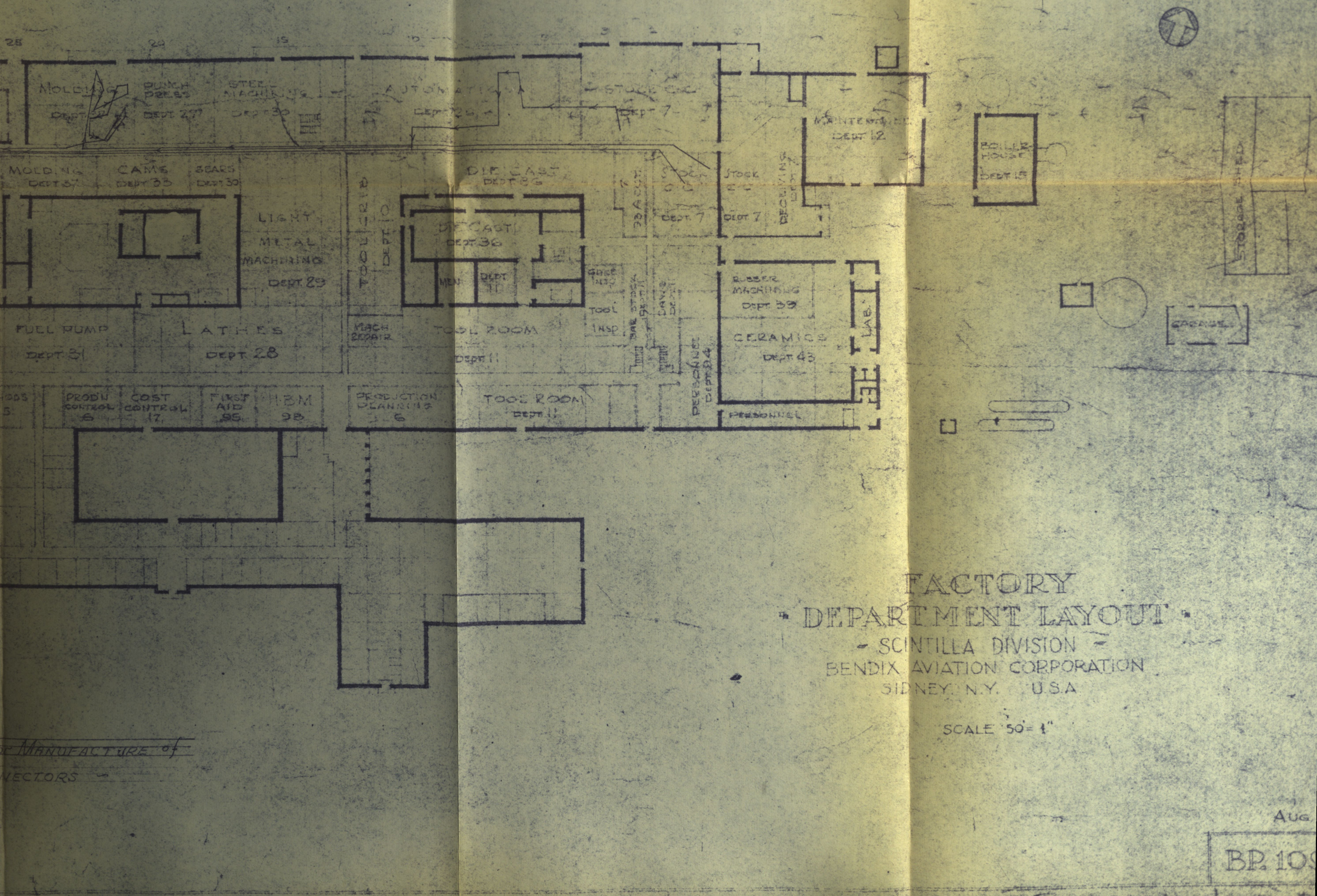
PROCESS: Manufacture of Electrical Connector

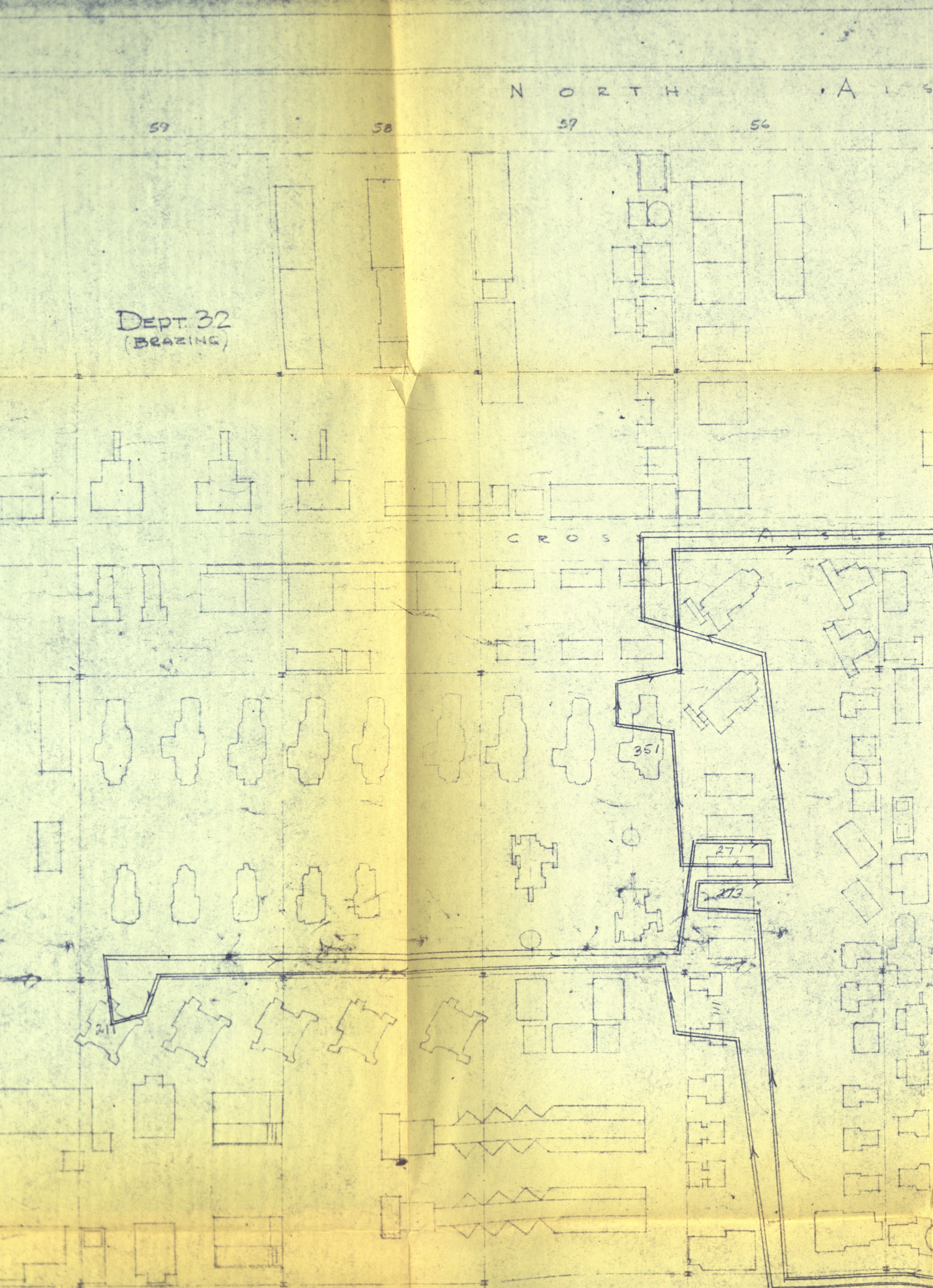
PRESENT METHOD

TIME Min.	DIST. Ft.	SHELL (Cont.)	SHELL (Cont.)	DIST. Ft.	Hrs. Min.
		Store in tote box at B.S. Chucker	Rinse		
	100	Transfer to Burr Bench	Transfer to Cadmium	4	
.35		Awaits oper. 273	Cadmium Plate (.5 hour)		
		Transfer to pin board	Transfer to rinse	21	
		Awaits completion of transfer	Rinse		
		Get piece from pin board	Transfer to wash	21	
		Burr inside diam.	Wash		
		Dispose of piece to pin board	Transfer to Iridite	21	
		Awaits completion of lot	Iridite		
		Operator make visual inspection	Transfer to rinse - H.W.	8	
		Transfer to tote box	Rinse		
		Stored at bench awaiting transfer	Transfer to oven	54	
	70	Transfer to insp.	Bake in oven - check for blister		
		Inspected	Transfer to insp.		
		Stored awaiting transfer to dep36	Final inspection		
	283	Transfer to dept. 36	Transfer to Storage	325	
.253		Stored in tote box awaiting plating	Stored awaiting assembly		
		Transfered to plating baskets	*****************		
		Stored in baskets awaiting op. 301			
	12	Transfer to wash			
		Wash			
	10	Transfer to zinc			
		Zinc plate			
	2	Transfer to rinse			
		Rinse			
	10	Transfer to copper			
		Flash copper plate			
	4	Transfer to rinse			

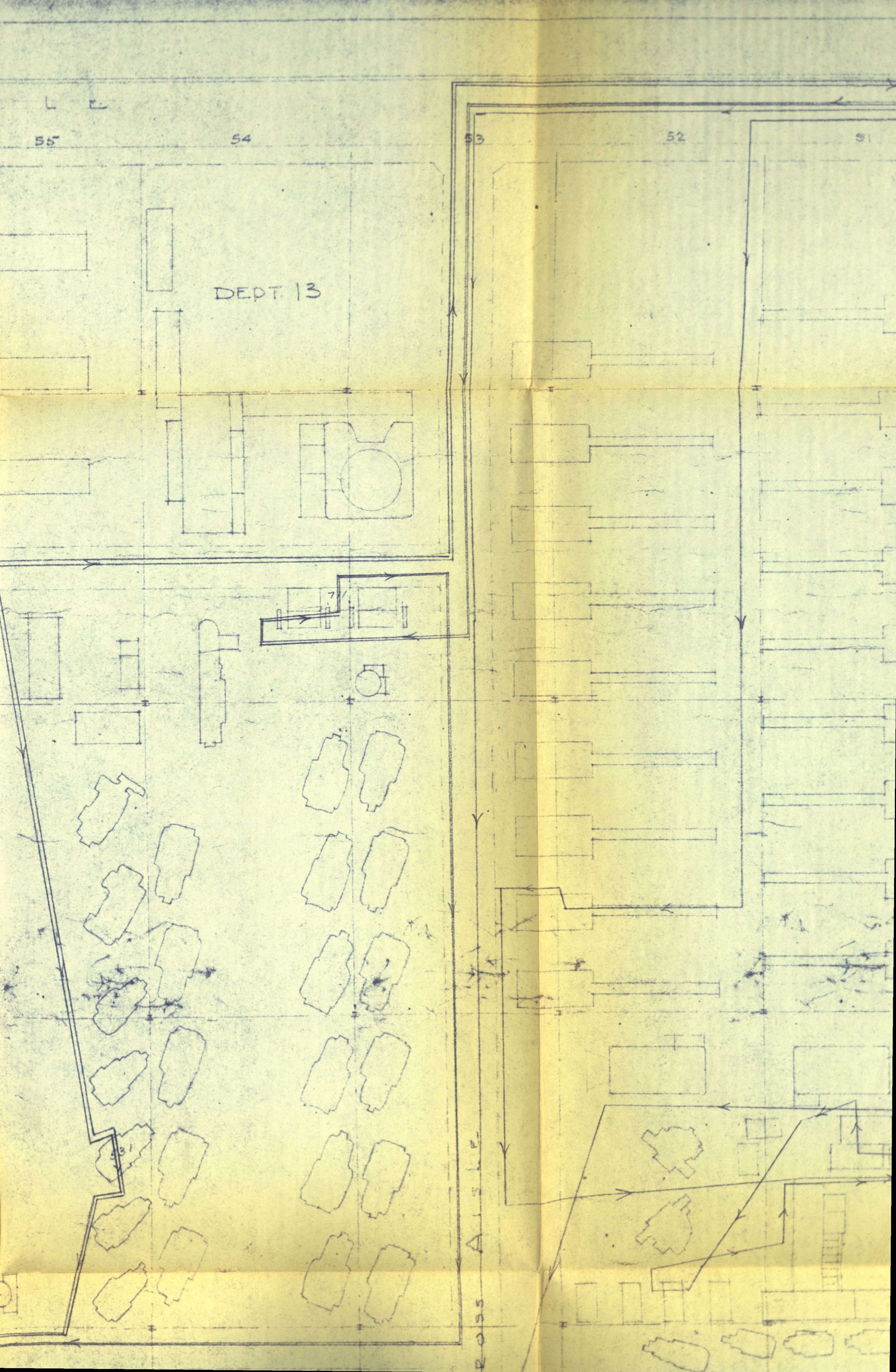


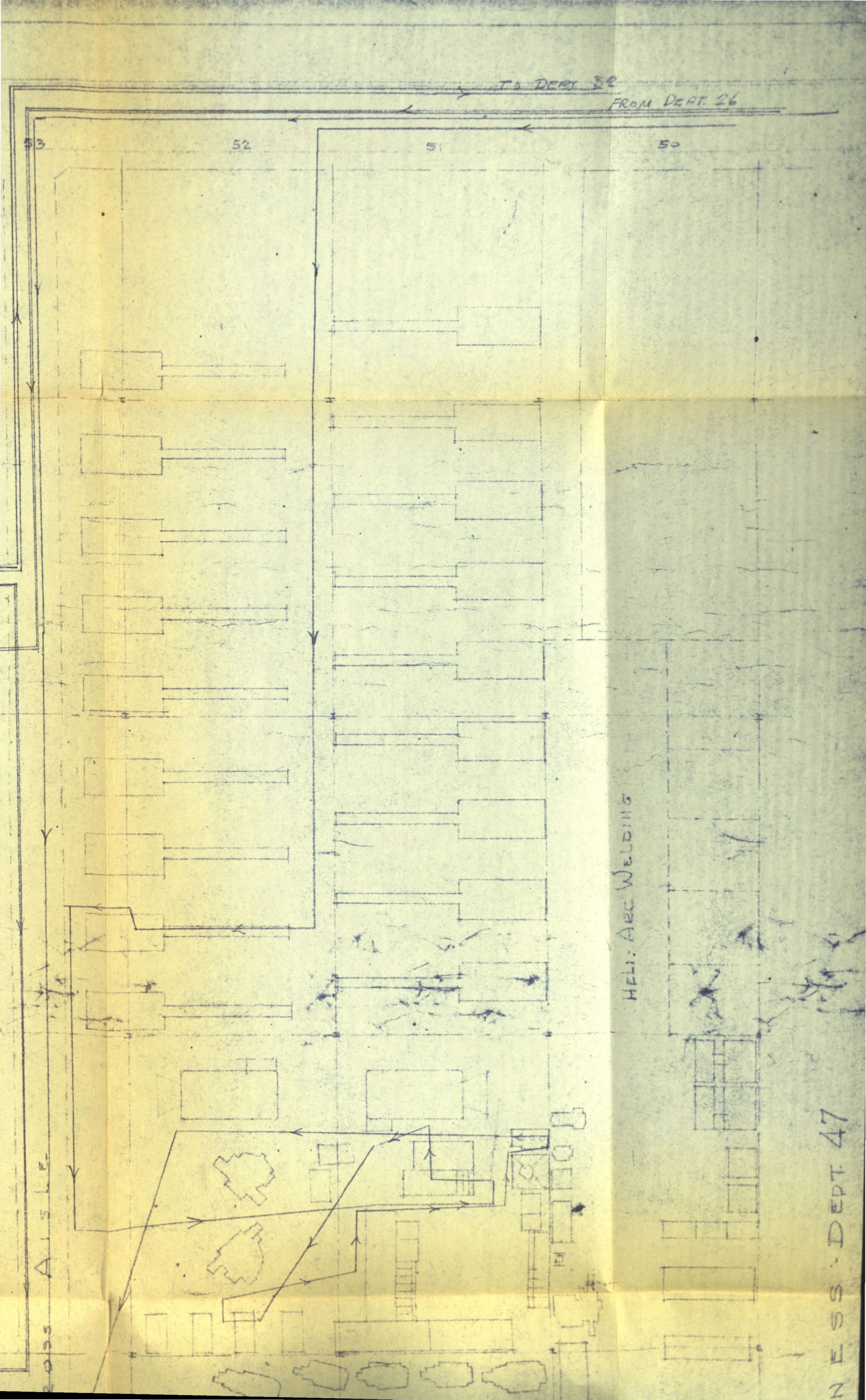
FLOW DIAGRAM for MANUFAC
PLUG IN CONNECTORS


MOLDING
PUNCH PRESS
DEPT 27
STEEL MACHINING
DEPT 30
AUTOMATIC
DEPT 26
STOCK
DEPT 7
MAINTENANCE
DEPT 12
BOILER HOUSE
DEPT 15
STORAGE SHED
MOLDING
DEPT 37
CAMS
DEPT 33
GEARS
DEPT 30
DIE CAST
DEPT 36
STOCK
DEPT 7
RECEIVING
LIGHT METAL MACHINING
DEPT 29
TOOL CRIB
DIE CAST
DEPT 36
RUBBER MACHINING
DEPT 39
CERAMICS
DEPT 43
LAB.
GARAGE
FUEL PUMP
DEPT 31
LATHES
DEPT 28
MACH REPAIR
TOOL ROOM
DEPT 11
TOOL INSP
PERSONNEL
DEPT 94
PROD'N CONTROL
6
COST CONTROL
17
FIRST AID
95
I.B.M.
98
PRODUCTION PLANNING
6
TOOL ROOM
DEPT 11
PERSONNEL
MANUFACTURE of
NECTORS
FACTORY
DEPARTMENT LAYOUT
SCINTILLA DIVISION
BENDIX AVIATION CORPORATION
SIDNEY, N.Y. U.S.A.
SCALE 50' = 1"
AUG
BP. 10

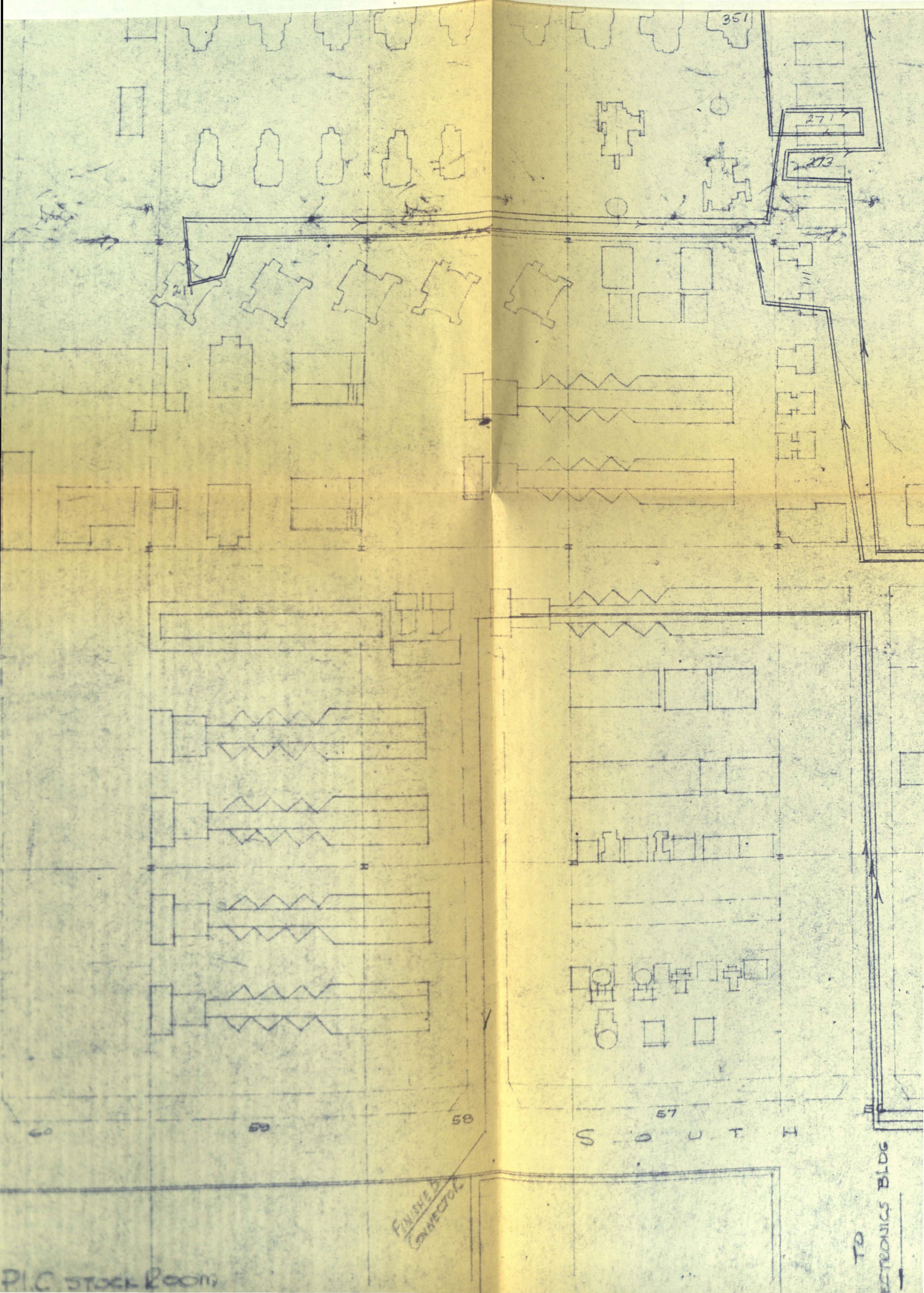


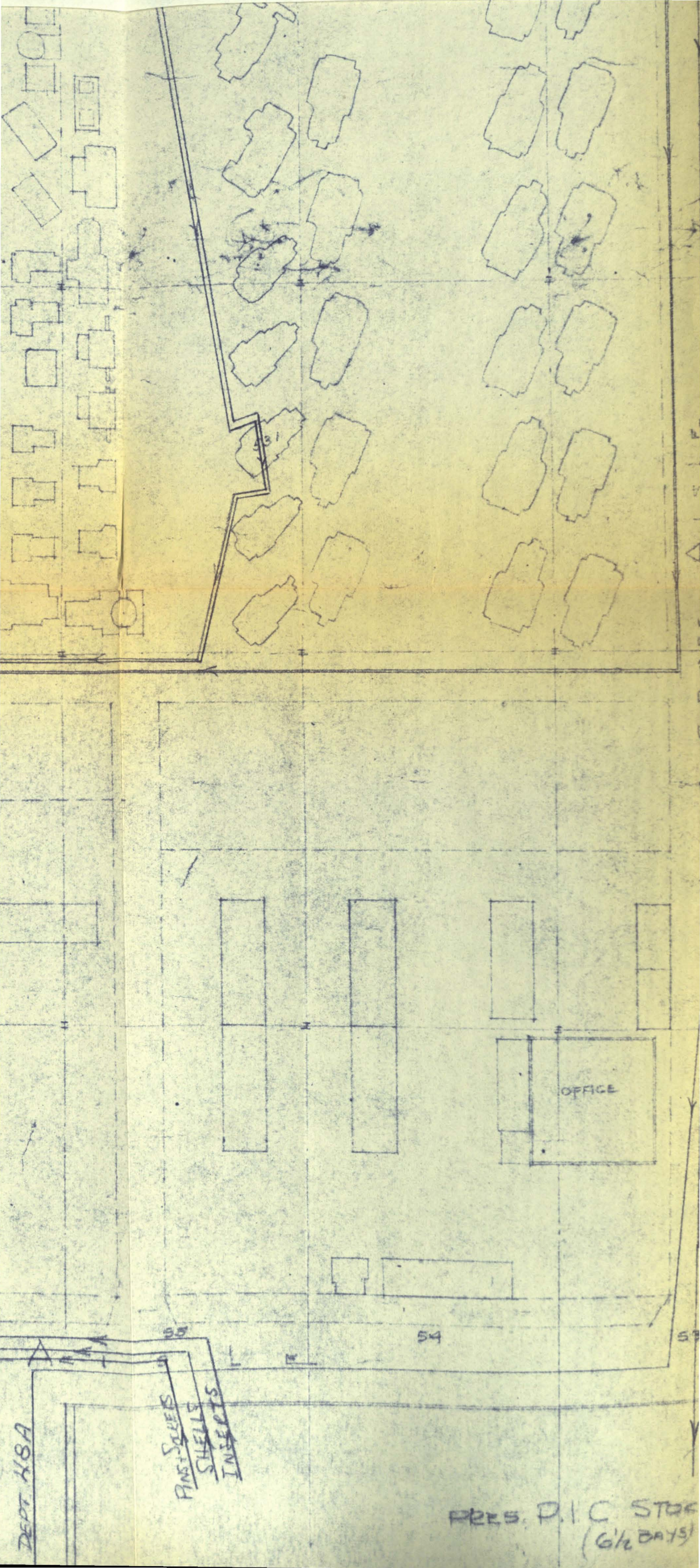
NORTH AISLE
59
58
57
56
DEPT. 32
(BRAZING)
CROSS AISLE
351
271
273
21


55
54
53
52
51
DEPT. 13

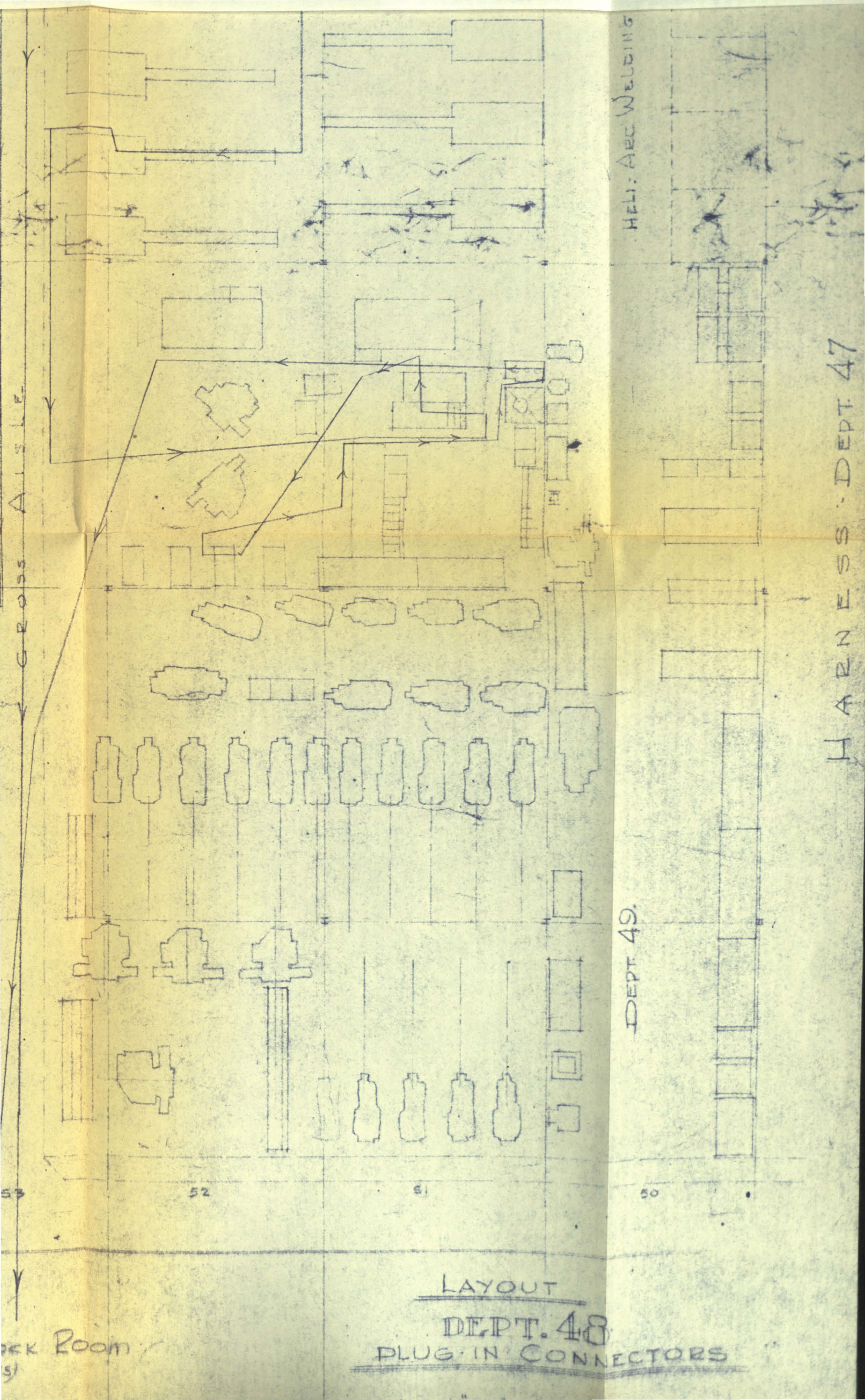


TO DEPT 32
FROM DEPT 26
53
52
51
50
HELI-ARC WELDING
AISLE
NESS · DEPT 47


351
271
273
21
60
59
58
57
S O U T H
FINISHED
CONNECTOR
TO
ECTRONICS BLDG
P.I.C. STOCK ROOM



331
OFFICE
55
54
DEPT 418A
SHELLS
INSERTS
PRES. P.I.C. STO
(6½ BAYS)


HELI: ARC WELDING
HARNESS · DEPT 47
CROSS AISLE
DEPT 49.
53
52
51
50
Room
LAYOUT
DEPT. 48
PLUG IN CONNECTORS

1.8.3.4 **Data**

Similarity of P.I.C. Dimensions:

Part No.	Size	Outside Diameter	Outside Thread	C Dia. or D Diameter	D Dia.Ref. or B Diam. Refer.	F Dia.or L Diam.
10-40452	14S	.8750 (-.0072)	.8750 (20NEF-2)	.802 (-.007)	.759	.696 (+.005)
10-40454	14S	.8750 (-.0072)	.8750 (20NEF-2)	.802 (-.007)	.759	.696 (+.005)
10-40454	14	.8750 (-.0072)	.8750 (20NEF-2)	.802 (-.007)	.759	.696 (+.005)
10-40452	14	.8750 (-.0072)	.8750 (20NEF-2)	.802 (-.007)	.759	.696 (+.005)
10-40456	14	.7500 (-.0094)	.7500 (20UNEF2A)	.677 (-.007)	.634	.562 (±.005)
10-40456	14S	.7500 (-.0092)	.7500 (20UNEF2A)	.677 (-.007)	.634	.562 (±.005)
10-40456	16S	.8750 (-.0094)	.8750 (20UNEF2A)	.802 (-.007)	.759	.688 (±.005)
10-40456	16	.8750 (-.0094)	.8750 (20UNEF2A)	.802 (-.007)	.759	.688 (±.005)
10-40454	16S	1.0000 (-.0072)	1.0000 (20NEF-2)	.927 (-.007)	.884	.822 (+.005)
10-40454	16	1.0000 (-.0072)	1.0000 (20NEF-2)	.927 (-.007)	.884	.822 (+.005)
10-40452	16	1.0000 (-.0072)	1.0000 (20NEF-2)	.927 (-.007)	.884	.822 (+.005)
10-40452	16S	1.0000 (-.0072)	1.0000 (20NEF-2)	.927 (-.007)	.884	.822 (+.005)
10-40456	18	1.0000 (-.0095)	1.0000 (20UNEF2A)	.927 (-.007)	.884	.812 (±.005)

Similarity of P.I.C. Dimensions (Continued)

Part No.	Size	E Gage Dia. or C Gage Diameter	G Diam.	H Dia. or M Diam.	J Diam.	K Diam.
10-40452	14S	.729	.692 (+.005)	.702 (+.01)	.578 (±.005)	.538 (±.005)
10-40454	14S	.729	.696 (+.005)	.702 (+.01)	.578 (±.005)	.538 (±.005)
10-40454	14	.729	.696 (+.005)	.702 (+.01)	.578 (±.005)	.538 (±.005)
10-40452	14	.729	.696 (+.005)	.702 (+.01)	.578 (±.005)	.538 (±.005)
10-40456	14	.604	None	.609 (±.005)	None	.538 (±.005)
10-40456	14S	.604	None	.609 (±.005)	None	.538 (±.005)
10-40456	16S	.729	None	.734 (±.005)	None	.663 (±.005)
10-40456	16	.729	None	.734 (±.005)	None	.663 (±.005)
10-40454	16S	.854	.817 (+.005)	.827 (+.01)	.703 (±.005)	.663 (±.005)
10-40454	16	.854	.817 (+.005)	.827 (+.01)	.703 (±.005)	.663 (±.005)
10-40452	16	.854	.817 (+.005)	.827 (+.01)	.703 (+.005)	.663 (+.005)
10-40452	16S	.854	.817 (+.005)	.827 (+.01)	.703 (±.005)	.663 (±.005)
10-40456	18	.854	None	.859 (±.005)	None	.788 (±.005)

Part No.	Size	L Rad. or FF Rad.	M Diam. or J Diam. (±.005)	N Dia. or H Diam.	P	R (±.005)	S (±.02)	T	V (±.005)	W (±.005)	Y (+.004) (-.002)
10-40452	14S	.062	.609	.719	.290	.238	1.188	.594	.906	.453	.150
10-40454	14S	.062	.609	.750 (-.0072)	.290	.238	1.188	.594	.906	.453	.150
10-40454	14	.062	.609	.750 (-.0072)	.290	.238	1.188	.594	.906	.453	.150
10-40452	14	.062	.609	.719	.290	.238	1.188	.594	.906	.453	.150
10-40456	14	None	.578	.672 (-.005)	None	.238	.817	None	None	None	None
10-40456	14S	None	.578	.672 (-.005)	None	.238	.817	None	None	None	None
10-40456	16S	None	.703	.797 (-.005)	None	.300	.942	None	None	None	None
10-40456	16	None	.703	.797 (-.005)	None	.300	.942	None	None	None	None
10-40454	16S	.062	.734	.8750 (-.0072)	.355	.300	1.281	.641	.969	.484	.150
10-40454	16	.062	.734	.8750 (-.0072)	.355	.300	1.281	.641	.969	.484	.150
10-40452	16	.062	.734	.844	.355	.300	1.281	.641	.969	.484	.150
10-40452	16S	.062	.734	.844	.355	.300	1.281	.641	.969	.484	.150
10-40456	18	None	.828	.922	None	.363	1.061	None	None	None	None

Similarity of P.I.C. Dimensions (Continued)

Part No.	Size	Z	AA or S	BB Min or S	CC (+.016) (-.000)	DD (±.005)	EE or P (±.005)	FF or NN	GG Diam.
10-40452	14S	.141*	.562	.391	.562	.698	.984	60	1.562
10-40454	14S	.142*	.562	.391	.562	.698	1.104	60	1.562
10-40454	14	.142*	.750	.625	.750	1.010	1.479	60	1.562
10-40452	14	.141*	.750	.625	.750	1.010	1.359	60	1.562
10-40456	14	None	.656	.562	None	None	1.469	None	None
10-40456	14S	None	.469	.375	None	None	1.094	None	None
10-40456	16S	None	.469	.375	None	None	1.094	None	None
10-40456	16	None	.656	.562	None	None	1.469	None	None
10-40454	16S	.142*	.562	.391	.562	.698	1.104	60	1.688
10-40454	16	.142*	.750	.625	.750	1.010	1.479	60	1.688
10-40452	16	.141*	.750	.625	.750	1.010	1.359	60	1.687
10-40452	16S	.141*	.562	.391	.562	.698	.984	60	1.687
10-40456	18	None	.656	.562	None	None	1.469	None	None

* Dimension should be the same, see explanation.

Determination of Average Tear Down - Set Up Time: (Max.: 15 Hrs.)

From 10-40452 14S to 10-40454 14S: 28 dimensions, 2 dissimilar	2/28 x 15 = 1.07 hrs.
From 10-40454 14S to 10-40454 14: 28 dimensions, 5 dissimilar	5/28 x 15 = 2.68 hrs.
From 10-40454 14 to 10-40452 14: 28 dimensions, 2 dissimilar	2/28 x 15 = 1.07 hrs.
From 10-40452 14 to 10-40456 14: 15 dimensions, 13 dissimilar	13/15 x 15 = 13.00 hrs.
From 10-40456 14 to 10-40456 14S 15 dimensions, 3 dissimilar	3/15 x 15 = 3.00 hrs.
From 10-40456 14S to 10-40456 16S: 15 dimensions, 12 dissimilar	12/15 x 15 = 12.00 hrs.
From 10-40456 16S to 10-40456 16: 15 dimensions, 3 dissimilar	3/15 x 15 = 3.00 hrs.
From 10-40456 16 to 10-40454 16S 28 dimensions, 26 dissimilar	26/28 x 15 = 13.93 hrs.
From 10-40454 16S to 10-40454 16: 28 dimensions, 5 dissimilar	5/28 x 15 = 2.68 hrs.
From 10-40454 16 to 10-40452 16: 28 dimensions, 2 dissimilar	2/28 x 15 = 1.07 hrs.
From 10-40452 16 to 10-40452 16S: 28 dimensions, 5 dissimilar	5/28 x 15 = 2.68 hrs.
From 10-40452 16S to 10-40456 18: 15 dimensions, 11 dissimilar	11/15 x 15 = 11.00 hrs.
Total Time:	67.18
Average:	$\frac{67.18}{12}$ = 5.6 hrs.

11.8.3.5 Discussion

Effect of Lack of Standardization. The effect of lack of standardization and classification in design is clearly illustrated by the error noted in the 'Z' dimension in the previous tabulation of plug-in-connector dimensions.

In the case of 10-40452 (any size) the thickness of the flange is denoted by the letter 'Z' and listed specifically in the table of dimensions. In the case of 10-40454, on the other hand, the flange thickness is not covered by a specific dimension even though the connector is almost identical. However, the thickness may be arrived at by subtracting the dimensions 'AA' and 'Z' from the dimension 'EE'. (The 'Z' in the latter case is different from the 'Z' in 10-40452.)

The situation outlined above is illustrated by using size 14S as follows:

	10-40452		10-40454
Flange thickness	.141 (+.01) (-.01)	EE	1.104
		Z	-.400
			.704
		AA	-.562
			.142
AA	.562 (+.016) (-.000)		.562 (+.016) (-.000)
Z	.141 (±.010)		.400 (±.010)
E	.984 (±.010)		1.104 (±.005)

10-40452:
Flange dimension width Z is .141 basic or .141 (±.010) = .131 min. to .151 max.

10-40454:
Flange width can be: .142 basic or .142 (+.031) (-.015) = .127 min.to .173 max.

(AA plus Z subtracted from EE)

Thus it may be seen that on almost identical connectors it is possible to have a variation between two acceptable flanges of .042 even though the normal tolerance is .01. This, of itself, could account for a considerable percentage of scrap and rework. There seems to be no reason why the flange dimension cannot be stabilized at .141 ($\pm$ .01) for all similar connectors; and all designated by dimension 'Z' on all prints.

The above two prints were a random selection for this purpose, both dated 1950, and accounted for a production of about 70,000 in the previous 12 months in sizes 14S and 22 alone.

11.8.4 <u>Connectors - Proposed</u>

11.8.4.1 <u>Data</u>. From the IBM data the following high volume plug in connectors were recorded: (figures are for an eleven month period ending February 1957)

10-35966 - 22B (machined)	43,655	564,492 (total machined)
10-40454 - 14S (machined)	35,312	
10-40714 - 12S, 14S (machined)	74,482	
10-113488 - 11 (machined)	25,945	
10-123009 - 1, 2 (machined)	57,286	
10-113498 - 11 (machined)	58,058	
10-40452 - 22, 28 (machined)	26,111	
10-40456 - 10S, 12S, 12, 14S, 14, 16S, 16, 18, 20, 22, 24, 28, 32, & 36 (machined)	243,643	
10-101902 - 8A (extruded)	28,550	
10-37157 - 22, 24, 28 (die cast)	157,697	3,545,674 (total die cast)
10-37260 - 20, 22, 28 (die cast)	132,260	
10-37262 - 11, 14, 16, 20, 22, 24, & 28 (die cast)	689,577	
10-37266 - 14, 16, 18, 20, 22, 24, & 28 (die cast)	949,916	
10-40085B (die cast)	162,556	
10-40228B (die cast)	82,680	
10-40750 - 16B, 22B, 28B (die cast)	133,785	
10-40751 - 11A, 16A, 22A, 28A (die cast)	581,167	
10-40752 - 11, 16B, 22B, 28B, & 36B (die cast)	656,036	
Total:	4,138,716	

DESIGNATION & SIZE	ANNUAL REQUIREMENTS	ACME-GRIDLEY 1st TURN & CTF. #541	BROWN & SHARPE C'BORE, CTF. SIDE #521	BUFFER OR WIRE BRUSH #711	DRILL PRESS DRILL & BURR #111
10-40454 14S	38,500	275 hours		130 hours	310 hours
10-40452 22, 28	28,500	205 "		95 "	230 "
10-40456 10S, 12S 12, 14S, 14, 16S, 16, 18, 20, 22, 24, 28, 32 & 36	266,000	1170 "	2050 hours	755 "	
10-40714 12S, 14S	81,300	630 "	625 "		
10-35966 22B	47,500	320 "	475 "	170 "	
10-113498 11	63,300	245 "	460 "		
TOTAL: T.D. - S.U.	525,100	2745 " 448 3193	3610 " 272 3882	1150 "	540 "

	8 STA. BROACH BROACH KEY #211	BROACH KEY #371	BURR BENCH BURR #271	CRIDAN or W.S. GENERATE THRDS. #351	BROWN & SHARPE FINISH TURN & FA #531
10-40454	340 hours		195 hours	400 hours	520 hours
10-40452	250 "		145 "	150 "	350 "
10-40456		1460 hours			3700 "
10-40714		535 "	420 "		2660 "
10-35966		260 "	110 "		
10-113498		600 "			1170 " (Op.311)
TOTAL:	590 "	2855 "	870 "	550 "	8400 "

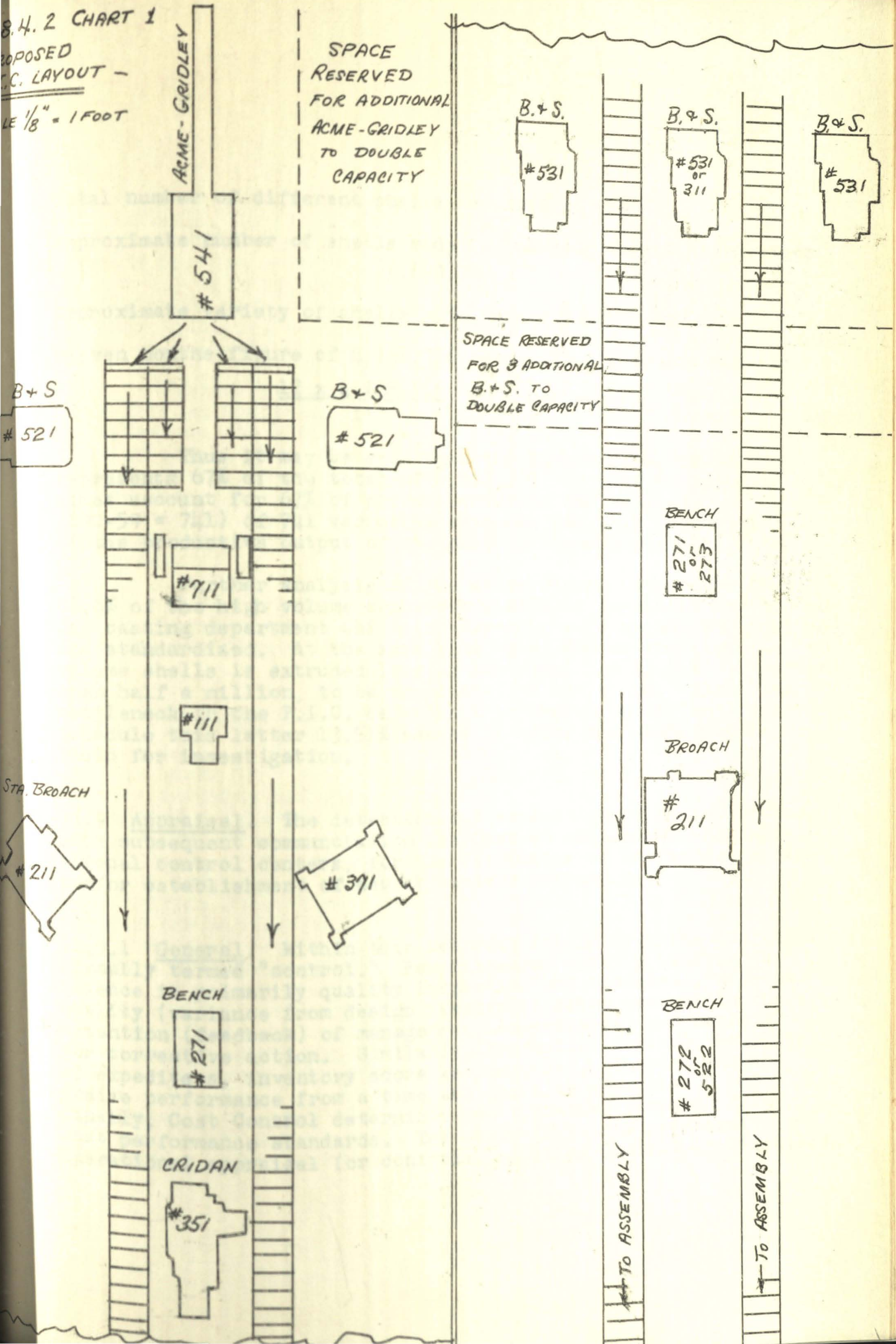
Chart 11.8.4.1-1

DESIGNATION & SIZE	BURR BENCH BURR #273/271	8 STA. BROACH PIERCE SLOT #211	BURR BENCH BURR #272	BURR SERRATIONS #522
10-40454	225 hours			
10-40452	130 "			
10-40456	900 "	755 hours	930 hours	
10-40714		230 "	230 "	
10-35966		135 "	165 "	
10-113498				285 hours
TOTAL	1255 "	1110 "	1325 "	285 "

It is assumed that total 2-shift plant capacity is approximately 3120 hours.

CHART 11.8.4.1 -1A

8.4.2 CHART 1
...ROPOSED
...C. LAYOUT —
...LE 1/8" = 1 FOOT



Total number of different shells or sizes : 59

Approximate number of shells made in one year in all categories: 6,800,000

Approximate variety of shells made in one year: 800

Eleven months figure of 4,138,716 corrected for twelve months:

$$\frac{12 \times 4{,}138{,}716}{11} = 4{,}520{,}000$$

Thus it may be seen that the figure of 4,520,000 represents 67% of the total of 6,800,000; or that 59 types or sizes account for 67% of production while the remainder (800-59 = 741) of 741 varieties accounts for only about 33% of the productive output of the plug-in-connector shells.

Further analysis of the above figures indicates that 85.8% of the high volume connector shells is accounted for by the die casting department which is extremely well organized, equipped, and standardized. At the same time only .69% of the high volume shells is extruded leaving the remaining 13.51%, or better than half a million, to be machined from bar stock. Since the bottleneck in the P.I.C. department seemed to be in the Gridley schedule this latter 13.51% seemed to offer the most fertile field for investigation.

11.9 Appraisal. The detection and evaluation of goal variance with subsequent communciation feedback to management and operational control centers, for the initiation of corrective action and/or establishment of new objectives and goals.

11.9.1 General. Within this activity should be those functions normally termed "control." For instance, Quality Control in essence is primarily quality inspection and appraisal, with bad quality (variance from design standards) being brought to the attention (feedback) of management, supervisors, and workers for corrective action. Similarly, Production Control, by means of expediters, inventory score keeping, etc., inspect and appraise performance from a time and quantity viewpoint. And finally, Cost Control determines and appraises variance from cost performance standards. The above functions represent operational appraisal (or control). Quality Control is discussed separately within this report, as are Production Control and Cost Control. In the latter case, it has been recommended under the manufacturing organization section to include a cost analysis section, external to accounting, as a functional unit related to, and familiar with, production operations so that the variances might be analyzed by detailed causes with fixing of responsibility. A further advantage would be that the cost standards themselves could be appraised.

Above the operational level there should be, of necessity, an appraisal function relating not only to manufacturing but to the plant as a whole in such matters as evaluation of plant objectives, economic studies pertaining to facilities, products, etc., interpretation of forecasts in terms of plant requirements and objectives, evaluation of plant performance in terms of the overall objectives, etc. Such a function is recommended as a Production Analysis section under a Planning Department.

This section of the report will in general deal with such top level appraisal, specifically product profitability and plant efficiency in terms of both time and cost.

11.9.2 Load Analysis. Due to the extremely large variety and complexity of the product mix Scintilla has found it impractical to maintain loads by each machine-code, or by-product, except in those areas that are determined to be critical. An example is cited in pygmy connectors wherein load requirements were developed for Type PC. Standard time for each component, of each particular connector in the type, is weighted by volume ratio. These weighted averages are then further weighted by component usage, i.e. a nut used on only one out of 5 units in the series would have a weight of .2. All the weighted averages for any particular machine code are then taken as the total, and load requirements are based on this value which Scintilla designates the "mother unit" for Type PC pygmy connectors. The only disadvantage to this system is that the task of applying it to all machine codes for all products would be too complex and unwarranted. The following procedure is recommended as a possible way of evaluating the billing for any period in immediate terms of machine requirements.

Development Data. The basic procedure here is statistical work sampling. Each machine in each code group is given an identifying number. For observation, random sequence is established from these numbers and the machines are observed for activity throughout a 24 hour period for as many months as are necessary to obtain an "average production" universe, and as many sampling personnel are utilized as are necessary to obtain sufficient observations for desired accuracy.

The activity sampling elements could be as indicated on Chart 11.9.2-1, although it is not intended that these be other than illustrative. The chart in this case is for operation code 54 (Gridley automatics). One chart would have to be made for each machine/operation code group. The "Producing" activity element is further subdivided by products for subsequent product volume (in number) evaluation.

After observations are completed, each category is totalled, i.e. total observations of operation 54 machines working on any particular product such as connectors, pygmy. Each of these is then divided by the total observations in the code group to determine activity classification percentages, or utilization factors. Then multiply each of the product percentages by 24ND, where N is the number of machines in the particular code group and D is the number of days the sampling was conduced. This figure will give the number of direct machine hours used by each product element in the code group, during the period, for productive output.

Concurrently during the observation period the number of processed units must be established. Since the average overall fabricating time of all products is around 3 months, about one third of the contracts will be two thirds of the way through their production cycle, one third will be one third of the way through, and one third will have been issued, during the first month of sampling. Assuming a five month sampling period, those contracts issued the first month of sampling will complete fabrication in the third month, finish assembly and shipment in the fourth. To ensure that the production volume average covers the period represented by the sampling: assume sampling is started 1 January and continued through May. Total shipments, by-products, should then be tabulated for February through June. Then, "mother unit" times can be developed. Total hours used by each product on each machine code is known from the sampling. Total units of each product processed is known from the shipping data tabulation. Dividing the first by the second gives hours/units, and multiplying by 100 gives hours/100 units.

With "mother unit" hours per 100 units thus developed for each product for each machine code, a load sheet can be made

MACHINE ACTIVITY
SAMPLING DATA SHEET

MACHINE CODE __ __ __ __ __ NO. of MACHINES __ __ __ __

PRODUCT	ACTIVITY (PRODUCING)	ACTIVITY (SETUP/TEAR DOWN)
CON CTORS (REGULAR)		
CONNECTORS (PYGMY)		
SPARES		
A/C MAGNETOS		
K&H _AGNETOS		
HARNESSES CAST		
HARNESSES TUBULAR		
VIBRATORS		
IG TION ANALYZERS		
etc.		

ACTIVITY (VARIOUS) (IDLE MACHINE)	
TOOL ADJUSTMENT	
TOOL REPAIR	
POWER STOPPAGE	
OPERATOR INSPECTING PRODUCT	
OPERATOR HANDLING MATERIAL	
OPERATOR RECEIVING INSTRUCTION	
OPERATOR STUDYING PRINT	
OPERATOR ABSENT (WORK HOUR)	
OPERATOR ABSENT (LUNCH HOUR ETC)	
SETUP/TEAR DOWN CYCLE, NO SETUP MAN	
NO MATERIAL	
NO JOB ASSIGNED	
NO OPERATOR ASSIGNED	
MACHINE INTERFERENCE	
NO SHIFT ASSIGNMENT	
SHIFT CHANGE INTERFERENCE	
OPERATOR PERSONAL DELAY	
MAINTENANCE, WORK IN PROGRESS	
MAINTENANCE, NO WORK IN PROGRESS	
OBSOLETE AND/OR NOT USED	

CHART 11.9.2-1

up such as the sample shown on Chart 11.9.2-2, which shows by shifts and machine codes the number of productive hours available for any period, and with standard hours/100 indicated after each product. The "available hours" are determined by multiplying the number of machines by total shift hours available in the period and further multiplying by "working time" percentage utilization as determined from initial sampling. In general those activity classifications considered as "working utilization" would be those titled: producing, operator absent (work hour), idle (setup/teardown), idle (no material), idle (no job assigned), idle (no operator assigned), and idle (no shift assignment). Of course, these would have to be considered in relative detail to determine which elements are inclusive or exclusive of being available for productive usage. A total of these percentages gives percent of productive time available on the machines. These totals are entered on the bottom of the load sheet for each machine code group.

Use. Any forecast, as provided by Sales in terms of volume (in numbers, not dollars) of each product, can be analyzed in terms of plant load. This volume, in hundreds of units, is then multiplied by its standard hours/100 mother unit time in each machine code and entered on the appropriate sheet. All product times are then totalled to determine the hours required for the period. These are compared with hours available. Decisions can, on the basis of this comparison, be made as to second and third shift requirements, subcontracting requirements, new machine requirements, etc.

Also, from the initial activity classification percentages analysis can be made, and planning data developed, for such things as setup/teardown requirements, machine utilization, maintenance requirements, etc. As a matter of fact they could be used to determine a few of the factors in Scintilla's machine efficiency factors presently used for mobilization planning. This formula is as follows:

Machine Efficiency =

$$\frac{\text{Std. Time x Setup \% x Rework/Scrap \% x Idle \% x Contingency \%}}{\text{Average Bonus Earning for Type of Process.}}$$

Std. Time: The normal corrected standard hour.

Setup: The normal time for tool and machine adjustment to produce the first acceptable piece produced. This includes the necessary procurement of tools, blueprints, fixtures, gages, etc., from tool crib or bin locations within the department.

LOAD ANALYSIS SHEET — CODE (54)

PRODUCT	STD HRS PER 100	1ST SHIFT NO. UNITS	1ST SHIFT HOURS REQ'D	2ND SHIFT NO. UNITS	2ND SHIFT HRS REQ'D	3RD SHIFT NO. UNITS	3RD SHIFT HRS REQ'D
CONNECTORS, REGULAR							
FUEL INJECTION							
SPARES							
etc.							
TOTAL HOURS REQUIRED							
% OF TOTAL HOURS AVAILABLE FOR PRODUCTIVE UTILIZATION			______		______		______
PRODUCTIVE HRS AVAILABLE			______		______		______

CHART 11.9.2-2

Rework/Scrap:	Allow for the time consumed to make and correct if possible faulty work.
Idle Time:	To allow for normal incidences such as: Machine repair Resetting of tools Sharpening of tools Department to department transportation of material. Power stoppage Line production unbalances
Contingency:	To allow for sundry abnormal work stoppage.
Bonus Earnings:	To balance load for normal incentive opportunity realized by those operators who come under the incentive plan.

These machine efficiency factors and their elements vary from .90 to 1.80 and are listed by machine code on Chart 11.2.1-4. From these factors production time required over a unit is obtained by multiplying the standard hours/100 by the efficiency factor.

With data determined from the sampling analysis these efficiency factors could be established easily and would aid in such things as machine loading a particular work station where a critical production bottleneck exists.

Notes

1. The machine-code groups may be such that individual machines should be sampled instead of the group, such as the 125 ton punch press.

2. If considered more practical, the sampling breakdown could be by department rather than machine code group.

3. A similar study could be made of manpower, on which subsequent planning and manpower requirements could be based.

4. After the data is developed it could probably be expeditiously utilized on data processing equipment.

5. The basic data would probably be quite stable. That is, only major processing changes, major changes of mother unit requirements for any particular product, or major changes in the product mix of a product category would adversely affect the accuracy of the established data.

6. If detailed sequential scheduling, dispatching, progressing, more supervision, and tighter work standards are adopted, as recommended in preceding sections, then setup/teardown time, material handling, etc., might be subsequently reduced to affect "productive" time utilization. Such factors would have to be considered.

11.9.3 Product Profitability. One of the primary decisions management must make is what product, or products should the plant produce with facilities available (or anticipated) and how, where, and when to make them. The criteria as to what to make is whether the product will contribute reasonable earnings and which product will contribute the most. The earning contribution, herein called "profit potential," is that margin remaining after variable (plant) costs have been subtracted from the sale price. This margin then goes to absorbing fixed costs and providing marginal profit. Since fixed (establishment) costs are relatively unaffected by the product they should not be a part of the product cost at this decision stage, since they must be arbitrarily allocated. The question must be, which product contributes the greatest unit amount toward paying these fixed establishment costs over and above the out-of-pocket expenses.

For an analysis of product profitability the technique of the "profit/volume" graph was used. Annual total direct variable costs for each product were subtracted from the estimated annual sales volume to give profit potential per year. Dividing this figure by the sales volume gives a ratio called "profit/volume", which relates earnings to volume. Further, since plant capacity is a function of direct labor, the profit potential per direct labor hour is a ratio indicating for each product the earning capacity with available manpower. A tabulation of the above relationships is provided on Chart 11.9.3-1.

The tabulated data is further graphed on Chart 11.9.3-2. From this, it can be seen that at zero sales volume there is an annual loss equal to the fixed establishment costs. This point is where the average profit/volume line crosses the

Product Category	Annual Dir Labor w/o Allowances	Annual Dir Labor with Allowances	Annual Direct Material	Annual Dir Mach&Equip Including Govt Rent	Total Annual Dir Costs	Annual Sale Volume	Profit Potential Per Year	Profit Volume Percent	Profit Potential Per D.L. Dollar
Electrical Connectors	$1,330,000	$2,035,000	$ 2,022,000	$118,000	$ 4,175,000	$ 9,000,000	$ 4,825,000	.536	$2.38
Harnesses,Leads,Cable Assy	655,000	1,000,000	1,720,000	80,000	2,800,000	6,500,000	3,700,000	.569	3.70
Jet Ignition Equip & Plugs	758,000	1,160,000	1,720,000	49,000	2,929,000	6,500,000	3,571,000	.549	3.07
Spares,Tools,Service Repair	390,000	600,000	1,350,000	45,000	1,995,000	5,000,000	3,005,000	.605	5.01
Ind,Ord,Auto, & Mags	635,000	970,000	1,210,000	75,000	2,255,000	4,000,000	1,745,000	.436	1.80
Aircraft Magnetos	475,000	725,000	654,000	32,000	1,411,000	3,500,000	2,089,000	.598	2.88
Fuel Injection Units	480,000	735,000	213,000	35,000	983,000	2,500,000	1,517,000	.606	2.06
Coils,Switches,Filters	300,000	460,000	750,000	31,000	1,241,000	2,500,000	1,259,000	.503	2.73
Ignition Analyzers & Equip	50,000	75,000	174,000	2,000	251,000	500,000	249,000	.499	3.32
Miscellaneous	375,000	590,000	640,000	36,000	1,266,000	2,200,000	934,000	.431	1.62
TOTALS	$5,450,000	$8,350,000	$10,720,000	$503,000	$19,573,000	$42,200,000	$22,894,000	.543	$2.74

Profit Potential equals Sale Price less Direct Cost.

Profit Volume equals Profit Potential Divided by Sale Price

Total Annual Costs & Expenses estimated at $38,000,000.

Annual Fixed Costs & Expenses equal Total less Direct equal
$38,000,000-$19,573,000 equals $18,427,000 (Establishment Cost)

Note: See paragraph 11.1.2 regarding the authenticity of the above data.

Chart 11.9.3-1

PROFIT-VOLUME
(PRODUCT PROFITABILITY-VOLUME RATIOS)

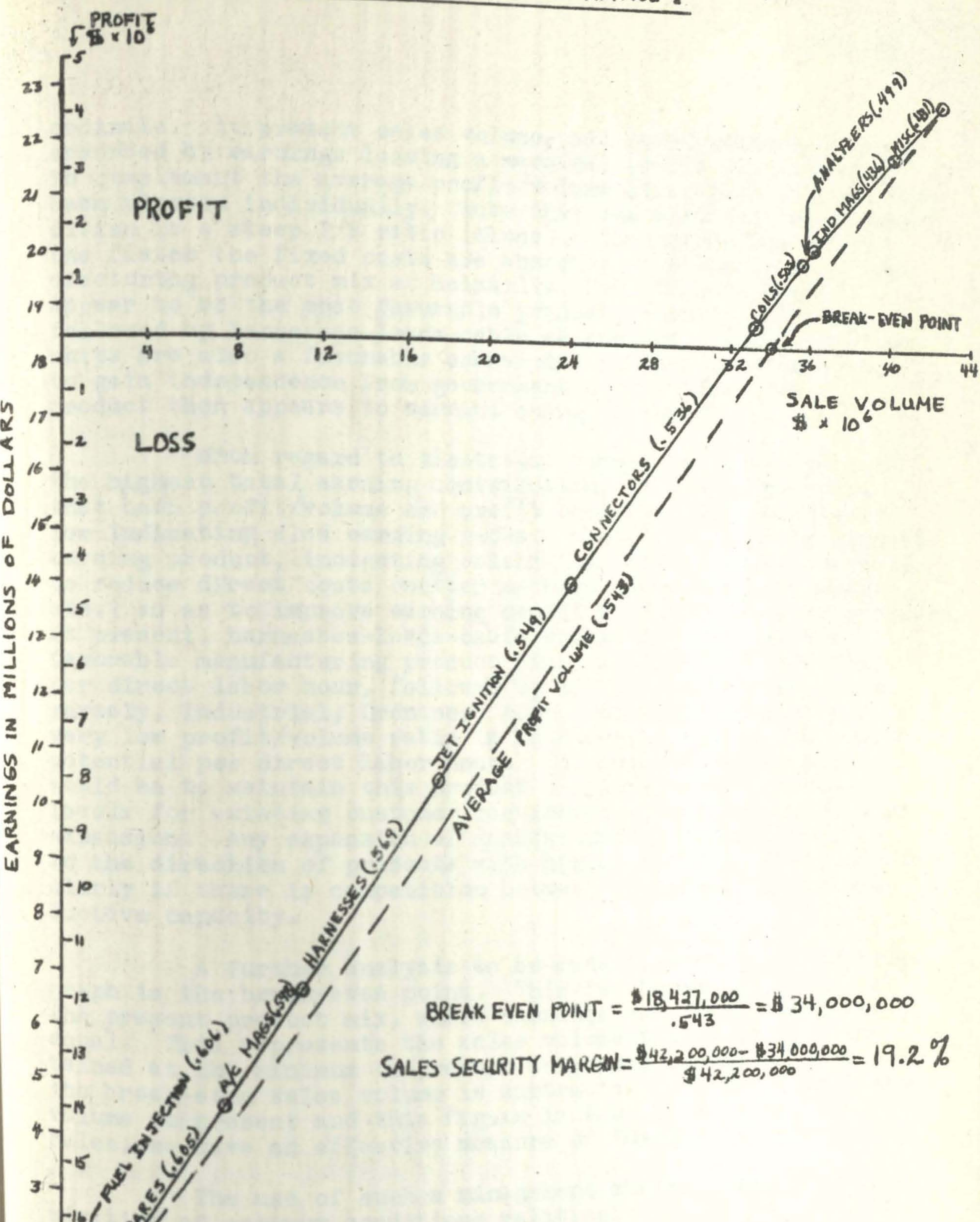


CHART 11.9.3-2

ordinate. At present sales volume, all fixed costs have been absorbed by earnings leaving a marginal profit as indicated. To complement the average profit/volume line, each product has been plotted individually. Note that the most desirable condition is a steep P/V ratio (slope). The higher the ratio the faster the fixed costs are absorbed. In the present manufacturing product mix at Scintilla, Fuel Injection Units appear to be the most favorable product, earning-rate wise, followed by harnesses-leads-cable assemblies. Fuel injection units are also a favorable commercial product in attempting to gain independence from government contracting. This product then appears to warrant being "pushed."

With regard to electrical connectors which provide the highest total earning contribution, it should be noted that both profit/volume and profit potential are relatively low indicating slow earning rates. Since they are the highest earning product, indicating salability, effort should be made to reduce direct costs (better methods, less scrap and rework, etc.) so as to improve earning capacity of this line of products. At present, harnesses-leads-cable assemblies are the most favorable manufacturing product line as to profit potential per direct labor hour, followed by Ignition Analyzers. Conversely, Industrial, Ordnance, Auto, and H Magnetos have a very low profit/volume ratio in addition to a very low profit potential per direct labor hour. The recommendation here would be to maintain this product category only at present levels for existing customer requirements, but to not attempt expansion. Any expansion of manufacturing output should be in the direction of products with higher earning rates, particularly if there is competition between the products for productive capacity.

A further analysis to be made from the profit/volume graph is the break-even point. This is the sales volume, at the present product mix, where earnings and fixed costs are equal. This represents the sales volume that must be maintained at the minimum to prevent an annual operating loss. If the break-even sales volume is subtracted from the total sales volume at present and this figure is then divided by total sales, we have an effective measure of "Margin of Security."

The use of such a management analysis is the determination of optimum conditions relating to: what products to make, what products to "push," what products require emphasis in reducing direct costs, what sales volume should be the company's objective, how much of the total plant capacity (i.e. three shift) to utilize, what expansion of facilities (fixed costs) would be justified economically, from a total profit aspect, to gain more capacity, what maximum sales volume could be realized, what product mix is most advantageous, etc.

11.9.4 Plant Efficiency

General. The efficiency of any industrial enterprise is a measure of customer contentment as portrayed in Figure 1 of Chart 11.1.2-1. This group was not able to measure customer content directly yet it is possible to state that, in general, Scintilla must be satisfying her customers for sales are on the up-swing and she is in a favorable profit position. This evidence is not conclusive however, for what is or should be the upper limit? It can be safely assumed that complete customer satisfaction would approach a monopoly situation. Since Scintilla does have competitors, it can be assumed that in some respects her competitors are filling customer needs better than she and her own satisfaction-giving must be somewhat less than 100%. Typical Scintilla indicators are the percentage of late deliveries, 21.8% (Chart 11.8.2.3-5), the percentage of product warranty claims against the company which were not evaluated, percentage of actual manufacturing time required versus total time taken to fill the order, 5.4% for connectors (Chart 11.9.4.1-1) indirectly depriving the customer of the fastest possible delivery time, and the percent of total costs that are non-reducible productive costs, 36%, (Chart 11.9.4.2-4) indirectly depriving the customer of lowest possible cost.

Another approach to determining Scintilla's contribution to the supply-demand function would be to analyze her regarding her sales position relative to other suppliers. This the group was not able to do.

Regardless of the approach, consumer satisfaction manifests itself in the profitability of the enterprise, an aspect that is relatively easy to measure. Referring again to Chart 11.1.2-1, Figure 2, we see that how well Scintilla uses her system elements ultimately results in profit via cost, time, quality, quantity, and the price the customer is willing to pay for the combination of these criteria. Now, how Scintilla chooses to combine these elements is of little interest to the customer provided his basic stated specifications are met. Thus efficiency is a combination of two functions.

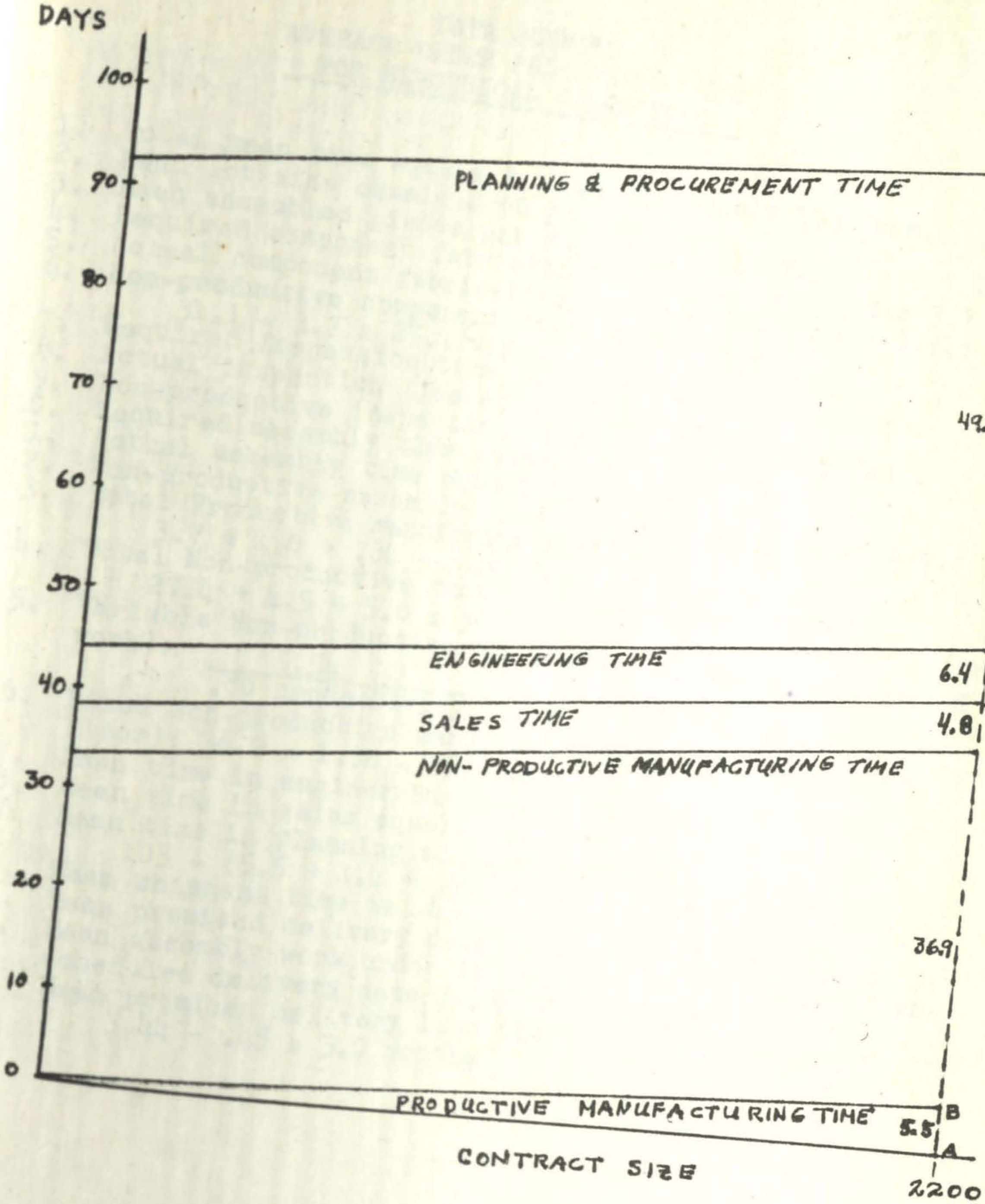
First, the external efficiency measuring how well the order specification was met (the what, when, how much and how many), and second the internal efficiency measuring how much profit was generated within the system after meeting the customer criteria. The customer expects to be charged for what he gets; if Scintilla provides "extra" outside of the stated specification and is not compensated a certain internal inefficiency is introduced. An example would be maintenance of high quality on items that are not so specified. Conversely, if the customer specification allows say 6 months on an order that requires only two months processing, certain cost savings are available to Scintilla that improves their internal efficiency with no effect on customer relations.

This study group attempted to analyze Scintilla from two viewpoints in this respect; time efficiency and cost efficiency which reflect both external and internal relationships. Quality efficiency aspects are discussed in the Quality Control chapter of this report, and Quantity aspects of efficiency are inherent in the time relationships.

11.9.4.1 Time Efficiency. (Refer to Chart 11.9.4.1-1) As stated above the time efficiency for connectors was 5.4%. Too little time was available to study more than one product, hence this will have to be considered representative. (Chart 11.9.4.1-A1 provides a data summary from which this efficiency was computed.) The percentage means in effect that of the total time taken to process the average customer order for connectors (order receipt to shipping date) only 5.4% of this time was theoretically required for productive manufacture. The remainder of the time was consumed by administrative time in sales, planning, procurement, and engineering, and by manufacturing delay time (including time the work was sitting in tote boxes, storerooms, etc., and the time lost while the work was on a machine or assembly work station with the operators not performing to capacity). In one sense the figure 5.4% is too high, since productive time required was based on present work standards which are functions of work methods, workplace layout, incentive wages, machine facilities and tools, etc. all of which represent possible reductions in time required. These matters are discussed elsewhere.

The time taken in Sales and Engineering is relatively insignificant, and the balance of the time taken for the Planning, Procurement, Non-Produdtive (fixed), and Non-Productive (variable) is controllable to a large degree by manufacturing

PRODUCTIVE TIME EFFICIENCY
(CONNECTORS)



PRODUCTIVE TIME EFFICIENCY $= \frac{\text{USEFUL TIME OUTPUT}}{\text{TOTAL TIME INPUT}} = \frac{AB}{AC} = \frac{5.5}{103} = 5.3\%$

CHART 11.9.4.1-1

DATA SUMMARY: AVERAGE ORDER PROCESSING TIME FOR ELECTRICAL CONNECTORS

1. Total mean time equals 3.44 months equals 103 days.
2. Mean lot size equals 2200 pieces.
3. Mean assembled pieces per day equals 27,100.
4. Required component fabricating time per lot equals 3.7 days.
5. Actual component fabricating time per lot equals 31.13 days.
6. Non-productive component fabricating time:
   31.1 - 3.7 = 27.4 days.
7. Required inspection time equals 1 day.
8. Actual inspection time equals 5.5 days.
9. Non-productive inspection time: 5.5 - 1 = 4.5 days.
10. Required assembly time equals .84 days.
11. Actual assembly time equals 5.86 days.
12. Non-productive assembly time: 5.86 - .84 = 5.02 days.
13. Total Productive manufacturing time:
    3.7 + 1.0 + .84 = 5.54 days.
14. Total Non-productive manufacturing time:
    27.4 + 4.5 + 5.0 = 36.9 days.
15. Variable Non-productive manufacturing time (delay during work):
    $$\frac{5.54}{.80 \text{ productivity}} - 5.54 = 1.38 \text{ days.}$$
16. Fixed Non-productive manufacturing time (delay on the floor): 36.9 - 1.38 = 35.5 days.
17. Mean time in engineering equals 6.4 days.
18. Mean time in sales equals 4.8 days.
19. Mean time in planning and procurement:
    103 - (5.5 + 1.4 + 35.5 + 4.8 + 6.4) = 49.4 days.
20. Mean shipment time is .45 months behind schedule.
21. Mean promised delivery date is missed 38.8% of the time.
22. Mean assembly work order is released to the floor after scheduled delivery date 22.3% of the time.
23. Mean promised delivery lead time:
    3.44 - .45 = 3.0 months.

Chart 11.9.4.1-A1

management, except where restricted by policies of higher management. Admittedly the ratio of the productive manufacturing time could never reach 100%. In fact little research has been conducted on this subject and nation wide averages are not available for comparison. However, it seems that the case in point falls short of a "desirable" time efficiency.

Fixed Non-Productive Manufacturing Time is "fixed" only in the sense that it does not vary with volume. This stems from the fact, for instance, that a tote box will sit idle for a certain number of days relatively independent of the number of pieces in it. Fixed does not mean non-reducible. In fact, the purpose of the illustration is to point to the relative significance of this time element (35.5 days, or 34.4%) as an indication that different scheduling and progressing procedures should possibly be adopted to get the work through the system faster. In addition to the undesirable delay time element, the 35.5 days represents that much more in-process inventory.

Planning and procurement time (49.4 days, or 48%) is that time consumed by administrative procedures and policies within the Manufacturing Department. It may be actual Production Planning time before the contract is issued, it may be tool planning, or it may be actually waiting for necessary material to be procured due to a not-in-raw-stock situation created by current inventory policy. This detail breakdown was not evaluated, but in total it is very significant as the amount of total time taken before the contract ever reaches the floor for production. It should be noted too that the 49.4 days cited is an average figure, not the maximum! The indication is inadequate pre-planning and forecasting of trends and relative inflexibility in handling month to month and day to day variations within the trends.

11.9.4.2 Cost Efficiency

Summary: Inferred Annual Costs (See Paragraph 11.1.2)

Material

A.	Direct Material as per Chart 11.9.3-1	$10,720,000
B.	Supplies	300,000
C.	Maintenance	345,000
D.	Research & Engineering	500,000
		$11,865,000

Work

A.	Direct Labor as per Chart 11.2.2-2	$ 8,350,000
B.	Indirect Labor as per Chart 11.2.2-1	11,530,000
		$19,880,000

Machine and Equipment

A.	Depreciation Scintilla owned mach/equip.	$ 455,000
B.	Depreciation government owned mach/equip.	430,000
C.	IBM data processing equipment rental	65,000
D.	Material Handling equipment depreciation	10,000
		$ 960,000

Facilities

A.	Facility (excluding mach/equip.) depreciation	$ 400,000
B.	Utilities	290,000
C.	Taxes and Insurance	1,000,000
		$ 1,690,000

Miscellaneous	$ 3,605,000
	$38,000,000

Productivity Factors

A. Direct labor utilization as per Chart 11.8.2.1-1
B. Machine and equip. utilization as per Chart 11.8.2.1-1
C. Floor space allocation as per Chart 11.2.1-1

Activity Cost Analysis

I. **Administrative**

a.	Indirect labor departments 1, 14, 72, 73, 74, 82, 94 and 95.	$ 725,000
b.	Direct labor (2.5% paper work utilization)	215,000
	Total Work Cost	$ 940,000
c.	Facilities (3% of floor space).	50,000
d.	Material (all supplies)	300,000
		$ 1,290,000

II. **Installation, Maintenance, Adjustment and Support of Facilities**

a.	Indirect labor departments 4, 10, 11, 12 and 15	$ 1,380,000
b.	Direct Labor: 2.3% (Machine Trouble) 1.1% (Tool Trouble)	280,000
	Total Work Cost	$ 1,660,000
c.	Machine and Equipment: 3.9% (Maintenance) 4.1% (Tool Adjust.)	70,000
d.	Facilities: (7.1% of floor space)	120,000
e.	Material	345,000
		$ 2,195,000

III. **Research & Engineering**

a.	Indirect labor departments 8, 9, 90, 91, 92	$ 2,940,000
b.	Facilities (12.7% of floor space)	215,000
c.	Material	500,000
		$ 3,655,000

IV. **Sales & Service**

a.	Indirect labor departments 80, 83, 87, 88	$ 1,170,000
b.	Facilities (3.3% of floor space)	55,000
		$ 1,225,000

V. **Planning**

a.	Indirect labor departments 2, 5, 6, 17, 75	$ 1,040,000
b.	Facilities (8% of floor space)	135,000
		$ 1,175,000

VI. Control

a. Indirect labor departments 3,70,98,99,100		$ 2,920,000
b. Direct labor:	1.1% inspection of product 2.7% studying prints 2.7% being instructed 3.6% inspecting own work	830,000
	Total Work Cost	$ 3,750,000
c. Machine and equip.:	IBM rental	65,000
	1.3% inspection	10,000
d. Facilities (8% of floor space)		135,000
		$ 3,960,000

VII. Material Handling

a. Indirect labor departments 7,13,16,18,81		$ 1,360,000
b. Direct labor:	4.0% material handling 1.1% counting	420,000
	Total Work Cost	$ 1,720,000
c. Machine & equip.:	(4.9% out of material)	45,000
	Handling equip depreciation	10,000
	Total mach & equip	$ 55,000
d. Facilities (16% of floor space)		270,000
		$ 2,105,000

VIII. Non-Work

a. Direct labor:	14.2% personal time 6.9% waiting for machine	$ 1,750,000
b. Machine & equip.:	7.2% not assigned 5.6% no operator	115,000
c. Facilities (6.5% of floor space)		110,000
		$ 1,975,000

IX. Non-Productive Work

a. Direct labor:	5.6% setup and teardown 7.4% scrap and rework	$ 1,090,000
b. Machine & equip.:	33.6% setup and teardown 5.5% scrap and rework	345,000
c. Facilities (19% of floor space)		320,000
d. Material (6% work scrap, 7% reject scrap)		1,385,000
		$ 3,140,000

X. Productive Work

a.	Direct labor 45.1%	$ 3,770,000
b.	Machine and equipment 33.8%	300,000
c.	Facilities (17% of floor space)	280,000
d.	Material 87%	9,335,000
		$13,685,000

XI. Miscellaneous

Advertising, Sales Expense, Home Office, Transportation Equipment, etc. $ 3,605,000

$38,000,000

This data is further tabulated on Chart 11.9.4.2-4 and graphed as follows:

Chart 11.9.4.2-1 Work Efficiency (Costs), representing Labor Cost application.

Chart 11.9.4.2-2 Facilities, Equipment, and Machine Efficiency (Costs), representing capital investment cost application.

Chart 11.9.4.2-3 Productive Efficiency (Total Costs), representing a combination of the two charts above and further including material cost application.

Productive Costs are defined earlier in the manufacturing section represent useful output and are those non-reducible costs of material present in a given end product of the conversion process together with the man and machine evaluated costs directly applied as useful work on it.

The measure of Productive Efficiency is the ratio of these costs to the total costs generated in the system, in this case 36%. This, however, is the total efficiency. Work efficiency is only 19%, and Facility efficiency is only 21.9%. Only by considering material usage do we get the total productive efficiency of 36%. Of the productive costs it is considered that the Facility, Machine, and Equipment costs of $580,000 are insignificant relative to the prime costs of Labor ($3,770,000) and Material ($9,335,000), and since Material has a high efficiency factor it follows that management should operate on reducing labor costs and improving work

WORK EFFICIENCY
(COSTS)

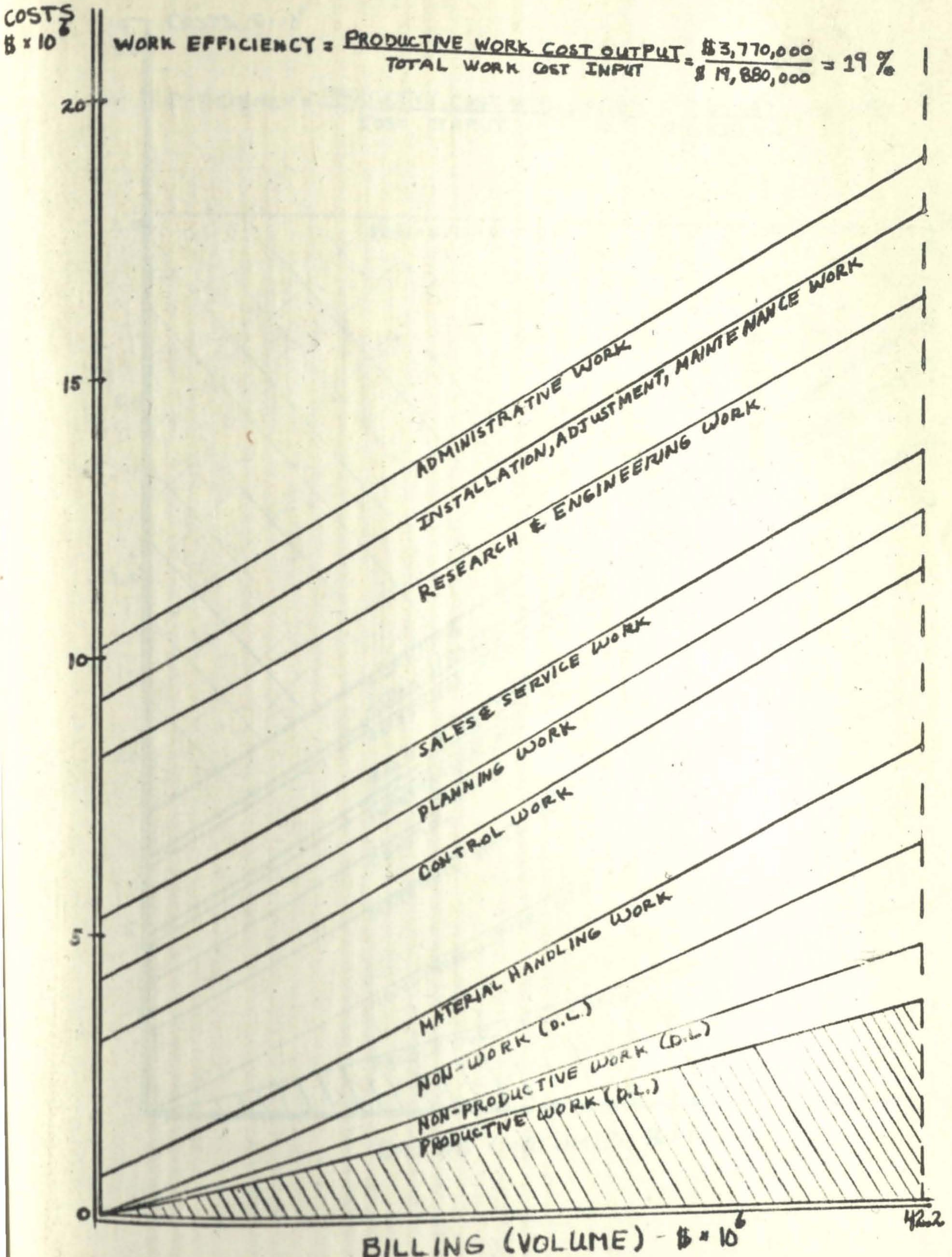


CHART 11.9.4.2-1

FACILITY, EQUIPMENT, MACHINERY EFFICIENCY (COSTS)

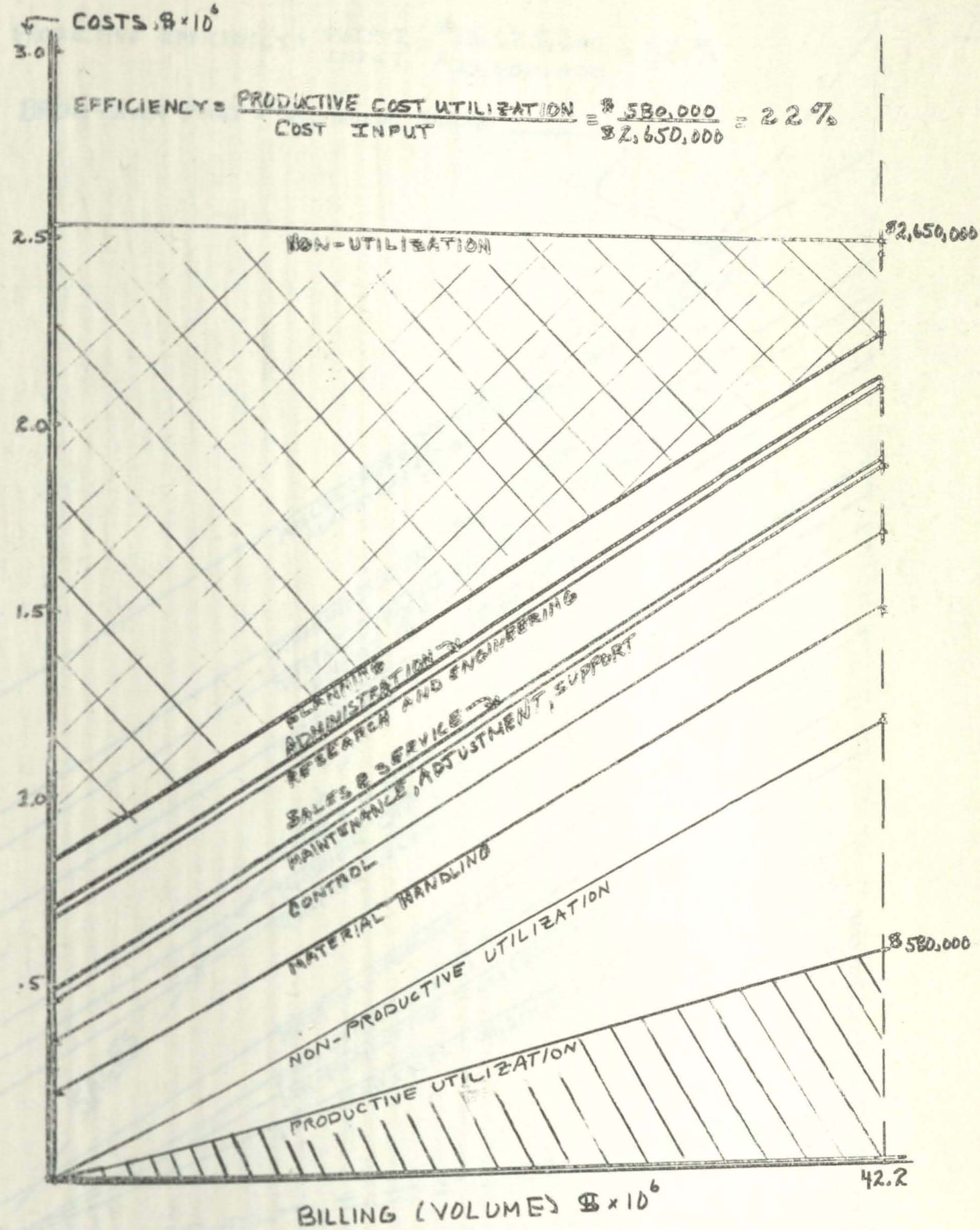


CHART 11.9.4.2-2

PRODUCTIVE EFFICIENCY
(TOTAL COSTS)

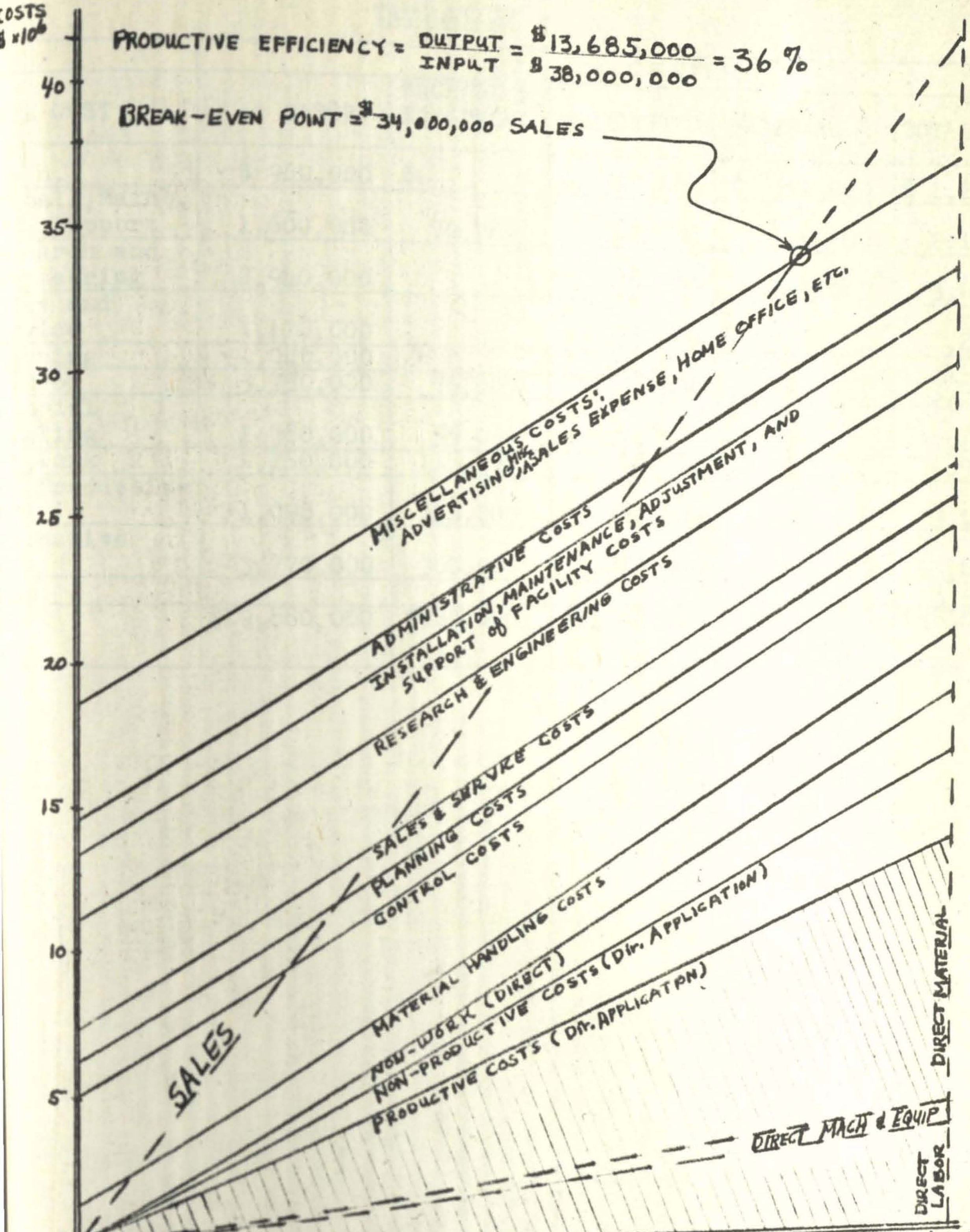


CHART 11.9.42-3

SUMMARY: INFERRED ANNUAL COSTS

TABULATION

TYPE COST	ACTIVITY CENTER				
	LABOR	MACHINE & EQUIPMENT	FACILITIES	MATERIAL	TOTAL
Admin.	$ 940,000	$	$ 50,000	$ 300,000	$ 1,290,000
Install, Maint. Adj., Support	1,660,000	70,000	120,000	345,000	2,195,000
Research and Engineering	2,940,000		215,000	500,000	3,655,000
Sales and Service	1,170,000		55,000		1,225,000
Planning	1,040,000		135,000		1,175,000
Control	3,750,000	75,000	135,000		3,960,000
Material Handling	1,780,000	55,000	270,000		2,105,000
Non-Work	1,750,000	115,000	110,000		1,975,000
Non-Productive Work	1,090,000	345,000	320,000	1,385,000	3,140,000
Productive Work	3,770,000	300,000	280,000	9,335,000	13,685,000
Misc.					3,605,000
Total	$19,880,000	$960,000	$1,690,000	$11,865,000	$38,000,000

Chart 11.9.4.2-4

efficiency. It is interesting to note that the productive costs are those that the customer would be grateful to pay. However, he must grudgingly pay the balance plus some markup, and these are a direct source of customer dissatisfaction.

It is felt that the computed factors are conservative. For instance, material handling for direct labor was taken only as that percentage an operator was away from the machine engaged in moving or otherwise handling material. Hidden in the productive direct labor is all the material handling where the operator may have been at the machine producing but continuously handling material in loading, unloading, reaching, transferring, etc. These activities are part of the time standards and the prescribed work method. However, it must be remembered that direct labor is justifiable for one purpose only, that of making the product, or "cutting chips." Every time a worker reaches for a piece two inefficiencies occur. (1) the wages he is paid during that time and (2) the productivity (capacity) that is lost. More methods study as related to people and as discussed under other headings would minimize much of this apparent activity.

Control Costs amount to $3,960,000, 10.4% of total. This percentage does not seem particularly high but there are two possibilities:

1. It is too high for the amount of control obtained, i.e. the high % of scrap and rework, the number and length of time orders are behind schedule, the value of in-process inventory, low machine utilization, low manpower utilization, low labor productivity, etc.

2. It is too low, which results in the characteristics described in the above paragraph.

It is suggested that this problem be closely studied with a view toward evolving the optimum policy atuned to the objectives of the parent company. Planning Costs present a similar analysis and problem.

Non-Productive Work Costs are those costs directly applied and paid for but do not result in useful output. Some portion of the total costs must always be present in this category. There will always be setup and teardown requirements, there will always be some scrap and rework, etc. To realize this is one thing, to be satisfied with the present level is quite another; i.e. $3,140,000.

Non-Work (but paid for) costs are discussed at length in sections 11.8 and 11.6. Suffice it to say that these costs are complete (though partly unavoidable) waste. It should be noted too that these costs were only evaluated for direct labor. If an analysis was extended to departments other than manufacturing, this cost category would be considerably higher.

Burden Efficiency Variance Cost. Scintilla allocates costs to products via a rate based on a certain percent of direct labor dollars expended. If direct labor dollars actually spent per accounting period matches the predicted, overhead will be fully absorbed by the products manufactured. An over or under variance in direct labor dollars spent results in an over or under absorbed overhead. The direct labor dollars spent is a function of these items:

1. The total number comprising the direct labor force, for once hired the person is paid, either on day rate or incentive.

2. The number of the direct labor workers on incentive and their productivity. With enough work to "keep every one busy" at normal effort 90% of the time productivity would be 100% (see section 11.8.2.2 for discussion and definitions). With either too little work or too many workers, productivity must suffer.

Productivity of Scintilla incentive workers is 80%. To be conservative the productivity of the day-rate workers will be assumed at this same level. Burden Efficiency Variance can then be computed:

$$\frac{\text{Dir.Labor \$ Spent} - \text{Dir. Labor \$ Required}}{\text{Dir. Labor \$ Spent}} \times \text{Burden Rate} \times \text{Dir.Labor \$ Spent.}$$

A burden rate of 220% per direct labor dollar will be estimated. Direct labor dollars spent (not including allowances) was $5,450,000 (see Chart 11.9.3-1).

Burden Eff. Variance =

$$\frac{\$5,450,000 - \$5,450,000 \times .80}{\$5,450,000} \times 220\% \times \$5,450,000 = \$2,400,000 \text{ annually.}$$

This represents the overhead cost wasted from inefficient utilization of the plant.

11.10 Summary of Recommendations

1. Organization

   (a) Modify existing organizational structure as outlined in section 11.3 and as justified throughout the remaining sections.

2. Re-Align Cost Centers along supervisory and departmental lines to firmy fix responsibility for incurring costs.

3. Manufacturing Classification. Develop a manufacturing classification system, combined if possible with a product classification system, that would achieve consistent identity of manufacturing similarity characteristics.

   Corollary:
   Standardization. Achieve manufacturing standardization in so far as possible, in conjunction with product standardization, by isolating and emphasizing the similarities disclosed by the classification system in order to achieve the most economic production.

   (See Variety Reduction by Simplification, Standardization, Specialization; two papers by Professor Harold W. Martin published by The British Standards Institution and the Institution of Production Engineers; 1956.)

4. Production Line Techniques

   (a) Segregate high volume production from low volume within the various product categories to facilitate production line techniques on the high volume items. The Chief Planner should keep a continuous watch on these parameters.

   (b) Analyze products with regard to summation of standard hours to make; if equal, or nearly so, to the time available in annual or otherwise acceptable periods over individual or grouped productive units, then organize those units into a continuous flow production line. This relates to single departments, or if subsequent departments are similarly balanced, then study the feasibility of combining all balanced operations into a single product line.

(c) Appraise quality concepts, particularly with respect to appearance, to see ifrejection criteria is really justified as to the production difficulties encountered.

(d) Appraise tolerances and other specifications that now limit output because of increased manufacturing difficulties to determine if really justified or if mere thumb rule criteria.

(e) Combine auto-mated machines in Department 48 into a single producing unit.

(f) Increase the use of transfer mechanisms and other material handling devices and concepts to eliminate the present hand methods now employed throughout the plant.

5. Scheduling, Dispatching, Progressing. Give serious consideration to the future adoption of a detail scheduling system implemented by Central Scheduling, Decentralized Dispatching, and Continuous Progressing.

(a) Provide for dispatching of production contracts.

(b) Assign production contract starting and ending dates in any given department.

(c) Provide for sequencing of contracts over machines in the order of part priority and/or similarity to promote maximum manufacturing efficiency.

(d) Provide for the directed movement of materials between manufacturing departments in a preplanned manner.

(e) Provide accountability of material as it moves from department to department or dispatcher to dispatcher.

(f) Relieve supervision of some planning, scheduling, organizing and administrative duties to enable concentration on product quality, product quantity, and personnel supervision and training.

(g) Provide for the availability of tools to the operator and/or set up man before actually required.

(h) Provide for insuring that material is available before a contract is dispatched.

(i) Incorporate a "channel" through which emergency jobs can flow without disturbing orderly schedule progress.

(j) Assign men to production departments to report on progress of all departmental work.

(k) Retain small, well coordinated product groups in the scheduling and control offices with similar duties to those presently being performed.

(l) Establish a Sales Liaison man to improve production response to customer requirements.

(m) Prepare schedules (such as Monthly Shortage Analysis) that cover all current production and that Production Control direct their efforts over the total work which is currently scheduled rather than just over assembly and pre-assembly work.

(n) It is recommended that production control and scheduling be based on "make spans" and automatic control be exercised through the development and use of "optimum decision rules" similar to the system being developed by the Ramo-Wooldridge Corporation.

(o) Modify Production Control progress reports (Daily Shortage Reports) to cover all current production, not just work on parts required for spares and next months assembly schedule, so that production troubles are detected at the time they first occur.

(p) Establish a manufacturing priority system to ensure that appropriate products receive the proper attention throughout their movement through the plant.

(q) Let the recommended planning department develop delivery date promises and thus better coordinate load input onto plant capacity.

(r) Institute procedures wherein the recommended production scheduling system utilizes the standard times for manufacturing developed by the Industrial Engineering section for planning purposes in liew of the one month delay-float procedure now used.

6. Product Profitability. Adopt the techniques of the Profit/Volume ratios and Profit Potential to provide a basis for making decisions regarding which products to emphasize in Sales, Cost Reduction, Price Changes, Facility Expansion, etc. Report data, developed from inferred estimates of the study group, tended to show that:

   (a) Direct costs of electrical connectors should receive added emphasis toward reduction since their profit/volume and profit potential per direct labor dollar are relatively, low, indicating a relatively low earning rate even though total earnings of this product group exceed any other.

   (b) Magnetos of the industrial, ordnance, and auto varieties should possibly be eliminated except as a continuing service to existing customers, for customer good-will, since both profit/volume and profit potential per direct labor dollar are very low.

   (c) Sales of harnesses-leads-cable assemblies should be "pushed", and production expanded since these assemblies prove the most favorable profit potential per direct labor hour.

   (d) Excess capacity should be applied to the more favorable product.

7. In-Process Inventory

   (a) Provide for adequate delegation of individual responsibility toward providing information as to the growth value, and cost of in-process inventory (in tote boxes) and for recommending ways to reduce these findings. It is recommended that this responsibility be assigned the Planning Department.

   (b) Obtain the help of a management consulting firm to determine the optimum amount of in-process inventory, and let this be the standard of performance to which the Manufacturing Department should conform.

8. Methods Engineering

   (a) Place emphasis on studying the cost of operations by thorough method analysis rather than on cost of the product, since the product costs are merely combinations of various operation costs, and cost control is best effected at the source of the costs.

(b) Emphasize methods engineering of the human variety since direct labor costs account for about 870% of machine costs. At present, nearly all the emphasis is on machine and process applications of machine bottleneck operations.

(c) Increase emphasis on work-place layout engineering to increase volume and worker productivity.

9. Cost Reduction and Analysis

(a) Create a cost analysis group external to accounting and familiar with operations so that production variances may be analyzed for detailed causes. An additional function would be to appraise cost standards themselves.

(b) Institute a vigorous cost reduction program in conjunction with (a) above to determine the various causes of inefficiencies discussed in section 11.9.4 and to find ways of reducing or eliminating the causes.

(c) Institute a cost reduction refresher training course. As a part of the program the principles of work simplification, production standards, and work measurement should be taught.

10. Economic Studies

(a) Make use of economic minimization and maximization and break-even studies for new tool costs and for other capital expenditures. The preparation of such studies and the reduction of the various factors to specific values can be used to illustrate the cost of not taking certain actions as well as indicating the economic advantages of expenditures.

(b) In relation to the above, establish decision criteria by which tooling classes and phases are determined. It is not felt that the present arbitrary numerical limits reflect forecast trends and economic optimization to a desired degree.

11. Production Standards

(a) Extend the coverage of production standards to as many areas of indirect labor as economically feasible including quality control, engineering, traffic, plant engineering and clerical jobs.

(b) Consider the possible application of work sampling as an aid in setting production standards, particularly in the indirect labor areas.

12. Incentive Wage Payment

(a) Conduct a comprehensive study of the effect of the present incentive wage plan on production and productive capacity. This study should analyze and compare the present incentive system with the possible advantages of a measured day work system including an incentive bonus for acceptable cost reduction recommendations.

(b) Issue a statement of policy from the General Manager that no employee will suffer a loss of wages as the result of the methods improvement and cost reduction programs.

(c) Discontinue the weekly report of personnel earning in excess of 150% on any job. Economically, it appears to the advantage of the Scintilla Division to encourage the highest production rate possible.

13. Planning Records (Present "Layouts")

(a) Expand the manufacturing layout to include a standard operation instruction sheet for each operation showing a standard work place layout if appropriate and the standard method of "HOW" as well as "WHAT".

(b) Institute procedures for ensuring that manufacturing planning records (layouts, prints, instruction sheets, etc.) are current and represent the actual manner of "making" intended at the time, and further, are not only available to the worker when needed but that he be required to use them when appropriate.

15. Utilization

(a) Reduce the amount of personal delay taken by workers by increased supervision of this activity.

(b) Reduce the time taken by operators for administrative work by preventing duplication of effort with inspection personnel and further by possible integration of the present worker administrative requirements with the recommended adoption of a crib-dispatch system.

(c) Reduce, by attrtion, the number of excess direct labor employees as indicated by the results of the manpower utilization analysis, or, increase the plant load by a corresponding amount. Concurrently, or before, of course work standards must be revised. These recommendations are contingent on the availability and application of suitable Industrial Relations techniques to maintain employee morale and keep from "shaking up the troops."

(d) Store or dispose of those obsolete or excess machines not now being used, to gain additional floor space.

16. Material Storage and Delivery

(a) Make a detailed study of the feasibility of a centralized stockroom to replace the present four in the Stores Unit, with a view to effecting substantial savings in operating personnel.

(b) Evaluate the economic feasibility of a mechanical materials handling system for Stock "C" and "P.I.C" Stock. This recommendation would also apply to the centralized stockroom if established.

(c) Combine the bulk of the functions of Stock "S" with similar functions under the Stores Unit in order to effect reductions in personnel requirements.

17. Load Analysis

(a) Develop a procedure for forecasting loads and load requirements. A possible method is outlined in section 11.9.2. The present method evaluates only critical bottleneck activities.

(b) Use the above procedure for maintaining a running machine load to be used by the planning department in accomplishing more exact master scheduling and furnishing timely information to production scheduling.

18. Product Quality. Tighten up quality control administrative procedures to better point the finger at those individuals who are responsible for any bad work, with application of penalty.

19. Set-Up Delay

Provide setup men in quantities sufficient to minimize machine down time, particularly in activities where operator/setup men have responsibility for two or more machines.

20. Electrical Connector Assembly

Reduce the 36% daily duplication of connector assembly orders by consolidating orders before release to the assembly foremen.

21. Raw Stores

Increase the level of raw stores to reduce delay in starting work.

22. Foremen Training

Institute a vigorous foremen training program to include at the very least subjects on all phases of cost reduction, development and execution of on-th-job training programs, and methods and procedures by which man and machine utilization can be increased such as work station scheduling techniques, etc.

BIBLIOGRAPHY

1. Industrial Engineering Handbook
H. B. Maynard
McGraw-Hill Book Company, Inc., 1956

2. Handbook of Industrial Engineering and Management
Ireson and Grant
Prentice-Hall, Inc., 1955

3. Production Handbook
Alford and Bang
Ronald Press Co., 1956

4. Industrial Organization and Management
Bethel, Atwater, Smith and Stackman
McGraw-Hill Book Company, Inc., 1956

5. Production Planning and Control
Thomas M. Landy
McGraw-Hill Book Company, Inc., 1950

6. Job Evaluation Methods
Charles W. Lytle
Ronald Press Co., 1954

7. Company Organization Structure
Ernest Dale
American Management Association, 1953

8. Organization of Industry
Alvin Brown
Prentice-Hall, Inc., 1947

9. (A) Investing in Simplification and Standardization
(B) Standards, the Standards Engineer and Economic Production.
Two papers by Professor Harold W. Martin, published by the British Standards Institution and Institution of Production Engineers.
"Variety Reduction", 1956

10. The Learning Curve as a Production Tool
Harvard Business Review, 1954

11. Modernization Makes a Million for Bosch
American Machinist Report No. 442

12. Mechanics of the Learning Curve
Aero Digest, Nov. 1952

13. Scintilla Management Conference Talk, 1957
by H. Keller, Master Mechanic

14. Introduction to Operations Research
Churchman, Ackoff, Arnoff
John Wiley and Sons, Inc., 1957

15. Cost Accounting
Clarence B, Nickerson
McGraw-Hill Book Company, Inc., 1954

16. Quality Control and Industrial Statistics
Acheson J. Duncan
Richard D. Irwin, Inc., 1955

17. Motivation and Morale in Industry
Morris S. Viteles
W. W. Norton & Co., Inc., 1953

18. Range of Human Capacities
David Wechsler
Williams & Wilkins Co., 1952

19. Psychology in Management
Mason Haire
McGraw-Hill Book Company, Inc., 1956

20. Psychology of Industrial Relations
C. H. Lawshe
McGraw-Hill Book Co., 1953

21. Operations Research for Management
McCloskey and Trefethen
The Johns Hopkins Press, 1954

22. Handbook of Advanced Time-Motion Study
L. Arthur Sylvester
Funk and Wagnalls Company, 1950

23. Operation Sampling and Analysis for the Determination of Production Time Standards
A paper presented before the Operations Research Society of America, Fall, 1953, by Professor Harold W. Martin, Rensselaer Polytechnic Institute, Troy, New York.

24. How You Can Put Work Sampling to Work
Factory Management and Maintenance, July 1952

25. Work Sampling in the Office
American Management Association Office Management Series
Report No. 140

26. The Importance of Plant Layout In Cost Reduction
American Management Association Manufacturing Series
Report No. 222

27. The Dynamics of Time Study
Ralph Presgrave
The Ryerson Press, 1956

28. The Development of Executive Talent
M. Joseph Dooper, Editor
American Management Association, 1952

29. "How to Increase Productivity by Using Modern Industrial Methods"
Mill and Factory, May, 1947. pp. 86

30. "Squeezing Indirect Labor Costs"
Factory Management and Maintenance, July 1956

31. "The Proper Approach and Solution to Wage Incentive Plan Problems"
Advanced Management,
W. C. Zinck, Feb., 1954

32. (101) Quality Control, Principles, Practices and Administration
B. V. Feigenbaum
McGraw-Hill 1951

33. (102) Quality Control Handbook
J. M. Jurran
McGraw-Hill 1951

34. Standard Cost for Manufacturing
Henrici, S.B.
McGraw-Hill, 1953

35. Accounting, A Management Approach
Robnett, Hill, Bechett
Richard D. Irwon, Inc., 1955