INDUSTRIAL DATA PROCESSING APPLICATIONS REPORT

Applications	Manufacturing Control
Type of Industry	Metal and Ablative Plastics Defense Products Manufacturer
Name of User	Power Systems Div. The Marquardt Corp. Ogden, Utah

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Equipment Used	IBM 1620 Data Processing System IBM 1001 Data Transmission Units Bell System Data-Phone Data Sets

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Synopsis

Manufacturing control is the principal computer application at the Ogden, Utah, plant of the Marquardt Corp. This moderate sized facility, which employs 650 employes, handles over 40 defense contracts involving more than 2,000 active shop orders. Control of this work, including scheduling, purchasing and surveillance, is the sole task of an IBM 1620 data processing system. Thus informed of the status of all jobs on an up-to-the-minute basis, the plant possesses the flexibility and efficiency needed to satisfy its manufacturing management mission.

Active control for every aspect of job fulfillment begins with the issuing of an engineering release, computer scheduling of production and creation of a WIP (Work In Process) file. The actual work orders used in the factory are "travelers" duplicated from typed masters. They travel with the jobs in an acetate jacket. The jacket also contains a "jicket", a single punched card bearing prepunched identifying serial data, which serves as a master job ticket. At each stage of production, the jicket is inserted into an IBM 1001 data transmission unit to provide job identification and variable information is transmitted via the 1001 keyboard. This data is received in card form at the data processing department.

At the close of each day, all transmission cards are fed into the 1620 which automatically generates three critical daily reports. The WIP Summary details the location and status of each job in the plant and indicates any which are behind schedule. It thus serves both a troubleshooting and a control function. The Parts Analysis reports the plant's inventory situation, listing total requirements for each part and detailing performance. The Ordering Analysis is similar to the parts analysis. It monitors parts coverage against schedule in-work dates and indicates quantities of parts that should be released to maintain schedule. Other management control reports are produced from the same data files as these basic documents.

Computerized production control is no longer an exclusive feature of large plants operated by giant corporations. A growing number of smaller plants is proving that, given the proper application of management ingenuity, advantages can be obtained in scheduling and controlling production and materials. In fact, these plants often have an advantage over larger ones in that the lines of communication needed for production control are shorter and usually more flexible. A case in point is provided by the Power Systems Div. of Marquardt Corp. in Ogden, Utah. This organization, which operates an IBM 1620 data processing system and an extensive data transmission network, now uses automated information collection and processing techniques for virtually every phase of job fulfillment control.

In terms of production control requirements, the Power Systems Div. of Marquardt Corp., Ogden, Utah, offers a profile-in-miniature of conditions in the aerospace industry. Its prize-winning 275,000 square foot plant was opened in 1957 for fulfillment of a single long-range defense contract -- production of ramjet engines for the BOMARC missile. The phasing-out of the BOMARC in 1962 led to a severe cutback in work backlog and to the recasting of the plant's role to that of a facility for production and short run, precision manufacturing of metal and ablative plastics products (rocket engine nozzles).

Presently, the Ogden plant handles approximately 50 different contracts from various customers, involving more than 1,400 different parts or assemblies. The contracts require upward of 4,000 blueprints and approximately 65,000 print copies. Out of the total work force of 650 employes, approximately 225 are direct production workers. There are now about 2,000 "shop travelers" to be monitored, with about 250 new travelers being released each week. Each of these shop orders involves an average of 15 separate manufacturing operations, as well as issuing orders and monitoring fulfillment of purchase of materials and needed subcontract items. More than 200 operation completions a day are signalled to data processing via data transmission terminals.

EDP at Marquardt Corp.

The increase in the number and variety of jobs caused by the change in the Ogden plant's activities made improved management control mandatory. The plant, however, had been designed solely as a production facility; manufacturing, including product engineering, being its sole responsibility. All administrative, accounting and design engineering functions of the Marquardt Corp. are performed at its head office in Van Nuys, Calif. The administrative controls, corporation-wide accounting, billing and payroll are processed there on an IBM 1401 data processing system. This meant that the Odgen production management staff could not ride any "supplementary application" coattails in setting up a computerized production reporting and control system. A new system would have to pay its own way. Furthermore, its feasibility had to be proved for a facility considered by many as too small for computerized production control.

Marquardt's philosophy is to fit the machine to the job. When the firm began evolving its present system, the bulk of the work in this field had been done on large scale computers. A thorough study proved, however, that it was practical to adapt existing techniques and applications to smaller, lower cost systems. Accordingly, another study was undertaken to select a data processing system that would satisfy the following requirements:

Fig. 1.

IBM 1001 DATA TRANSMISSION UNITS convey job information from the plant floor for entry into computer memory.

1. It would provide linear programing capabilities for the detailed shop-loading applications planned.
2. It could be used on a part time basis both by the manufacturing engineering staff and for the manufacturing control activities.
3. It could calculate machine functions and generate operating control tapes for the plant's four numerically controlled machine tools.

This study led to the installation of an IBM 1620 data processing system with 20,000 positions of alphanumeric core storage. The system was supported by unit record equipment consisting of keypunches, verifiers, an interpreter and reproducers. The system configuration was later expanded with the addition of an IBM 1443 output printer and two IBM 1311 disc drives. With this new configuration, data stored on interchangeable disc packs, storing up to two million characters of information apiece, replaced voluminous punched card master decks in the maintenance of production and material status data.

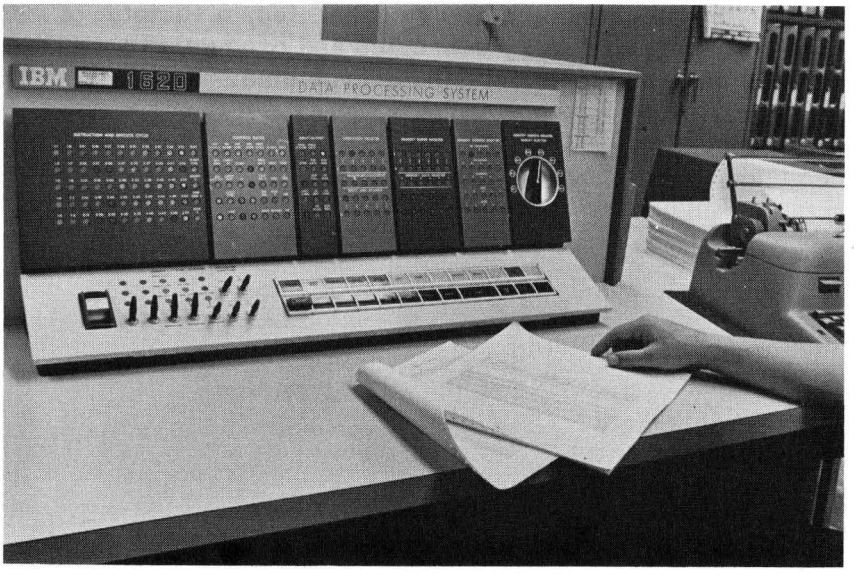

Fig. 2.

IBM 1620 DATA PROCESSING SYSTEM produces daily work-in-process and parts inventory reports.

In addition, an IBM 1001 data transmission system and Bell System Data-Phone data sets (Fig. 1) were installed to facilitate the gathering of production control data from the plant floor. This system presently includes 18 IBM 1001 data transmission terminals, two IBM 026 Model 4 receiving units for the 1001s, and two IBM transceivers. The transceivers which are used as keypunches during business hours are used at day's close to transmit information from Ogden to Van Nuys. The 1001 data transmission terminals are now used in all phases of the manufacturing activity. They are located in various fabrication and assembly areas to report the movement of jobs as well as the results of on-line production inspection. The terminals are also installed in receiving, the blueprint room, the tool crib and work-in-process stores (to record final completions, issues and parts inventory control).

During the several months between order of the then relatively new 1001 terminals and installation, management began training plant personnel for their future data reporting functions. To do so, a master file of job cards was set up in the data processing department. A telephone was installed at each station in the plant where job progress information would be reported. Dispatchers at these stations were instructed to telephone job completion data to a clerk in the data processing department, who withdrew the proper cards from the file and entered them into the system. This approach immediately improved the timeliness of production control reporting and also served to prepare the plant for 1001 reporting.

Following installation of the 1001s, operations were conducted with a card-oriented system for over a year. Under this plan, the cards punched in the data processing department as a result of 1001 transmissions were sorted on the swing shift and collated with a job status deck to produce daily reports that were current as of the close of the previous business day. The system was then further refined with the installation of the two 1311 disc drives.

This approach has permitted the application of management by exception techniques to purchasing, inventory, tooling, and blueprint control. The reports, thus produced, highlight any information which require management's immediate attention. In each case, data processing applications have been requested and defined by departmental managers, assuring that the information provided is of direct benefit to the department involved.

Applications

The parts ordering and inventory and production control problems of the Ogden plant are common to factories having multiple contracts with various delivery schedules, a variety of parts, constant engineering changes, and changes in delivery schedules and production rates. The present control system was specifically designed to relieve these problems. Its specific objectives are to:

- Control inventory balances
- Release shop orders on schedule
- Maintain constant line flow
- Prevent parts shortages
- Eliminate over-ordering against contracts
- Provide rapid input on line loss and scrap items
- Supply timely data to inventory control and order release groups.

To achieve these objectives, the system is based on the following approaches:

- Utilization of an item and indenture scheduling technique
- Tying in of on-order balances with current production control
- Utilization of the data collection system as a means of input
- Establishing a means of modifying inventory records through data collection devices.
- Reporting scrap and order cancellations as they occur

Production Programing and Control Dept. groups together the functions of production programing and scheduling, order releasing, material control, shipping, receiving, raw materials stores and work-in-process stores. This grouping of functions permits the implementation of several integrated data processing systems (Fig. 4) which aid the department in:

1. Programing new business
2. Scheduling and shop loading
3. Controlling raw materials and work-in-process inventory
4. Evaluating the progress of a program against planned schedules for physical parts, and budgetary and cost status.

Active control for every aspect of job fulfillment begins when a shop order is released. The ordering control group then assigns it a serial number which identifies the order throughout its life in the manufacturing cycle. The serial number is related to all pertinent identifying shop order information (part number, charge number, quantity, scheduled due date, etc.). The identifying information is sent to data processing on a release notification form. This document includes a complete explosion of materials requirements and full details on manufacturing hours in each of the plant's 18 operating cost centers. All planning is built around the completion date part of this release.

In data processing, data on job and parts requirements are punched into cards and fed into the 1620. The computer, which has access to time standards and work-in-process disc files, operates under a linear program especially developed for this application. Scheduling is done under the indenture method: starting with the final delivery date, individual setbacks are calculated for each manufacturing step. These forecasts include full allowances for lead time, inspections, and all other scheduling requirements all the way from initiation of the job through final testing and delivery. As a result, the 1620 creates, in conjunction with a routing and time standards file, an activity work-in-process file (WIP) for each job. The location of the job, which is shown on this file, is updated with information obtained from the plant floor through the 1001 data collection system.

The actual work orders used in the factory are "travelers" duplicated from typewritten masters. These travel with jobs in acetate jackets, serving as authority to perform specified jobs, to release materials, and so forth. In the same jacket is a "jicket", a single punched card which serves as a master job ticket. Additional cards are kept at points which originate other 1001 data transmissions, such as the store room, tool crib and blueprint department. Jickets contain prepunched serial data only. Variable information identifying operations performed and/or plant location is transmitted via the keyboard of the 1001 to data processing

where it is received in card form. These cards are immediately ready for computer entry, and there is thus no delay for source data creation or verification. This approach places responsibility for accurate reporting on the lead men and supervisors in the plant, making for tighter, more effective over-all management control.

Approximately 1,000 cards are created daily by keyboard transmissions. The data processing swing shift sorts them according to application, such as work-in-process, purchasing, blueprint and so forth. The cards then are fed onto the 1620 under a program which updates the three million character disc pack memories of two IBM 1311 disc memory files. These files accumulate and maintain complete data on functions controlled by the system.

In addition, the 1620 processes all transmission cards at the end of each day to generate three critical daily reports automatically:

W.I.P. Status Summary Report (Fig. 3) shows, for each job in the plant, location, work done to date, current work being performed, and operations to be completed. Each individual operation carries a scheduled completion date. Any jobs behind schedule are called out in this report, which also indicates the number of days behind schedule for each late operation.

DATE 05/12/64 M-DAY 088 — W. I. P. STATUS SUMMARY — TMC C-4047

DESCRIPTION							PRESENT STATUS												TO-DATE				YET-TO-DO				
								OPEN OPERATION					COMPLETION M-DAY		DAYS IN THIS COST CENTER	DAYS AHEAD OR BEHIND SCHED.	LAST LABOR CHARGE M-DAY	COMPLETED		TOTAL ACTUAL SET UP TIME	M OF MFG WT. IN '00	REMAINING STANDARD RUN TIME	NEXT PLANNED COST CENTER	SCHED. COMP. M-DAY NEXT OPER.	NEXT PLANNED MACH. NO.	TOOLING
PART NUMBER	CONTRACT & ITEM	TRAVELER SERIAL NO.	QTY. ON TRAVELER	BLUE PRINT REVISION	M	B	TRAVELER COUNT	OPER. NO.	COST CENTER	MACH. NO.	LOAD HOURS	ACTUAL HOURS RUN TIME	OPER. COMP.	TABLE COMP.				STANDARD RUN TIME	ACTUAL RUN TIME							
520945-000	0789-11	50954	1	4	W	M		0500	4700		.5	3.0	078	081	3	10-	087	5.5	6.8		3	1.2	4433	079		
520945-000	0789-11	50956	1	4	W	M		0500	4700		.5	1.3	078	081	1	10-	087	5.5	4.9		3	1.2	4433	079		
520945-000	0789-11	50952	1	4	W	M		0600	4433		1.2	.5	079	081	1	9-	087	6.0	6.3		2	.	7230	080		
			312				4				2.2	4.8						17.0	18.0			2.4				*
521948-000	0789-10	47765	34	1	A	S		0200	7240				303	307	2	215+					1		7240	307		
			34				1																			*
523659-000	0789-15	60003	185	1	B	M		0200	4421	2216	12.0	.	211	221	1	123+					7	48.3	4426	214	2302	
523659-000	0789-14	59261	185	1	B	M		0300	4426	2302	8.2	1.5	173	180	10	85+	085	12.0	14.4	5.0	6	36.3	7230	174		
523659-000	0789-13	58404	188	1	B	M		0500	4423	1303	16.6	19.2	133	138	12	45+	078	21.6	25.9	8.3	4	19.3	4422	135	1202	
			558				3				36.8	20.7						33.6	40.3	13.3		103.9				*
524648-000	0789-13	54004	185	5	B	M		0200	4421	2216	15.2	.	124	144	3	46+						156.9	4423	128	1609	
524648-000	0789-12	53017	185	5	B	M		0600	4426		23.8	5.3	097	102	9	9+	087	133.1	187.2	10.5	4	12.2	7230	098		
			370				2				39.0	5.3						133.1	187.2	10.5		169.1				*
524649-000	0789-13	54005	185	5	D	M		0750	4422	3201	10.7	2.0	102	140	3	14+	087	75.1	76.3	5.0	18	247.4	4424	105	2005	
524649-000	0789-12	53018	185	5	D	M		0770	4424	2005	30.0	21.5	062	098	2	26-	087	81.2	82.9	7.3	17	228.9	4426	064		
			370				2				40.7	23.5						156.3	159.2	12.3		476.3				*
524651-400	0789-12	53061	185	1	G	M		2300	4422	2306	16.1	5.9	086	106	1	2-	087	202.1	224.3	13.4	15	222.9	7230	087		
524651-400	0789-11	53029	93	1	G	M		9600	4433		22.5	30.1	082	085	3	10-	087	198.1	215.5	18.3	2		7230	084		
			278				2				38.6	42.0						400.2	439.8	31.7		222.9				*
524652-000	0789-12	54121	185	7	L	M		0900	4427	2333	25.2	30.5	078	098	3	10-	086	41.9	38.1	2.6	9	103.4	4426	082		
524652-000	0789-11	53005	46	7	L	M		1500	4481		6.8	4.9	085	088	1	9-	086	47.2	43.4	3.3	3		7230	086		
			231				2				32.0	35.4						89.1	81.5	6.1		103.4				*
524652-400	0789-14	33429	30	1	L	M		0850	4423	1106	.6	1.5	186	211	3	98+	083	31.7	31.9		37	246.1	4423	187	1106	
524652-400	0789-14	33424	37	1	L	M		0900	4423	1106	14.6		178	203	1	90+	085	38.8	37.5	7.0	36	293.8	4424	179	2118	
524652-400	0789-14	33425	30	1	L	M		0900	4423	1106	11.9	6.5	171	196	1	83+	087	31.7	37.7	4.0	36	238.6	4424	172	2118	
524652-400	0789-14	33426	30	1	L	M		0900	4423	1106	11.9	.	164	189	1	76+	085	31.7	42.3	.	36	238.6	4424	165	2118	
524652-400	0789-14	33427	30	1	L	M		0900	4423	1106	11.9	.	158	182	1	70+	085	31.7	32.8	.5	36	238.6	4424	159	2118	
524652-400	0789-14	33428	30	1	L	M		0900	4423	1106	11.9	.	151	175	1	63+	085	31.7	29.0	.	36	238.6	4424	152	2118	
524652-400	0789-13	33339	29	1	L	M		1850	4422	1701	11.0		161	168	2	73+	086	176.0	179.2	.5	16	87.5	4422	162	1701	
524652-400	0789-13	33340	30	1	L	M		1850	4422	1701	11.3		154	161	2	66+	085	181.6	145.3	2.5	16	90.2	4422	155	1701	
524652-400	0789-13	33343	35	1	L	M		1850	4422	1701	12.8		145	153	1	57+	086	212.3	197.0	1.5	16	105.5	4422	146	1701	
524652-400	0789-13	33341	30	1	L	M		1870	4422	1701	11.3	.	139	146	2	51+	086	187.6	162.6	9.0	15	84.2	4423	139		
524652-400	0789-13	33342	30	1	L	M		1870	4422	1701	11.3	13.5	132	139	2	44+	087	187.6	167.3	2.3	15	84.2	4423	132		
524652-400	0789-13	33338	31	1	L	M		2200	4423	1109	6.7	1.5	127	132	2	39+	087	218.7	190.4	.5	11	63.5	4426	130		
			372				12				127.2	23.0						1361.1	1253.2	27.8		2009.4				*
524653-000	0789-11	58153	56	3	B	M		0010	4540				081	086	10	7-					4	14.9	4540	082		
524653-000	0789-12	55264	185	3	B	M		0010	4540				091	099	10	3+					4	49.3	4540	093		
			241				2															64.2				*
524654-000	0789-10	47676	778	1	F	B		0100	2100				084	115	10	4-					1		7240	114		
524654-000	0789-10	47616	118	1	F	B		0100	2100				035	066	10	53-					1		7240	065		
524654-000	0789-10	56041	97	1	F	B		0100	2100				062	093	10	26-					1		7240	092		
			993				3																			*

Fig. 4. **WIP STATUS SUMMARY** is produced daily and serves in both a troubleshooting and control function, alerting production management to situations which must be expedited.

This summary is used by shop dispatchers in moving orders, by manufacturing personnel to anticipate workload, by project schedulers to control their contract status, and by a budget controller to assess a project's percentage of completion. It thus performs both a trouble-shooting and control function. In addition, the information is used, in relation to project schedules and quantities, as input to the ordering and parts inventory control system.

Parts Analysis Report details the inventory situation in terms of parts needed to sustain current production schedules. For each part, it lists total requirements and details performance in terms of quantities ordered, on hand, already issued and still needed. Any time projected parts availability falls behind production requirements, the computer prints an exception code which triggers follow-up action.

Ordering Analysis is similar to the parts analysis. It monitors parts coverage against scheduled in-work dates and notifies the order release group of the quantities of parts that should be released to maintain schedules. The lead time for each release is calculated by the 1620. This report provides notification five days in advance of the required shop order issue date and, as such, indicates to the order release group those parts which require order activity within sufficient time to establish availability of the necessary material. This machine analysis eliminates line stoppages due to late releases.

Other management reports emanate from the same data files as do the daily reports. For example, as needed, the computer will produce a complete shop load analysis. This report is projected over 18 four-week operating periods. Similarly, a blueprint control and activity report is produced semi-weekly. Prints are charged out of the blueprint crib to the shop traveler or on temporary loan to a department. Those charged on a temporary basis are audited on a five-day follow-up. When the print is returned, notification is sent to the data processing department via 1001. Prints overdue for return are automatically flagged. The advantages of this control are the assurance that engineering change orders are known immediately by everyone, reduction in blueprint copies required, and reduction of clerical effort in the administration of blueprint control. Similar controls are applied to the issuing, inspection and calibration of inspection devices.

Results

Marquardt management cites a number of specific advantages gained through the new system. Among them are the following:

- The order group is signaled to release orders without supplemental records.
- Orders released are computer audited.
- Behind schedule orders are flagged.
- Schedule change effects are quickly reflected in ordering and parts status.
- Inventory balance is entered daily to order release.
- Inventory balances are computer maintained.
- Over-ordering against contract is reduced.
- Work-in-process is reflected in analysis.
- Manpower used in the order release group is minimized.
- Reorder requirements are automatically generated by in-process scrap.

This approach has given the company a manufacturing information system (Fig. 5) which provides complete production, material, purchasing, tooling and blueprint control as a cost which can be borne by a plant with only 650 employes. In many instances, the system's value predates the receipt of a contract. When Marquardt marketing executives are negotiating for a promising contract, the contract requirements are frequently superimposed over a computer produced shop load forecast, which is maintained for 13 four-week accounting periods. This procedure is helpful in ascertaining production capabilities during the life of the prospective contract.

By performing its functions, the 1620 is deemed to pay for itself in clerical savings alone. Yet, still greater savings are realized through improved records on in-plant job locations. Enjoying fully updated records, the company has been able to reduce greatly the number of expeditors needed to find work in process and to report on its status to management. Production management personnel believe that the entire plant's efficiency now reflects the scheduling accuracy and positive records made possible by computer produced records.

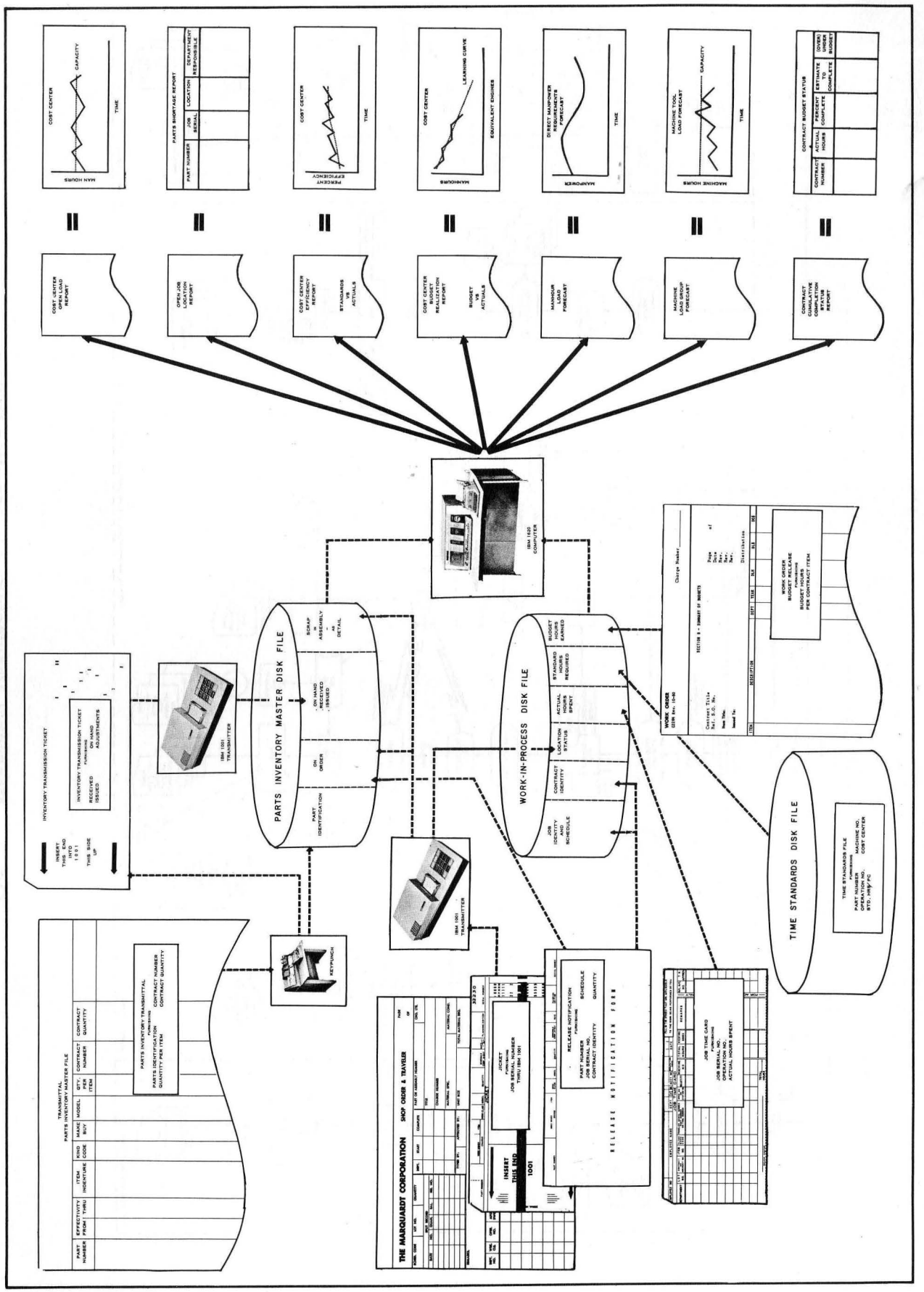

Fig. 4. Marquardt Manufacturing Status and Cost Control System.

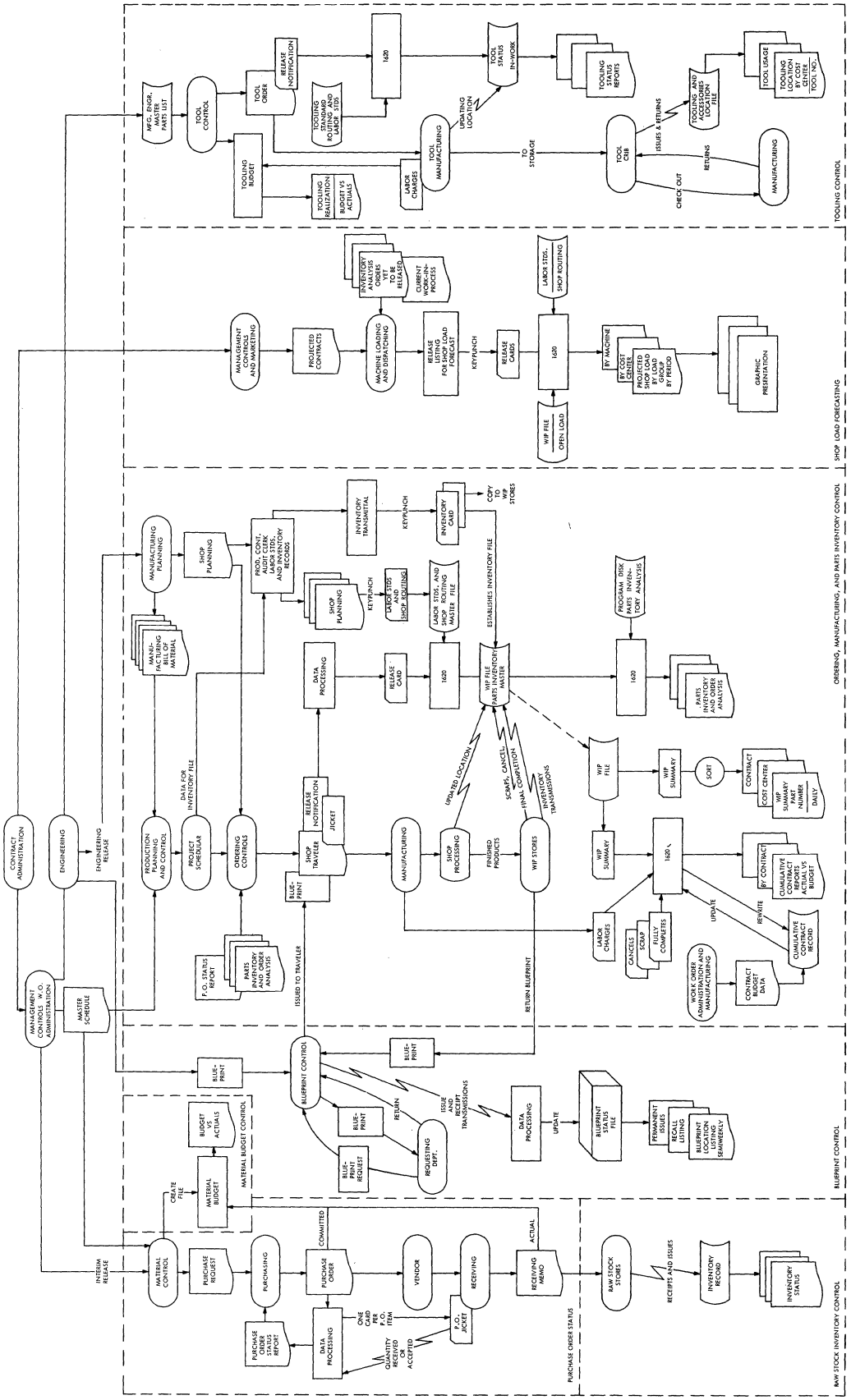

Fig. 5. Marquardt Manufacturing Information System.