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ABSTRACT

A STUDY OF A PRODUCTION CONTROL SYSTEM
IN A JOB ORDER DIE CASTING PLANT

by

R.G. Woodnorth

This thesis examines the production planning and control system in a job-order die casting plant. After comparing to the criteria for an ideal system the following changes were recommended.

1. Central work storage and dispatching. This would reduce work in process and workload fluctuations through closer planning. It would also provide a perpetual inventory system and a central control point which would be constantly informed of production progress.

2. Operator trucking. By having operators do their own trucking material handling costs and production delays would be reduced.

3. Simplified job cost accounting. The use of standard costs for finishing and inspection operations would reduce accounting clerical work and eliminate all timekeeping activities in the Finishing and Inspection

departments.

4. Simplified timekeeping. By basing bonus payments on the operator's overall daily efficiency rather than on each job, all checking out except at the end of the day is eliminated.

5. Punched card equipment. One of the objects of this thesis was to examine the possibility of applying automatic office equipment to the production planning and control system. However the expense of a tabulating system is not justified, if the foregoing recommendations are carried out, because the repetitive clerical tasks have been largely eliminated. Therefore the purchase or rental of punched card equipment is not recommended.

6. Application. It is recommended that the installation of central work storage and dispatching and operator trucking be postponed until the new plant is built because of space limitations in the present plant.

The recent adoption of tabulating equipment for payroll preparation and job cost accounting should be evaluated when the installation is complete and the system should be compared to the proposals for simplified job cost accounting and simplified timekeeping.

A STUDY OF A PRODUCTION CONTROL SYSTEM IN A JOB ORDER DIE CASTING PLANT

BY

ROBERT G. WOODNORTH

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NEWARK, NEW JERSEY

JANUARY, 1958

PREFACE

This thesis will examine the production planning and control system presently being used by a job-order die casting plant. Changes will be proposed if the system is found to fall short of meeting the criteria for an effective production planning and control system.

The feasibility of applying modern automatic office equipment such as tabulating systems, computers, etc., to production planning and control will be considered in particular. The advances which have been made in this field make it a very promising area of investigation; however, it is possible that the expense of automatic equipment are not justified for this application.

Chapter I, INTRODUCTION, presents the background material for this thesis with a brief history of production control and description of automatic office equipment.

Chapter II, PRESENT SYSTEM OF PRODUCTION PLANNING AND CONTROL, describes in detail the system now in use.

Chapter III, ANALYSIS OF PRESENT SYSTEM, compares the present system to an ideal system.

Chapter IV, PROPOSED CHANGES, presents several suggested changes in general terms.

Chapter V, PROPOSED SYSTEM, describes in detail a production planning and control system incorporating the changes suggested in Chapter III.

Chapter VI, CONCLUSIONS AND RECOMMENDATIONS, summarizes the conclusions reached in this thesis and presents recommendations for applying the proposed system.

Thanks are due to my advisor, Professor Oliver J. Sizelove, who directed my efforts and made valuable suggestions.

My wife, Margaret, also deserves appreciation for her contribution in preparing and typing this thesis.

The National Association of Accountants and Prentice-Hall Inc., publishers, have kindly granted permission to include the quotations on pages 8 and 52.

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CHAPTER I

INTRODUCTION

This chapter presents the background material for this thesis with a brief history of production control from its beginning during the Industrial Revolution to the present. The development of machines for office work is also summarized and a short discussion of modern electronic computers is included. The factors which encourage the mechanization of clerical work are discussed and the impact of "office automation" is considered.

THE DEVELOPMENT OF PRODUCTION CONTROL

The techniques of production control were developed concurrently with the growth of the Industrial Revolution. The evolution of industry from the "domestic system" to the "factory system" brought an increasing need for those activities which are known as production control.

Prior to the Industrial Revolution production was generally carried on in the home. The tools of production were inexpensive and could be owned by the worker. They were usually muscle-powered and required a high degree of skill and experience to operate. This was the "domestic system" and the worker was the supreme element of the manufacturing process. This system, however, could not

satisfy the increasing demand for goods in the second half of the eighteenth century.

Productive output was increased by the adoption of the "factory system" in which the workers congregate in a central place and use tools owned by the factory. This change was characterized by advanced production machinery, steam power, and the rise of the capitalistic system.

The factory system started a trend which subordinated the worker to his machine. Mechanization and mass production techniques lowered the skill level of the individual worker. Skilled craftsmen yielded to semi-skilled workers, and were often replaced by women, children, and prisoners.

Even under the factory system production control was not complex during the nineteenth century. The factories were small and tightly knit and there were still many skilled workers who were responsible for a product from start to finish. These workers and groups of workers could understand other operations in the factory and they still retained enough pride and interest in their work to associate their efforts with the objectives of the company.

As manufacturing became more complex and the workers grew more specialized the production control system changed too. In early factories the chain of command was usually organized as follows: The general manager, the superintendent, the foremen, and the workers. When an order was received the salesman would tell the superintendent who, in turn, told the foremen and gave them his instructions. The foremen instructed the workers who supplied any missing information from their own experience or asked questions if in doubt. The foreman assigned the new job when the previous job was done and the foreman and the workers assumed the responsibility of insuring that the work was done properly. The foreman and worker also had to schedule the necessary tools and materials and they had to decide on the best production method. When questions arose which the foremen could not answer they referred to the superintendent. Stock chasers were employed to break up production bottlenecks, and when the bottlenecks persisted, more stock chasers were hired.

The factory system was not to remain quite so simple however. The insatiable demand for more production and lower unit costs resulted in more mechanization, assembly-line techniques, and further dilution of skills. The highly trained artisan gave way to lower-paid and less-skilled machine and assembly-line operators, each one

performing only one or two operations on a component part or subassembly of the product.

The manufacturing problems of production control had become much too complex for the ordinary mechanic or foreman to manage. A formal system of progress control and record-keeping became essential if delivery dates were to be met and expensive machines were to be kept busy.

Advantages of a Production Control System

The increased administrative work of a formal production control system, as compared to the previous informal system, could be justified by the savings and improvements resulting from the new system. The major advantages of a successful production control system may be listed as follows:[1]

1. More deliveries are made on time.
2. Shop foremen are assisted by control specialists.
3. Men and equipment are more fully utilized.
4. Inventories are maintained nearer to optimum levels.

1 Advantages derived from a variety of sources; among them are: Bethel, Knoepke, Ireson, O'Donnell and Parton. (See Bibliography for complete information).

5. Production bottlenecks can be foreseen and avoided.

6. Less time is lost waiting for tools and materials.

7. Work flows smoothly and rapidly through the plant.

8. Employees' morale is improved by working for a smooth-running, well managed organization.

Modern production control is much broader in scope then in the early days and includes many elements and devices, some of which are; budgets, inventories, methods, standards, materials, machines, tools, inspection, purchasing, and plant capacity. The functions of modern production control are: planning, routing, scheduling, and dispatching.

THE DEVELOPMENT OF MACHINES FOR OFFICE FUNCTIONS

Today's complex office machines are descendants of a device used in ancient times, the Roman Abacus, which is still used in the Orient. In the seventeenth century Pascal developed a mechanical calculator based on the abacus. In 1780 Joseph Marie Jacquard invented the loom control card which is still the foundation of the pattern weaving machines which weave textiles of all sizes and types. These advances laid the foundation for further developments. In the middle nineteenth century an

English statistician, Charles Babbage, tried to adapt the Jacquard principle to facts and figures. His "Analytic Engine" was unsuccessful because the machining methods of that time could not meet his requirements for precision. His machine used pre-punched cards to replace finger operations.[2]

In the United States, the national census which began as a straightforward counting operation grew into an impossible task because of the country's growth and the increasing requirement for information. The 1880 census involved so much clerical work that improved methods were obviously needed if the results of the next census were to be ready in time for them to be useful.

Dr. Herman Hollerith, a statistician and inventor, was employed by the Census Bureau to solve this problem.[3] He improved on the Jacquard and Babbage machines by mounting a pair of magnetic brushes on either side of the punched card which contacted when passed over a punched hole. The resulting electrical impulse actuated the machine. This principle was superior to the preceding one

2 W.T. Donegan, "Holes That Build Business," Science Digest, Vol. 28, November 1950, pp. 63-64.

3 Ibid. 2 p. 64.

which used mechanical pins which dropped through the holes in the punched card to work the machine. Dr. Hollerith's machines transcribed data in two thirds the usual time and tabulated it eight times faster than previous hand methods.[4]

After leaving the Census Bureau Dr. Hollerith formed a company which eventually became known as the International Business machines corporation. IBM machines have advanced considerably since then, but they still use Hollerith's basic principle of the electrical contacts and the punched holes.

However the machine which punched the cards would not be fast enough for the 1910 census, so another inventive statistician was called upon; James Powers.[5] Mr. Powers' invention was the die-set punch which allowed the operator to set up all the information and make corrections before punching the card. Using the die-set punch as a foundation Mr. Powers developed a tabulating system that is now an important division of the Remington Rand corporation.

4 Ibid. 2 p. 64.

5 Ibid. 2 p. 64.

Punched Card Capabilities

Punched cards are the basis for most mechanized office systems today. The major capabilities of a punched card system are:[6]

1. A punched card system can absorb many facts and then can group and arrange these facts as required.
2. A punched card system can count and make prescribed computations.
3. A punched card system can include an automatically operated typewriter to prepare reports.

Punched Card Limitations

Punched cards, however, seem to have about reached their peak when compared to the tape controlled electronic computer which is the most recent development in mechanizing clerical functions. With reference to high speed computers even the best punched cards installations appear to have these limitations:[7]

1. "The amount of time and expense incurred in converting information into punched card form is often substantial. The extent to which this cost is warranted depends generally upon the number of uses of the cards.

6 Capabilities derived from a variety of sources, including: Habermann, Porteous, "Office Automation: Evolution Not Revolution," "Which System to Select?" (See Bibliography for complete information).

7 Reproduced from J. Pelej, "Electronic Accounting Possibilities," NACA Bulletin, Vol. 34, July 1943, p. 1517, by permission of the publishers.

2. At the present time, the cards contain less than one hundred decimal digits of information per card. When more information for a given item or transaction is needed additional cards must be prepared, thus increasing the possibility of information loss by misfiling.

3. Information entered in punched cards is nonerasable. A new card must be prepared each time a change is necessary. This of course has the advantages of permanence of recording but lacks the flexibility of erasable medium.

4. A number of operators is required to tend the machine and to transfer the cards from one machine to another. The ratio of operators to machines is very close to one to one in many installations.

5. The machines do not possess sufficient ability to perform certain of the more complex business calculations without stopping at artificial intermediate stages.

6. The operational speed of individual machines may be quite rapid, but the speed of the over-all system must be considered to be quite slow as compared to the present digital computers.

7. Conversion and installation of new procedures is usually difficult and time consuming and requires a considerable degree of technical skill."

The problems connected with a computer installation will be discussed later.

Electronic Computers

The first practical electronic computer was built in 1946 to solve ballistic problems, and the machines that

followed it for the next few years were also intended for scientific and engineering problems.[8]

About three years later the proponents of these machines began to realize they could be used in business to perform clerical operations. By 1953 the use of electronic computers for business and industry was a reality. The new development is called "electronic data processing," and is often abbreviated as "EDP". In the year 1954 interest in the new machines grew rapidly and there were enough pioneers to monopolize several years of one leading manufacturer's production.[9]

Advantages of Electronic Computers

The main advantages provided by electronic data processing over punched card installations are greater speed and operation flexibility, and reduced personnel and space requirements.[10]

8 R.G. Canning, Electronic Data Processing for Business and Industry (New York: John Wiley and Sons, Inc., 1956), p. 2.

9 Ibid. 8 p. 2.

10 G. Kozmetsky and P. Kircher, Electronic Computers and Management Control (New York: McGraw-Hill Book Company, Inc., 1956), p. 1.

Some of the more specific features of electronic computers are:[11]

1. They can add, subtract, multiply, and divide up to 250,000 operations a minute.

2. They can make over one million logical choices a minute; for example, discern the greater or lesser of two values.

3. They can work with probability methods and can compute by repeated trial and error the expected value of a combination of variable phenomenon.

4. They can list a large number of sets of possible actions.

5. They can work with complex problems like scheduling which involve vast numbers of possibilities and inter-relationships.

6. They can sort or arrange in alphabetical or numerical sequence.

7. They can start the next problem when the first is done.

Disadvantages of Electronic Computers

Although electronic data processing has many advantages over punched card installations there are several other factors which should also be considered; a great deal of money is required for a computer installation, not only for the equipment, but for the preliminary study and research on methods and systems, conversion of reports and records

11 C.R. De Carlo, "Electronic Computers Solving Production Engineering Problems," Mechanical Engineer, Vol. 78, May 1956, p. 416.

processes, training of personnel, and housing and air conditioning the computer.

The two systems, punched cards and EDP, are compatible and the less expensive punched cards can be used as a foundation upon which to build an electronic data processing system.

Integrated Data Processing

Electronic data processing has a companion term; "Integrated Data Processing," a recently coined phase, which has also been called "the Industrial Revolution in the Office". IDP and EDP, as they are known, are related because the basis for IDP is usually the high speed electronic computer.

The basic principle of integrated data processing is the use of a "common language vehicle," usually punched or magnetic tape, which carries information from the orginal input process through all the subsequent operations without the necessity of re-processing or transcribing the information required at any of the operations.

REASONS FOR MECHANIZING OFFICE FUNCTIONS

There are number of trends in the business world which stimulate the search for improved techniques for office work and clerical functions.

In recent years tremendous advances have been made in the factory; while not universal, automation and mechanization have greatly improved the individual worker's productivity, however the office lags behind. Many aids to office work have been developed: accounting machines, calculating machines, duplicating machines, punched cards, etc.

These improvements have helped, particularly punched cards, but their effect has not been as far reaching as factory improvements have been; many of today's office procedures have remained basically unchanged over the past one hundred years.

In 1820 there were 11 clerks for every 100 factory workers, and in 1952 there were 25 clerks.[12] Overhead costs have risen four times as fast as direct production costs since the turn of the century.[13]

12 R.W. Fairbanks, "Electronics in the Modern Office," Harvard Business Review, Sept. 1952, p. 83.

13 Ibid. 8 p. 2.

There are many factors which have contributed to this increase; management's need for information has grown by leaps and bounds. Narrowing profit margins require that decisions which were once made by hunch must now be based on solid facts and detailed examinations of costs. The trend toward de-centralized operations increases the need for reports and a flow of information between the divisions and top management. More records must be kept to satisfy the requirements of tax and labor laws. The tempo of business life has also accelerated, so that managers need this information faster in order to meet competition.

As the task to be done grows steadily larger and more difficult, the people who are expected to accomplish it present their own set of problems too. Good clerical help is becoming increasing hard to find and keep. The prestige of being a white collar worker often cannot compensate for the difference in wages below the factory worker, especially when the office job can be just as onerous as the factory production job. Such attendant problems as the high turnover rate, absenteeism, low productivity, and the possibility of white collar unionization, all encourage an investigation of the new machines.

An additional factor is the cost of the machine rental. Machine rental costs have remained relatively constant

during a period of rising clerical costs.[14] It is also possible to save on rental fees by contracting with a service bureau for machine time on a lease basis. Organizations that cannot justify the purchase or full time rental of a large machine can more readily afford to rent its services on a part time basis.

Business is now beginning an era which will see the application of mass production techniques to the routines of office work to the same extent that they have applied to factory production process. The basic components have been devised; but the systems are not perfected yet because some functions lag behind others; however the needed improvements will not take long.

There is a fear in some quarters that the introduction of office automation will mean technological unemployment for a majority of clerical workers. Experience so far does not bear this out. It is inevitable that occasional severe displacements will occur, but in most cases the reduced personnel requirement is adjusted through normal attrition. In the long run society is certain to benefit from the elimination of dull, repetitive office jobs and the finding of more important and challenging tasks for the human mind.

14 J.L. Marley, "Punched Card Installations Must Be Planned," NACA Bulletin, Vol. 32, Sept. 1950, p. 27.

Recent experience has also shown that the major benefits of office automation will come in a more important area than the reduction of clerical costs. Office automation will help management make better decisions for better utilization of their resources and will feed back reports for management control purposes faster and in more significant detail.

SUMMARY

Because of the growth of industry since the industrial revolution the techniques of production control had to become more inclusive and complex. Today's systems are highly organized to realize the advantages of mass production.

Office methods are now undergoing a modern "Industrial Revolution". Punched card systems, electronic data processing, and integrated data processing offer opportunities for cost reduction and improved management control.

The problem of production planning and control is an important one in the plant being studied. This will be further explained in the next chapter. In addition, the tense competitive situation demands that all possibilities be explored for ways of improving performance and making

savings. It appears that modern office equipment might be successfully applied to the plant's production planning and control system. The following chapters will examine that possibility.

CHAPTER II

PRESENT SYSTEM OF PRODUCTION PLANNING AND CONTROL

This chapter describes the plant under consideration and details the operation of the present production planning and control system from the time an order is received until the order is shipped. A diagram of the system is shown in Figure I.

DESCRIPTION OF THE PLANT

The plant being studied is a job order die casting plant employing about six hundred people. The plant holds its customers' dies and when a customer orders castings the die is put on a casting machine and the required castings are produced. About 1500 active dies are kept in storage and orders for castings from the individual dies range from a few hundred a year to several thousand a week. The plant specializes in die casting aluminum and magnesium.

A die casting as it is produced by the machine is not ready for shipment to the customer. All castings must have the runners and other excess metal removed and then be inspected before being packed for shipping. Many castings also receive additional operations such as filing, machining, grinding, and polishing.

The operating facilities in the plant are divided into three major departments; the Casting Department, the Finishing Department, and the Final Inspection Department. The Finishing Department is divided into four sub-departments: Gate Breaking, Filing, Buffing, and Machining.

Department Functions

Brief descriptions of the operations performed in various departments follow:

Casting Department -- The castings are made here and for some jobs they are also trimmed at the casting machine.

Gate Breaking Department -- This is where the gates, flash, and overflows are removed from the castings. Most castings are trimmed on presses, some are sawed, and a few have the excess metal removed by hand.

Filing Department -- Hand filing operations are employed here to remove rough edges from the castings. In some cases flash left after the trimming operation is removed by hand-operated or hydraulic punching fixtures.

Machining Department -- The operations usually performed here are: drilling, tapping, reaming, turning, and milling.

Buffing Department -- Belt grinding is the main operation in this department. Castings are also barrel ground, ball burnished, and washed here.

Final Inspection Department -- In this department the completed castings are inspected for casting and finishing defects before being packed into cartons.

The Finishing Department is located between the Casting and Inspection Departments. Castings traveling through production go from the Casting Department into the Finishing Department and then to the Inspection Department.

Material Handling

There are two types of work containers: stubens, which measure 60" x 24" x 36" and must be moved by truck; and carriages, measuring 20" x 24" x 36", which have wheels and can be pushed on the floor. Truckers using hand trucks and industrial fork trucks move work in and between the departments.

Each department has racks to hold the containers of work waiting to be processed in the department. Carriages are usually stored on the floor although they can be put in the racks too.

Timekeepers' Booth

A timekeepers' booth is centrally located to serve the Finishing and Inspection Departments. The operators in these departments go to the booth to check out after completing each job. The timekeeping procedure will be expanded later.

The plant uses a lot system for cost control and planning purposes. A lot, basically, is the quantity of castings which will fill a stuben or carriage, so each container-full is a separate lot of castings. A lot book travels with each lot, and its use will be explained later.

The New Plant

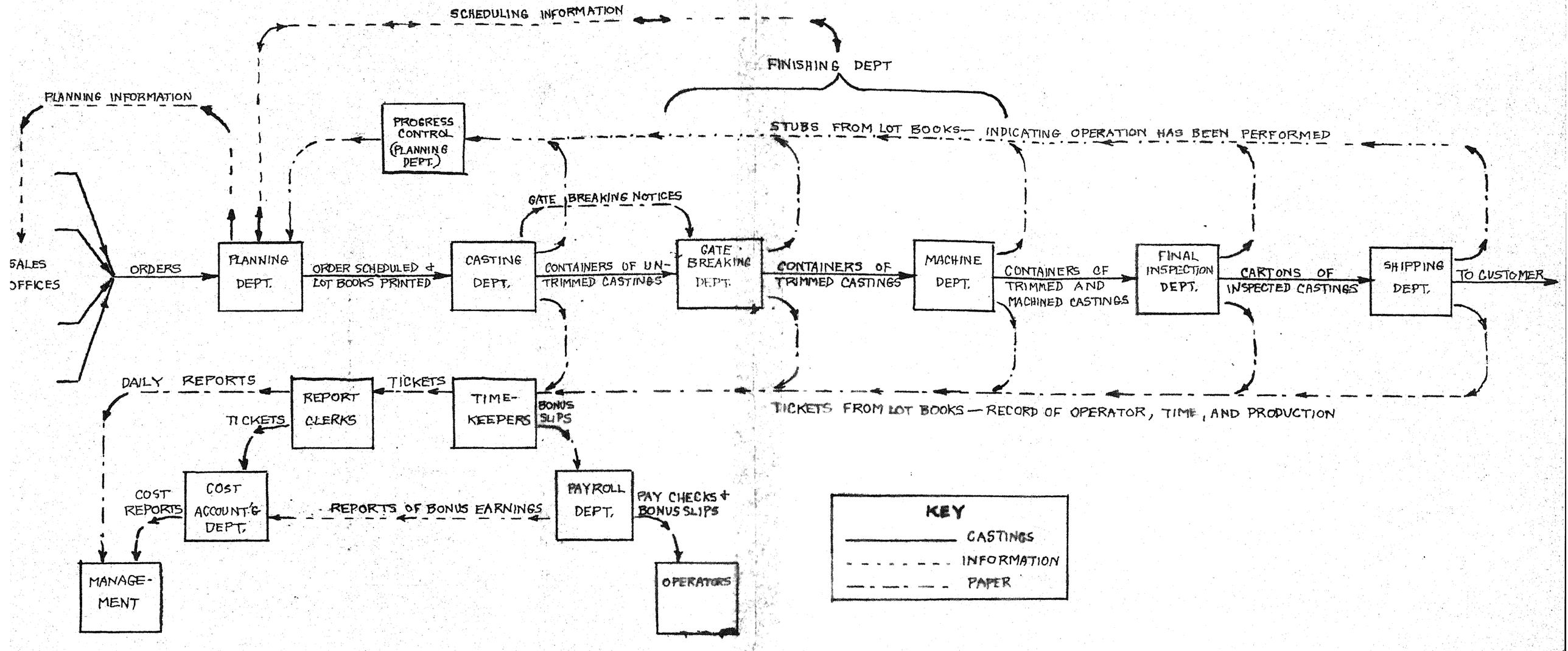
A new plant with almost twice the present plant's area is planned for 1959. Since space is a major problem now the move will allow more flexibility in planning new systems. The change will also present a good opportunity to inaugurate new production control procedures.

THE SYSTEM

The following pages will describe the paperwork procedures and the physical handling of an order of castings from the time the order is received until it is shipped. Reference to the diagram in Figure I will help the reader follow the text.

Orders are sent to the plant by teletype from company sales offices all over the country. The salesmen base their delivery promises on information supplied by the Planning Department in a weekly report. If, occasionally, orders conflict then a new promise date is arranged by the Planning Department which is responsible for the preparation and scheduling of orders.

FIGURE I PRESENT SYSTEM


SCHEDULING INFORMATION
FINISHING DEPT
PLANNING INFORMATION
PROGRESS CONTROL (PLANNING DEPT.)
STUBS FROM LOT BOOKS— INDICATING OPERATION HAS BEEN PERFORMED
GATE BREAKING NOTICES
SALES OFFICES
ORDERS
PLANNING DEPT.
ORDER SCHEDULED & LOT BOOKS PRINTED
CASTING DEPT.
CONTAINERS OF UN-TRIMMED CASTINGS
GATE BREAKING DEPT.
CONTAINERS OF TRIMMED CASTINGS
MACHINE DEPT.
CONTAINERS OF TRIMMED AND MACHINED CASTINGS
FINAL INSPECTION DEPT.
CARTONS OF INSPECTED CASTINGS
SHIPPING DEPT.
TO CUSTOMER
DAILY REPORTS
TICKETS
REPORT CLERKS
TIME-KEEPERS
BONUS SLIPS
TICKETS FROM LOT BOOKS—RECORD OF OPERATOR, TIME, AND PRODUCTION
TICKETS
COST REPORTS
COST ACCOUNT'G DEPT.
REPORTS OF BONUS EARNINGS
PAYROLL DEPT.
PAY CHECKS & BONUS SLIPS
MANAGE-MENT
OPERATORS
KEY
CASTINGS
INFORMATION
PAPER

The teletype form on which the orders are printed is a "Ditto" master sheet. This master is used to reproduce copied of the order for distribution.

The order is thoroughly checked for omissions, inconsistencies, special delivery dates, specifications, etc., before being registered. A daily report of orders received is distributed to all sales offices.

The order is then analyzed to determine: number of lots required, number of shipping containers required, and number of man-hours for each operation to be performed. This information is derived from an Operation Sequence Card which is maintained by the Industrial Engineering Department. A monthly forecast of man-hours for each production department is prepared to assist in establishing employment levels.

A multi-lith master is then typed up for the order. The master is used to print information on the lot-follow-up card used by the Planning Department and on the pages of the lot books which accompany the castings through the plant. The required number of lot books for the order is then prepared on the multi-lith machine.

A wooden strip is typed for each order. These strips contain information to be used by the Casting Department Scheduler. He can arrange and rearrange the strips on a planning board to establish schedules.

At this point the order is ready to be scheduled. The strips for a month's orders are divided by general casting machine type (there are six types) and then sent to the Casting Department Scheduler who divides the strips further and assigns the orders to individual casting machines. The strips are placed on a planning board by running order under their assigned casting machines.

The main considerations in scheduling orders are customer promise date and required production time. Production time is based mainly on casting machine capacity. The time required for Finishing and Inspection operations is only roughly allowed for in a safety margin. In a few cases which require exceptional finishing time an extra safety margin is allowed.

The scheduling of orders on casting machines is a complex job because so many factors must be considered. Although there are only six basic types of casting machines every machine in the plant is unique and these differences dictate which machines can run which dies. Some of the factors are: furnace capacity, machine booth space, type of ladle, machine dimensions, type of injection, etc. There are at least a dozen major characteristics with many more sub-characteristics. Each die has many requirements which must be matched to the machine characteristics. Because of his experience and knowledge

of the situation the Scheduler is able to solve this problem.

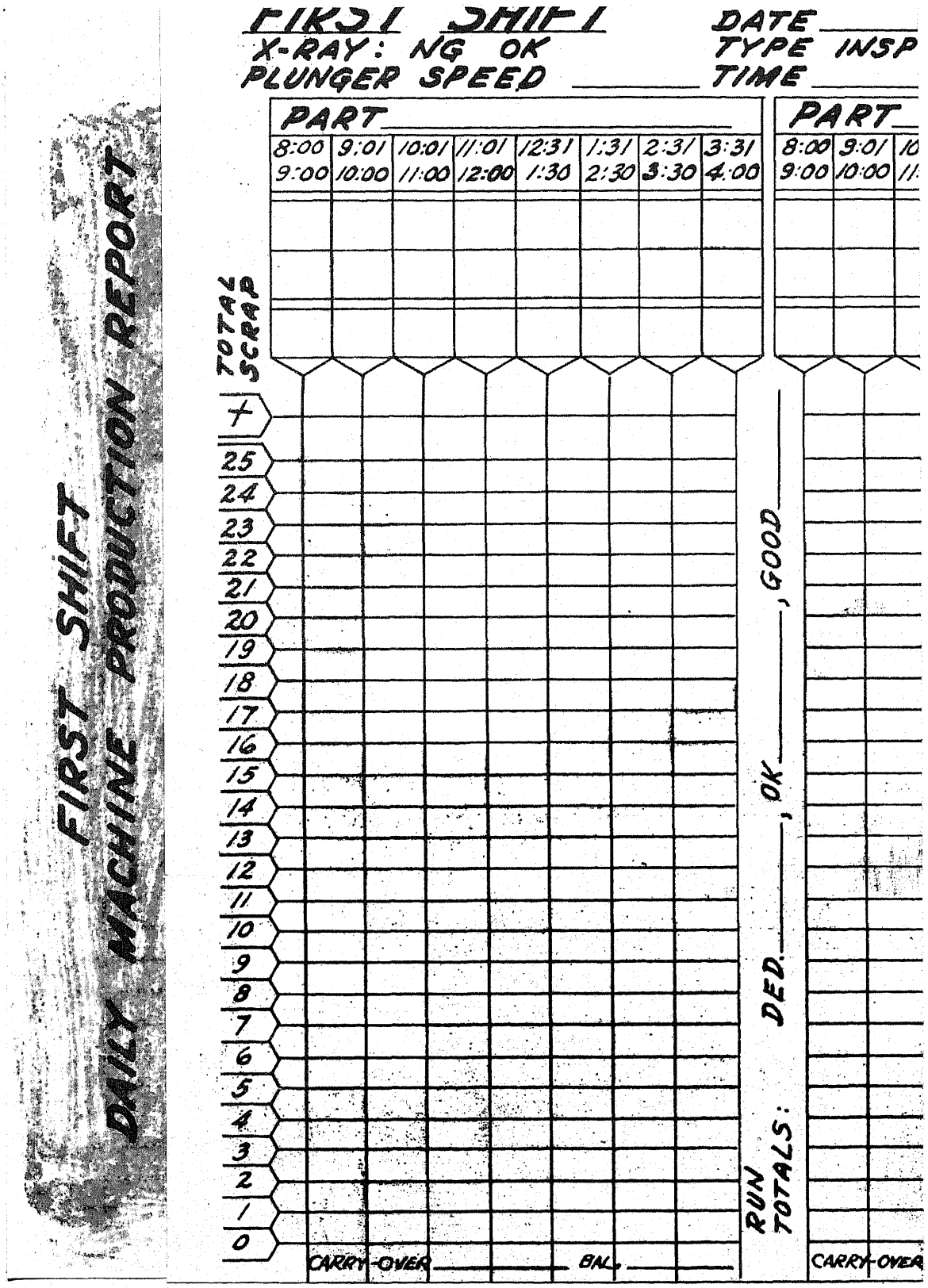
In addition to the above requirements the Scheduler must also consider the immediate needs and problems of the plant. Such problems as lack of space, overwork in a particular department, underwork in another department, etc., are brought to his attention. The Scheduler must then give consideration to scheduling orders which will consume little space, orders with a lot or a few hours of work in certain departments, etc.

There is no detailed schedule for work in the Finishing and Final Inspection Departments. The Planning Department supplies a weekly list of urgent orders to guide the foremen in scheduling work in their departments and expediters are employed to follow up rush jobs and locate missing work. Non-rush orders are worked according to the foreman's preference.

A Brief Explanation of Documents

Machine sheet. A shift production record is kept at each casting machine. When the die is changed the sheet is also changed. The information kept on this record is: productive and non-productive time, casting production, and reasons for scrap and breakdowns. The machine sheet is illustrated in Figure II.

FIGURE II MACHINE SHEET



FIRST SHIFT
DAILY MACHINE PRODUCTION REPORT

TE _____ ALLOY _____ FOREMAN _____

CHINE _____ DIE _____ PART NO. _____

CUSTOMER _____

ERATOR _____ HELPER _____ HELPER _____ HELPER _____

NG LEADER _____

CASTING EFFICIENCY — PRODUCTION

PROD. HRS.	IDLE HRS.	SHOP HRS.	85% HRS.	STD. CSTG.	RATE SETS	GOOD OPR.	INSP. SCRAP	OK SCRAP	TOTAL CSTGS.

FOREMAN'S REPORT

ACHINE TIME		MACH. REP. 16		EJTR. PINS 17		CHGE. JOB 27		
TOP TO		FURNACE EQ. 25		GRIND GATE 17		ELEC. RELAY 16		
TART FROM		MISC. MACH. 16		WATER LINES 17		SHOP		
TOP TO		TIP CHGE. 23		DIE HYD. 16		FIRST AID 31		
START FROM		CORE REPL. 17		AIR RELAY 16		UNION BUS. 35		
LAPSED TIME		CORE REP. 17		DIE ALIGN. 21		FIRE DRILL 29		
		STUCK CSTG 26		MISC. DIE EQ. 16		85%		
		POLISH DIE 17		MISC. MCH. PR. 15				

ELEC. COUNTER READING

STOP	
START	

LOT NO.	QTY.	LOT NO.	QTY.

CODE FOR DEFECTS

B - BLISTERS
C - CRACKS
D - DRAGS & SOLDERING (BROKEN OUT)
F - NOT FILLING (COLD SHOTS)
H - HOLES IN HOLES
L - EXCESS OIL
M - DIE PARTS (INSERTS, BROKEN & BENT CORES & EJECTOR PINS.)
S - SHRINK CRACKS
W - WARPAGE & BENT

REMARKS:

FORM NO. 1100R

Lot book. This document accompanies each lot of castings through production. A page is included for each operation and as the operation is performed the page is removed. Half of the page is used for timekeeping and the other half is used by the Planning Department for progress control. A typical lot book page is shown in Figure III.

Bonus slip. This is a record of each production worker's daily production. It records productive and non-productive time, production, standard rate, efficiency, and bonus earned. Bonus earnings are paid from the information entered on the bonus slips. Refer to Figure IV for a typical bonus slip.

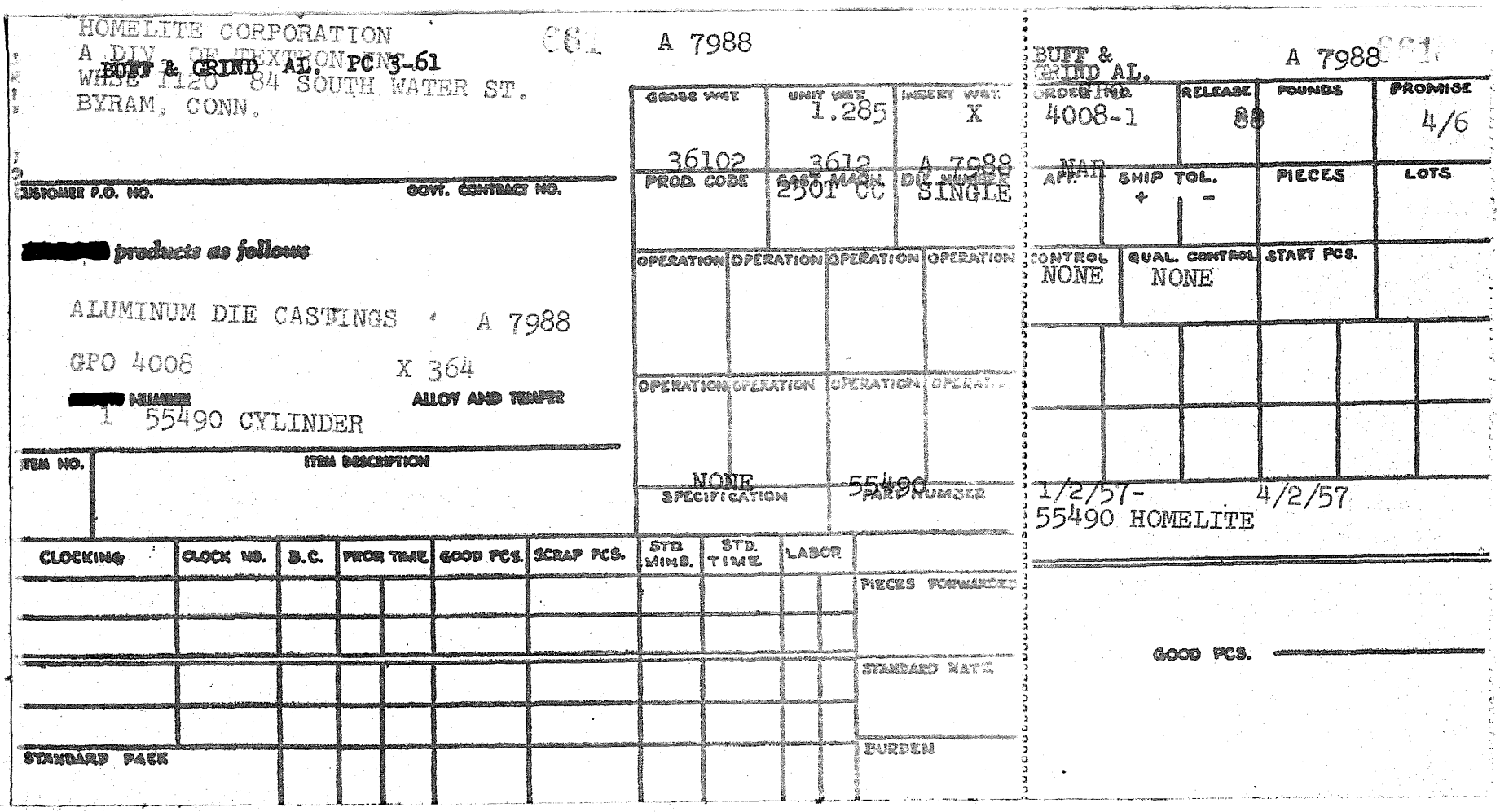
Procedure -- Typical Job

1. The die is scheduled to run by the Casting Department Scheduler.

2. The die is mounted on a casting machine and prepared for production.

3. The timekeeper takes the lot books and machine sheet to the casting machine.

4. The timekeeper removes the cost notification ticket from the lot book. This is sent to the Cost Accounting Department as a signal to start accumulating costs on the lot. A cost notification is shown in Figure V.



HOMELITE CORPORATION
A DIV. OF TEXTRON INC.
WHSE 1120 84 SOUTH WATER ST.
BYRAM, CONN.

881 A 7988

BUFF & GRIND AL. PC 3-61

GROSS WGT 36102 | UNIT WGT 1.285 | INSERT WGT X
PROD. CODE | CAST WGT. 3612 | DIE NUMBER A 7988
SINGLE

CUSTOMER P.O. NO. | GOVT. CONTRACT NO.

[redacted] products as follows

ALUMINUM DIE CASTINGS A 7988

GPO 4008 X 364

[redacted] NUMBER | ALLOY AND TEMPER

1 55490 CYLINDER

ITEM NO. | ITEM DESCRIPTION

OPERATION | OPERATION | OPERATION | OPERATION
OPERATION | OPERATION | OPERATION | OPERATION
NONE | 55490
SPECIFICATION | PART NUMBER

CLOCKING | CLOCK NO. | B.C. | PRIOR TIME | GOOD PCS. | SCRAP PCS. | STD. MINS. | STD. TIME | LABOR

STANDARD PACK

PIECES FORWARDED

STANDARD RATE

BURDEN

BUFF & GRIND AL. A 7988 881

ORDERING 4008-1 | RELEASE 88 | POUNDS | PROMISE 4/6

APP. MAR | SHIP TOL. + - | PIECES | LOTS

CONTROL NONE | QUAL. CONTROL NONE | START PCS.

1/2/57 - 4/2/57
55490 HOMELITE

GOOD PCS.

FIGURE III LOT BOOK PAGE

FIGURE IV <u>BONUS SLIP</u>

EMP. NO.	B. C.	DATE	SHIFT	DEPT.	MACH. NO.

	PRODUCTION								
	LOT NO.	TIME	GOOD	PS / REJ.	DED SCR.	TOTAL	BONUS		
DIE NO.								BONUS PCS.	RATE
PART NO.								STD. TIME	PROD. HRS.
UNIT WGT.								STD. MIN.	% EFF.
INSP. / C. P. G.								P. C.	OPER.
DIE NO.								BONUS PCS.	RATE
PART NO.								STD. TIME	PROD. HRS.
UNIT WGT.								STD. MIN.	% EFF.
INSP. / C. P. G.								P. C.	OPER.
DIE NO.								BONUS PCS.	RATE
PART NO.								STD. TIME	PROD. HRS.
UNIT WGT.								STD. MIN.	% EFF.
INSP. / C. P. G.								P. C.	OPER.
DIE NO.								BONUS PCS.	RATE
PART NO.								STD. TIME	PROD. HRS.
UNIT WGT.								STD. MIN.	% EFF.
INSP. / C. P. G.								P. C.	OPER.

NON-PRODUCTIVE LABOR				
ACCOUNT NO.	TIME	ACCOUNT NO.	TIME	
				DAY'S BONUS

EMPLOYEE'S DAILY BONUS SLIP

FORM 4646 - 8OMS - 10-56

COST NOTIFICATION 456

WESTERN ELECTRIC CO., INC.
300 CENTRAL AVE.
KEARNY, N.J.

A-8036

GROSS WGT.	UNIT WGT.	INSERT WGT.
	.848	X

PROD. CODE	CAST. MACH.	DIE NUMBER
36102	3612-24 250T CC	A-8036 COMB.

OPERATION	OPERATION	OPERATION	OPERATION

OPERATION	OPERATION	OPERATION	OPERATION

CUSTOMER P.O. NO. KE-10C403-5 — GOVT. CONTRACT NO.

[redacted] products as follows

ALUMINUM DIE CASTINGS A-8036

[redacted] NUMBER NR-28425C — ALLOY AND TEMPER 380

ITEM NO.	ITEM DESCRIPTION
1	PART P10C403 LEFT CASE

SPECIFICATION	PART NUMBER
NONE	P10C403

METAL STARTED			TOTAL PIECES CAST
GATES CAST	STICK & MOLTEN METAL (LBS.)	SALVAGE CSTGS. (LBS.)	

PRODUCTION		
GOOD PIECES CAST	NET	
	PIECES	POUNDS

OPERATIONAL COST

DETAIL	LABOR	BURDEN
CASTING		
FINISHING		
INSPECTION		
SALVAGE-CASTING		
SALVAGE-FINISHING		

G.B. NOTICE A-8036 456

ORDER NO.	RELEASE	POUNDS	PROMISE
NR 28425C-1	1	56 Y-1 13(10x20)	1/4/58

AFF.	SHIP TOL.		PIECES	LOTS
NAR	10	-10		

CONTROL	QUAL. CONTROL	START PCS.
NONE	NONE	

500	917	.716	717	804	909 10
9	11	9	710-9	11	9 8
.197	.406	.240	1.200	.80	.10 .
304	148	250	50	75	600 1

11/21/57-C1 C7-1/2/58 CLEANED, MC
& PAINTED P10C403 WESTERN ELEC.

FIGURE V COST NOTIFICATION AND GATE BREAK NOTICE

5. The casting machine operator starts producing castings.

6. The hot inspector inspects the castings as they are made and records the number of good and scrap castings on a quality control chart at the machine. He also records quantities and lot numbers on the machine sheet.

7. The foremen record reasons for breakdowns, etc., on the machine sheet.

8. When the lot is completed (the proper quantity of castings is in the container) the timekeeper removes the casting ticket, casting stub, gate breaking notification, and the hot inspection ticket and stub from the lot book. The following lists the uses of each of these documents.

a. Casting ticket. The timekeeper records the operator's number, the quantity of castings produced (good and scrap), and the elapsed time on the casting ticket. This is used by the timekeeper at the end of the shift to make out the operator's daily bonus slip. It is then sent to the Cost Department to record the casting cost for the lot.

b. Casting stub. The timekeeper records the quantity of castings in the lot on the stub. This is sent to the Planning Department to signal that the lot is cast and has been moved to the next operation.

c. Gate breaking notification. The timekeeper records the quantity of castings in the lot on this stub. This is sent to the Gate Breaking Department to signal that the lot is coming through for trimming and also helps to schedule the mounting and dismounting of shaving dies on the presses. A gate breaking notification is shown in Figure V.

d. Hot inspection ticket and stub. The timekeeper's handling of these is similar to that of the casting ticket and stub and the uses are also similar.

9. The timekeeper writes the number of pieces in the lot on the ticket of the next operation to be performed on the castings. This is the "pieces forwarded" entry.

10. The timekeeper puts the lot book in the work container and notifies the trucker that the lot is ready to be moved to the next operation. This is accomplished by writing a note on a pad located in the center of the Casting Department.

11. The trucker takes the container of castings to the next department (for this example the Gate Breaking Department) and places it in the racks.

12. The Gate Breaking foreman schedules the shaving die to be mounted on a press when a number of containers have accumulated in the racks. His inventory is based on

the gate breaking notifications he recives which are kept in a pocket board. When the shaving die is mounted on a press the notifications are placed in the pocket corresponding to the press.

13. When the shaving die is mounted and a press operator assigned the trucker is instructed to get a container of castings and place it at the press.

14. The press operator performs the shaving operation on the castings.

15. When the lot is completed the operator takes the lot book to the Timekeeper's booth and punches the gate breaking ticket in the timeclock.

16. The operator hands the lot book to the timekeeper who enters the operator's number, number of castings shaved, elapsed time (figured from the time just punched on the ticket and the time punched on the operator's previous ticket), and the number of scrap castings discarded on the gate breaking ticket. The number of castings is entered on the gate breaking stub and both are removed from the lot book, then the timekeeper enters the number of castings in the lot on the next operation ticket (pieces forwarded). The timekeeper reads the next operation to be performed on the castings and puts a trucking sleeve on the lot book. This sleeve is printed with the initial of the department where the lot is to go next (for example: M for Machining Department) to direct the trucker. The timekeeper then

returns the lot book with the trucking sleeve (and minus the gate breaking ticket and stub) to the operator.

17. The gate breaking ticket is used by the timekeeper to prepare the operator's daily bonus slip and is then sent to the Cost Accounting Department.

18. The gate breaking stub is sent to the Gate Breaking Department Scheduler to signal that the lot has been trimmed. The stub is matched with the gate breaking notification for that lot in the Scheduler's pocket board and they are both sent to the Planning Department to signal that the lot has been trimmed.

19. The operator returns from the Timekeeper's booth and places the lot book with trucking sleeve in the work container.

20. The operator notifies the trucker to remove the finished container and bring a new container of castings.

21. The trucker takes the finished container to the next department, as indicated by the trucking sleeve, and places it in that department's storage rack.

22. The department foreman takes at least one daily inventory of his rack and keeps abreast of the work that is waiting to be done.

23. The foreman schedules the various jobs on the basis of several factors: the ability of the operator who needs work, the urgency of the job (based on information from the Planning Department's weekly list

of rush jobs and the expediter's requests), the availability of necessary equipment, and the operator's preference.

24. The foreman or operator instructs the trucker to get the container and place it at the proper machine.

25. When the operator has finished the lot he takes the lot book to the timekeeper's booth and the previously described checking-out routine is repeated:

a. The operator punches the operation ticket in the time clock.

b. The timekeeper enters elapsed time, operator's number, number of pieces, and pieces forwarded on the lot book.

c. The timekeeper removes the ticket and stub from the lot book.

d. The timekeeper records the ticket information on the operator's bonus slip and sends the ticket to the Cost Department.

e. The timekeeper sends the stub to the Planning Department.

f. The timekeeper puts the trucking sleeve on the lot book and returns it to the operator.

26. The operator puts the lot book and sleeve in the work container and instructs the trucker to remove the container and get the next container to be worked.

27. The trucker takes the container to the next department. Since the procedure is the same for all Finishing Department sub-departments (except Gate Breaking) the next department for this example will be Final Inspection.

28. The foreman schedules the work and it is brought to the inspector just as in the Finishing departments.

29. The inspector, however, instead of returning the castings to a work container packs the acceptable castings in a carton for shipment.

30. The inspector writes the required information on the lot book ticket himself and he enters the number of good, scrap, and reclaimable castings, and his number, and then punches the ticket in a time clock. The lot book ticket and stub are left by the timeclock to be collected by the timekeeper.

31. The rest of the lot book is placed on top of the cartons of castings.

32. The packed cartons are then placed on a conveyor which carries them to the Shipping Department.

33. In the Shipping Department the carton is sealed, labeled, weighed, and stored for shipment. No time is kept on the shipping operations.

34. The last tickets in the lot books are packing tickets, which refer to the work done in the Shipping Department.

35. When the lot is shipped the Cost Department is notified to close out the lot and accumulate all the costs for the lot from the operation tickets which have been sent up previously.

Reports

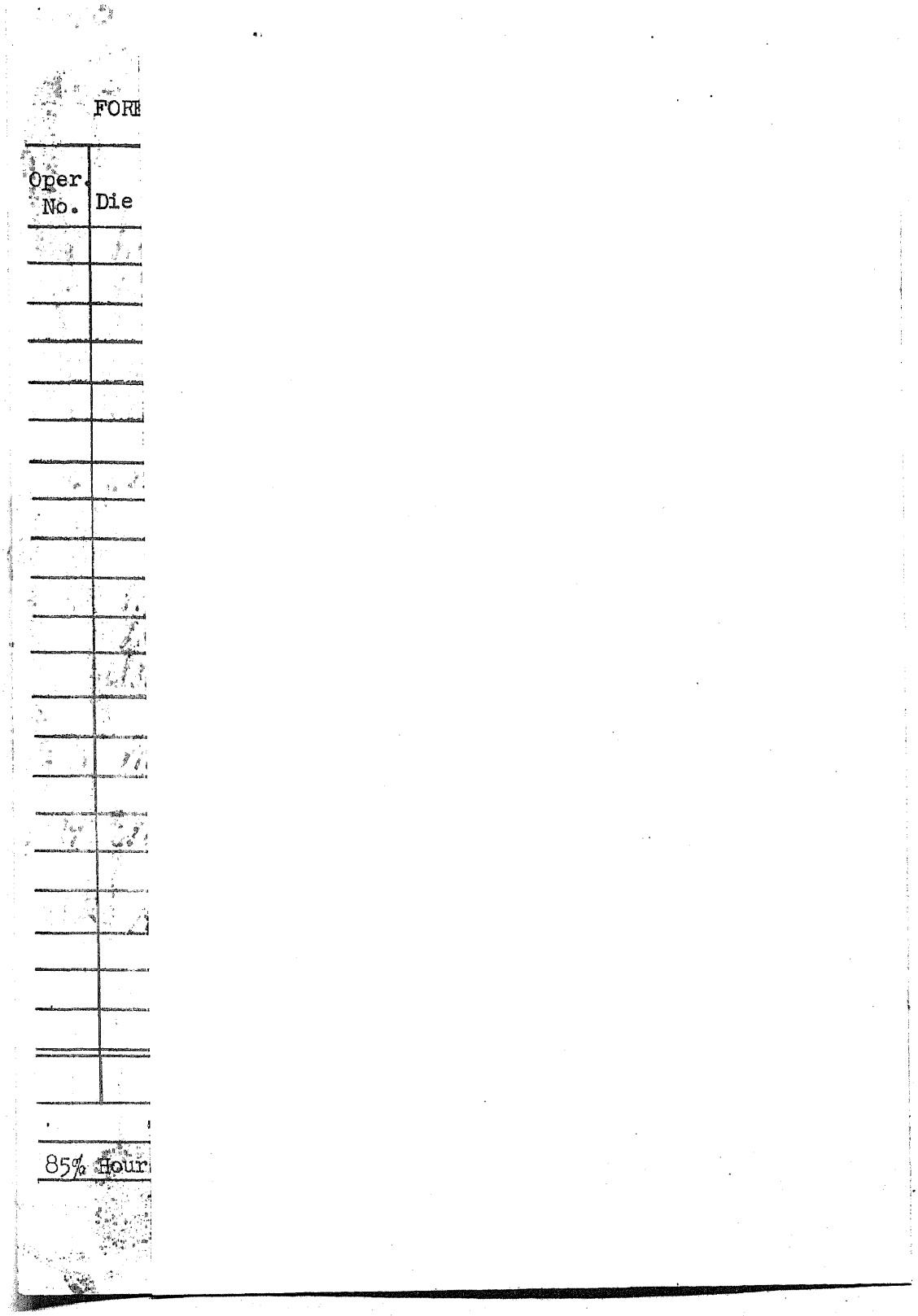
The following are the principle reports used in the plant's production control system.

Daily production report. This report is confined to casting production and is broken down by foreman, shift, operator, die, and casting machine. The information recorded is: production hours (possible and actual), production quantities (good and scrap), downtime and explanation. The information that is computed and entered on the report is: per cent production efficiency, per cent scrap, and weight of metal cast, and overall efficiencies.

This report is made up from information on casting lot tickets and machine sheets. A typical production report is shown in Figure VI.

Finishing Department daily production report. This report records operator efficiency and production on each job in the sub-departments of the Finishing Department. This information is derived from the operator's daily bonus slips.

FIGURE VI DAILY PRODUCTION REPORT



B-10 C-19
C-11
C-12

FOREMAN Gellner SHIFT First DATE 12/26/57

Oper. No.	Die No.	Mach No.	Customer	Part No.	HOURS AND EFFICIENCY Poss Hrs.	Prod Hrs.	Std Rate		% Eff.	PRODUCTION Good Cstg	Scrap	Total Cstg	% Prod.	% Scr	WEIGHT Unit	Tot.	DOWNTIME Idle	Shop	Remarks Downtime Expl. etc.
446	8142	(B-9)	McKee	274	6.0	8.0	190			1248	2	1330	98	5	.327	502			
944	8230	(C-3)	Keying	1061	7.5	2.5	38			303	73	376	116	13	.864	434		0.5	
527	8232	(C-7)	Keyion	1063	8.0	4.0	70			531	4	535	74	5	.565	300	0.5	1.5	
396	7432	C8	mmm	87432	9.0	7.0	40			704	1	900	112	5	.187	169			
506	6821	(C-10)	NAT PNEU	633	4.0	2.5	64			140	3	143	51	4	.365	51		2.2	
				8636						140	2	145		4	.135	19			
700	8144	(C11)	ALCOA	1085	7.0	4.0	32			1003	32	1035	84	3	.039	42			
	8016		Scott Fet.	16065						524	46	570		22	.233	164			
	8312		STANLEY	1846						274	21	345		21	.185	67			
745	8164	(C14)	Scott-Fetzer	13566	8.0	7.5	50			378	21	459	97	6	1.266	491	0.5		
429	8109	(C-16)	NAT. PNEU.	633	7.0	3.7	55			200	—	200	91	5	1.090	218	0.3		
33.2	7463	(C-18)	G.E.	1715-145	1.5	0.3	32			8	8	16	17	64	6.127	49			
	"	"	"	"	—	1.2	—			—	—	—	—	—	—	—	—	—	85 %
																		0.1	
																	0.3	0.5	
		0.2																	
										1140	334	1474	—	6	Alum.	2508	1.3	3.7	
TOTALS AND AVERAGES					52.0	47.0				—	—	—	—	—	Mag.	—	—	—	

85% Hours: 1.2 No Rate Hours: 0 Sample Hours: 0 Group Efficiency: 91 Percent Util:

* THIS TIME NOT CHARGEABLE TO ANY PARTICULAR MACHINE OR DIE

G-1099 Rev-65

Daily scrap report. This is a report of scrap found in the Final Inspection Department as recorded on the inspection lot tickets. It lists quantities and percentages of scrap and reclaimable castings. Figure VII is an example of this report.

Production and inventory report. This is a daily report which lists the current figures for weights of castings in process, scrapped, and shipped, also cumulative operator production hours, idle hours, and efficiency. This data is complied from figures on the daily casting production report and the daily scrap report. Refer to Figure VIII for an example of this report.

Department efficiency report. This is a weekly report which gives a breakdown of operator hours into productive, idle, set up, etc., by departments. This report is prepared from the operator's daily bonus slips.

FIGURE VII DAILY SCRAP REPORT

LIST OF CODES USED FOR SCRAP,

CASTING DEPARTMENT

B--BLISTERS
C--CRACKS
D--(DRAGS - SOLDERING)
(BROKEN OUT)
F--NOT FILLING - COLD SHOTS
H--HOLES IN GATES - THIN SLUGS
L--EXCESSIVE OIL
(Inserts)
M--(Die Parts)
(Broken - Bent Cores - Ejectors
N--POROSITY AFTER MACHINING
R--CAST WRONG PART
S--SHRINK CRACKS
W--WARPAGE - BENT

TYPE

CLEANING DEPARTMENTS

A--MACHINE CLEANING
G--BUFFING
K--FILING
T--GATEBREAKING

S P E C I A L

E--SHIPPING
P--PLANNING
X--LABORATORY

— Daily Scrap Report —

DEPARTMENTS OTHER THAN CASTING

DATE 10-23-57

#2

ALLOY ALUMINUM

DIE NO.	CUSTOMER	PART NUMBER	OPER. NUMBER	TOTAL CASTINGS INSPECTED	SCRAP						RECLAIMS			HOT INSP. CODE
					CASTING DEPT.			CLEAN. DEPT.						
					QUANTITY	%	CODE	QUANTITY	%	CODE	QUANTITY	%	CODE	
B8118	Mink Honey	362389-2	1010	553				36	7	T	21	4	T	—
B8118	" "	362390-2	1010	1720	461	27	F							0/0
B8122	Blair Lock	47986	1000	229	8	4	F	13	6	C				—
A8197	New Process	C 92197	1035	313										3
A8200	R.C.A.	C 471585-1	1010-R	759	15	2	FBH				32	4	F	—
A8218	Mergenthaler	88-006801-S	1000	48	18	38	CF							XX
A8230	Regina	B-1061	1010	466				8	2	T	39	8	F	XX
A8232	"	B-1063	1010	152	2	1	F							—
A8236	"	B-324	1035	661	83	13	F							0/0
A8242	S.F.	160056	1010	850	130	15	FC							0/0
A8284	B+D	35981-R	1000R	42	30	71	F							—
		— NOT INCLUDED IN TOTALS —												
A8232-61	Regina	B-1063	SCREENED	267	28	10	W							
B7772	Driesafty	37935	Shipping	65	65	100	R							
	SEE REVERSE SIDE FOR CODES			26747	1977	7.4		168	0.6		1171	4.4		

FORM-1104F

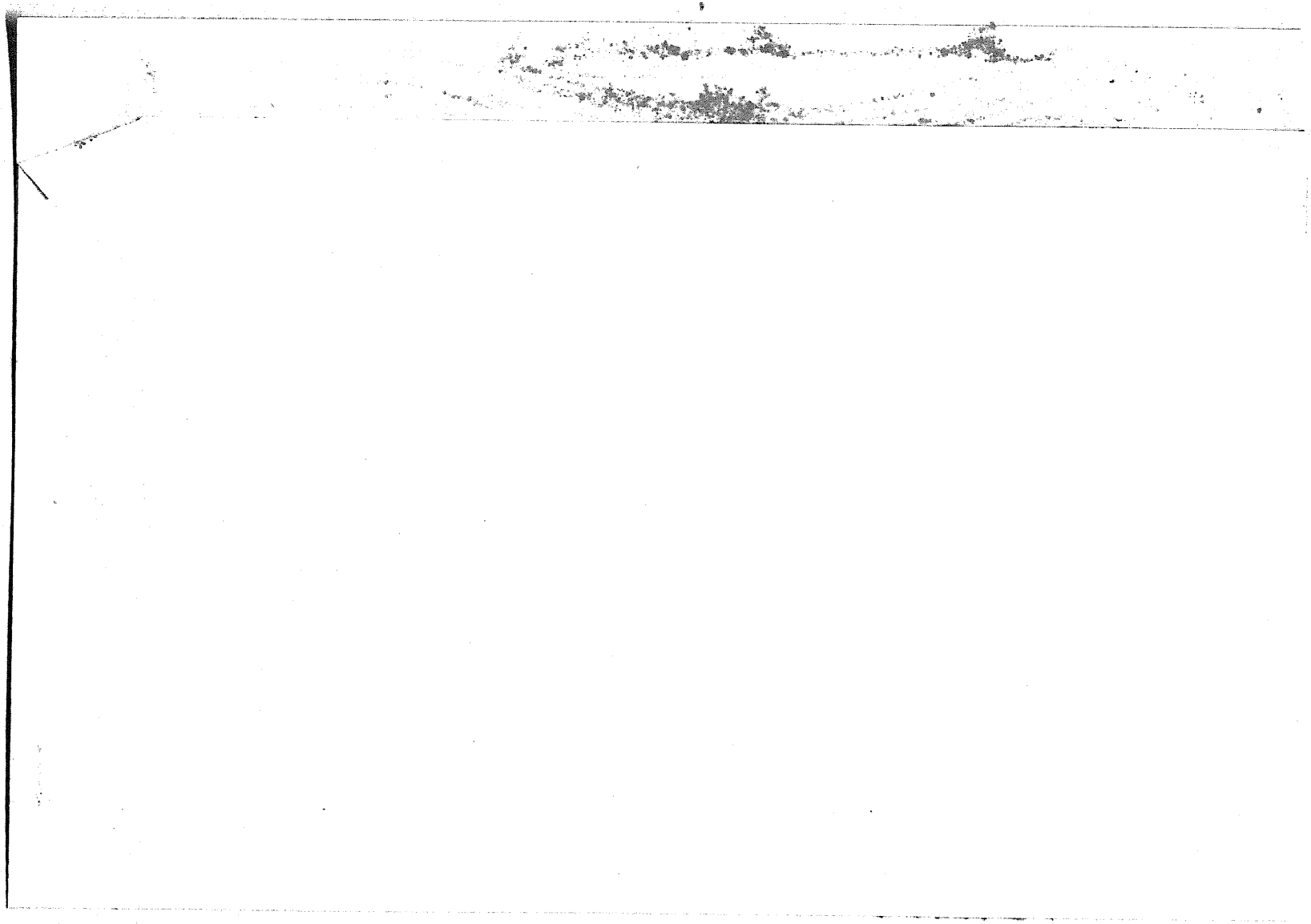


FIGURE VIII PRODUCTION AND INVENTORY REPORT

[redacted] WORKS

DATE 12-31-57

PRODUCTION AND INVENTORY REPORT

AS OF 12-30-57

POUNDS

	ALUMINUM		MAGNESIUM	
	TO-DAY	TO-DATE	TO-DAY	TO-DATE
IN PROCESS - START	124463	(150464*)	4786	(3845*)
CUSTOMER RETURNS - RECLAIM	-	1573	-	-
CAST	19404	428417	-	17585
HOT SCRAP	1548	46189	-	2574
THRU. HOT INSPECTION	17856	382228	-	15011
FINAL INSPECTION SCRAP	697	24069	29	1235
NET GOOD PRODUCTION	17152	357406	29	13776
DELIVERED TO SHIPPING	14855	383351	681	13545
TO STORES - D/C INSERTS	9	27	-	-
IN PROCESS - END	126758	-	4076	-
SHIPPING INVENTORY - START	87799	(60038*)	3184	(2501*)
RECEIVED FOR SHIPMENT	14855	383351	681	13545
SHIPPED	5806	345795	586	12847
SCRAPPED IN SHIPPING	7	753	-	-
SHIPPING INVENTORY - END	96841**	-	3199**	-
TOTAL PLANT INVENTORY - END	223599	(210502*)	7275	(6346*)
HELD FOR SHIP DATE	-	-	-	-
OPERATOR EFF. RATED 85%	104.9%	95.8%	-	97.5%
OPERATOR PRODUCTIVE HOURS	251.6	4933.8	.4	258.6
OPERATOR IDLE HOURS	11.0	276.1	.2	14.8
OPERATOR SHOP HOURS	24.2	464.6	-	41.8
OPERATOR TOTAL HOURS	286.8	5674.5	.6	315.2
HOT SCRAP % - LBS./PCS	8.0 / 14.7	10.8 / 17.8	- / -	14.6 / 13.9
FIN. & MISC. SCRAP % - LBS./PCS	3.6 / 13.0	5.8 / 9.1	- / -	7.5 / 9.7
TOTAL SCRAP % - LBS./PCS	11.6 / 17.7	16.6 / 13.8	- / -	21.7 / 23.6

*INVENTORY BEGINNING OF MONTH

R. E. CAFFREY

SUMMARY

The present system of production control is based on lots, or containers, of castings. The procedures are completely manual and employ no mechanized aids. A lot book which accompanies each container serves as a route card and supplies information for cost control and progress control. Orders are scheduled mainly by the primary operation, casting; and the subsequent adjust to this schedule. The next chapter will analyze the production planning and control system just described.

CHAPTER III

ANALYSIS OF PRESENT SYSTEM

In this chapter the present system will be evaluated by comparing its performance to a list of criteria for an effective production planning and control system.

CRITERIA

The following is a description of the criteria which will be used to analyze the present system of production planning and control. The selected criteria are those which can be applied to the plant being studied.[15] The criteria are necessarily somewhat interdependent and a degree of overlap exists in some cases. However the list is a useful device for an orderly analysis of the plant's planning and control system.

1. Accurate delivery predictions. Maintaining a company's reputation for reliable delivery promises is as important as maintaining price and quality standards. Late deliveries can be very serious if the customer's production is stopped for lack of components. Revisions must, of course, be made occasionally and it is even more

15 Criteria were collected from a variety of sources. Among them are: Bethel, Knoepke, Ireson, O'Donnell, and Parton, (see Bibliography for complete information).

important that the revised dates be met because few customers will tolerate repeated broken promises.

2. Uniform work loads. Fluctuations in production levels increase costs in several ways. If enough capacity exists to handle peak production then idle facilities costs mount up during slack periods. Excessive employee overtime and idle time usually accompany fluctuations because of management's reluctance to be constantly hiring and laying-off workers with each rise and dip. This problem is complicated by differences in jobs within a plant; an excess in one department and a shortage in another will not necessarily cancel each other because of the production worker's specialization and inability to change jobs.

3. Advance provision for tools and materials. To minimize machine and operator idle time it is necessary to prepare the required tools and materials in advance. Unforeseen delays due to faulty preparation can also be minimized when there is time to correct the situation before production starts.

4. Central control, constantly informed. One person or group should have accurate, current information on work progress, impending breakdowns and shortages, and should be adjusting plans to meet the changing conditions.

5. Accurate, current reports of production. The principle of management by exceptions requires that managers be informed of unusual conditions. These reports should relate the actual condition to the standard or expected condition and the variance should be explained if possible. Reports should also be in time for effective action.

6. Record of responsibility. It should be possible to assess responsibility to departments and individuals for excessive costs. This will encourage corrective action and continuing efforts to reduce costs. This record would also allow credit to be given to those who succeed in making improvements.

7. Accurate and adequate cost records. Cost records should have sufficient accuracy and detail for effective management analysis. A few mistakes can destroy the value of a report by creating doubts of its accuracy in its readers' minds, and reports which lack detail can present only generalizations which are ineffective in stimulating specific corrective actions.

8. Information for future planning. Records of past experience should be maintained to improve future performance. Repeat orders should be handled with minimum of repeated administrative expense.

9. Minimum work-in-process. Inventories represent money invested in materials, space, and equipment. This investment should be maintained as low as possible consistent with the costs that would be incurred by inventory shortages.

10. Minimum non-productive time. A certain amount of lost time is necessary for job changes and set ups but it can be minimized by thorough pre-planning.

11. Minimum expense for benefits. Production planning and control costs should be as low as possible. Systems should be designed to arrive at an optimum balance of the benefits obtained against the cost of operating the system.

EVALUATION

The following is an evaluation of the plant's production planning and control system with reference to the preceding list of criteria.

1. Accurate delivery predictions. The plant's record for meeting promise dates is fairly good, and broken promises are largely caused by unforeseen technical difficulties rather than poor planning. Because the plant's record of fulfilled promises is close to one hundred per cent it is concluded that the production planning and control system offers slight possibility for improvement in this area.

2. Uniform work loads. Because of the job-order nature of the die casting business it is impossible to avoid fluctuations in the plant's work load. The casting operation is the primary operation and its scheduling is determined by many factors such as; promise date, casting production time, and machine and die characteristics. These restrictions make a reduction in Casting Department work fluctuations very difficult or impossible.

The Finishing Department work loads could be made to be more uniform by planning in greater detail when scheduling the Casting Department. This would minimize the problems of having shortages in some departments and overages in others, with the difficulties of working with "farmed-out" operators who are transferred temporarily to unfamiliar departments. Although the scheduling of Finishing Department work must always be subordinate to the efficient scheduling of the primary casting operation and the meeting of promise dates it is felt that an improvement could be made in this area.

3. Advance provision for tools and materials. There are occasional delays caused by tool shortages, most of them due to unexpected technical problems. Usually, however, advance preparation of tools is not a problem because production is started well ahead of delivery date. This practice, of course, tends to increase work-in-process

inventory and more detailed planning could minimize the required lead time for tool preparation.

4. Central control constantly informed. There is no sharply defined central control group. The responsibility for production control is divided between Planning Department personnel, operating department heads, and foremen. The areas of responsibility are not specifically described and the lines of communication are informal occasionally resulting in confusion, duplication of effort, and misunderstandings. The constant variety of the plant's work places great burden on the present system and enough problems exist to warrant a search for possible improvements.

5. Accurate, current reports of production. The accuracy of the present reports is very good however their currency might be improved. Instead of being distributed early in the following day; they could stimulate more effective corrective action if made available shortly after the end of the shift or periodically during the shift. The most effective report, of course, would be a continous account of production as it progresses.

6. Record of responsibility. These records do exist; however they are too inconvenient for extensive use. The compilation of an operator's record on a particular job, for example, requires extensive searching thru records.

If management decides to place a greater emphasis on individual responsibility the system would be too cumbersome, but it is concluded that for present uses the system satisfies this criterion.

7. Accurate and adequate cost records. Existing records satisfy this criterion; however, it is often time consuming and difficult to prepare break-downs of costs that have not been prepared for in advance and separated as they occurred. The same situation exists as in the previous criterion, and it is concluded again that unless management decides to place greater emphasis on records the criterion is satisfied.

8. Information for future planning. Again, the records exist but the inconvenience of searching out the required information limits their usefulness. There does not appear to be a great need for more information for future planning. Until this need becomes more acute the criterion is considered to be satisfied.

9. Minimum work-in-process. This is a major problem, particularly in the present plant because of its limited space. Congestion is sometimes severe and some orders take as long as two or three months to travel through the plant. The investment tied up in inventories is considerable, amounting to almost a half a month's production. Inventories are subject to the fluctuations

of a job-order business but closer production planning and control would allow a reduction of backlogs and an increase in the velocity of work through the plant.

10. Minimum non-productive time. A large amount of idle time in the Finishing Department is caused by work shortages in the sub-departments and considerable time is lost during job changes. More detailed planning could reduce work fluctuations in the departments and closer production control would minimize the time lost between jobs.

11. Minimum expense for all benefits. The cost of several timekeepers, report clerks, Planning Department clerks and expediters, in addition to the time spent by foremen and supervisors in production planning and control as part of their duties, indicates there is sufficient possibility for improvement to justify a study of the present system.

Automatic Office Equipment

Modern mechanized aids to office functions may be able to improve the plant's performance under these criteria: (5) Accurate, current reports of production, (6) Record of responsibility, (7) Accurate and adequate cost records, (8) Information for future planning, and (11) Minimum expense for all benefits. The improvement would result from a reduction in the costs of repetitive

clerical operations and an increase in the effectiveness of the system. The suitability of automatic equipment will be considered in the following chapter and, if the adoption of this equipment is economical, proposals for its use will be made.

SUMMARY

A comparison of the plant's present production planning and control system to the list of criteria for an ideal system directs attention to several major areas which appear to offer possibilities for improvement.

1. Uniform work loads.
2. Central control, constantly informed.
3. Minimum work-in-process.
4. Minimum non-productive time.
5. Minimum expense for all benefits.

The next chapter will propose changes in the production planning and control system which are intended to improve the system's fulfillment of the criteria.

CHAPTER IV

PROPOSED CHANGES

This chapter describes the method of approach for improving the present production planning and control system and then presents several suggested changes in general terms. The operating details of the proposed system will be presented in Chapter V.

METHOD OF APPROACH

There are two factors to be considered when one is seeking to improve a system; they are the benefits and the costs. The object is to reduce the "cost per benefit" and this can be accomplished in five ways.[16]

1. Obtain a large increase in benefits with a small increase in costs.

2. Obtain an increase in benefits with no change in costs.

3. Obtain an increase in benefits with a reduction in costs.

4. Maintain the same benefits with a reduction in costs.

5. Make a small reduction in benefits with large reduction in costs.

16 From Lawrence F. Bell, "Factory Systems and Procedures" in Handbook of Industrial Engineering and Management, William Grant Ireson and Eugene L. Grant, Editors, p. 410. Copyright, 1955, by Prentice-Hall, Inc., Englewood Cliffs, N.J. Reprinted by permission of the publisher.

The costs of benefits are comparatively easy to assess, but the values of some benefits are intangible and impossible to determine with accuracy. Because of these intangibles the solution to the problem cannot be calculated in a precise manner but must be based largely on the judgement and experience of those who will use the system.

A preliminary examination of the present system suggests that important improvements can be made in the direction of reducing costs. Improved benefits can also be obtained of course but the biggest gains are likely to be made in the area of cost reduction.

This statement is based upon the following conditions: management demands and obtains the results it feels are essential; so, as a starting point, it may be assumed that the major results of the present system are both necessary and adequate, and; it is a universal tendency for administrative functions to grow, thus making them fertile territory for simplification and cost reduction.

One of the propositions of this thesis is that modern office equipment appears promising for application to production planning and control situations. However before an investment in new equipment is recommended the system should be improved to its most efficient state with standard techniques. Then a valid comparison can be made

and an objective judgement offered.

PROPOSED CHANGES

Central Work Storage and Dispatching

It is proposed that the present departmental racks[17] for storage of work-in-process be replaced by a central rack and that all work in the Finishing and Inspection departments be scheduled by a central dispatcher.

The present problems of lost work, fluctuations in work load, emergency expediting, broken promises, and general confusion could be alleviated by assigning a capable individual to schedule and dispatch work from the central storage racks. This person would coordinate the requirements of the Planning and production departments to obtain an efficient and rapid flow of work through the plant. The dispatcher would operate a central control point which would be constantly informed of changing conditions and he would know the location and status of each container of work. His services would replace the work now done by Planning Department expediters and progress control clerks. Foremen would be relieved of inventory taking chores and the department head would have qualified assistance in planning daily manpower distribution in his department.[18]

17 Supra., Chapter II, p. 20.

18 Supra., Chapter II, p. 23.

By employing a system of tags and an in-line rack type of control board [19] the dispatcher would be able to keep a perpetual inventory of work-in-process. Each work container would be represented by a tag which would be moved about on the control board as the work is moved. A Keysort-type of card file system would enable the dispatcher to quickly total the man-hours ahead of each operation.

A major result of this change would be to transfer responsibility for scheduling from the foremen to the dispatcher. The foremen could still exercise their judgement in assigning work to suitable operators, but the problem of scheduling work out of a few weeks of inventory would be the dispatcher's.

The information available to the central dispatcher would allow him to minimize many of the problems that exist under the present system. He should be able to plan far enough ahead and with enough accuracy to virtually eliminate emergency jobs and extreme work fluctuations. Even in the case of a job being cast late due to technical problems the dispatcher should know in advance and be prepared when the work arrives in the Finishing Department. The central dispatching system would not be an automatic system; it would require earnest cooperation and a free

19 Ibid. 16, p. 477.

flow of information from the Planning and production departments. The success of this system would also depend to a great extent upon the ability of the dispatcher; he must be able to handle figures in order to plan future schedules; he must be familiar with the production processes and problems; and he must be capable of exercising sound judgement when resolving the often conflicting problems of the Planning and production departments.

An incidental advantage of central work storage is a saving of storage space. The present arrangement requires a rack in each department which is large enough to hold a peak inventory for that department. High inventories in one department are generally counter-balanced by low inventories in other departments with the result that peak plant inventory is considerably less than the sum of the peak inventories of each department.

Central work storage and dispatching would be suitable for installation in the new plant. A shortage of space makes orderly storage impossible in the present plant.

Operator Trucking

To obtain the best results from central work storage and dispatching a change should be made in material handling practices.[20] It is proposed that all intra-department trucking be done by the operators themselves. That is, after being delivered to the department from central storage by a fork truck the work would then be handled by the operator to whom it is assigned. Each department would have a small area to store finished work and the immediate work ahead. The central trucker would deliver to this area and when an operator finishes a container of work he would move it by hand truck to the storage area and hand truck the new work container back to his machine.

Advantages of operator trucking. Operator trucking offers several advantages over the present arrangement in which all material handling is performed by special truckers.

1. Fewer truckers would be needed. One or two truckers would be assigned to transport work between the department storage areas and the central storage rack, but no intra-department truckers would be required.

2. Less production time would be lost during work container changes. The operators

20 Supra., Chapter II, pp.32-34.

would not have to wait for trucking service but would be able to serve themselves immediately.

3. Operator morale would be improved. Each operator's production would be dependent entirely upon his own efforts and it would be unnecessary to enlist the cooperation of a partially disinterested trucker. It is disheartening to the operator to achieve a high efficiency on a job only to lose it because of excessive trucking time. This intangible advantage should increase production through improved operator morale.

Simplified Job Cost Accounting

It is proposed that pre-determined standard job costs be applied to the finishing and inspection operations and that the present use of actual costs be restricted to just the casting operation. This is based on the opinion that some of the precision of the present job cost system can be sacrificed in the interests of simplification and that the accuracy of the proposed standard cost system would be adequate. This measure would save accounting work and would also allow simplifications to be made in the present timekeeping procedures.

The finishing and inspection operations are comparatively inexpensive and production does not vary from timestudy standards to a great extent. These operations, therefore, are suitable for the application of standard costs. Correction factors would have to be applied to the standard production rates to compensate for average departmental production efficiency. This method, in effect, assumes that the production efficiencies of different operators on the various jobs do not vary significantly from the average. Since the casting operation is relatively expensive and subject to large variations in production the use of standard costs would be too inaccurate and records of actual casting costs should continue to be maintained.

Present procedure. The adoption of standard costs would eliminate several bookkeeping operations. The present practice is to multiply the actual production time for each operation on each lot of castings times the operator's hourly rate and then to add the operator's bonus earnings which are supplied by the Payroll Department. Thus, the production cost for each lot of castings is accumulated. When a profit and loss statement or a job cost construction sheet is prepared these lot costs are totaled to obtain a job cost. Lot costs are not used as such but serve only to accumulate the job cost.

Proposed procedure. Under the suggested standard cost system job costs would be calculated directly when required, as for weekly checks against payroll input, monthly profit and loss statements, and occasional job cost construction sheets. The computations would be brief because the standard costs would be prepared in advance and would need only to be applied against the quantities of castings produced. These standard costs could also be used in re-pricing estimates prepared by the Industrial Engineering Department.

Pro-rated Lot Costs

If it is decided that standard costs for finishing and inspection operations cannot be adopted a compromise is suggested, that is: to pro-rate each operator's production time to each job worked during the day on the basis of standard times. This method, in effect, would assume that the operator maintains a uniform production efficiency on all jobs throughout the day. The accuracy of this system and the cost of operating it would lie between the present actual lot cost system and the previously proposed standard job cost system. The pro-rating calculation could be done in the Cost Accounting Department at less cost than the present method but at a higher cost than the proposed standard job cost system.

Simplified Timekeeping

It is proposed that each operator's bonus payments be based on his overall efficiency for the day rather than his efficiency on each job. This change in the method of calculation does not change the amount of bonus paid, and has the advantage of making it unnecessary for the operators to check out after each job and therefore allows taking timekeepers out of the Finishing and Inspection Departments. Small changes in the lot book would eliminate most of the work now performed by the timekeepers.

This change would virtually eliminate the timekeeping function in the Finishing and Inspection Departments and would also reduce the amount of bonus calculation work done in the Payroll Department. Another advantage is that, combined with operator trucking, there would be no necessity for workers to leave their departments except for personal relief. So beside allowing the operators more time for working this change would also allow the foremen to maintain closer control of the operators' activities.

Present procedure. The present procedure requires the operator to walk to the timekeeper's booth after each job, punch the operation ticket, wait for the timekeeper to make the necessary lot book entries, and then walk back to his work place. The timekeeper then copies the lot ticket information onto the operator's daily bonus

slip. When the bonus slip is sent to the Payroll Department at the end of the day the efficiency and bonus for each job are computed and entered on the bonus slip. The individual job bonuses are totaled to arrive at the operator's bonus for the day. A copy of the bonus slip is given to the operator and a copy is kept in the Payroll Department.

Proposed procedure. The proposed change would result in the elimination of several of these clerical steps. By totaling the standard times of all the jobs during the day and comparing to the operator's actual production time for the day an overall efficiency can be computed. The daily bonus computed this way is the same as when computed by the present method. This is important because any change in the amount of bonus payments would arouse serious objections. The adoption of standard costs or pro-rated costs by the Cost Department would eliminate the need for actual production times for each job so it would not be necessary for the operator to check out except at the end of each day. He would then have a collection of job tickets representing his work for the day which would be fastened together and sent to the Payroll Department for bonus calculation.

Punched-Card Equipment

It is proposed that a punched card system be used to prepare the daily reports;[21] however this is recommended only if punched card equipment is available, it should not be obtained specially for the production control reports. This qualification is made because the savings in clerical costs are insufficient to justify the expense of a tabulating system. Punched -card equipment would save some work in preparing the reports but the main advantage would be to provide convenient records of past performance which could be easily sorted and tabulated when historical information is required.

A card would be key-punched for each die's production for each shift. The necessary information would be; die number and part prefix, production, scrap and code, production time, downtime and code, and unit weight. The punched card calculators can be set up to figure machine, group, and overall efficiencies, and total weight of metal cast. If an automatic printer is available it could be used to prepare the Daily Production Report directly from the punched cards, otherwise the report would have to be written or typed by hand. The cards could then be used by the Cost Accounting Department to obtain casting job costs.

21 Supra., Chapter II, p. 37.

A similar card would be punched for inspection information. The information on this card would be: die number and part prefix, number of castings inspected, scrap, unit weight, and statistical quality control records, After automatic calculation of scrap percentage and, possibly, automatic printing of the Daily Scrap Report these cards also could be used by the Cost Accounting Department in preparing job costs.

The unit weight item on both sets of punched cards would furnish data for the Daily Inventory Report and the calculation of metal cast and of metal shipped could be done entirely by machine.

Comparison With Criteria

The following chart, Figure IX, compares the five major proposals of this thesis with the criteria for an ideal production planning and control system.[22] It shows areas where the suggested changes are expected to make improvements on the system's ability to fulfill the criteria.

22 Supra., Chapter III, pp. 43-46.

	Central work storage and dispatching	Operator trucking	Simplified job cost accounting	Simplified timekeeping	Punched card equipment
1. Accurate delivery predictions.					
2. Uniform work loads.					
3. Advance provision, tools, materials.					
4. Central control, constantly informed.					
5. Accurate, current production reports.					
6. Record of responsibility.					
7. Accurate, adequate cost records.					
8. Information for future planning.					
9. Minimum work in process.					
10. Minimum non-productive time.					
11. Minimum expense for benefits.					

FIGURE IX COMPARISON OF PROPOSALS WITH CRITERIA

SUMMARY

Five major proposals are offered for improving the plant's production planning and control system.

1. Central work storage and dispatching. All work in the Finishing and Inspection departments would be kept in a central rack. A dispatcher would schedule the work and send it out to be processed.

2. Operator trucking. All material handling within the departments would be done by the production operators.

3. Simplified job cost accounting. Standard costs would be applied to finishing and inspection operations; or, if this is not acceptable, a compromise system based on pro-rated daily costs would be used.

4. Simplified timekeeping. Bonus payments would be based on the operator's overall efficiency for the day, instead of being calculated for each job and then totaled. Operators would not check out after each job but would hand in all their operation tickets at the end of the day.

5. Punched card equipment. If punched card equipment is made available from another function it would be used to prepare the daily reports.

CHAPTER V

PROPOSED SYSTEM

This chapter describes in detail a production planning and control system incorporating the changes proposed in the previous chapter. A diagram of the system is shown on page 68.

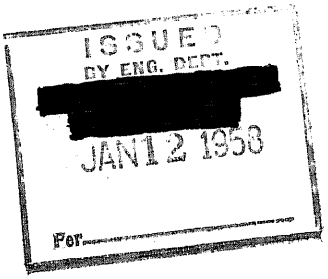
THE SYSTEM

There are no changes in the initial steps of planning and scheduling a casting order. The proposed changes would not appear until the casting die has been mounted and the castings are being made.

Combined Machine Sheet and Bonus Slip

The first apparent change would be the revised machine sheet which is combined with a bonus slip. This form has been designed by the Chief Timekeeper and combines the functions of both the present machine sheet and the present daily bonus slip. The new machine sheet is shown in Figure XI. The combined machine sheet and bonus slip form has two pages with a sheet of carbon paper between them. The top sheet is to be detached and utilized as a bonus slip and the back page is to be used as a machine sheet.

FIGURE X PROPOSED SYSTEM



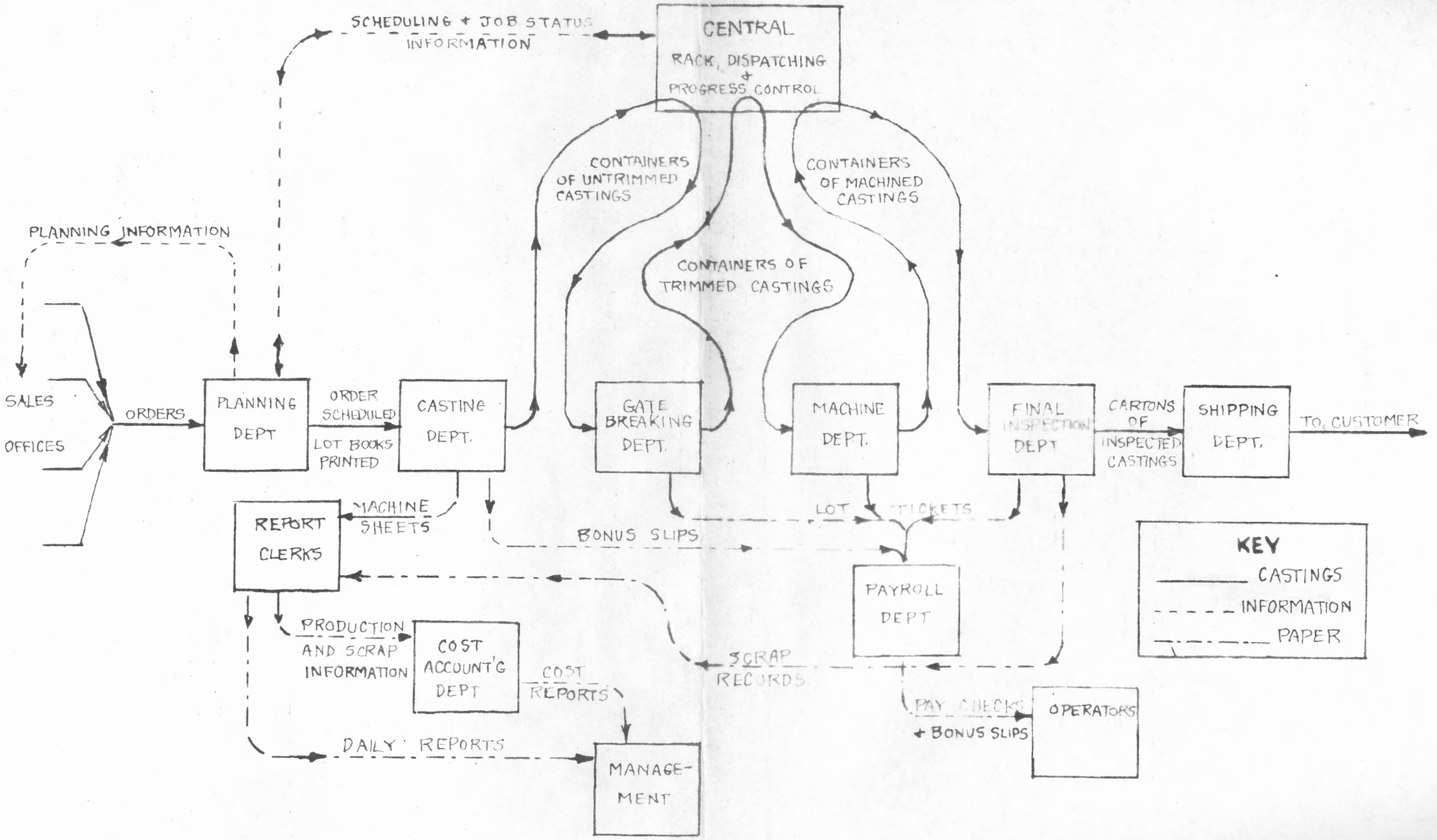
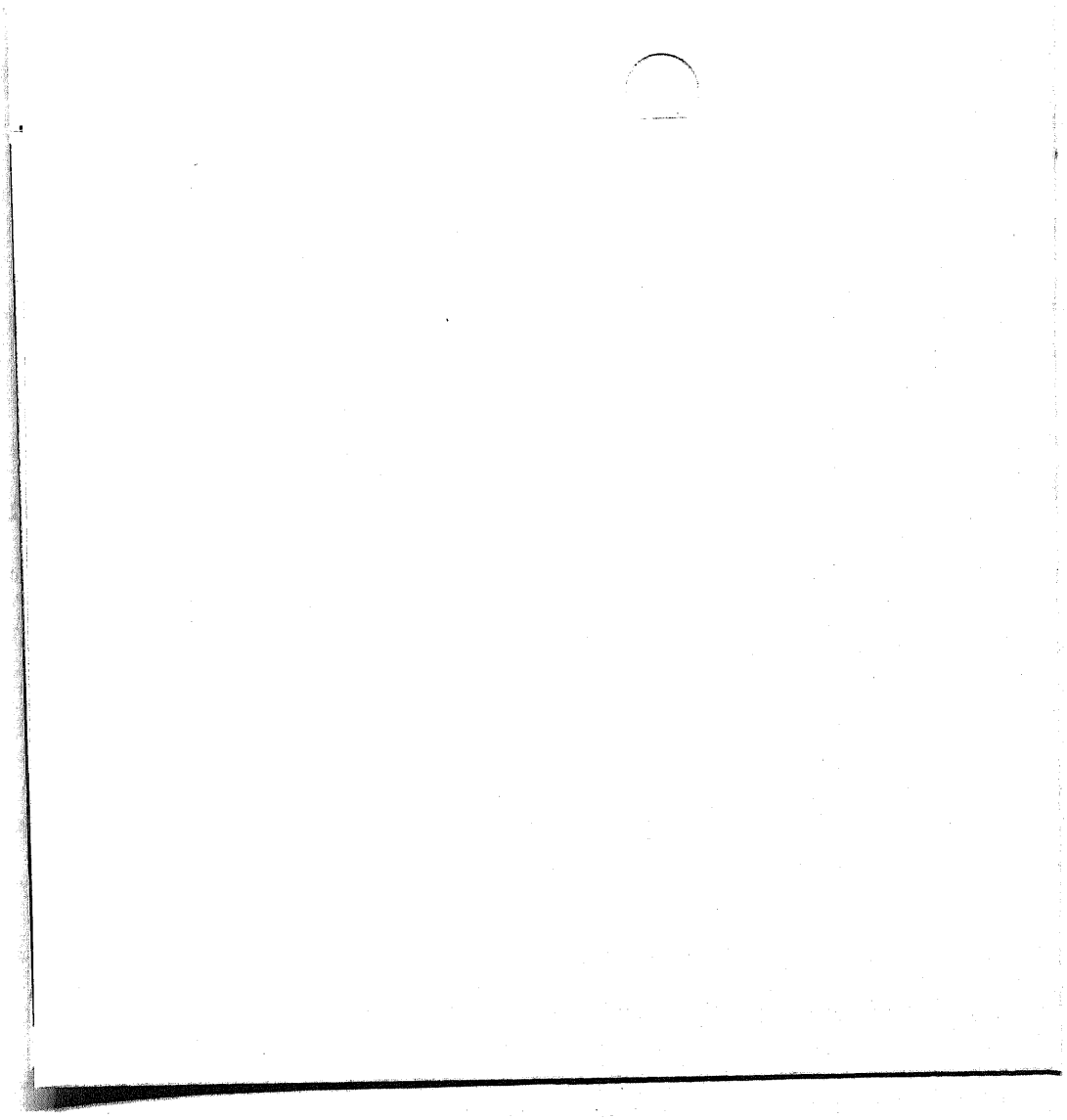

SCHEDULING + JOB STATUS INFORMATION
CENTRAL
RACK, DISPATCHING & PROGRESS CONTROL
CONTAINERS OF UNTRIMMED CASTINGS
CONTAINERS OF MACHINED CASTINGS
CONTAINERS OF TRIMMED CASTINGS
PLANNING INFORMATION
SALES
OFFICES
ORDERS
PLANNING DEPT
ORDER SCHEDULED
LOT BOOKS PRINTED
CASTING DEPT.
GATE BREAKING DEPT.
MACHINE DEPT.
FINAL INSPECTION DEPT
CARTONS OF INSPECTED CASTINGS
SHIPPING DEPT.
TO CUSTOMER
REPORT CLERKS
MACHINE SHEETS
LOT TICKETS
BONUS SLIPS
PAYROLL DEPT
KEY
CASTINGS
INFORMATION
PAPER
PRODUCTION AND SCRAP INFORMATION
COST ACCOUNT'G DEPT
COST REPORTS
SCRAP RECORDS
PAY CHECKS + BONUS SLIPS
OPERATORS
DAILY REPORTS
MANAGE-MENT

FIGURE XI COMBINED MACHINE SHEET AND BONUS SLIP



CST'G. ROOM INSPECTION &

MACHINE SHIFT REPORT

DIE No. _____

HRS.	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
OVER																								
14																								
13																								
12																								
11																								
10																								
9																								
8																								
7																								
6																								
5																								
4																								
3																								
2																								
1																								
0																								
SCRAP																								
OK																								
GOOD																								

PART			% SCRAP				PART			% SCRAP				PART			% SCRAP			
LOT	HRS.	GOOD	OK / REC.	SCRAP	BONUS	S	LOT	HRS.	GOOD	OK / REC.	SCRAP	BONUS	S	LOT	HRS.	GOOD	OK / REC.	SCRAP	BONUS	S
TOTALS																				

DATE _____ P.C. _____ OPERATION _____

LADLE WT. _____

HLP. _____

HLP. _____ STD. TIME _____ B.C. ____/____ 85% HRS. _____

HLP. _____

OPER. _____ FOREMAN _____ G.L. _____

INDIRECT LABOR

TO _____ STOP _____

INSP. CODE _____ FROM _____ START _____

TYPE INSP. _____ TO _____ STOP _____

INSPECTOR _____ HRS. FROM _____ START _____

CON. LOAD _____ SHIFT _____ MACH. No. _____

FORM 2143

The procedure for handling the combined machine sheet and bonus slip is as follows: At the beginning of each shift, or when a job is started, the combined form is posted at the casting machine by the foremen. He also fills in the heading information pertaining to die number, operator number, etc. As each lot of castings is completed the hot inspector who releases the lot writes the inspection information on the sheet; lot number and quantity of castings. The hot inspector also places a lot book in the container of castings and if the casting quantity differs from the standard he writes in the actual quantity. The foreman enters the operator's starting and finishing times on the machine sheet if they differ from the normal shift hours. At the end of the shift or when the operator is changed to another machine the top page is removed and sent to the Payroll Department for bonus calculation. The back page is removed at the end of the shift or when the die is changed. This page is the machine sheet and is given to the report clerk by the foreman. The report clerk posts the number of castings produced on the Casting Department scheduler's control board and then transcribes the necessary information for the Daily Casting Production Report. The clerk then sends the information regarding production hours and number of castings produced to the Cost Accounting Department and files the machine sheet.

Lot Book

The lot book is completely redesigned and is intended to serve several functions. It is illustrated on page 72. The top two pages are light-weight paper and the backs are carbonized; they are to be used as bonus slips. The back page is heavy stock and serves as a routing card and lot record.[23] The back page also includes packing tickets, the dispatcher's tag which is a marginal punched card, and a move ticket.

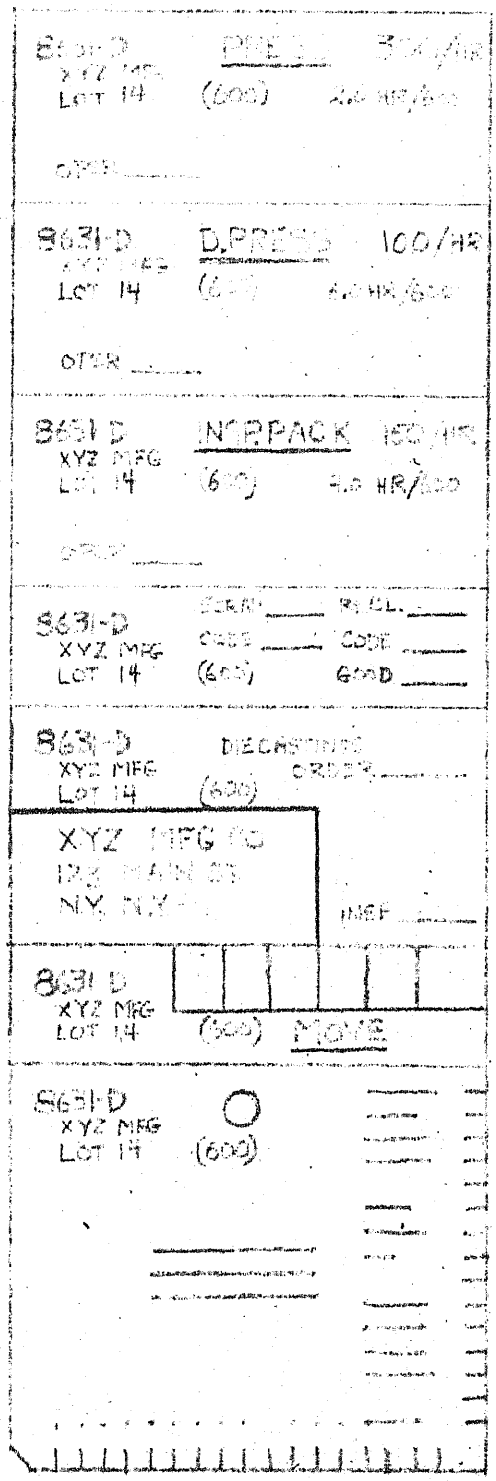
The uses of the parts of the lot book are as follows:

Lot book. The lot book is placed in the container of castings by the hot inspector who releases the lot from the Casting Department. If the lot quantity differs from the standard quantity printed on the book the hot inspector writes in the actual quantity on each of the operation tickets.

The container is taken to the central racks by the trucker who detaches the move ticket and the dispatcher's tag from the book. The lot book itself stays with the lot of castings.

23 J.A. Mauriello, "Labor Accounting and Reporting Procedures," Industrial Accountants Handbook, W.P. Fiske and J.A. Beckett, Editors, (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1956) p. 794.

FIGURE XII LOT BOOK



GATE BREAKING TICKET

MACHINING TICKET

INSPECTION TICKET

SCRAP RECORD

PACKING LABEL

MOVE TICKET

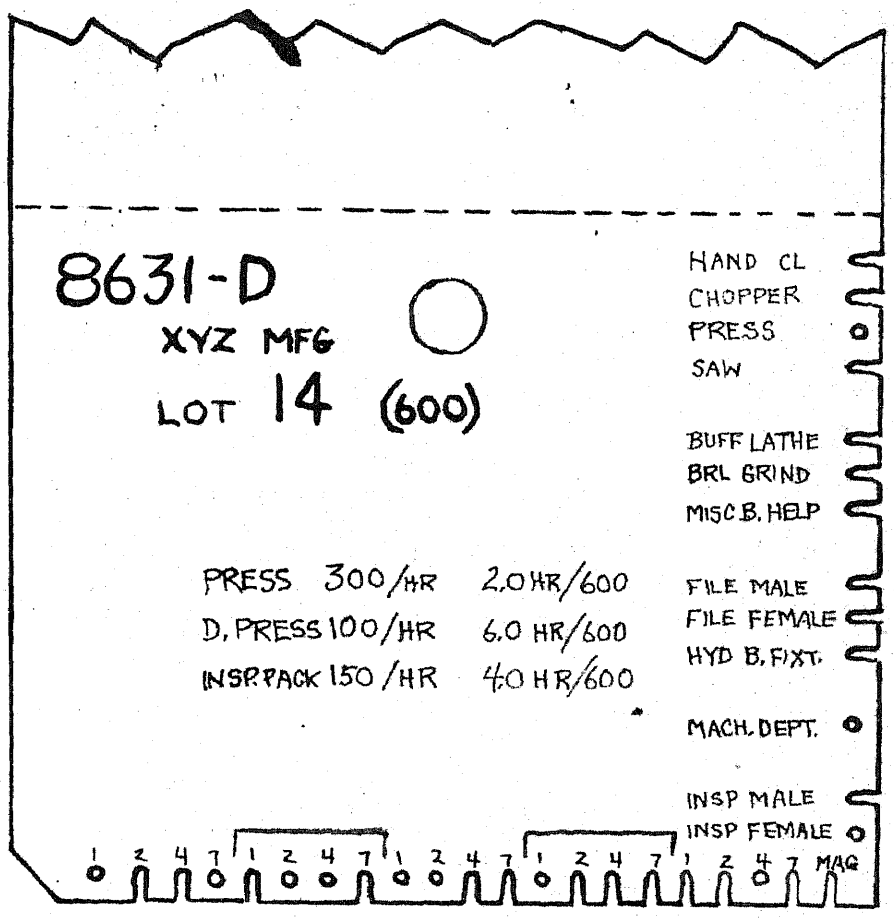
DISPATCHER'S TAG
(SEE FIGURE XIII)

Dispatcher's tag. The dispatcher's tag is a marginal punched card which is used to track the lot's progress through the plant. The marginal punches are utilized by the dispatcher to plan work levels in the various departments. A detailed illustration of the dispatcher's tag is shown in Figure XIII.

Each marginal hole on the bottom edge represents a production center or type of work which must be considered separately when scheduling. By inserting a sorting needle through a stack of cards the dispatcher can separate from the stack all the cards, but only the cards, which require a certain operation. After the operation is performed the dispatcher clips out the hole to leave a notch. The marginal holes on the sides of the card allow sorting by die number. The digits are combined for these holes to reduce the required number of marginal holes.

Use of dispatcher's tags. When planning production in the Finishing and Inspection departments the dispatcher might work like this; first he would sort out all the rush jobs by die number, then he would determine the man hours required to finish the rush jobs. By multiplying the hours per standard lot for each operation times the number of lots the dispatcher determines the totals of required man hours. Another method would be to separate all the cards requiring a certain operation from the

FIGURE XIII DISPATCHER'S TAG



stack representing all the lots in process and then add the hours as listed on the cards. The dispatcher can establish the status of an order by separating all the cards of the die in question and then sorting out those cards which have gone through each operation.[24]

Move ticket. The move ticket is used to record the location of containers in the central storage rack and also to authorize the movement of the container to the production centers. The trucker detaches the move ticket and dispatcher's tag from the lot book when the container is first moved from the casting room. He then writes the rack number on the move ticket and gives both the ticket and the tag to the dispatcher. When the dispatcher wants the container to be moved to a work location he writes the location on the move ticket and gives it to the trucker. The move ticket stays with the lot book until the container is returned to the central storage racks; then the new rack number is written on the ticket by the trucker and it is given again to the dispatcher.

Packing label. The packing labels are removed from the lot book and glued to the shipping cartons when the castings have been inspected and packed. The number of

24 R.S. Casey and J.W. Perry, Punched Cards, Their Application to Science and Industry, (New York: Reinhold Publishing Corporation, 1951) p. 6.

packing labels included in the lot book depends on the number of cartons which will be filled from the lot.

Scrap record. The scrap record is filled out by the final inspector who enters on it the quantity and causes for scrap and reclaimable castings. This record is sent back to the report clerk to be used as a source for the Daily Scrap Report and then for cost accounting records of castings shipped versus castings produced.

Dispatching Procedure

Assume the container is now in the central storage racks and at the disposition of the dispatcher. He knows what operations are to be performed on the castings and how long they will take; this information is furnished by the dispatcher's tag. The dispatcher is also informed of the urgency and promised delivery date of each job by the Planning Department, and from the department heads and foremen he knows the conditions existing in the production centers regarding man-power, equipment, etc. By coordinating these factors the dispatcher can schedule work to the best advantage and plan department work loads for maximum efficiency. Changes will, of course, occur but the dispatcher will be able to adapt his schedule with a minimum of difficulty.

The proposed procedure for dispatching containers of castings and accounting for their location is as follows.

1. Each production center is represented by a pocket on the dispatcher's control board.

2. The tags in the production center pockets represent the containers in the central storage rack which the dispatcher has scheduled for that production center. The front tag would be the next container scheduled.

3. The dispatcher decides to send the next container to a production center.

4. He removes the tag and its move ticket from the pocket and writes the production center on the move ticket.

5. He places the marked move ticket in the trucker's "out" box and he places the tag on a hook in front of the pocket; this credits the production center with having the container.

6. The trucker drives by and picks up the marked move ticket from the "out" box. Then he gets the container from the central rack and takes it to the production center as directed.

7. At the production center the trucker clips the move ticket to the lot book, which is in the container, and leaves the container in the production center's storage area.

8. The trucker then picks up a container of completed castings from the storage area, unclips the move ticket from its lot book, and carries the container back to the central storage rack.

9. As he passes the "out" box the trucker picks up his next move ticket, he then continues on to the racks and places the container in an empty rack.

10. He writes the new rack number on the move ticket for the returned container.

11. He then picks up the container for his next "out" trip and on his way past the dispatcher's desk he drops the move ticket showing the rack location of the returned container into the "in" box.

12. Steps 6 through 11 describe the trucker's routine which is repeated for each container of castings.

13. The dispatcher removes the tag for the returned container from the production

center hook on the control board and clips it to the returned move ticket for that container.

14. The dispatcher then clips out the marginal hole on the tag for the operation just completed, and places the tag and move ticket in the pocket for the next production center. He positions the group of tags in that pocket according to the precedence he has assigned to the jobs.

15. By making sure there are always one or two more containers at each production center than the number of operators assigned there the dispatcher can insure the operators always having enough work.

Production Center Inventory

The result of the above procedure would be to maintain an inventory of work ahead in each production center. Several hand trucks would be kept in the department to allow the operators to truck their own work from the inventory area to their machines and then back to the inventory area when finished.

The "work ahead" inventory would allow the foremen to pre-plan operator assignments, equipment set-ups, method changes, timestudies, etc. If, for some reason, a

container cannot be worked on it can be returned to the central racks without incurring any operator idle time.

Job Costs

Job costs under the proposed system would be composed of two main costs: actual casting costs, and standard finishing and inspection costs. The actual casting costs would be derived from time and production information on the combined machine sheet and bonus slip. The standard finishing and inspection costs would be based on timestudy standard production rates and a correction factor.

If tabulating equipment is available it can be utilized to record casting production information on punched cards. Monthly summaries of casting production by die can then be obtained automatically and, if required, summaries by machine can also be calculated easily.

The standard cost for a particular operation would be calculated by multiplying the production center's hourly labor and burden rate times the standard hours per one thousand castings for that operation and dividing by the average departmental efficiency. The form of the standard cost would then be, for example; costs per thousand castings of die 8001: $21.80 for filing, $14.65 for washing, etc. The standard cost would have to be revised whenever a significant change occurs in the average

departmental efficiency.

Unusual jobs or high volume jobs might warrant the establishment of a more precise standard cost, one that would more accurately represent the actual costs for the job alone. This can be done by determining the average efficiency for the job in question by examining the bonus slips of operators who spend entire shifts on the job.

When determining job costs on orders that are not completed it is necessary to know the extent of completion of the order. The dispatcher can quickly discover from his tag system just how many lots or castings have passed through each operation.

Reports

The Daily Casting Production Report and the Daily Scrap Report would be handled in much the same way as at present. That is, the machine sheets and scrap records would be sent to a report clerk who summarizes the results and writes the daily reports.

If tabulating equipment is available this procedure would be modified to take advantage of the capabilities of punched cards and a key punch operation would be substituted for the report writing operation. A punched card would summarize a die's production performance for the shift and another card would summarize the die's scrap

and reclaim record in the Final Inspection Department for the shift. These cards when fed through a card controlled typewriter would prepare the reports automatically. The overall performance calculations can still be done on tabulating equipment and then the report can be written by hand if an automatic typewriter is not available.

The main advantage of tabulating equipment in this application is not economy or speed but the accessibility of records of past performance. The entire history of a die can be easily reviewed, or the die's performance can be evaluated against its machines and operators.

Operator's Procedure

The operator's responsibilities under the proposed system are simple; after completing a container of castings he writes his number on the appropriate operation ticket (which makes a carbon copy on the back page) and detaches the operation ticket (the operator saves his operation tickets until the end of the shift). The operator then hand-trucks the container of completed castings to the production center inventory area and then hand-trucks the next container back to his machine. At the end of the shift the operator clips his operation tickets together and gives the tickets to his foreman who adds any indirect labor or idle time tickets and then forwards the set to the Payroll Department. In the Payroll

Department the operation tickets are used as bonus slips for calculation of the operator's bonus earnings.

Payroll Department Procedure

Under the proposed system the procedure for calculating operator bonus would be slightly modified. A set of bonus slips (operation tickets) would be sent to the Payroll Department for each operator; each slip representing a lot of castings worked on by the operator. The standard lot quantity of castings would be printed on the bonus slip and if there is no written entry correcting the lot quantity the payroll clerk would assume the standard quantity is correct, and therefore the standard lot time applies. A deviation from the standard quantity would change the standard lot time by the same ratio.

The operator's total accomplishment for the day would be obtained by adding the standard lot times on all his bonus slips. The operator's clock card tells how long he is on the job during the day; so, his production efficiency for the day is the total standard time divided by the total actual time. This computation and the corresponding bonus payment would be entered on the top bonus slip of each set. The set would be retained in the Payroll Department and a duplicate of the top slip returned to the operator as his record.

SUMMARY

The foregoing chapter has detailed the proposed production planning and control system. The features this system incorporates are:

1. A combined machine sheet and bonus slip which eliminates timekeeping functions in the Casting Department.

2. A revised lot book which also supplies bonus slips.

3. A dispatcher's tag attached to the lot book which helps the dispatcher plan work loads and schedules.

4. A move ticket which is used to direct trucking and to keep track of the location of each container of castings.

5. A dispatching procedure which allows the dispatcher to schedule each lot of castings.

6. A small inventory of work ahead in each production center, thus allowing the foremen to pre-plan their work.

7. A job cost system utilizing standard costs for finishing and inspection operations which eliminates timekeeping functions in those departments and also saves accounting work.

8. A revised method of calculating operator's bonus which saves work in the Payroll Department by basing earnings on overall daily efficiency, rather than individual job efficiency.

9. A changed procedure for operators which eliminates checking out after each job and which has the operators doing their own trucking.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the conclusions reached in the foregoing thesis and presents recommendations for applying the proposed changes.

CONCLUSIONS

The present system of production planning and control was concluded to be subject to improvement in the following respects.

1. Fluctuations in work load. Although this is a characteristic of a job order business it is felt that work load fluctuations in the Finishing and Inspection departments could be reduced.

2. Central control point. There is no central control point which is constantly informed of production progress.

3. Work-in-process inventory. An improvement could be made by reducing the inventory of work-in-process.

4. Cost. It was also concluded that the cost of the present production planning and control system could be substantially reduced;

this saving is estimated to be approximately $25,000 a year, the equivalent of the services of five people. This includes the activities of timekeeping, job cost accounting, material handling, expediting, and inventory control; no figure is included for the savings resulting from improved production scheduling, operator trucking, and operator morale.

LATEST CHANGES

Recently, several changes have been made to the present production planning and control system, as described in Chapter II, with the adoption of a tabulating system. The changes are:

1. The foremen have been assigned the tasks previously performed by the timekeepers.
2. The information entered on the lot book operation tickets is now used to prepare punched cards.
3. The punched cards are used to prepare payroll checks and lot costs.
4. The combined machine sheet and bonus slip is now in use.

Other changes are still in progress and, at the time of this writing, the installation is incomplete. It appears, however, that the resulting savings will be less than those provided by the basic changes in job cost accounting and timekeeping which were described in Chapter III.

RECOMMENDATIONS

The following changes to the present system of production planning and control are recommended.

1. Central work storage and dispatching. The central dispatching system would alleviate several problems.

   a. The dispatcher using the information at his disposal could prepare detailed schedules which would minimize both work load fluctuations and the work-in-process inventory.

   b. The dispatcher would maintain a perpetual inventory of work-in-process thus reducing present inventory control costs.

   c. The dispatcher's station would be a central control point

which would be constantly informed of production progress. This would facilitate planning and expediting activities.

2. Operator trucking. All material handling within the departments should be done by the individual operators. This will minimize material handling costs and improve production through faster trucking service.

3. Simplified job cost accounting. It is recommended that standard costs be used for the finishing and inspection operations. This would reduce clerical work in the Cost Accounting Department and eliminate all timekeeping activities in the finishing and inspection departments.

4. Simplified timekeeping. Bonus payments should be based on the operator's overall efficiency for the day instead of on each job. This procedure results in the same earnings and makes possible the elimination of all checking out except at the end of the day.

5. Punched card equipment. One of the objects of this thesis was to examine the application of automatic office equipment to

the production planning and control problem. However the expense of a tabulating system is not justified if the foregoing recommendations are carried out because the repetitive clerical tasks would be largely eliminated. Therefore the purchase or rental of punched card equipment is not recommended.

6. Application. It is recommended that the installation of central storage and dispatching and operator trucking be postponed until the new plant is completed because of space limitations in the present plant.

The new punched card system now being installed will have an effect on the costs of operating the production planning and control system. It appears, however, that further savings will still be possible through the adoption of simplified job cost accounting and simplified timekeeping. When the installation of the new tabulating system is complete it is recommended that its costs be compared to the costs of a simplified system. The feasibility of combining the two systems should also be examined.

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CRITICAL EVALUATION

The Department of Management Engineering requires that a thesis be presented to qualified persons for evaluation. Two evaluations are included on the following pages.

January 20, 1958

Dear Mr. Woodnorth:

At your request I took on the obligation to act as a Critical Evaluator for your thesis which you are presenting as part of your work to obtain a degree of Master of Science. I am submitting to you this report presented, as I understand it, as a frank expression of the practicality and workability of the proposition set forth in your thesis.

I have enjoyed reading your thesis a great deal, not only from the standpoint of a well organized and easily read paper, but also it is obvious that a great deal of thought, research and preparation has gone into this effort.

Being familiar with the operations which you have chosen to discuss, I have tackled this assignment with considerable interest, looking for results in your recommendations that could be applied in a constructive manner and result in an economic advantage to the plant.

The recommendations for the most part have definite value and in my opinion are quite workable. To substantiate this is anti-climatic to some degree as there are certain features of this program that have been put into effect establishing the practicality of some of your specific ideas. The entire program cannot at this time be established because of physical reasons, i.e. Central Dispatching Area, as noted in your report. However, in the future plant this will be expected to become a reality with the attending advantages in cost reductions.

In your discussion referring to the application of standard costs as compared to actual job costs, some rather interesting ideas were presented which should be explored to a greater extent. My feeling is that either system is quite workable although standard costs may be hazardous in that by the averaging of costs one can invite high cost business and discourage simple, low cost operations. Experience in a highly competitive jobbing business dictates the need of a quite accurate cost systems although further study in this area may reveal certain possibilities for greater improvement and control of costs.

Your opinion in regards to tabulating equipment may be justified in so far as your proposition dealt with job costs alone, this however, is only one segment in the over-all plan for tabulating equipment. When all of the uses for this equipment are integrated, it would appear that some major savings can be had. As an example, in addition to payroll, bonus calculations, costs, etc. many valuable records pertaining to maintenance, personnel and others can be had with very little additional cost but considerable savings when compared to manual records.

These two general criticisms are not intended in anyway to detract from your thesis but rather to indicate the value of such work in stimulating other ideas in addition to presenting a very workable program.

I have enjoyed reviewing your thesis and wish to compliment you on a "job well done".

C. G. Wistar

January 20, 1958

Professor Oliver J. Sizelove
Thesis Advisor
Department of Management Engineering
Newark College of Engineering

Dear Professor Sizelove,

Having read the candidate's thesis, I would like to submit the following critical appraisal.

The treatment of the social economic problem of clerical employees is very good in these days of increasing labor cost and deficiency of good clerical help. Since this is also a problem in our plant, the candidate has recommended after an analytical approach that a combination of work simplification and tabulating equipment be used.

Although the plant in question has embarked on the installation of a complete tabulating installation, it is to be pointed out that the candidate's recommendations would produce the same results. It is difficult at this time to determine which system is more economical and whether in the long range planning of our organization which would produce greater economies. The candidate presents a system which, because of our unique situation, requires will and desire to make changes by management. The approach taken

is one which is always necessary in a dynamic management.

In summation, I feel that the candidate's research, treatment and presentation of our problem is very good and much of his thinking will be used at our new plant operation.

Sincerely,

Howard G. Griem
Works Chief Industrial Engineer