MECHANICAL ENGINEERING APRIL 17, 1953

MECHANICAL AIDS FOR PRODUCTION CONTROL

Submitted in Partial Fulfillment of the

Requirements

For the Degree of Master of Engineering

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PREFACE

In writing the thesis, the author has dealt lightly with, or excluded, many of the control and planning operations which normally occur in texts on the subject. It is not to be taken from this that these are considered superfluous. Rather, the information presented should be considered as observations which add to the knowledge of the subject. Because the field is so broad, the main points would be lost in the maize of detail which would accompany a description of all operations. The only consideration is control and the subject is treated to emphasize this.

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INTRODUCTION

The importance of good production control is increasing with the steady increase in productivity found in Canadian and American industry. (Normally, the United States manages to achieve a yearly gain of 2% in productivity.)

In view of this it is insufficient to compare lost time, commonly called waiting time, of say ten years ago, with that of today and assume, because there has not been an increase, that the control system is operating satisfactorily. A much better indication of the effectiveness of the control system is a ratio of waiting time to productive time since the latter will likely have been decreasing steadily for the same unit of product.

Present day accounting methods do not show waste due to inefficient systems. And many outdated production

control systems continue to exist. In addition, there is usually no means of appraising or rating of how well the control is being performed. In other words, the control system may be out of control.

There are two trends worthy of consideration. The first and more common trend is - simplification of production control systems by applying flow analysis and work simplification principles to the operations involved in controlling. The second trend which is not so common, is to modify the method of production and change the design of the product so that control may be completely automatic.

Both trends will be discussed in this thesis since it is believed that the ideal control system for most industries is a combination of the two. The degree of mechanization depends on the economic conditions involved.

The analysis will be directed to determine the ideal control system. We shall first deal with control through the written record. This control is aptly stated as follows:

> "The modern conception of control is based upon the sound principles of preplanning and foresight with adequate means of immediately measuring the actual performance with predetermined standards." [1]

Texts on the subject of production planning and control deal mostly with the functions of planning and inventory control. Few provide "adequate means of immediately measuring the actual performance with the predetermined standards." Modern accounting machines and systems are used to decrease the delay between reception of the information and the tabulating and reporting of the results, but there still exists a delay before the information, as recorded at the scene of action, is transported to the tabulating departments. This delay may be sufficient to cause lack of control.

With this in mind, the process of production will be reviewed with the aim of simplifying and improving it through the introduction of mechanical aids.

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[1] Thomas M. Landy Production Planning and Control McGraw Hill Book Company Inc. 1950 P. 4

It is proposed to reduce the control to its lowest level and, if possible, perform the measuring of actual results with the predetermined standards at the time that the operations are being performed.

DEFINITIONS:-

Control: Control is, "the way in which an industrial enterprise is made to conform to satisfactory predetermined procedures and policies."[1] Controls may be applied to administrative work, to finances, to sales and distribution, and to production. Thus defined it is readily seen that controls do not necessarily restrain, but rather direct and accelerate the procedures and processes of an industrial activity.

Control of Production: Production control is, "the mental and physical techniques and procedures employed to the end that the right quantity and quality of a product shall be produced at the right time by the best and cheapest methods."[2]

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[1] Lawrence L Bethel Phd (ed) Production Control McGraw Hill Book Company Inc. 1948 2nd ed. P. 1 .

[2] Idem.

Planning:

Planning is an important function of management and, in order to accomplish anything of importance, planning should precede doing. Planning in an organization covers a wide scope. For example, when considering production control functions, planning may range from what is called master planning performed by the administration to what is called secondary planning performed by the foreman or even by the operators.

Budget:

> "A budget may be defined as a collection of estimates of income and outgo for a coming period (based upon records of past experience, present business conditions, and indicated trends) integrated into a single comprehensive plan. Budgets are not restricted to dealing solely with dollars and cents. The budgets necessary for adequate control of a business give estimates of the probable accomplishments of every department, as well as the probable cost of running the department and provide a means of checking the actual performance against the plans made." [1]

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1 William B Cornell Organization and Management in Industry and Business The Ronald Press Company. New York 1947 3rd ed. P. 572

Considering this definition it will be noted that the production schedule is just one form of budget. It is an estimate of income (raw materials, labour, power, etc.) and outgo. (The finished product for a given period.)

CONTROL BY WRITTEN RECORD

Production control as it is understood in the present day metal working industries is control accomplished by means of the flow of paper. In practically every case the medium of control is the written record and elaborate and costly systems have been devised to obtain control in this manner.

> "Control is a basic process and whatever the type or whatever the subject it embraces the following elements:
>
> 1- Objective - what is desired.
> 2- Procedure -
> a) Plan - how and when it is to be done.
> b) Organize - who is responsible.
> c) Standards - what constitutes good performance.
> 3- Appraisal - how well it was done."[1]

Production control is actually control of four factors, labour, equipment, material and product. We can therefore fit in the elements of production control as follows:-

OBJECTIVE

The object of production control is to control quantities of labour, equipment, material and product so that;

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1 P. E. Holden, L.S. Fish and H.L. Smith Top Management Organization and Control Stanford Univ. Press, 1941 P 77

staying within predetermined limits of time, quality, effort and design; cost is kept at a minimum and schedules are met.

PROCEDURE

The statement of the procedure for production control becomes involved since we find that the identical procedure is not ideal for each of the four factors being controlled. In addition, since the four factors are interrelated, each cannot be controlled independently. The usual and most successful method is to select one factor as the prime controlling factor and fit systems for the other three to the procedure devised for it. The basic principle governing the choice of the prime factor is to choose the one which contains the least number of individual items.

Procedure is thus influenced by the type of production being controlled and by the characteristics of the product.

APPRAISAL

The production control supervisor in the typical factory usually has only one answer to the question - "how well is the control being performed?" This is, "we meet our schedules and do not have excessive waiting time."

It is quite likely, however, that the objective as stated is not being met because in many cases in order to meet schedules unbalanced loads are thrown on various sections of the factory. For example, there may be excessive set up time; or the equipment may be loaded to extreme at one time and then idle at another.

It is suggested, that the extent of utilization of the factory capacity might provide a means of appraisal to suppliment a measure of the ability to meet the schedule. Two ratios which may be used when measuring capacities are capacity and load factors.

Capacity Factor

> "Capacity factor is defined as the ratio of the average capacity actually used to the available capacity." 1

Load Factor

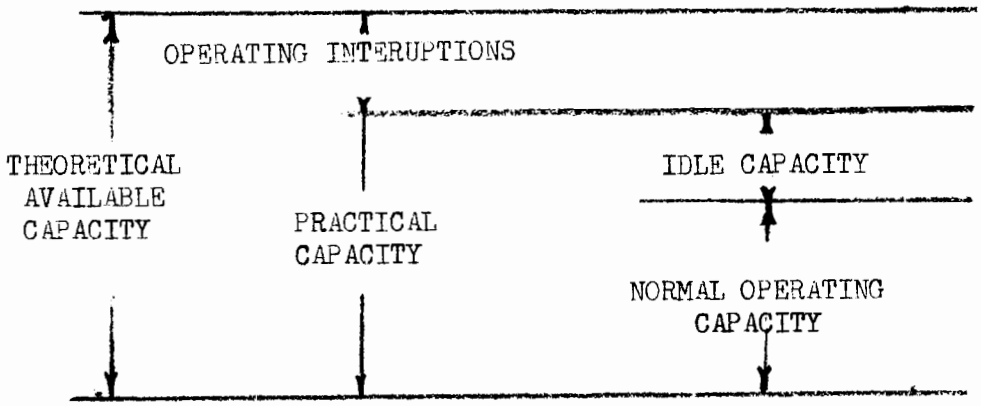
The ratio of peak to average load is called the load factor. This is defined as "the ratio of average demand to the maximum demand." 2

1 Baldwin M. Woods and Paul De Garmo - Introduction to Engineering Economy The Macmillan Company New York 1942 P. 246

2 Ibid. P. 248

Capacities

In order to use these factors the relation of various capacities must be known. These are best shown graphically as follows:-



It is recognized that the capacities will not be in balance throughout the factory and there should be a means of pacing or controlling them. Certain machines will produce at higher rates than others; or operating delays will not occur as predicted so that, if work is allowed to flow naturally without control, the flow will be unbalanced.

From this it is seen that the capacity factor, which is set by the schedule, will vary for each production center. In addition, it should never be set at 100% for, to be realistic, it should take into consideration actual conditions as they would exist at the period of operation. If set too high, the capacity factor will eventually cause trouble by creating hardships for both the operating and servicing personnel. On the other hand, if set too low, the idle time will be excessive.

Capacities (cont'd.)

The capacity factor has been suggested as one measure for the appraisal of production control because it indicates the degree of control accuracy needed. The closer the operating capacity approaches to the theoretical capacity the more difficult the control will be.

It is suggested that the load factor could be used to measure the stability of the control. It is difficult to operate with large load fluctuations and the more stable control is the best.

PRODUCTION TYPES

Production types may be considered from the point of view of how the product is shipped and how the orders are received. This affects the way that the equipment may be arranged in the factory, which in turn affects the control system. A major factor in the control system is whether the equipment is set out in a functional or in a line type of layout.

The three divisions or ways in which the product may be shipped can be termed as follows:

1) Manufacture to stock
2) Manufacture to order
3) Manufacture to stock and finish to order.

1) Manufacture to stock

This is a common method of producing items which are in continuous demand. By producing to a bank of finished items, economical lots may be processed before changing over the set up. The stock of finished items acts as a buffer to absorb the shock of large orders. Control when producing to stock is usually easier than when manufacturing to order.

2) Manufacture to order

Manufacturing to order is common for special items. Planning is usually rushed because often operators must be trained, tooling provided and all other planning and procuring processes performed after receipt of the order. This may not be the case however, since many items are planned in advance and simply manufactured to order.

3) Manufacture to stock and finish to order

This production is a combination of the previous two types. It is an attempt to reduce the problems of producing to order by producing to stock as many standardized items as possible. Control of this type is more difficult than production to stock, but not as difficult as manufacture to order.

An important principle to note when considering the complexity of the problem of production control is - that it is the type of production, not the kind of product that is the determining factor. It is true that the kind of product may govern what type of production is used. Because of this there has been a tendency to compare systems on a basis of the product rather than on a basis of the production process.

The manner in which the orders are received is another consideration. Items may be ordered once never to be repeated, or they may be continuously repeated until there is a design change of the item. The common names for each of these is Job Lot Production and Continuous Production.

Job Lot Production:

Job lot production is production of custom built items which are produced to a specific order received from the customer. It is inconceivable that you would have job lot production and produce to stock; therefore, the problems of job lot production are those of producing to order. All planning is done after the order has been received, and the planning for this type is a major portion of the control process. Once planning has been completed the control can be performed in a similar manner to control of continuous production.

Continuous Production

In the case of continuous production the job of production control may be reduced to a few fundamental steps which will permit operations to proceed in an orderly

Continuous Production (cont'd.)

fashion to the accomplishment of the predetermined results.

Preplanned

Whatever the type of production, it should be controlled by following the principle of preplanning and foresight with the adequate means of immediately measuring the actual performance with the predetermined standards. The difficulty observed with job lot production has been the setting of the predetermined standards. This difficulty is overcome by the use of standard data. One such form is "Methods Time Measurement," a procedure which enables time standards to be set from drawings of the parts. Whatever the type of production, predetermined standards are essential to control. The manner in which these are set is beyond the scope of this thesis since it will deal only with the measuring and the actions which follow.

Areas of Operation

In order to visualize the problem of control by written record the areas of operation which would be included in a light metal working industry will be considered. These areas would exist no matter what type of production is being followed. The major controlling

Areas of Operation (cont'd.)

factor in this consideration is the product and the control systems of material, equipment and labour are fitted to the system devised for the product.

It is to be realized that these are typical areas of operation and that the nomenclature is not standard.

AREAS OF OPERATION

1) Sales analysis
2) Sales forecast and Master Manufacturing Schedule
3) Explosion of Master Manufacturing Schedule
4) Material Control
5) Production Planning and Production Control
6) Time keeping for direct and indirect labour
7) Labour distribution and overhead costing (Manpower control)

These areas of operation will be considered from the point of view of, how they relate to the four factors of production; product, equipment, material and labour. It will also be shown how a paper control system could be built around them.

Sales Analysis

Sales analysis is a means of using a scientific approach as a basis for foresight. The results of this may, in the end, depend a great deal upon the judgement of the person or persons making the analysis. For this reason the production control system must be adaptable to change.

Sales Forecast and Master Manufacturing Schedule

The sales statistics developed through the procedure of sales analysis could constitute one of the principal bases for a Sales Forecast. In order to be sufficiently sure that the proposed manufacturing program based on this

Sales Forecast and Master Manufacturing Schedule (cont'd.)

Sales Forecast can be executed by available plant capacity. It is necessary that the Forecast be first converted into terms of Machine and Man Hour Loads. In order to do this, the standard times to produce each of the items of the product must be known,along with the quantities of items required.

Explosion of the Master Manufacturing Schedule

To determine the number of individual items required and the material going in to make up these items, the Master Manufacturing schedule must be broken down from assembly lists or the equivalent into all component parts. For purpose of discussion this is described as Explosion of the master manufacturing schedule. This is usually a simple mechanical breakdown and is often performed by bookkeeping machines.

Material Control

Various material control systems are used in industry. Considering the areas of operation as they have been stated, the material control section would be responsible for:

Material Control (cont'd.)

a) Explosion of the Master Manufacturing Schedule
b) Operation of material control records covering products, assemblies, manufactured parts, purchased parts and raw material.

The material control records constitute the base from which detailed production planning proceeds, manufacturing orders are originated, and the overall position controlled. The closest co-ordination and co-operation between Material Control and Production Planning and Control is therefore essential.

Production Planning and Control Systems

A number of functions are covered by the planning and controlling sections of a factory using the written record as control.

Functions of the planning section would be as follows:

1) Load Record.
2) Conversion of Sales Forecast into terms of load for analysis and adjustment.
3) Development of the Master Manufacturing Schedule.
4) Special Order Scheduling and Delivery Promises.

Production Planning and Control Systems (cont'd.)

5) Manufacturing Order origination and preparation, grouping of lots into economic runs.
6) Manufacturing Order Scheduling.
7) Follow-up on raw material required to release Manufacturing orders.
8) Release of Manufacturing Orders to Dispatching section when material is available.
9) Observance of over-all execution of the production plan.
10) Answer customers' enquiries as to position of their orders.

Functions of the Dispatching section are as follows:

1) Issuance of jobs to operators.
2) Methodical follow up of all manufacturing orders.
3) Maintaining and operating the control mechanism.
4) Immediate reporting of all delays.

Time keeping for direct and indirect labour

Time keeping may not be considered as a production control function. It is interesting to note, however, that a good production control system will serve to secure complete and accurate recording of employee's time throughout the factory. Since one of the factors controlled is labour, time keeping has been included as an area of operation. In most industries the payroll department is assigned this work.

Labour Distribution and Overhead costing

Here again it may be questioned whether this is a production control function. Information which is developed during the planning will either aid or serve in its entirety the function of labour distribution and overhead costing.

A TYPICAL PRODUCTION CONTROL SYSTEM

It will now be shown how a written record type of production control system could be built around these areas of operation. Since this thesis is to deal only with control, the planning functions will not be covered.

The type of production being controlled can be described briefly as: - Functional equipment layout with line type of assembly, items manufactured to stock with orders received continually. The commodity is complex since it contains numerous individual parts.

ORGANIZATION

The various factors which are controlled are interrelated but control is mostly performed by the persons or departments indicated:

Labour - Dispatcher, Department Foremen, Factory Manager.
Equipment - Dispatcher, Department Foremen, Factory Manager.
Material - Stockroom and Production Planning.
Product - Production Planning and Department Foremen.

Labour:

Time study rates are set as standards on all production jobs. The time it took to perform the job is

Labour (cont'd.)

recorded on cards by the operator. This in turn is entered by the dispatcher on employee record cards along with the time it should have taken had the employee been producing at the standard rate. At the end of each month the dispatcher computes the employee's average efficiency from the employee record cards and presents this information to the foremen. The standards plus a knowledge of operating efficiency furnish the planning with the information needed to calculate the number of employees required for a given schedule.

Equipment

The departments are divided into work centers according to equipment types. The same cards which are used to obtain the employee's records are used to compute machine utilization. Reports of this are sent by the dispatcher to the Factory Manager and the Foremen at the end of each week indicating to them the waiting time at the various machines.

Material

For the purpose of this discussion material will be either the parts or raw stock which are stored in

Material (cont'd.)

the stockroom. Material will be classified as raw, incomplete, or complete. Raw is basic stock such as rod or strip steel as it would be received from the rolling mills. Incomplete is partly processed but it is not in a condition to be placed into the product. Complete is ready for assembly.

Material is controlled mainly by the stockroom based upon information received from the production planning department. This is control by maximum and minimum stock entries. Whenever stock falls below the minimum or above the maximum, the stockroom notifies the production planning and the dispatcher.

Product

The quantities of product are controlled by the product planning department. This department schedules what type and what quantity of product is required at a definite time. All other control must be coordinated to attain this schedule.

ROUTINES

Master Schedule

The master production schedule is issued by the production planning department. This states the type,

Master Schedule (cont'd.)

quantity and assembly date for each product. It forms the basis for all other controls.

Explosion of Master Production Schedule

The master production schedule is exploded to determine requirements of raw material, purchased parts and manufactured parts. This is done by means of lists which record the parts in terms of the product.

Material Control

Material is controlled by means of minimum and maximum stock entries made on stock control cards filed in trays. Plastic markers at the base of the cards give visual control of the material. The record clerk slides these markers along to indicate the status of the raw material recorded on the card. Minimum stock entries are adjusted to agree with the schedule.

Incoming and outgoing material is recorded daily. Material going to the manufacturing department is ordered by the Dispatcher on a stock issue requisition, which is a blue copy of the dispatch traveller. If there is stock, the stock issuer fills the order and places the white copy with the parts. The blue copy is given to the record

Material Control (cont'd.)

clerk who records the stock withdrawal and then sends the blue copy back to the Dispatcher. If there is insufficient stock to fill the order, the stock available is marked on the blue traveller and both blue and white travellers are returned to the dispatcher.

Production Planning and Control

Planning

This applies to a specific system.

All production planning for manufacture is based upon a production of 1500 units per lot. That is, orders are issued to make this number of units and it is the time allowed to complete the orders that is varied to meet the production schedule. This means that the quantities stated on the manufacturing orders are fixed. It is the frequency of issuance that is varied.

Control

Control of manufacturing is aided by using a dispatch board. The Dispatcher issues the travellers in triplicate retaining the pink copy. When he receives the blue copy indicating that the stock has been issued, he

Control (cont'd.)

notifies the trucker to pick up the stock and take it to the first work center. The Dispatcher has a record of the routing on cards beside the dispatch board. When the trucker takes the work to the first operation, the Dispatcher places the pink traveller in the dispatch board in the proper work center compartment. Control is then accomplished by moving the pink traveller through the dispatch board agreeing with the flow of work.

Labour and equipment control

The Dispatcher receives notification of every stock move by a flow of employee time cards, which are brought to him by the truckers. He also fills out the operation, employee and machine record cards with the desired information. The flow of the employee time cards is as follows:

1) Employee receives cards from tub placed in the department.
2) When job starts employee punches time on the card by means of a time clock.
3) When job is finished the employee refers to the routing sheets in the department and enters on the card - part number, operation number and work center number. He then punches in the time finished.

Labour and equipment control (cont'd.)

4) A weigher with a travelling scale counts the parts and enters the quantity finished. He also notes that this agrees with the white traveller which remains with the parts.
5) The trucker moves the parts to the next operation, picks up the time card and takes it to the Dispatcher.
6) The Dispatch clerk moves the pink traveller to the next work center compartment in the dispatch board, and then fills out the required records from the time card.
7) The time card is then sent to the Cost Control Department.

RECORDS

Operation record

The operation record card is a permanent record of an operation. One card is made out for each operation and includes operation number, part number, work center number and standard time in the heading of the card. The dispatcher fills out the remaining information as the time cards are received. These entries are: operator number, quantity, date, time taken and time it should have taken (calculated).

Employee record

The operation record is summarized on the employee record cards and an additional calculation of employee efficiency is made and entered. The Foremen and Factory Manager refer to this record when considering advancement.

Machine record

The machine record is also a summary made from the operation record card. In addition, a weekly report of machine utilization is compiled from the machine record. This report is sent to the Foremen and Factory Manager.

ORDERS

The dispatcher is motivated to issue travellers from three sources.

1) Stock shortage notes received from the stockroom.
2) Work center load shortages indicated by the dispatch board or requested by the foremen.
3) Factory assembly orders received from the planning department.

Shortages

Shortages receive first priority when travellers are issued. The over-all control, however, is not based on shortages. The Dispatcher knows from the parts list and factory assembly order that a certain number of parts must be processed during a certain period. He also knows, from the time standards, how many hours should be spent processing the parts. Since he is recording the actual times spent processing he can calculate the average efficiency of the various work centers and will know how the work is actually proceeding.

Work Center Load

In practice, as long as all work centers contain the correct number of employees, keeping the work centers loaded will maintain the schedule, provided that the operators are producing only the correct number of each part. To assure that there isn't duplication of, or over-production of orders, the Dispatcher maintains a record of the quantity of parts or, of orders outstanding, by means of a simplified Gantt chart.

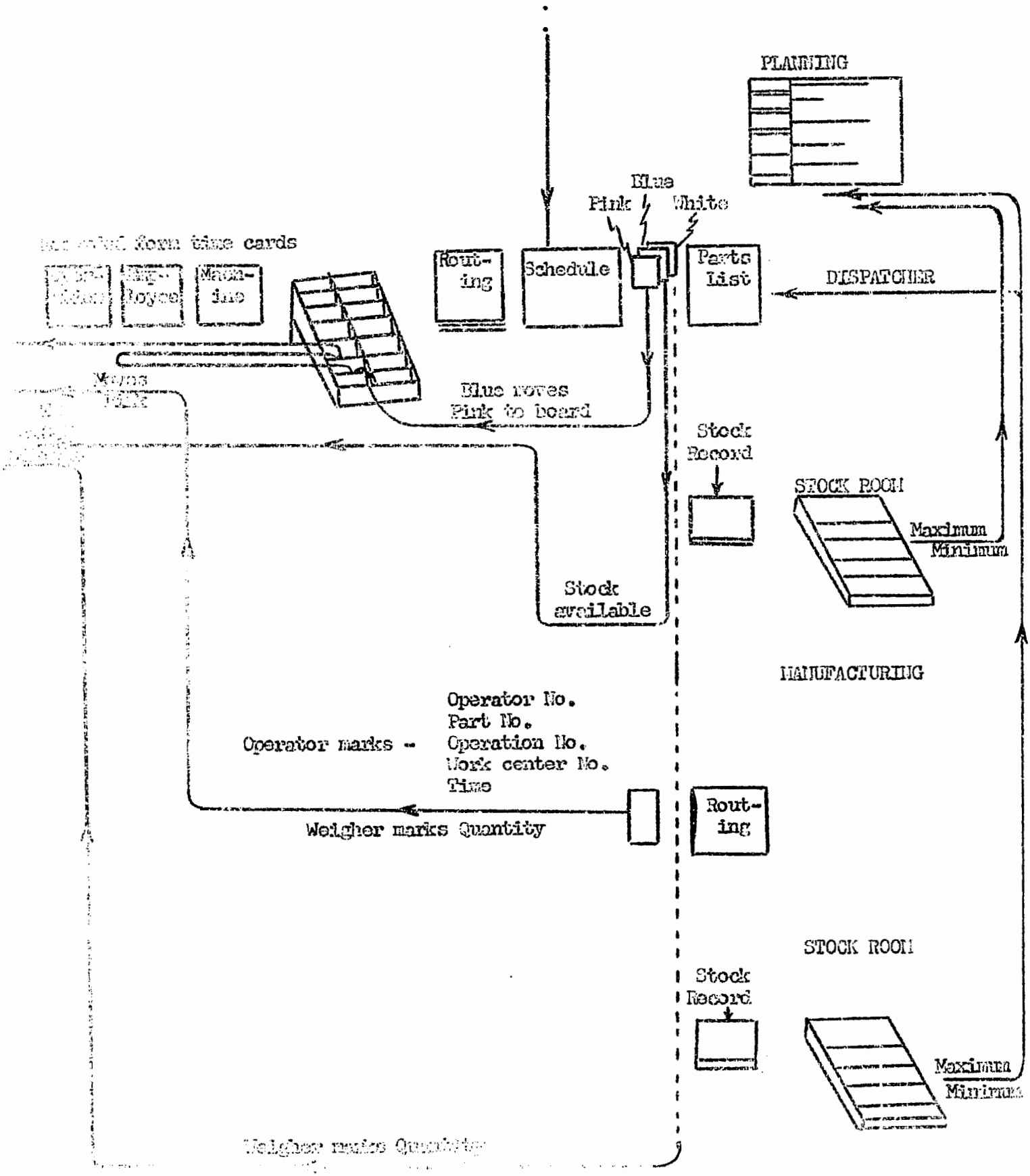
Non Standard Procedures

If, due to faulty material, workmanship, or some other cause, it is found necessary to modify the routing; the change is stated on a special order. The Dispatcher receives a copy of this order and routes the work by means of this copy.

Discussion

It may appear from the foregoing that the typical control system is overly complicated. Actually this system is not as complicated as many in operation today. It was chosen for two reasons: First, it provides a definite means of controlling each of the four factors of production. Secondly, it is an operating system which can be readily analysed by the author.

GRAPHICAL REPRESENTATION OF THE TYPICAL PRODUCTION CONTROL SYSTEM.



Discussion (cont'd.)

A system of control is only as good as the weakest section in it. Certain deficiencies have been noted in the system described, and it is felt that these are basic and worthy of discussion. The aim, of course, is to determine what mechanical aids may be used to advantage when controlling production, and the analysis will be directed to this end.

INFORMATION

When one considers the description of a control system, paying close attention to the wording, it will be found that certain words or phrases are repeated. For example, the word "notifies," will occur many times.

No matter what system is used it should be designed so that information is rushed to the person or persons who are to make decisions. Thus it appears that the basic operations, common to all production control systems, are operations performed on, or performed with, information. In addition, if the original conception of control is considered it will be realized that at every decision level in the organization a comparison is made between information from two or more sources before that decision is made. It might be stated that decisions can be made without comparing information in the usual sense; such as analysing two reports on the same subject. In this case, the person compares the information received with information stored in his memory and makes a decision accordingly. Such actions are poor for control since memory is not accurate and facts may be distorted.

The case in discussion is aptly demonstrated by the stock keepers found in many industries. Code numbers for parts may be presented to these persons in rapid order and

they will call upon their memory to supply the description, quantity and stockroom location of each of these. Such persons are very handy but records must be kept to guarantee that errors do not occur. The persons with the astounding memories should be used to supplement the records, and not vice versa. If the records are kept by this person they will be inaccurate since he will tend to first utilize his memory and then make the entry when time is available - usually some entries are forgotten.

STUDY OF FLOWS

In order to study the operations performed on,or with, information it is advisable to consider why and how information must flow.

Why Information Flows

We must have an information flow to the various levels in the organization. The basic reason for flow is that the operating or working personnel are not the same as the deciding or planning personnel. Once the areas of responsibility are clearly defined, and this is essential for control, the flow of information must emanate from and return to these areas. The difficulty found when the areas of responsibility are assigned, such as, by an organization chart, is that a stronger personality will gradually take over the duties of the weaker so that eventually the organization changes. While this transition is in process confusion will exist. The other extreme may occur where the persons perform only what is assigned as their duty so that when a fringe duty, that is one which is partially the responsibility of one and partially that of another, occurs the duty is not performed.

One answer to this problem of assigning responsibilities is to assign them to a committee composed of persons at the same level in the organization. The stronger personalities will naturally lead this committee but they will not have

any higher authority so that discussion will flow freely.

With this in mind we shall simply state that information must flow to and from the various levels of authority. It is to be realized that a level of authority may consist of only one person or of a committee of persons, but whatever the case, it is their responsibility to decide upon the action and see that the decision is carried out. If the decision is such that a higher level of authority is needed, each lower level should be so well versed in their duties that the information is expedited to that level with the least loss of time.

How Information Flows

The flow of information is bi-directional. First there is the flow of decisions from higher to lower authority levels. Certain actions are taken and then there is the return flow which carries information back to those who initiated the decisions. As the information flows it passes through various processes. It is these processes which are basic. For the purpose of discussion,we shall name each flow. Flow from the higher to lower levels we shall call "Directing" and the flow from the lower levels to the higher we shall call "Reporting".

Directing

Much has been done to improve directing and most Managers and Executives realize the importance of keeping those under them well informed. The timeliness of directing depends upon how many levels of authority the information must pass through. The manner in which authority has been delegated will therefore affect the directing flow.

> "A supervisor should delegate all authority it is possible to delegate in order to get work done, reserving for himself the necessary remainder of authority to oversee, check, and direct work of others."[1]

The principle behind this statement is the exception principle which is utilized to advantage when controlling production.

Reporting

When one considers reporting it is noted that it is usually incomplete or untimely. One reason for this is that the person or persons reporting may be recording their own actions and will consciously or sub consciously highlight the more pleasant information. Thus, if unpleasant information is to be reported, the person may withhold the information in hopes that the condition will change. Since it usually is this adverse information which is the more important when

1 William Staniar M.E. Plant Engineering Handbook McGraw-Hill Book Company, Inc. 1950 1st. ed. P. 28

Reporting (cont'd.)

controlling production this is a weakness of reporting which must be considered. Another is, that the reporting flow originates at the lower levels where the tendency is to do work rather than talk about it. Often the flow is broken because the person responsible for initiating this flow is too busy removing the trouble which should be reported.

Conclusions

From the foregoing we see that information must flow freely for good control. For in every case, the operation of control is to receive and act upon information. It is incorrect, however, to assume that a flow of information sent at random to all levels of authority is the answer to good control. Each level should receive information useful to it. The tendency is, that the higher the level the more general the information. For this reason, the information will usually pass through the various levels to be processed for each succeeding level. When an emergency occurs, the information may pass up through the organization in its original form, but it is essential to note that it must pass through each level or, at least, each intermediate level should be notified. The same occurs with directing flow. It must follow the proper channels or lack of control will occur.

Conclusions (cont'd.)

The best control occurs when the trouble is anticipated and the remedial actions start immediately, or even before, the trouble starts. This is more nearly approached by having the reporting flows so adjusted that the first indication of an exception to the directing flow is reported immediately. In order that the directing will be timely it should originate at the lowest possible level.

The flow of information, directing and reporting should form closed loops if plotted on a chart. In other words, there should be a reporting flow for every directing flow.

COMMUNICATION BY WRITTEN RECORDS

When humans are performing the controlling actions, the information they receive must be in a form which they may interpret. In addition, it must be in a state that may be transported, sorted, compared or filed. There are the two ways of communicating, either: (1) by verbal methods, or (2) by written methods. Since it is the general opinion that verbal communication in the factory is not satisfactory because of the chance of mis-interpretation and error, the written method of communication is the more common.

A detailed study of communicating devices might be considered at this point. Only a few of the many devices which are available will be included because many, especially those used for long range communication, are not considered practical for factory use.

We are dealing with communication between various levels in the organization and, because the characteristics of the personnel and the type of work they perform varies at the different levels, it seems reasonable to assume that one means of communication is not best for all levels. The approach will be to examine the means at our disposal and then fit, or modify, these for use in a control system.

Before the means of communicating are considered, the method of producing the written record will be discussed.

Transcribing

Information must be transcribed so that it is in a state that may be transported, translated, sorted, compared or stored. Typewritten information is the most legible but in some cases information written in longhand is suitable.

There are various ways in which information may be prepared for typewriting. Three common ones are as follows:

(1) Dictate and record by shorthand
(2) Dictate and make recordings
(3) Write out in longhand.

The relative times taken for each of these depends to such an extent upon the persons performing the operations that accurate comparisons cannot be made. It is sufficient to say that (1) and (2) are comparable as to time consumed. A rate of 60 words per minute is close to average for these operations. To write out longhand will take much longer and an average figure of 25 words per minute is suggested as good transcribing rate for this operation.*

The gain by using a recording machine is realized by releasing the stenographer so that she may be performing other operations at the time of dictating. The time elapsed to dictate into a machine or to dictate to shorthand will be

* Time study figures.

Transcribing (cont'd.)

the same so that a recording machine does not shorten the time cycle to process; providing that typing is not delayed because the stenographer is taking the dictation.

Transcribing time may be reduced, however, by using written forms.

Written forms

The advantage of the written form is, that it is an orderly standardized arrangement of presenting information. When a form is used it forces the type of information that is presented and in this respect it is good for reporting. Directing by means of forms is also good because the form usually reduces the possibility of confusion through it's simplicity. If the form is well planned it will lessen the time for recording the information.

It is good policy to use forms wherever practical to replace reports. Examples of forms used in production control are stock requisitions and routing sheets. In this we find an application of the principle of pre-planning to the act of recording information.

Written Reports

When more detail is required or when information is of a special nature, written reports may be used instead of

Written Reports (cont'd.)

written forms. In this case, the information is not standardized and it takes longer to prepare. The important fact to consider is that reports and forms do not accomplish any positive action. They simply act as information carriers or retainers and it is the interpretation of them and the actions which follow which benefit the company. From this it is seen that there should be a minimum of forms and reports.

It is not possible to visualize the company which operates without records but it is conceivable that our conception of written information such as forms and reports might change. Possibly some other form of record keeping, such as coded systems or recordings, which may be stored or processed faster than written information, could be used to advantage. This appears to be the trend and we find some installations with tabulating machines and automatic feed back control systems performing most of the controlling operations. Because the expense of these restricts their use, we shall deal mostly with the written type of record.

Disadvantages of Written Records

The greatest disadvantage of the written record is time delay. Not only does it take time to write or fill out the

Disadvantages of Written Records (cont'd.)

information but also it takes time to transport it. A common method is to employ mail clerks who pick up and deliver the media. This means that the rate of delivery is dependent upon a periodic messenger service and it is controlled by the whims of low paid clerks. The disadvantage of this has already been recognized by business machine manufacturers and equipment has been developed to perform this operation.

The time taken to perform the transcribing has already been discussed and it was noted that recording machines are sometimes used to save time for the secretaries, but that these do not reduce the overall cycle time taken. There are types of equipment however, which transmit the information as it is transcribed. These save time by combining the operation of transcribing with that of transmitting.

WRITTEN RECORD TRANSMISSION

Pneumatic tube

The Pneumatic Tube Systems are a familiar sight in many large departmental stores where they are used to carry orders and money from the work floor to a centralized office. Similar systems may be used to advantage in factories.

Advantages of Pneumatic Tubes

The Pneumatic Tube System will transmit the media directly from one point to another without chance of it being incorrectly routed. Drawings and even small parts, as well as written records may be transmitted by the system. It is a mechanical substitute for the mail clerks and guarantees quick delivery.

Disadvantages of Pneumatic Tubes

Once the Pneumatic Tube System is installed, the route over which the information may be transmitted is fixed. Thus the system is not flexible. Also, because of the expense of installation, it is only practical to use the tubes where a large traffic of mail will occur and it is likely that the tubes will feed only large groups so that a secondary transporting system would be required. Another transmitting system would be needed if there is any traffic of large reports such as books.

Conclusions

The Pneumatic Tube Systems are good when considering them as a substitute for mail clerks. They will aid control by speeding the transmission of information, but they must be operated where there will be a large flow of mail.

Teletype Machines

When large distances are to be covered, the teletype machine might be considered. With these machines the information typed on a sender will be duplicated on a receiver.

Advantages

The teletype machine gives permanent record of the information both on the sending and receiving machines. This reduces the chance of an error. Any message which may be typewritten may be sent by teletype. It is not likely that it would be used to send information on forms but the machines are often used to transmit coded information.

Disadvantages

The main disadvantage of the teletype is its expense. Because of this it is common practice to find that only one machine is available for all transmitting and receiving at one station. This restricts sending and receiving to only one message at a time.

Conclusions

The teletype machine is a communicating device for two main communicating centers situated miles apart. It is not suitable for inter-plant communication when there is the likelihood that more than one message will be sent or received at the same time on the same machine.

CODE COMMUNICATION

In order to simplify the messages sent and received, codes are often set up. The equipment already described will transmit codes but there are special machines suitable for this.

Temporator Network

The temporator machine is a simple number recording machine. A dial similar to that on a dial telephone is connected to step type relays so that when a number is dialed it appears in a window both on the receiving and on the transmitting sets. Any number of digits may be operated by the dial but a common number for each unit is twelve. When used from a central office, the unit in the office may contain several rows of indicating windows so that more than one signal may be received at one time. Thus a central dispatch office could operate several outlying tempor units which were located in work centers.

Advantages

There is little chance of an error in transmission since, when the numbers are dialed, the digits show up on the sending station. This gives immediate confirmation that the report is correctly sent, since, the numbers remain in the

Advantages (cont'd.)

windows of the units until changed either by the sender or receiver. It is possible to attach printers to the temporator units, but such additions considerably increase the expense of the equipment and the possibility of the receiving operator making an error in transcribing is slight.

Disadvantages

Messages are limited to coded numbers and are restricted to the number of digits on the units.

Conclusions

The Temporator Units are suitable for inter-plant communication in numbered codes. Thus, they would be suitable for routine reporting of quantities produced, operator numbers and work center numbers. Discussion is impossible with this type of unit and likely it would be used in conjunction with some other information transmitting unit for complete control. It would force reporting flow since all messages travel to the one center. Because the numbers actually appear where they may be read off, the chance of shop noise or poor reception causing error is non-existent. This type of unit would fit

Conclusions (cont'd.)

into a scheme where pre-planning and foresight preceeds operation since in this case only simple reporting is required. When trouble occurs, however, some other means of reporting would be required.

TRANSCRIBING COMBINED WITH TRANSMITTING

Transcribing or writing down the information is usually done on a typewriter so that the writing is legible. This is not necessarily the case for all businesses and at times forms or reports are written in longhand. Recognizing that information must be transmitted from one level of authority to another, business machine manufacturers have developed equipment which combines the operation of transcribing with that of transmitting.

Telescriber

A machine called the telescriber combines the operation of transcribing and transmitting. This machine will duplicate written messages on receivers located in various positions in the factory. I will transmit sketches, as well as written messages.

SUMMARY

It has been noted that there is a wide choice of suitable equipment which will transmit or carry information from one point to another in the factory. Nothing has been said about expense of this equipment but before any installation is considered an economic study should be made. Factors which are sometimes overlooked are as follows:

1) Cost of special forms
2) Flexibility
3) Installation expense and maintenance expense
4) Indirect savings such as reduction of waiting time

These mechanical aids have been grouped as information transmitting and transcribing. However, transmitting and transcribing are only two of several basic operations performed when processing information. It is incorrect to choose the mechanical aids for transcribing and transmitting without considering their effect on the other basic operations.

OTHER BASIC OPERATIONS

Control involves decisions. These are made by comparing alternatives consisting of arrangements of the information. Since this information as it is received from one source may not be in a form ready for comparison with that received from another, it may be necessary to process it. The purpose of processing the information is to aid decision making. If it does not do this the operation is superfluous and should not be performed.

Basic operations which might be performed to aid decisions are:

1) Classify
2) Record
3) Extract
4) Calculate

The basic operations, transporting and transcribing have already been discussed.

Classification

> "Data should be classified to save time and simplify their use. The act of classifying is that of arranging and segregating persons, items or ideas having similar characteristics of rank, order, time, dimensions, or principle into orderly related groups." 1

1 William Stanlar M. E. op cit p. 38

Classification (cont'd.)

Because production control is control of quantities of labour, equipment, material and product with respect to time, these will form the classification groups. Thus, there could be at least five ways in which the information might be classified. In addition, the media carrying the information will likely arrive from several different sources so that there would be a random sequence of information in each group. The common classification operation is to first arrange the information into the groups and then arrange each group into code numbers in numerical sequence. If it is a large group and each number is to be selected visually, the operation of arranging into numerical sequence will be extremely long. The use of color to bracket a group into sub-groups (e.g. separate tens from hundreds) will help this operation, but it is recommended that some punched card system should be used when the classifying operation is long. The operation of classification when performed with punched cards is commonly called sorting.

Sorting Tabulating cards

The tabulating or punched card systems are used to an advantage for mechanical or manual sorting. The cards for manual sorting have holes perforated along the edges, whereas, those for mechanical sorting are free of holes and have the code perforated across the face of the cards. This means that a greater number of code holes may be entered on a card for mechanical sorting. The portion of the cards which is left free of punchings is usually marked off as a form and has written on it information which may or may not be duplicated by the punchings.

Manual

The code which is entered on manual cards is punched into them by cutting away the outside portion of the respective holes. The sorting is performed by taking a stack of the cards; lining them so that the edges are even and pushing a sorting needle through the same hole in all cards. Cards which have the edge of the hole cut away will drop out when the stack is lifted by the needle. Manual sorting time with this method is shorter than any other manual method. A skilled operator can arrange 260 cards in sequence in 3.5 minutes by this method. Whereas, by sorting manually and visually it would take 15 minutes to perform the same operation.

Mechanical

Mechanical sorting is extremly fast. The stack of cards are simply placed into the machine, which automatically sorts them into the arrangement that it has been set to give.

Disadvantages

Most of the disadvantages of punched card procedures are common to both manual and mechanical systems. It must be realized that to function properly the cards must be thick enough to retain their shape after handling. This means that the cards take more room for storage than thin paper records. In addition, since the cards are part of the process which may be patented, they will likely be more expensive than other forms. The time required to punch in the code is another factor. Usually for production control purposes some of the sorting codes are punched in the cards before they are issued to the factory. Any error in this operation could cause trouble and so it is usually checked by some method. This checking is also time consuming.

Mechanical sorting may not give the high rate of output expected due to the machines being overloaded at one period and idle at others.

It is quite common to find overloaded conditions caused by too great a variety of work passing through the one machine. This may be indirectly caused by the high

Disadvantages (cont'd.)

cost of the machines. In order to justify its purchase, time savings should be realized on large volumes of manual work. Few Canadian industries have the required volume without including work from a number of different functions.

Advantages

The common advantage of punched cards for sorting is speed. Since this operation is performed easily and quickly there is more likelihood that all necessary sorting operations will be performed and that the information will be recorded systematically and uniformly. When other methods are used, there is a tendency to cut down on the amount of sorting with the result that important information is not recorded in a manner for easy reference.

Record

The dictionary describes the act of recording as "to set down in writing, as proceedings in a meeting." 1

For the purposes of production control, the act of recording includes the setting down of information in any manner. We have already discussed transcribing which may be a part of the process of recording.

1 Webster's new international dictionary of the English Language G. & C. Merriam Company, Springfield, Mass., 1947

Record (cont'd.)

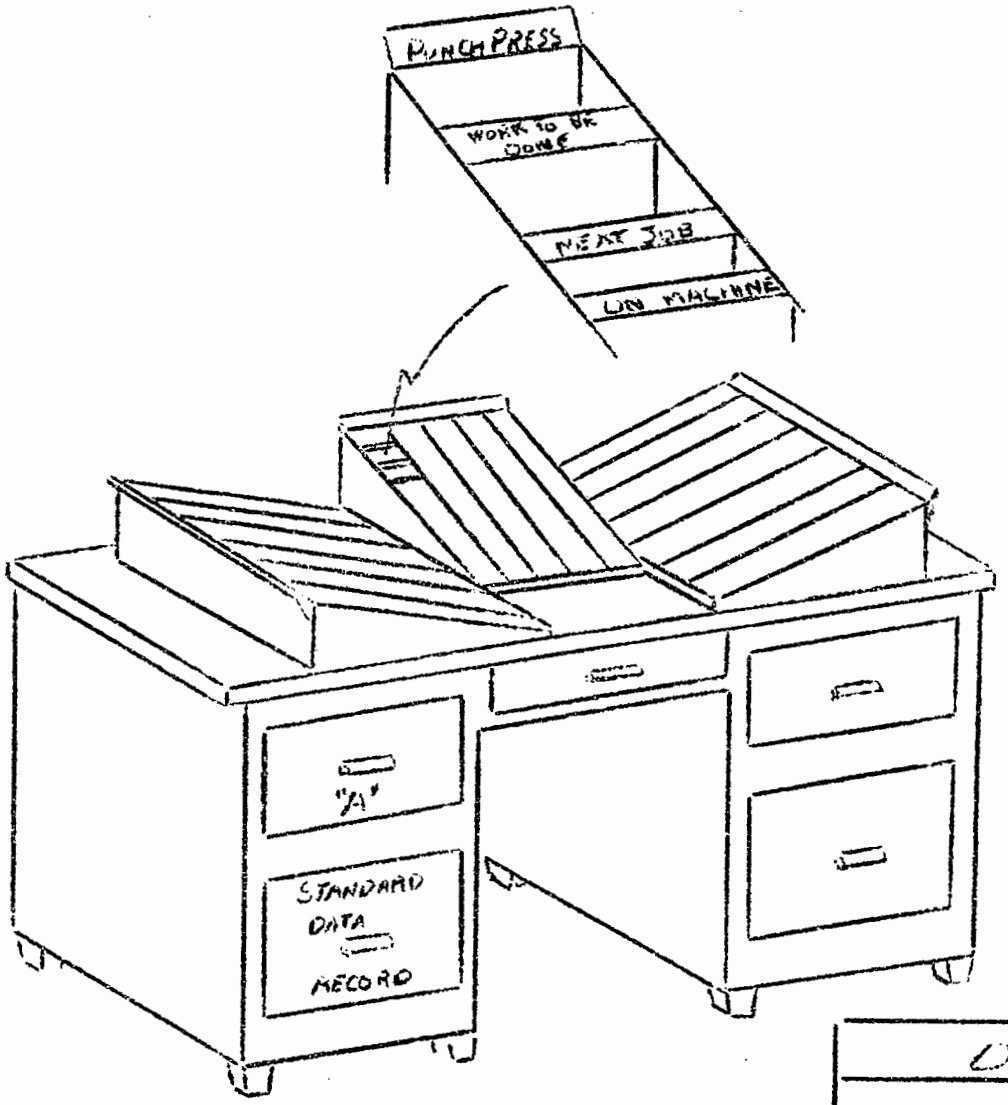
Filing is another action which may be a part of recording. If the record is a journal type it will tell a story of happenings one after the other in a time sequence. On the other hand, the record could be a ledger type which tells the story of a complete situation as it exists at one time. Two mechanical aids used in production control which illustrate each type are: The Gantt Chart and The Dispatch Board.

Gantt Chart

The Gantt Chart is a common type of record used in production control which graphically presents a record. There are many mechanical adaptations of this chart which for the most part do not reduce the time required to enter the record. They may, however, present the information more clearly or in a neater manner than a chart drawn on paper. They are also very flexible.

Dispatch Board

The Dispatch Board is another means of recording which furnishes visual aid. In this case the board presents a ledger type of record. The board is simply a representation of a floor plan. Compartments take the place of work centers



PART OPERATION WORK CENTER MACHINE PARTS/HR.

DISPATCH CARD

DATE	OPERATOR	QUAN.	TIME	ACT.	%	DATE	OPERATOR	QUAN.	TIME	ACT.	%

DISPATCH TABLE + CARD

Dispatch Board(cont'd.)

or equipment and the flow of work is controlled visually by a flow of paper orders in the dispatch board. The flow of paper is simply a duplicate of the flow of work (see the sketch of a dispatch board on page 57a).

Conclusions

The method of recording depends to some extent upon the media used to carry the information. It also depends upon what type of record is required. Some calculating machines and all of the transcribing machines may be used to aid recording. When the recording is performed as a basic operation of production control, graphical or mechanical means might be used to help comparing for decisions.

Filing could be considered as a way of recording. Information may be placed on cards which, when arranged in a certain order become a record. This forms a flexible way of recording since the same cards may be sorted to present either a journal or ledger type of record.

In some cases, only a portion of the information will vary from one record to another. Yet each record, to be complete, must contain all the information. When this is the case, the time to record may be reduced by duplicating the constant information. A Hectograph Master or a stencil may be used as a means of duplicating. The Hectograph Master

Conclusions (cont'd)

will produce as many as three hundred copies, whereas, the Stencil Master will, with care, last indefinitely.

Extract

Information must be extracted from various sources before it can be compared. Extraction depends upon how the information is stored. The punched card procedures will aid extraction since, when they are used, it is simply a method of sorting. Some of the copying or duplicating methods may also be used. In most cases, other than the punched card methods, extraction is a manual method of transcribing portions of an original report or form. Extracting may be reduced by using forms on which the information is grouped. Tearing off or duplicating the portion of information required simplifies the operation of extraction.

There are a few mechanical aids which simplify the operation of extraction. The visible or Kardex tray for filing is one. Another is the wheel method of filing. Each of these may be operated electrically so that the operator has simply to push a button to bring the correct card into the working area.

Calculating

The calculations needed to control production should be kept as simple as possible; because speed is essential for control. Since the operations are performed only so that the information will be in a state ready for comparison, the usual calculations are simple and do not require extreme accuracy. It is to be realized that the standards in most cases will be set either from estimates or from time study figures, so that slide rule accuracy is all that is required in the determination of ratios.

The simple additions and subtractions could be performed by machines, but it has been the authors experience to note that the calculations may be entered on the forms in less time than it takes to place the forms into a machine. If the work is catalogued so that a number of similar operations are performed at one time then an inexpensive calculating machine might be of benefit.

There are many calculating machines available, but the relative merits of each will not be discussed. It is sufficient to say that the calculating aids should be simple and the number of calculations kept to a minimum.

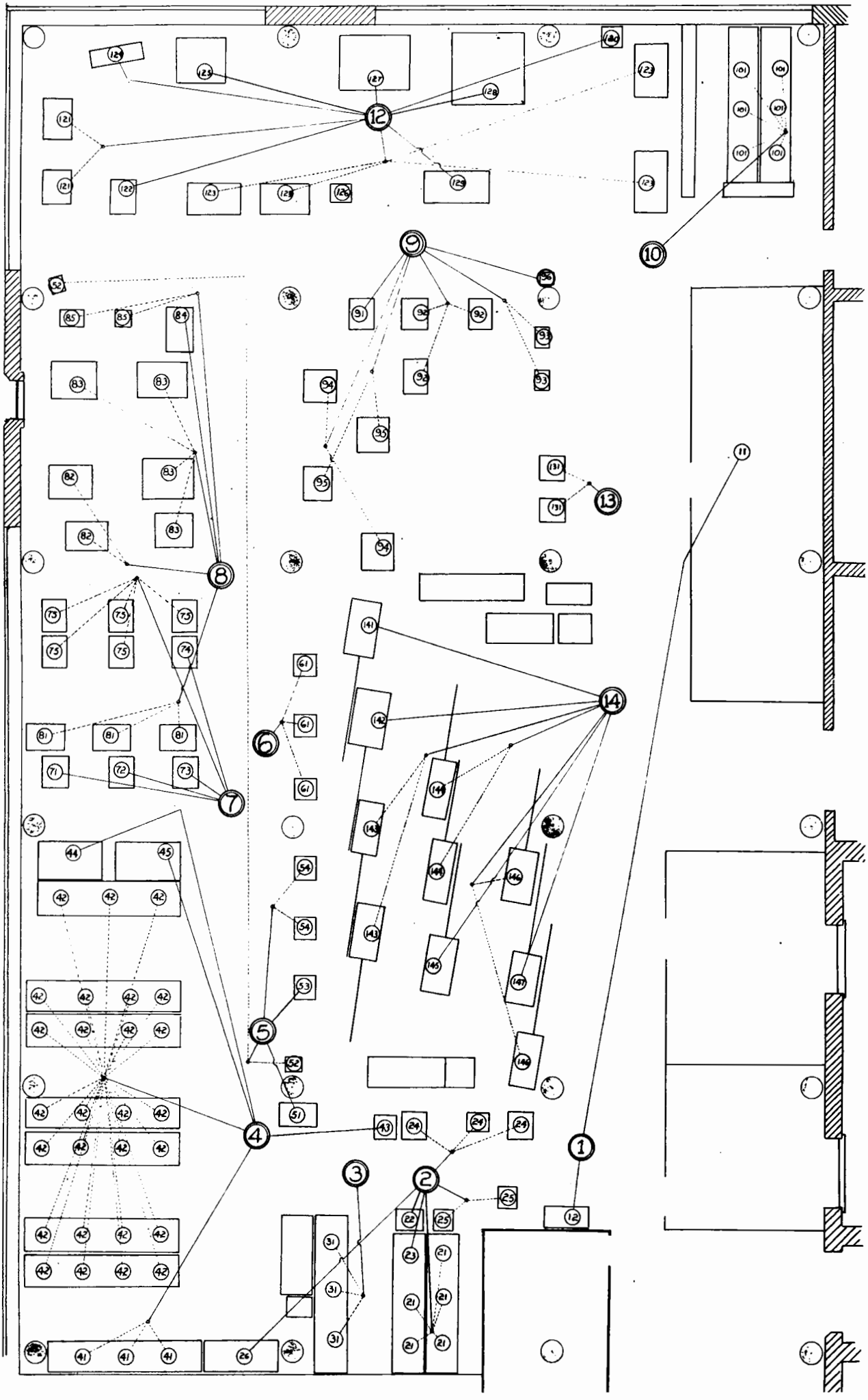
APPLICATION

The typical production control system discussed in the previous chapters will be used to illustrate the mechanical aids. It should be noted, that the choice is greatly influenced by; the physical arrangement of the factory, the routes or paths of the various flows and the behaviour of the flows. Mechanical devices must always be aids to an end. Depending upon how and where they are used, they have a definite psychological effect which may be advantageous or, on the other hand, detrimental to the control of production. If at any time the system is designed to fit the aid rather than the aid chosen to suit the system, trouble will result.

A floor layout with work centers is shown. (Fig.1) The choice of the work centers is an important study in itself. They must be grouped so that only like work is performed in each center. If they are not chosen properly, the flows which are to be controlled will not be standardized and confusion will exist.

Prime Factor

In this case, the factor involving the least number of individual items is the equipment, designated by work centers.



Prime Factor (cont'd.)

The work centers will be our prime factor, and all control systems will be based on the control system devised for this factor. The object of the control of the work centers is to keep each operating at a predetermined rate of capacity. In other words, the capacity factor for any mix of products must be maintained at the figure set for that period by the planning department.

All capacities will be expressed in hours. The capacity utilized can be determined by converting quantity produced into the standard hours that should have been taken. This is done by multiplying the quantity produced by the number of standard hours allowed for one piece. We will assume that the quantities of equipment and operators have been chosen to suit the load predetermined by the planning department. Under this condition, if the operators are producing at better than the standard rate, the remaining load will be reduced so that at some period there will be insufficient work for that work center. The reverse condition would eventually result in an overload for the work center. If capacities are used to control equipment, trends in either direction can be noted. It is the responsibility of the dispatcher to see that the Foremen are notified as soon as a trend is noted. The aids should help the dispatcher to note these trends.

Needs at Worker Level

In order to overcome the main disadvantages of reporting which are caused by a person reporting his own actions, it is suggested that all reporting should be done by a person separated from production. The person who we have called the weigher could be assigned the responsibility of reporting. His equipment consisted of a weighing and counting scale mounted on a truck so that he could travel from one work center to the other. The information transmitted from work centers to the dispatch center will, in the most part, consist of coded numbers. Since there are 14 work centers, each including only a few pieces of equipment, any mechanical communication device must be relatively inexpensive if there is to be an aid for each center. In addition, the recording type is essential because there will be a high volume of noise.

Reviewing the requirements, we see that a recording type of transmitting unit should be used and that only one person will be operating the unit. Since the weigher already has a truck equipped with a counting scale, it is suggested that his truck could also contain a transmitting and receiving device. If this is followed, each weighing and communicating station would be wired so that the communicating device could be plugged in for communication. This

Needs at Worker Level (cont'd.)

would reduce the number of units used and would allow purchase of better equipment.

The communicating station could also serve as a shipping and receiving dock for work to and from the work center. It is quite possible that the weigher will not be near a work center when the work is completed. Verbal contact with the dispatcher will be maintained from each transmitting center at all times with an intercommunicating device, so that the worker can contact the dispatcher who will, in turn, call the weigher from some other center. The time that the operator starts and finishes is reported by the weigher when he reports quantity completed. This eliminates the need for a punch clock and will save the time taken by operators who would have to travel from their work place to the clock and back whenever a job is changed. The only trouble with time recordings might be when the weigher is late in arriving at the work center. This could be overcome by allowing the worker to report the time finished when he calls in to the dispatcher requesting services of the weigher.

The truckers who transport the work from one work center to another are also under the direction of the dispatcher. They move the work after the weigher has reported the

Needs at Worker Level (cont'd.)

the information to the dispatcher. Routings are predetermined and are stated on routing sheets which describe where and how the work is to be done. These forms are standardized and codes are used wherever practical.

If at any time a shortage exists; the dispatcher, the weigher and the truckers can work as a team to expedite the work from one center to the next. As soon as a worker has completed a portion of the order, it is possible for the weigher to ship these to the next center leaving the remainder with the worker. In this manner the weigher acts as a travelling shipper who can rush work from center to center as directed by the dispatcher. This eliminates the need of separate expediters.

This system has been designed for a factory with a large variety of work centers, as may be noted in the floor plan*; only a few pieces of equipment exist in each center. This reduces the distance that the weigher must travel and makes the system practical. If the distance were greater two weighers could operate, each covering a section of the floor.

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* The floor plan is shown on page 61a

Summary

We have considered the requirements from the viewpoint of the worker. These may be summarized as follows:

1) A person not engaged in actual production should do the reporting.
2) The transmitting equipment must overcome a high level of noise.
3) The worker should receive a report of the information sent to the dispatcher.
4) The foremen should receive a copy of the information given to the worker.

Before the transmitting equipment can be selected, all ends of a network must be investigated. In this case, the communicating network has only two ends which should be considered, the work center and the dispatch center. The needs at the work center have been summarized above and there remains to be considered only the needs of the dispatch center.

Needs at Dispatcher Level

The dispatcher must see that the work flows according to plan. He is the first level of authority which makes decisions relative to the control of production and the information he receives must be processed to aid this function. Although the prime factor in this case is equipment, the other three factors must receive attention. Each will be considered.

Duties

The planning department furnishes the dispatcher with the plan of action and it is his duty to control actual conditions so that the plan is followed. The information provided by the planning will be schedules, work center loads, standard times, material requirements and routings. At this point an analogy might clarify conditions of dispatching.

If we consider the drawing of a machined part, we know that tolerances must be added to the basic dimensions to compensate for the inaccuracies of processing. Information provided by the planning might be compared to the basic dimensions. Depending upon the policies of the company, tolerances may, or may not, be added. In most cases it is left to the judgment of the dispatcher to decide the tolerances. The reason for this is that few companies know what production variations are assignable to chance causes. The control chart technique could be applied to an analysis of production variations to determine this. If the information was expressed in measurable quantities, which could be plotted by a method similar to the Shewart technique for quality, chance variations could be separated from the assignable variations. Since this

Duties

would be a study in itself, it is beyond the scope of this thesis and we will accept the fact that the dispatcher must use judgment when deciding whether or not the system is out of control. For this reason, we will state that arbitrary limits are set and the dispatcher must control production to stay within these limits.

The fact that the allowable variations in production are not known is a weakness of most control systems. Often a system will be out of control and, because limits have not been applied, the out of control condition is not recognized.

The dispatcher will control the product to meet schedules and at the same time he will control quantities of equipment, labour, and material so that the work center loads are maintained. The schedule is most important but, "to meet the schedule at all cost," is not the duty of the dispatcher. A higher level must decide what should be done when there occurs an out of control condition which will jeopardize the schedule. Before deciding upon the needs of the dispatcher, we will list the operations that he will perform:

Duties (cont'd.)

1) He will translate the orders received from the planning department.
2) He will transcribe and transmit information to the weigher, truckers and work center leaders.
3) He will transcribe information for records and transmit this to the production control supervisor.
4) He will receive information catalogued by work center number and he will sort this so that in turn it will be catalogued by worker number and then product number.
5) He will record the flow of work on a dispatch board.
6) He will calculate the amount of work completed in the various work centers in terms of standard hours and will translate this into capacity and load factors.
7) He will requisition material from the storeroom and will see that the surplus material is returned.

Needs

We are considering the network between the dispatch center and the work center. Operations two, four, five and six are pertinent for this consideration and the needs will be as follows:

1) The dispatcher must have a communicating device which will enable him to communicate at any time with the persons he is directing.
2) The reports that he receives must be sorted easily.
3) The information must be in a form for easy calculation.

Needs (cont'd.)

When we review the aids discussed, we find that not one fulfills all the needs from both worker level and dispatcher level. Since we are restricted by the volume of work to manual type of tabulating cards, we might consider means of communicating with these.

Suggestion

There appears in this case to be a need for a transmitting and receiving unit which would transcribe, transmit and code punch at the same time. The special requirement would be the code punching of manual sort tabulating cards. The transmitter at the work center should transcribe on inexpensive forms, an original and two copies of the information. The receiving end in the dispatch center should record the information and punch in the sorting codes.

AUTOMATIC CONTROL

The mechanical aids discussed will speed or combine some of the basic operations of written record control, but they do little to remove the weaknesses caused by human failings. On the other hand, automatic control,where all the operations are performed mechanically, will eliminate the possibility of human error. The same principles stated for the written record type of control apply to automatic control but the fundamental concepts may be written in terms of automatic control. These are:

" 1) A sensor which checks the process. It reports what is happening in terms of speed, size, weight, or any other measurable variables.
2) A memory, which is a master record. It knows what should be happening, and what to do if it is not happening.
3) A collator, which compares information from the memory. In case of any difference, it "calls up" from the memory instructions on what to do.
4) An effector, which changes the process on the basis of instructions relayed by the collator."[1]

When these elements are compared to the controlling operations performed with the written record type of control previously discussed, it will be found that each element could be substituted for a section of the system for the written record type of control. Obviously it would not be

[1] Factory Management and Maintenance McGraw-Hill Publishing Co. Inc. Volume 110 Number 4 April 1952 P. 80

economical in many cases to substitute a complex machine, or a series of complex machines, for a simple operation. Since we have restricted our study to a factory with a functional type of layout, complete automatic control would not be found economically feasible.

It is possible, however, that sections of the system might benefit from the use of automatic controls. These will be discussed to complete the study.

Sensor

The reporting operations performed by the weigher are equivalent to those which would be reported by a sensor in an automatic system. The question is; "could an automatic sensor unit replace the duties of the weigher and improve the system?" In this case, it seems likely that automatic reporting would not be practical. The variety of individual pieces which must be counted is great and the material handling is not automatic. If it were possible to mechanize the material handling, the use of a sensor unit might be considered, otherwise it would not be practical.

Memory

We have already suggested that the tabulating cards are the best means of recording information in the dispatch center. This is an approach to automatic control since many of these units operate with punched cards. In this case, the size of the factory and the number of individual pieces rules out the complete mechanization of the dispatch operation. The dispatch board and file records act as the memory units. It seems possible that, if volume warranted, an automatic dispatch board could be built. This could operate either from the information sent by the weigher or from information sent by a censor unit.

Collator

Limits have not been set for the control of production and, since machines are not capable of judgment, it seems likely that this operation would be performed by a person. Another factor to consider is that planning must include more detail if automatic control is to be used. This would increase the cost of planning. It is difficult to visualize a machine which could take care of all the variables involved in the control of the type of production under consideration, and so this operation would be performed by a person.

Effector

Because the same machines are used to process more than one part, it is unlikely that the processing under consideration could be changed by an effector. Before an effector may be used, the design of the product must be suitable for automatic handling, conveying and operating. If this were possible the effector could speed up, retard or divert the flow as instructed. The type of production is not suitable for an effector.

CONCLUSIONS

We have studied some of the problems and the weaknesses of the written record type of control and have found that a breakdown of the system may be caused by human failings. Persons tend to rely upon their memory instead of upon records; those with strong personalities may gradually take over the work which should be performed by others; executives may be afraid to delegate sufficient authority to those under them; persons who are recording their own actions may tend to highlight the more pleasant information.

It has been seen that it is possible to reduce the likelihood of control system failure by furnishing mechanical aids. These may be classified into two types; (1) those which have been developed to speed the basic operations as they would be performed with the written record by humans and; (2) those which have been developed to perform the control operations without human assistance. The first may be fitted to any written record system with only slight modifications. Those of the second, however, are not aids in the true sense because they are capable of performing the operations. Rather than call these, "machines which aid control," it would be more correct to call them,"controlling machines." The method of production and even the design of the product may require modification before these may be used.

The advantage of any machine over a human operator is; (1) freedom from error; (2) freedom from laziness; (3) freedom from emotion and; (4) high speed operation. The disadvantages is that machines, as yet, do not possess the human talent to select the obscure alternatives. Thus, machines are not sufficiently flexible to control a variety of items.

The proper approach to the use of mechanical aids, is to recognize and compare the advantages and disadvantages of mechanical and human operation. The system must always provide for the elements of control, objective, procedure and appraisal. In addition, the machines, or humans, must perform operations which will be equivalent to those of the fundamental concepts of control. These have been expressed in terms of automatic control as; a sensor, a memory, a collator and an effector; but they are essential to any type of control. If the control is the written record type, these concepts will be covered when the basic operations are performed on information. If, on the other hand, the control is automatic, a machine will take care of each concept. Whatever the type of control, it should be performed at the level of the dispatcher or lower and he should have sufficient authority to enforce his decisions.

It is concluded that automatic control is possible but not practical for light metal working industries of the type discussed in this thesis. The variety of work is too high when compared to the volume. Even in the American Automotive Industry, where there is a high volume of production, automatic control has been found practical for only a few easily handled items, such as, pistons and valves. In view of this, it has been decided that there remains a need for equipment which will aid human control. One suggestion is a machine which will combine the operations of transcribing, transmitting and code punching. These are routine preparatory operations which are time consuming. If these were combined and performed by machine the information would be received by the dispatcher in a condition which could be easily sorted for comparison.

With such an installation, the control process could easily approach the ideal, having continuous reporting followed by immediate directing which is based on accurate decisions. This is the essence of control.

This thesis was directed to determine the weaknesses of production control systems and the aim was to make improvements by utilizing mechanical aids. During the investigation, fields for further study were disclosed. These are as follows.

The simplest possible control has been visualized as a communicating loop consisting of four parts: (1) reporting; (2) preparing; (3) deciding; (4) directing. It is suggested that every control loop will contain at least one of each part (possibly some parts are taken care of by mental processes and are not apparent). In actual practice many loops contain more than one of each part and it seems that this approach might be followed to simplify the control problem. Control will be made more complex by increasing the number of parts in a loop and by increasing the number of loops in the system. Standards for control system appraisal could be set by a measuring system based on this fact.

Control charts similar to those used for quality control have been suggested for production control. A study should be directed to determine a means of controlling idle time. A system based on load factors which are set and maintained by control charts would do this.

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