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A TREATISE ON THE ORGANIZATION OF MACHINE BUILDING PLANTS AND THE SYSTEMATIC METHODS THAT ARE ESSENTIAL TO EFFICIENT ADMINISTRATION

BY

FRANKLIN D. JONES

AND

EDWARD K. HAMMOND

ASSOCIATE EDITORS OF MACHINERY

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PREFACE

The purpose of this book is to give definite information on various systems that have been adopted, particularly in machine-building plants, to insure orderly and effective methods of procedure in the administration of manufacturing, designing, and purchasing departments. Practically the entire volume is filled with specific examples showing the exact details of different working systems and just how they are applied under various conditions. The fact that concrete examples are given rather than general and abstract theories is regarded as a commendable feature of the book. While the systems described may not be directly applicable to other industrial organizations without modification, they form a definite basis upon which to work, and enable the student of management to see more clearly the relation between the system and that branch of work to which it may be applied.

Most of the systems described are used to assist in the control of manufacturing processes. They include means of recording what has been done and methods of systematically governing different departments so that concerted action may be obtained and work be done efficiently and in accordance with necessary requirements. The general subjects treated include methods of ordering materials, accounting for materials in stock, following the progress of work during manufacturing processes, insuring the prompt delivery of tools or parts to various departments, controlling the purchase or manufacture of special tools, caring for and maintaining small tool equipment, insuring adequate inspection of manufactured products, and other subjects related to efficient industrial organizations. The various forms and blanks used with different systems for recording useful data and as a means of governing manufacturing processes are included to show more clearly the exact methods of procedure.

This treatise is not only intended for works managers and shop superintendents, but for everyone who aspires to an executive position in industrial plants. The fact that the most modern equipment in machine shops or other manufacturing establishments cannot be used efficiently without systematic methods of control, is generally recognized, and it is believed that students of engineering and manufacturing methods, whether in the shop, drafting-room, or college, will find helpful information in this book.

Many of the articles which have been published in MACHINERY on the general subject of shop systems have been included in this volume, and we are especially indebted to Ralph E. Flanders, Alfred Spangenberg, William B. Wessels, C. W. Thayer, and A. L. Valentine for valuable contributions descriptive of different systems that have been employed in connection with shop and factory administration.

THE AUTHORS.

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SHOP MANAGEMENT AND SYSTEMS

CHAPTER I

INDUSTRIAL ORGANIZATION AND MANAGEMENT

While management and organization are essential in all industrial enterprises, there is a great difference in the way organizations are formed and directed. These variations in practice may be due to differences of opinion on the part of managers or to variations in the conditions under which work is done. The organization, in any case, is composed of individuals having different duties to perform, and a certain number of executives with varying degrees of authority. The exact duties of each member of an organization may be clearly defined or there may be considerable latitude in this respect or independence of action. It is quite evident that the form of the organization is not related to the individuals composing it, although the efficiency of an organization or its effectiveness as a means of production may be decidedly affected by the intelligence, experience, and skill of each member in the organization.

The primary object of every manufacturing organization is to produce work of the required standard of quality, on a more efficient basis than would be possible without an organization. The formation of an organization, then, involves selecting the individuals composing it, defining their relations to one another, and determining their responsibilities and duties. The type or exact form of an organization must, of course, be governed in part by such factors as the size of the plant, the number of variations in manufacturing processes, the nature of the work, the number of trained specialists that may be necessary for controlling manufacturing operations, the extent to which coöperation is necessary between different departments, and the type of management which is directing the organization. Because of these and other factors, it is not practicable to lay down fixed rules which can be used as a guide in planning the exact details of an organization, although there are general principles underlying different systems of management that are capable of wide application.

Line Organization. — The simplest class or form of organization and the one most extensively applied, at the present time, especially in the smaller shops or factories, is known as the "line" or "military" organization. The relation of different members of such an organization is shown graphically at *A* in Fig. 1. This diagram, however, is not supposed to represent a complete organization, but merely the principle upon which it is based, since the exact arrangement and extent depends upon variable conditions. The characteristic feature of a line organization is that the authority is direct from the highest executive through the different lower executives down to the workmen. Each employe is responsible to the foreman of his particular department, and each department foreman is directly under a higher authority, such as the general superintendent or works manager. The foreman of one department has no authority over a foreman of another department and the methods of handling work in any one department and by any one workman may be governed partly by the department foreman or some other executive and partly by the workman himself. For instance, in a machine shop, the exact method of performing a certain operation may be decided beforehand by the general superintendent or chief draftsman, and possibly a special jig or other tool is made to insure doing the work exactly as planned. Ordinarily, however, under line organization, the workman has considerable latitude, and he may decide as to the method of procedure, more or less assistance being given in some cases by the department foreman.

With this form of organization, the responsibilities are clearly defined and each executive knows what he is supposed to do and just where his authority begins and ends. The line organization may be very strong and effective, if each executive is competent to govern properly every branch of work under his supervision. If the organization is large and the work of manufacturing in each department requires a special knowledge of different subjects, it may be impossible to secure foremen competent to operate the

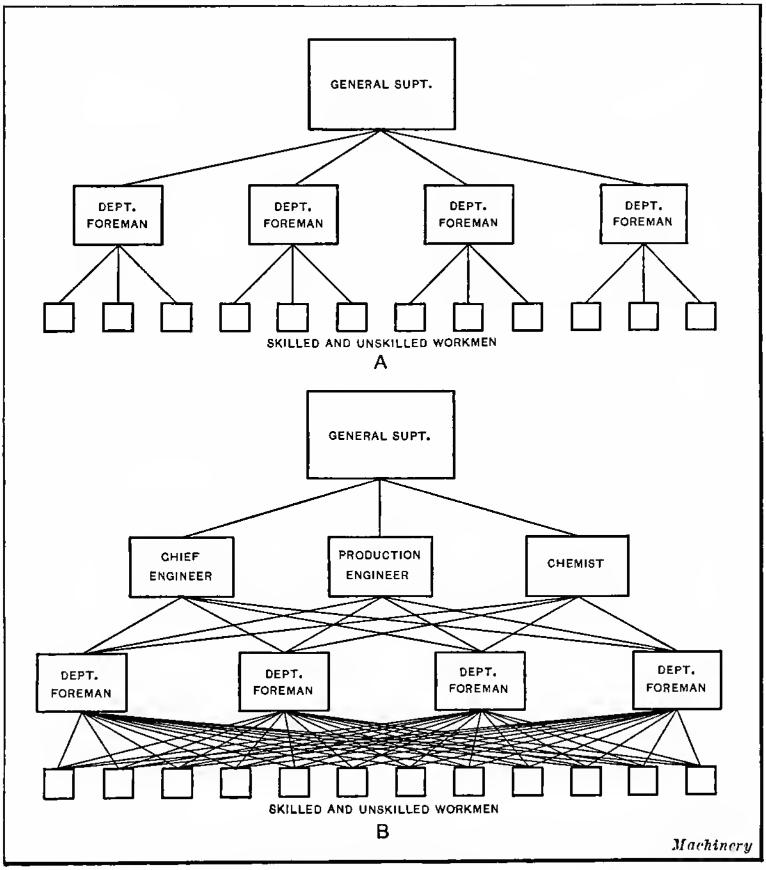


Fig. 1. Diagram illustrating Line and Staff Organizations

various departments on an efficient basis. Because of this defect, organizations which conform strictly to the plan illustrated at *A* in Fig. 1 have been largely replaced by modified forms, especially where the plant is large and complex conditions exist. The effect of these modifications is to relieve certain executives of duties which are of a decidedly different character and which they may not be entirely competent to assume. While the term "military organization" has been applied to the form previously described, this name has become a misnomer, because modern military organizations have also been modified to some extent, the same as those which are commercial or industrial.

Staff Organization. — A form of organization which differs entirely from the one described in the foregoing is known as the "staff" or "functional" organization. The object of this kind of organization is to focus expert knowledge on every department of a shop or factory, by employing specialists whose authority, instead of being confined to any department, extends wherever the knowledge of each specialist can be utilized effectively. The principle is illustrated by diagram *B*, Fig. 1. The general superintendent or works manager, instead of attempting to directly control the foremen of different departments, has under him two or more specialists having equal authority. The diagram shows, by way of illustration, a chief engineer, a production engineer, and a chemist. The chief engineer may control all matters pertaining to designing, testing, etc.; the production engineer is responsible for the actual work of manufacturing; and there may be some other executive, such, for example, as a chemist, to see that materials (either being purchased or in the process of manufacture) such as metals, lubricating oils, etc., are up to the required chemical standards. Between these executives and the workmen there are special or functional foremen to instruct the workmen in whatever branch of work is under their supervision.

The advantages of the staff organization, when composed of competent men, is that each workman is guided and assisted by several experts. The chief disadvantages cited against the staff organization are the overlapping of authority because of so many executives having equal authority, and the lack of discipline. These objections, however, have been overcome where the staff organizations have been so thoroughly developed that each man's duties and responsibilities are clearly defined, by preliminary planning based on scientific investigation of all the factors affecting the problems of management.

In many manufacturing plants, the line and staff principles of organization are combined, although frequently this is not the result of a deliberate plan but is simply a natural development brought about by conditions which obviously require a modified form of organization. For example, if an attempt were made to adopt a strict line organization, it would soon be apparent in most cases that there was not sufficient coöperation and that more efficient results could be obtained by employing to some extent, at least, the good features of the staff or functional organization.

Advisory Committees. — Another variation which is regarded very favorably by some authorities on organization is known as the "committee" system. This plan, which is intended for comparatively large concerns, is based on the old adage that "two heads are better than one." Committees are formed to advise regarding policies of management, changes in manufacturing practice, etc. For instance, there may be a manufacturing committee which would consider general policies, a tool committee to discuss the design of new tools or the improvements of existing tools, a safety and welfare committee, and so on. These committees would be composed in each case of men best fitted by training and experience to suggest changes or improvements. For example, a tool committee might include a tool designer, the tool-room foreman, the shop superintendent or department foreman, and anyone else whose experience or special knowledge might prove helpful. The committee is simply intended to advise or suggest, and it has not been advocated as a substitute for a strong executive.

General Types of Management. — Management may, in a general way, be classified either as (1) unsystematic, (2) systematic, or (3) scientific. It does not follow, however, that the entire management of any one plant belongs entirely to one of the classes mentioned. The unsystematized form of management is based upon personal experience, judgment, and initiative, and its success depends largely upon the ability of both executives and employes. The tendency with unsystematic management is to follow along conventional lines, and methods of doing work are chosen either by executives or workmen and are selected because past experience has demonstrated that a certain method of procedure will accomplish the desired result. Whether any particular method could be improved is not investigated in a systematic manner, and the results of experience are not recorded (except probably in a haphazard way), in order to serve as a guide for future reference.

Accounting under the unsystematized form of management generally includes an annual or semi-annual statement as to the assets, liabilities, profits, and losses. If the statements indicate an unsatisfactory financial condition, the cause has probably existed for some time before it is discovered and an attempt is made to eliminate it. The purchase of materials may not have been done in accordance with specifications that are essential, nor the amount of stock regulated strictly with reference to the demands of the manufacturing departments.

Systematized Management. — Systematized management is based on classified information and records of performance. The object, in part, is to improve present practice, whenever this can be done by the substitution of one method for another which is inferior, according to the record of a similar operation which has been performed in a different manner. The accounting is more complete and data are available showing cost of materials and labor, relative annual cost for a given department or product, proportion of overhead charges, etc. In brief, systematized management aims to secure correct costs in order to establish selling prices and determine where costs may be reduced. The purchase of materials and their storage is also done systematically, and a perpetual inventory is kept showing the amount of material in stock at any time. Written orders are issued for manufacturing operations and records kept of the time expended, in order to determine labor costs. The workmen in a machine shop under systematized management are not necessarily directed as to the precise manner of performing work. For instance, general manufacturing processes on a machine like a lathe or a planer may be done in different ways by different workmen. The same method of procedure, however, may be followed in producing duplicate parts, especially if special jigs, fixtures, or other tools are used, but, in general, the manufacturing practice is based largely upon the personal opinions and experiences of the foremen and workmen. This general method of manufacture is entirely eliminated under the plan of management to be described.

Scientific Management. — What is generally known as "scientific management," or the Taylor system (because of the pioneer work of Frederick W. Taylor), may be defined as a system of management which aims to govern every department of an organization in accordance with demonstrated facts and the results of scientific investigation, instead of relying upon rule-of-thumb methods and individual opinions. Methods of performing work are carefully analyzed in order to eliminate useless efforts and make every stroke count. When a superior method of performing work has been found, it is embodied in the organization just as a new and more efficient machine would be installed in the shop. While scientific management substitutes definite and accurate information, as far as possible, for individual judgment and experience, judgment must, of necessity, have a place in any system of administration, either because it may not always be possible or feasible to obtain accurate information or because to obtain it would cost more than it is worth. According to H. L. Gantt, a system of management to deserve the term "scientific" should aim to meet the following four conditions:

1. It should provide means for utilizing all of the available knowledge concerning the work in hand.

2. It should provide means for seeing that the knowledge furnished is properly utilized.

3. It should award liberal compensation for those who do use it properly.

4. It should provide liberal means for acquiring new knowledge by scientific investigations with adequate rewards for success.

Time Study. — One of the important and fundamental branches of scientific management has to do with time study. One object of applying time study to a method of performing work is to determine what movements are useless, or what is wrong with an existing method and how the same work can be done with an expenditure of less physical effort and time. This is the first step in the application of a scientific system of management, and is commonly referred to as "motion study." Time study is also an analysis of every element or phase of a process. It is not merely determining the length of time for performing a given operation, but a study of every detail which enters into that operation and the recording for future reference of the exact time required for each motion or element connected with the work. One of the difficulties connected with the application of scientific management is in properly classifying, tabulating, and applying such data, especially where the work is greatly diversified. After time studies have been made, it is necessary to correct, as far as possible, faults in materials, methods, and mechanical appliances, and this part of the work requires judgment and ingenuity. Standards must also be established and systematic methods be adopted for maintaining those standards.

Preliminary Planning. — A basic principle of scientific management is to first determine a good method of performing work and then to follow it. In order to apply this simple principle, preliminary planning is necessary and the time study previously referred to constitutes a very important part of this work. Every machine-building plant equipped with a drafting-room has one kind of planning department, since indicating on a drawing what is to be done is nothing but preliminary planning. The planning department under scientific management represents a further development in that it decides *how* and *when* work is to be performed.

With any system of management, some one must determine what procedure is to be followed, and under an ordinary system, as applied to machine shops, the judgment and experience of the foreman or workmen is largely relied upon, excepting where the work is merely that of operating a special tool or machine which entirely controls the manufacturing process. The object of a planning department is to avoid guesswork and to control an entire manufacturing plant in accordance with definite plans and schedules. The classified data in the planning department covering every phase of work make preliminary planning practicable and economical; moreover, by planning in advance, any special tools or materials that may be required can be obtained beforehand, thus avoiding delay. Planning at the time work is done means, in many cases, that a machine must remain idle while the method of procedure is being considered. The planning department of a machine shop operated in accordance with the principles of scientific management not only specifies the time in which each operation should be completed, but it provides for supplying the necessary tools and materials in advance, so that all unnecessary delay is avoided. The foreman has nothing to do with the kind of work done on different machines nor with the methods of machining or assembling parts. In order to show clearly just how a planning department controls the means and methods of production in a machine shop, a general outline of the methods and procedure at the Tabor Mfg. Co. will be given. After a machine is designed, it is divided into general groups which can be assembled as units, the aim being to so plan all work that the various parts of a machine may be finished in a successive order which conforms to the natural and most direct way in which the machine would be built. The successive order of all operations, as well as the tools and machines to be used, is determined beforehand, and the exact methods of procedure are outlined in detail so that all parts not only conform in size and shape to the approved design, but all work is done in the manner prescribed. A route chart is first made up which shows graphically every step in the building of a machine. This chart may be compared to a river and its tributaries, the main river representing the complete machine, and the tributaries the different units and parts which, when united, form the machine. Every operation and tool is listed, and these lists are so arranged that the parts which form units and the different units which make up main groups are merged together graphically on the chart just as they would be made and assembled if all the work were done in a systematic and orderly manner from start to finish. In addition to this route chart, there are smaller route sheets for the different parts which also show what operations are required and their successive order. On these route sheets, there is a record of all

Fig. 2. Bulletin Board of Tabor Mfg. Co. for Controlling Manufacturing Operations and Delivery of Tools

work which must precede the manufacturing operations, such as making the necessary detail drawings or special tools that may be required, ordering the material, recording the delivery of material, etc.

When all the material and tools are ready, the work of manufacture may begin, but the order in which machines and parts of different machines are built is also governed systematically and in accordance with their relative importance. The route chart previously mentioned may not be needed for minor manufacturing operations, in which case there is only a route sheet. An operation order or slip is made out in triplicate for each job. These three slips are of different colors, which indicate where each slip belongs when they are transferred, as described later. On each order there is a special symbol, the letters of which indicate the exact nature of the operation. The machine number, the drawing number, the number of pieces required, the amount of bonus, and the time within which the work must be finished to earn the bonus are also given on each operation order.

Control of Manufacturing Operations. — In the planning department, there is a large bulletin board (see Fig. 2) containing three pairs of hooks for each machine, vise, or other working place in the various departments. A symbol shows which machine, vise, etc., each set of hooks represents. The three duplicate operation orders are first placed together on the lower pair of hooks to show that the work represented by these slips is to be done. The operation orders are perforated so that they may readily be placed over the hooks. Assume that the operation order is for a casting which is to be planed. Before the planer on which the work is to be done is ready for it, an order is issued to move the casting from the place of storage to the machine. When the casting or any other material required has been placed near the machine (suitable storage racks or spaces are provided), the operation orders are transferred to the set of hooks marked "jobs at machine ready to be done." When the work is started, one slip is placed on the hooks marked "job on machine." This slip is left on the bulletin board in the planning department, and, as other slips are made out for each job passing through the shop, a thorough knowledge of working conditions throughout the entire plant may be obtained by studying the board and noting the location and number of the various operation orders. One of three order slips previously referred to is transferred to a separate bulletin board in the planning department to show that the

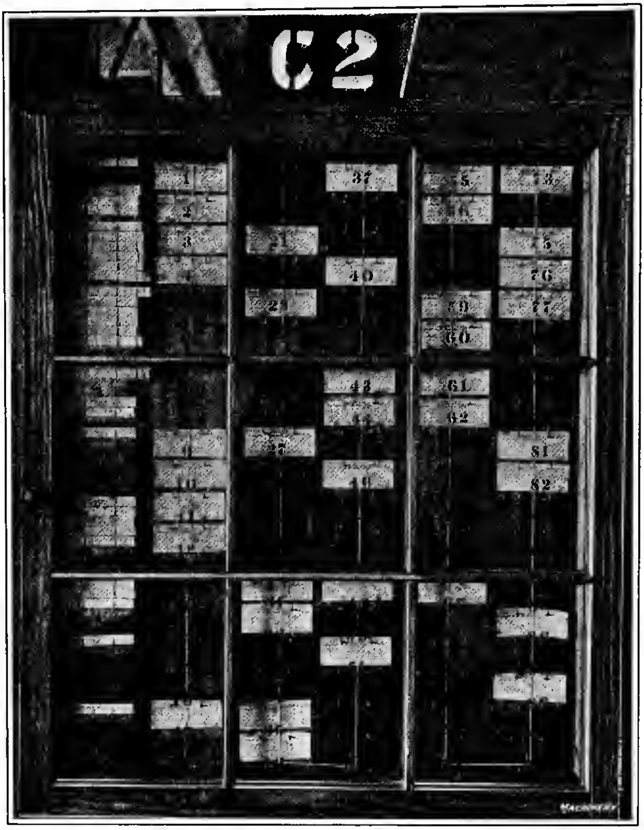


Fig. 3. Shop Bulletin Board which shows Department Foreman what Work is to be done

list of tools and the card of instruction for that particular job should be transferred from the file to the machine or wherever the work is to be done. The third operation order is placed on a bulletin board (see Fig. 3) in whatever department is to do the work. This bulletin board shows the department foreman or "gang boss" what operations have been assigned to each machine, bench vise, or other working place, and the order in which they are to be completed. It is the duty of the foreman to see that each man has whatever tools may be needed from the tool supply room for at least three jobs ahead of the one on which the man is working at the time, or more than three, if the total time for three jobs requires less than three hours.

The order in which the various parts are to be machined is shown by the relative positions of small index slips seen at the left-hand side of the shop bulletin board. These slips are numbered in accordance with the numbered positions of the operation orders on the board, and, as previously mentioned, the sequence in which work is done is regulated entirely by the planning department in accordance with the class of work and its importance.

Up to this point, the work has been controlled entirely by the planning department which has attended to ordering and delivering the necessary material and has specified just how and where the work is to be done. Each operation order on the shop bulletin board shows the number of the machine, vise, or other working place to which the work has been assigned.

Organization of the Planning Department. — As the planning department controls the entire manufacturing plant, it is evident that this department must have considerable reliable information and data, and men trained especially for looking after different branches of work. The principal functions of the planning department, aside from time and cost keeping, are in planning how to do work and when it should be done. The general method of procedure is determined by route clerks, instruction card men, and time study men; whereas the production clerk and order-of-work clerk are concerned with the element of time, so that all manufacturing departments will operate in unison and different jobs will be completed in the proper sequence or order.

The route clerk should be a man of practical experience, as it is his work (in connection with machine-building plants) to analyze a design, consider the relative importance of different parts or groups of parts, the time required for obtaining the necessary forgings, castings, or special parts, the amount of machining and assembling work to be done, the order in which different parts should be completed so as to avoid delays in assembling, etc. The general order of procedure is laid out in the form of a diagram or chart, as previously explained. The types of machines to be used are listed, the kinds of materials, quantity, the operations that must be performed, the number of parts required, etc. A series of such charts may be needed if the machine in course of construction is complicated, whereas, for comparatively simple work, a small route sheet may be used instead of a chart. The instruction card is used by the planning department for instructing both the shop foreman and the men in all the details of their work. This instruction card contains not only detailed instruction regarding the exact method of doing the work, but also specifies the time for each of the elements which make up the complete operation, and gives speeds and feeds to be used whenever machine work is to be done. This card is made out by one or more members of the planning department, according to the nature and complication of the instructions, and bears the same relation to the planning room that the drawing does to the drafting-room. The tool list, which also accompanies the instruction card, indicates what auxiliary tool equipment is to be used.

The " production clerk " has been defined by H. K. Hathaway as " the connecting link between the shop and sales department " in that he furnishes information upon which the sales department bases its promises of delivery and is responsible to the sales department for meeting the deliveries promised. The production clerk prepares a schedule or " order of work," which is a list of all orders for each department arranged with reference to their relative importance. In preparing this list, the amount of work on each order and the desirable date of completion is considered. The order of work for each department is revised at regular intervals by the production clerk, who also sees that it is followed in the designing, planning, and manufacturing departments.

The " order-of-work clerk " determines in what order various jobs in the shop are to be completed. The relative importance of different jobs must also be considered, and the schedule or order of work prepared by the production clerk serves as a guide. The order-of-work clerk sees that each machine is continually supplied with enough work to avoid delay, and he also controls the transfer of men when necessary owing to fluctuations in the amount of work on different machines. The bulletin board shown in Fig. 2 is used by the order-of-work clerk constantly, in order to determine when and what work should be assigned to different men or machines. In addition to the clerks mentioned, there are others engaged in making out order tags and in doing other work essential to this systematic method of controlling a manufacturing organization.

Work of the Functional Foreman. — The functional shop foremen, who are such an essential feature in the Taylor system of management, differ from ordinary foremen in that they have charge of special branches of work or functions, as previously explained, instead of being in charge of a certain number of men. The four types of functional foremen for a machine shop are known as the gang boss, the speed boss, the inspector, and the repair boss. Unfortunately, the names "gang" and "speed" boss are rather misleading to one not familiar with their duties under the scientific system of management. The gang boss, as explained by Mr. Taylor in his treatise on Shop Management, has charge of the preparation of all work up to the time that the piece is set in the machine. It is his duty to see that every man under him has, at all times, at least one piece of work at his machine, with all the jigs, templets, drawings, etc., that may be required, so that the work is ready to go into the machine as soon as the preceding piece is finished. The gang boss must show his men how to set the work in their machines in the quickest time, and also see that they do it. He is responsible for the work being accurately and quickly set, and should not only be able, but willing, to demonstrate how to set the work in record time.

The speed boss must see that the proper cutting tools are used for each piece of work, that the work is properly driven, that the cuts are started in the right part of the piece, and that the best speeds and feeds and depth of cut are used. His work begins only after the piece is in the machine, and ends when the actual machining ends. The speed boss must not only advise his men how to best do this work, but he must see that they do it in the quickest time and that they use the speeds and feeds and depth of cut as directed on the instruction card. In many cases, he is called upon to demonstrate that the work can be done in the specified time by doing it himself in the presence of his men.

The inspector is responsible for the quality of the work, and both the workmen and speed bosses must see that the work is all finished to suit him. This man can, of course, do his work best if he is a master of the art of finishing work both well and quickly.

The repair boss sees that each workman keeps his machine clean, that he oils and treats it properly, and that all of the standards established for the care and maintenance of the machines and their accessories are rigidly maintained, such as the care of belts and shifters, cleanliness of the floor around machines, and orderly piling and disposition of work.

Another executive of importance in connection with scientific management is known as the "shop disciplinarian." His authority extends over the entire plant and he applies whatever measures may be necessary to prevent insubordination, such as a refusal to follow the instructions given by one of the foremen. The disciplinarian has to do with discharging incompetent men and, in many cases, he also hires new men. Before any readjustment of wages is made, it is considered advisable to at least consult the disciplinarian.

Importance of Establishing Standards. — Under the scientific system of management, the data required pertaining to speeds, feeds, and the time for each element in a complete operation represent a vast number of experiments and tests which have been made previously and under certain standard conditions. Therefore, it is necessary for the management to maintain standards which are, at least, equal to those existing when the tests were made, because if this were not done, it would obviously be impossible for the men in the shop to duplicate the time and the speeds and feeds listed on the instruction card. For instance, after the best combination of speed and feed has been determined for turning a given material in a lathe when using a tool that is properly ground and a driving belt capable of supplying the necessary power, it is apparent that such data would be of little value as a guide for similar turning operations unless the same or better conditions were maintained. In other words, the management assumes certain responsibilities and prescribes the exact conditions under which work must be done; consequently, standards must be established and maintained. This means that cutting tools must be kept sharp, that forged tools such as are used on turning and planing machines must be ground in accordance with approved principles and to standard shapes, that bolts, clamps, and packing blocks be standardized, that belts be kept at a tension which will enable the necessary power to be transmitted, and that the tool equipment in general be maintained in good condition.

The relation of standardization to scientific management is clearly explained in the following extract from a report by Morris L. Cooke to the Carnegie Foundation for the Advancement of Teaching. As explained in this report, "A standard under modern scientific management is simply a carefully thought out method of performing a function, or carefully drawn specification covering an implement, or some article of stores or of product. The idea of perfection is not involved in standardization. The standard method of doing anything is simply the best method that can be devised at the time the standard is drawn. Improvements in standards are wanted and adopted whenever and whereever they are found. There is absolutely nothing in standardization to preclude innovation, but, to protect standards from changes which are not in the nature of improvements, there should be certain safeguards. All that is demanded under modern scientific management is that a proposed change in a standard must be scrutinized as carefully as the standard was scrutinized prior to its adoption; and, further, that this work be done by experts who are as competent to do it as were those who originally framed the standard. Standards adopted and protected in this way produce the best that is known at any one time. Standardization practiced in this way is a constant invitation to experimentation and improvement."

CHAPTER II

GENERAL SHOP SYSTEMS

THERE are practically as many shop systems in use as there are shops or factories, because in every shop there are some conditions peculiar to that shop which cannot be covered by any system of universal application. There are, however, certain fundamental principles that should be embodied in all shop systems, and these can be best explained by describing in detail systems that have been successfully applied in practice. The

FACTORY COST.

ACHINE NO. 126 STYLE P Issued to Dep'ts No. 1-2-3-4-5-9

rder No.	No. Fin.	Material	Department Costs																	Total Cost		Average Cost	
			1	2	3	4	5	6	7	8	9	10	11	12	13	P	D				
1567	24	1239.80	40.90	90.46	74.64	62.96	48.60				276.40					18.32	4.60	1856	58	77	36
1745	24	1196.64	38.12	112.40	66.90	65.75	52.70				[illegible]							1829	61	76	24
1854	12	657.98	22.18	50.40	36.42	34.20	26.31				154.00							981	63	81	81

Fig. 1. Superintendent's Office Reference and Record Card of Machine Costs

systems outlined in this and following chapters have proved their value in the manufacturing establishments where they are used. They may not apply directly to the conditions in other plants, because certain details may have to be changed and some of the forms modified; but the general outlines can be followed, and will prove of value to those who have to devise new systems or who are endeavoring to improve old ones.

The shop system to be described first is simple and so arranged that all information regarding the affairs of the works is under the complete control of the works superintendent. It makes him entirely independent of the various heads of departments in determining the progress of all work through these departments, and enables him, at a glance, to stop or "push" such work as is important or is wanted in a hurry. This system also provides an authentic record of all facts pertaining to the cost of material and labor, and other particulars of equal importance. In case of emergency, it assures the delivery of any special order, rush order, etc., on schedule time.

The fundamental principle of the system is not building the completed machine as a unit, but building the machine by the

FACTORY COST.

PART NO. 26 No. required each machine 1 Order issued to Dep'ts No. 2-3-4-9
For Machine No. 126 Style P

Order No.	No. Fin.	Material	Department Costs															Total Cost		Average Cost	
			1	2	3	4	5	6	7	8	9	10	11	12	13	P	D				
1567	24	149.40		18.45	14.62	15.40												197	87	8	25
1745	24	150.94		16.30	19.56	14.90												201	70	8	41
1854	12	80.34		9.45	10.30	6.47												106	56	8	88

Fig. 2. Superintendent's Office Reference and Record Card of Parts Costs

part. Considering that, in most manufacturing establishments, the machines are standardized and fully detailed with complete drawings of all parts, this can readily be accomplished, and means the grouping together of the equipment in accordance with the best method of handling the work without any undue shifting of material. To do this, the following departments (designated in most cases by number) have been established in one machine-building plant where the system described is used: (D) Drafting-room; (P) pattern shop; (1) planer, boring mills, and large radials; (2) lathe; (3) milling machine; (4) shaper and drill press; (5) tool and diemaking; (6) grinding; (7) experimental; (8)

small part assembly; (9, 10, 11, and 12) assembly; (13) miscellaneous.

The method of procedure is as follows: The sales department issues its order to the superintendent in the customary manner for a given number of machines of a certain type; all machines are known by number. The superintendent then secures from the drafting department a complete set of blueprints showing all

REQUISITION FOR MATERIAL.

To Store Keeper, Date 2/13/11

Please deliver the following supplies,

Quantity	Patt. No.	Part No.	Mach. No.	Order No.		
24	P-16	16	126-P	1567		
24	P-4	4	"	"		
24	Forgings	26	"	"		
48	P-24	24	"	"		

Williams Foreman.

Department No. 2

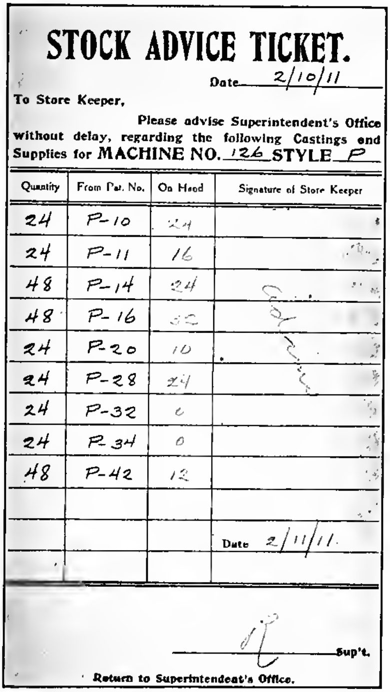
Fig. 3. Requisition Blank

the details, and from which the orders calling for these parts are issued to the various departments.

Record of Machine Costs. — When the superintendent receives the order for the machines, he will cause the order number to be recorded on a card like that shown in Fig. 1; eventually this card will contain a full record of all costs of the machine; it is known as the " Machine Factory Cost," and is printed on blue paper so that it may be readily recognized. This card is ruled into columns, and will contain, as before stated, all factory particulars, including the number finished, cost of material, cost in every department that does any work on this particular job, and finally the total cost of the order and the individual cost of each machine. Each successive order is recorded on this card, and a comparison of the fluctuations in operating expenses for departments are immediately noted for investigation with a view to ascertaining the causes.

Record of Parts. — The parts of each machine are numbered in rotation, and a separate record (Fig. 2) printed on yellow paper is kept of each part in connection with the blue card. This " Parts " card will eventually contain a full record of departments that handle the part, its weight, cost of material, costs of each department, and also the total and individual or average cost per part. Each successive order is recorded the same as on the first card and the loop-holes in manufacturing due to negligence on the part of the foreman or operator are immediately shown by the comparison of costs of labor, etc., in each department.

Requisition for Material. — The large and heavy castings that represent the main parts of the machine are never kept in stock, but are provided for immediately by the superintendent on a requisition blank like that shown in Fig. 3, which is sent to the purchasing department. These blanks are made up in book form, four on a page; they have perforated edges, and are made in duplicate, the copy remaining in the book as a part of the superintendent's record.



STOCK ADVICE TICKET.

Date 2/10/11

To Store Keeper,

Please advise Superintendent's Office without delay, regarding the following Castings and Supplies for MACHINE NO. 126 STYLE P

Quantity	From Pat. No.	On Hand	Signature of Store Keeper
24	P-10	24	
24	P-11	16	
48	P-14	24	
48	P-16	32	
24	P-20	10	
24	P-28	24	
24	P-32	0	
24	P-34	0	
48	P-42	12	
			Date 2/11/11.

Sup't.

Return to Superintendent's Office.

Fig. 4. Superintendent's Office Stock Advice Ticket

Ordering Castings and other Parts. — For the smaller parts or castings, the superintendent causes the list shown in Fig. 4 to be sent to the store-keeper. This list, which is printed on heavy flexible paper and put up in pad form, gives all particulars, and asks for the information indicated. The store-keeper, on receiving it, ascertains the number of parts or castings he has on hand as requested, fills in the date, signs his name or initials, and returns the list immediately to the superintendent's office. Upon the advice thus received, the balance of supplies, if any, are immediately ordered by the superintendent through the purchasing department, using the blank shown in Fig. 3. By adopting this plan, a check is kept on all castings and supplies, which prevents the continual accumulation of such supplies, — a condition that

2 DEPARTMENT SHOP ORDER.

Order Issued to Dep'ts No. 2-3-4-9 Date 2/10/11.

Order No.	Quantity	Part No.	For Mch. No.	B/P. No.	Patt. No.	Dep't Work Fin.	Sent to	Received By
1567	24	26	P-126	P-3	Forging			
"	48	42	"	P-4	P-42			
"	24	10	"	P-2	P-10			
To be used by Foreman of Department as a Memorandum of PARTIAL ORDERS only.								
1567	12	26	P-126			2/28/11	#3	[illegible]

Foreman.

Return to Superintendent's Office when all work is finished.

Fig. 5. Department Shop Order Ticket

would occur if they were ordered on each successive order without first ascertaining whether or not any stock was available.

Department Shop Order. — The parts being all provided for through the superintendent's office, department shop orders (Fig. 5) are now issued to the various departments for all the parts to make up the completed machines. These orders have the number of the department printed in heavy black type in the upper left-hand corner, and are printed on flexible paper (preferably white), so that they may be typed in multiple, to include all the departments handling or machining that particular part. Suppose an order is issued for twenty-five crankshafts for a certain style of press; orders are issued to departments 2, 3, 4, and 9.

The lathe department, No. 2, handles the work at the beginning; the milling department, No. 3, receives it after No. 2; and so on. Similar orders are issued to the first three departments, the orders being distinguishable by the number representing the department printed in the upper left-hand corner as previously stated. A separate order, similar to the others, calling for the number of the complete machines, is issued to department No. 9, which is the assembly department for this type of machine.

Upon the receipt of this order by the head of department No. 2, or the department that first handles the work, a requisition on the store-keeper is issued on a blank similar to that shown in Fig. 3, for the number of forgings required to fill the order, and, as these have been provided through the superintendent's office, they are sent as requested, having a red tag (Fig. 6) attached to one of the lot to identify them. This tag contains all particulars as to quantity, part number, machine and style, and order number. As the work is completed in this department, this same tag or a duplicate is attached to one of the crankshafts already machined, and is sent to the next department handling the work, which, in this case, is No. 3. The same procedure applies in this department; the work is then sent to the next, which is No. 4, with the red tag still attached. This department, in turn, sends the shafts when finished to the final department, No. 9, which is the assembly.

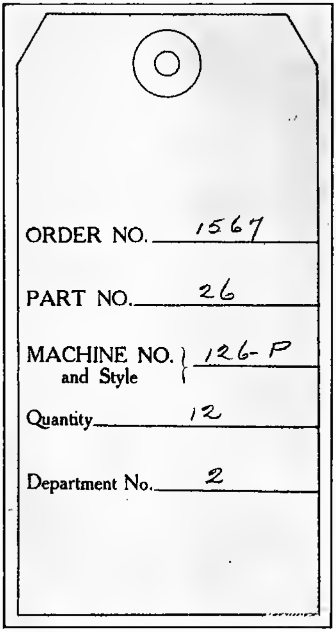


Fig. 6. Identification Tag

Responsibility for Spoiled Work. — Should one of these crankshafts be spoiled or incorrectly machined through an error on the part of some mechanic, this system compels the foreman of the department to report this fact immediately to the superintendent, thus causing an investigation to be made as to how it happened, whether through negligence or accident, and gives no opportunity for anyone to quietly scrap it without the full knowledge of the superintendent. As the work is finished in each department, the shafts are sent on, the head of department sending them to the head of the next department, who acknowledges their receipt by signing his name in the space provided on the department shop order, at the same time filling in the date. This compels the receiving foreman to verify the number of pieces so that it tallies

2 **PARTIAL ORDER TICKET.**

Order No.	Quantity	Part No	For Mch. No		Dep't Work Fin.	Sent to	Received By
1567	12	26	[illegible]		2/21/11	#3	[illegible]

[illegible] Foreman.

To be used for ONE ITEM ONLY when impossible to finish up full number of Parts on Dep't Shop Order.
Return to Superintendent's Office.

Fig. 7. Department Partial Shop Order Ticket

with the number on the red tag, Fig. 6. After obtaining the signature of the next department foreman, the shop order is returned to the superintendent and is filed, until all departments through which this part has passed have turned in their shop orders. All labor being completed on the part, the costs are transferred to the factory cost ticket, Fig. 2, which is then a complete record of actual costs.

Record of Partly Finished Orders. — At various times, through the excessive rush of work and piling up of orders, it may be found advisable in some departments to make up only a part of the order. To record this, another blank (Fig. 7) called the "Partial Order Ticket," printed on brown paper, is used by the head of the department in lieu of the regular department shop order, and after going through the same routine as the original order, being signed by the foremen of the departments, is turned in to the superintendent's office. As this is done the fact is recorded on the original shop order in the space provided for this purpose; this acts as a constant memorandum of parts still due on the original order. Each department, in turn, on completion of the work to be done turns in a similar ticket to the superintendent; these are in pad form as issued to the heads of the departments. This partial order ticket, as it is turned in to the superintendent's office, forms part of the record and shows what progress is being made on this particular part through the works. The adoption of this plan enables the superintendent to take steps to push through and direct what parts are to be rushed, and avoids the holding up and delaying of parts in the various departments, as he has the information at hand to locate the part by looking up the department shop orders returned to his office.

Time Ticket for Determining Costs. — A "daily time ticket," shown in Fig. 8, is an important part of the system. It is ruled and printed, as shown, provision being made for all particulars of both stock and time; it also forms part of the superintendent's record. These tickets are collected daily and filed in respective order number rotation, and, upon the completion of any department shop order, all information is transferred to factory cost cards as before described. This daily time ticket is an important factor in determining actual costs, etc.

Summary of Features. — To sum up, a system such as the one described in the foregoing is automatic in operation and has much to commend it: 1. There is a complete and actual record of labor costs by departments. 2. A constant check is kept of costs by comparison, and a means provided for locating any excessive expenditures due to negligence, incompetent help, or other conditions. 3. The cost of each individual part or piece of every machine is recorded — information that can be advantageously used in computing the cost of duplicate parts when needed. 4. There is a correct tally of the material used for both the part or machine, and the actual cost of each. 5. After a complete record of all parts and the machine have been established on the factory cost cards (Figs. 1 and 2) and the department shop order (Fig. 5), the information is all there to facilitate the issuance of any further orders for similar parts.

Routing System in a Machine Tool Shop. — Any shop system must be judged by what it accomplishes and the cost of its administration. The simpler a system, other things being equal, the better it is when judged from the practical man's point of view. The following system of routing work through a machine

2 **DAILY TIME CARD.**

Date 2/13/11.

Employe's No. 156 Name J. Brown

Order No.	Part No.	TIME	Description	Rate	Cost	
1543	14	1	Finishing Studs	30		30
1622	8	3	Facing Castings	30		90
1567	26	6	Turning Crankshaft	30	1	80
Order No.	**Part No.**	**Weight**	**Material Only**		**Cost**	
1543	14	20	C.R. Shafting	4		80
1622	8	56	Cast Iron	3	1	68
1567	26	415	Forgings	18	74	70

Approved by Williams Foreman.

R Sup't.

Fig. 8. Daily Time Ticket

shop has been applied to the building of horizontal boring machines by the Lucas Machine Tool Co., Cleveland, Ohio, and is commended for its simplicity and the complete control and knowledge of the progress of work through the shop.

The detail drawings are made on sheets $19\frac{1}{2}$ by 26 inches. The sheets are divided into sections by horizontal and vertical lines, the size varying according to the size or complexity of the parts to be shown. On the lower part of the sheet, space is reserved for symbols indicating the machine and pattern number and the corresponding operation numbers. If the part number or symbol is, say, 8–40, the first figure represents the machine number, and the second, the pattern number, in case the part is a casting. The operation numbers are placed opposite the part number and show what kind of machining operation or type of machine is to be used. The accompanying list shows what the different numbers represent.

Operation Numbers

1. Planing.
2. Boring machine.
3. Drilling machine.
4. Helping.
5. Cleaning castings.
6. Painting (including filling and rubbing).
7. Cutting off.
8. Centering.
9. Lathe.
10. Lo-swing lathe.
11. Turret bar.
12. Turret chuck.
13. Gear-cutter.
14. Thread milling machine.
15. Milling machine.
16. Keyseater.
17. Grinder.
18. Polishing.
19. Scraping.
20. Fitting.
21. Miscellaneous hand work.
22. Erecting.
23. Inspecting.
24. Store-room.
25. Graduating.
26. Spindle boring machine.
27. Automatic turret machine.

It will be noted that the list gives the name of the operation in some cases, but more frequently it gives the name of the machine. The reason for this is that the operations on the lathe, milling machine, etc., are minutely specified in separate lists that accompany the routing tag and blueprint, as determined in the planning department. These lists of operations are typewritten and blueprinted, and are pasted on the back of the shop blueprints.

Two blueprints are made of each group of details in the drawing-room and issued for each lot of twenty-four machines. One print is made on paper and is kept in a binder in the shop office. The other print is made on cloth and is cut apart, making as many individual prints as there are separate details on the sheet. These small prints are provided with a ring at the top to which is attached a routing tag. (See Figs. 9 and 10.) The routing tag is filled out in the shop office and sent into the shop with its blueprint to accompany the parts until finished and delivered to the assembling floor or the store-room.

For the purpose of illustration, assume that twenty-four "first-driving" bevel gears are to be machined. The symbol of this part on the drawing is 32-139. Each operation is designated in the space opposite the part symbol on the drawing, as previously explained. The operations in this case are 12-a, 12-b,

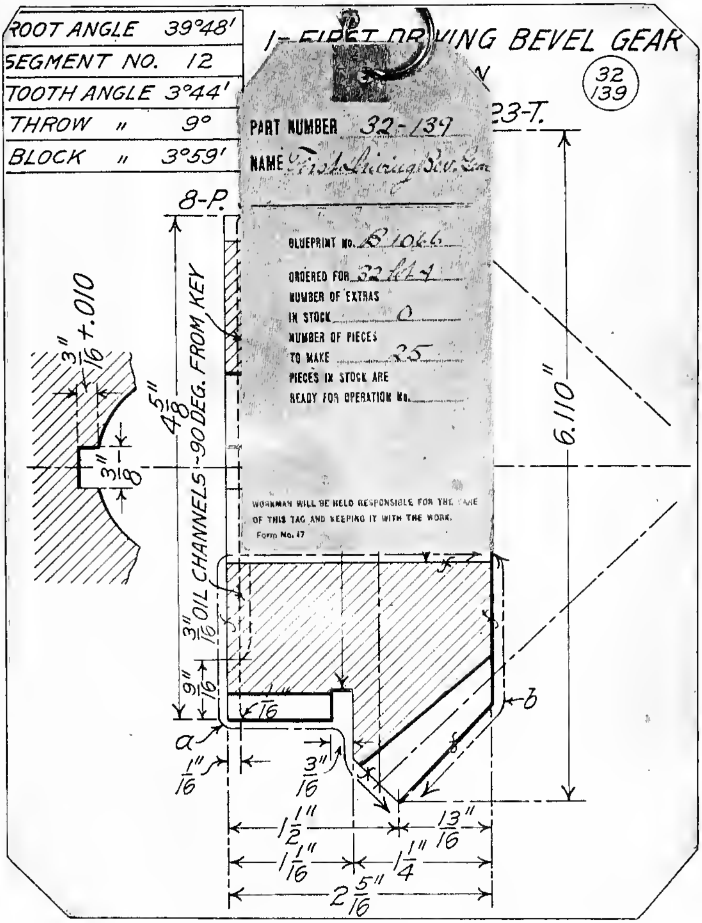
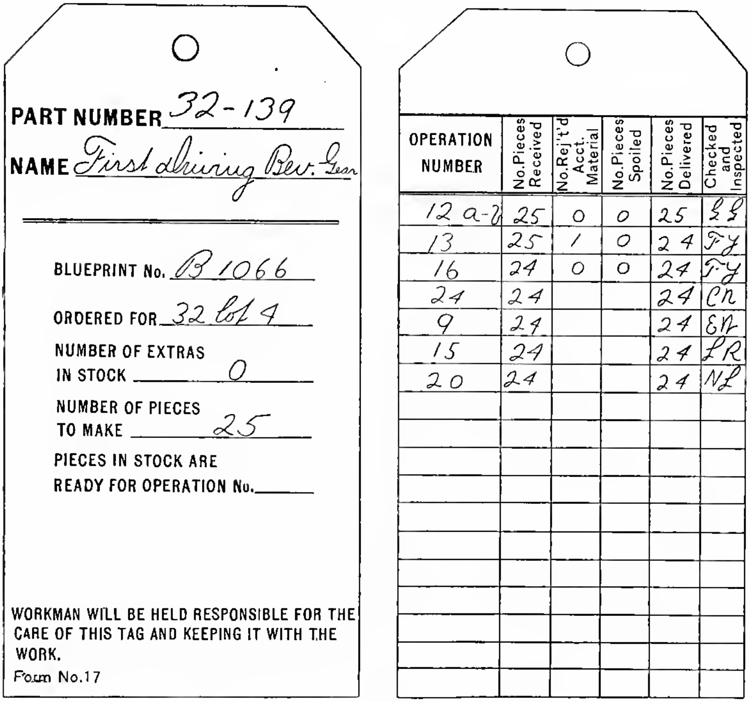


Fig. 9. Detached Detail Drawing with Routing Tag

13, 16, 24, 9, 15, and 20, representing the "turret chuck" (a and b), "gear-cutter," "keyseater," "store-room," "lathe," "milling machine," and "fitting," as shown by the list of operation numbers.

The first operation on the bevel-gear blank is that of chucking in the Gisholt turret lathe and performing operation "a." This operation consists of boring, facing, and turning the surfaces designated by the line *a* on the drawing (Fig. 9) which starts in the bore and terminates at the outer angle of the tooth section. This line is broken, the break being one short dash. One short



PART NUMBER 32-139

NAME First driving Bev. Gear

BLUEPRINT No. B 1066

ORDERED FOR 32 lot 4

NUMBER OF EXTRAS IN STOCK 0

NUMBER OF PIECES TO MAKE 25

PIECES IN STOCK ARE READY FOR OPERATION No.

WORKMAN WILL BE HELD RESPONSIBLE FOR THE CARE OF THIS TAG AND KEEPING IT WITH THE WORK.

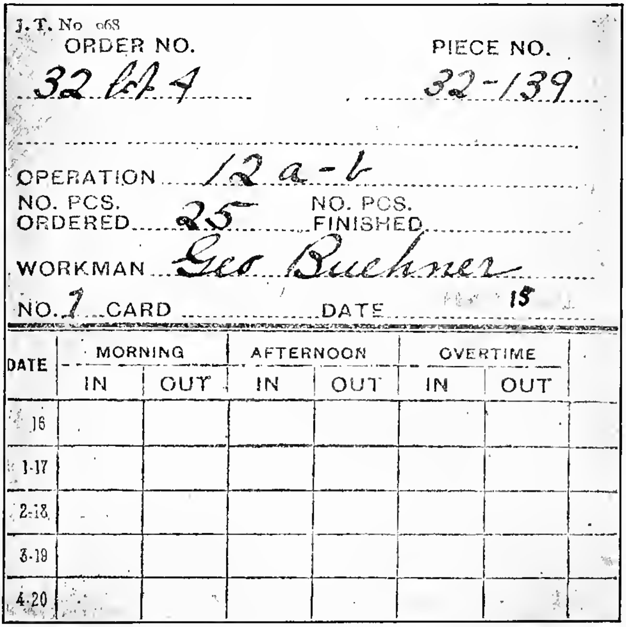
Form No. 17

OPERATION NUMBER	No. Pieces Received	No. Rej't'd Acct. Material	No. Pieces Spoiled	No. Pieces Delivered	Checked and Inspected
12 a-b	25	0	0	25	[illegible]
13	25	1	0	24	F.Y.
16	24	0	0	24	F.Y.
24	24			24	Cn
9	24			24	E.N.
15	24			24	L.R.
20	24			24	N.L.

Fig. 10. Front and Back of Routing Tag

dash indicates that it is the first operation. The second operation "b" is indicated on the drawing by another broken line *b*, the break consisting of two short dashes. The operator on the turret lathe does not change from one operation to the other on each piece; he does one operation on each piece first and then changes his chuck and tools to do the second operation, and so on.

When the lot of castings and the routing tag are delivered to the turret lathe, a check mark is made by the clerk on the shop office drawing, opposite the symbol. This mark shows that work has been started on these parts. Further records are made from the cost cards, a sample of which is shown in Fig. 11. The cost cards are stamped in a time recording clock when the job is started and when completed. They are partly filled out by the shop office clerk, the order number, piece number, operation, and number of pieces being the items entered. The cards then go to the foreman who keeps them in a card rack with index tab cards to designate the various operations. Thus there will be cards for



J. T. No 068

ORDER NO. 32 [illegible] PIECE NO. 32-139

OPERATION 12 a-b

NO. PCS. ORDERED 25 NO. PCS. FINISHED

WORKMAN Geo Buchner

NO. 7 CARD DATE 15

DATE	MORNING		AFTERNOON		OVERTIME		
	IN	OUT	IN	OUT	IN	OUT	
16							
1-17							
2-18							
3-19							
4-20							

Fig. 11. Top Portion of a Cost Card

practically all the operations enumerated on the schedule of operations.

The turret lathe operator who machines the bevel-gear blanks is charged with twenty-five pieces, an extra piece being supplied to replace any casting found defective or spoiled. When he finishes operations 12-a and 12-b, the time of completion is stamped in the time recorder, and the card is turned in to the foreman, who then gives the workman another job, and the cost card for the operation is stamped in the "in" column. The cards for completed operations are collected each morning, and the completed operations are checked off on the shop office blueprints for operations 12-a and 12-b. The same is done for all the other parts on this sheet and on the other sheets for the lot of machines going through.

When the turret lathe man completes the lot of bevel-gear blanks and so reports to his foreman, the report indicates to the shop office that the lot has been delivered to the machine for the next operation. An order is not considered complete until the delivery is made.

The next operation in this case is that of gear cutting. Twenty-five turned and bored blanks are delivered to the gear-cutting department together with the routing tag and blueprint, Fig. 9. The operator to whom they are given stamps the time of beginning in the "in" column of a cost card filled out for operation 13, and, when the lot is completed, the time is stamped in the "out" column, as before. In this case, one blank was found defective when cut so that only twenty-four perfect gears were turned over to the keyseater for operation No. 16. The cost card is sent into the shop office and operation 13 checked off on the shop office record blueprint.

The orders for castings also originate in the drawing office, and the prints are not issued to the shop office until the castings are delivered by the foundry. The drawings are made to convey all necessary instructions to the workmen; thus, when parts are to be drilled or bored in jigs, the jig number is given on the drawing. For example, the driving pulley sleeve and driving chain sprocket sleeve, symbols 32–108 and 32–109, are drilled in jig No. 616. This jig will be found in the tool-room in rack 6, on shelf E, in section 1–2. The description and location of the jig are given on a card, Fig. 12, filed in a card index in the tool-room.

From this outline, it will be understood that a constant record is available in the shop office which shows, from day to day, the progress of work on any lot of machines, and the location of all parts. It also shows the number of parts spoiled and indicates on what operation they were spoiled. The costs can be calculated for a machine or lot of machines in any stage of construction. The simplicity of this system is shown by the fact that one clerk attends to all its details after receiving the blueprints from the drawing office.

System of American Machine & Foundry Co. — The drafting-room is necessarily the starting point of all machine shop work, but at the plant of the American Machine & Foundry Co., Brooklyn, N. Y., the drafting-room is of more than usual prominence. Not only is it called upon to fulfill the usual function of

JIG NO. 616 PART No. 32-108 32-109 DRAWING No. B-520
RACK 6 SHELF E SECTION 1-2
No. OF MACH. & NAME OF PIECE No. 32 H.B.M. ~~Driving Pulley Sleeve & Chain~~ Sprocket Sleeve. JIG FIRST USED ON M.32-L2
REMARKS:
Jig for drilling oil and screw holes.
Loose piece - 13/32 Bush.

Fig. 12. Sample Index Card showing Location of a Jig in the Tool-room

designing, but it also includes, as a subsidiary department, the production department which has charge of ordering the patterns, castings, and material for filling each order that is received, and of determining the best method of machining each part, and the most satisfactory way of routing the work through the factory. The production department also looks after issuing blueprints and material to the factory, sending the necessary jigs and fixtures to each department in which they are to be used, and keeping a record of the progress made with each individual order.

As the work handled by this company consists of building high-grade special automatic machinery, the designing is of a diversified character, but there are certain customers for which the same general class of work is constantly being done. For instance, a great many automatic machines for the manufacture of cigarettes are constantly being built. It is obviously desirable for men with previous experience in this class of designing to handle all such work which comes to the factory. In order to make this possible, the drafting-room is subdivided into departments, each of which is in charge of a chief draftsman of wide experience in his particular line of work. Thus, the cigarette machine department is in charge of a man who has designed a great many machines for the automatic manufacture of this particular product, and he has a wider knowledge of the field than any general designer could be expected to possess. Parts of a cigarette machine will be considered in describing the shop system.

Symbols and Part Numbers. — Each machine is designated by a symbol that usually consists of the initial letters of the name of the machine. For instance, the standard cigarette machine built by this company is designated by the symbol "SCM." Each part of this machine is designated by a number, and parts which assemble together in the machine have consecutive numbers. For instance, a certain shaft for use on this machine is designated by the symbol and number "SCM-408," while a bushing which is assembled on this shaft has the number "SCM-409." The convenience of this method lies in the fact that an assembler looking over his detail drawings is able to determine what parts go together by their numbers. The detail drawing of each part is made with a partial cross-section of those parts which assemble on it, each part being referred to by its symbol and number, thus doing away with the necessity of giving special instructions to the assembling department.

Work of the Production Department. — When an order is received from a customer, a typewritten copy is sent from the office to the production department, where a memorandum of this order is made out expressed in the symbols and numbers used for designating the machines or machine parts that are called for. Spaces are left for the insertion of serial order numbers, and the memorandum is sent down to the office to have these numbers assigned to the order. The correspondence form for use between different departments, which is shown in Fig. 13, is employed for this purpose. When the memorandum is received in the office, the order numbers are inserted and it is returned to the production department, where one of the clerical force proceeds to make

Form 21 5000-5-13

AMERICAN MACHINE AND FOUNDRY CO.

DEPT. Office AVOID VERBAL ORDERS. ORDER No.

~~MR.~~ Miss O'Neill DATE, 9/24 1913

Please issue J.O.'s as follows:-
For building (15) Standard Cigarette Machines. Equipped with single heavy type cutoffs, full printers, folder and change parts to make cigarettes 29½ m/m circ. oval, using 31 m/m paper. Length of cigarette 68 m/m.
Delivery 90 days from 9/22/13.

(A.X.CO. letter 9/22/14)

Shop J.O. 19500
Shop A. J.O. 19500A
D.R. A. J.O. 20477A
Patt. J.O. 19501

Signed, W.O.L.

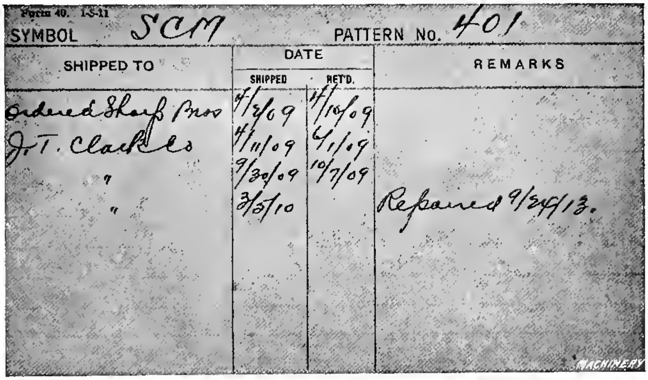
Fig. 13. Production Department's Call on Office for Assignment of Order Numbers

SYMBOL SCM PATTERN No. 401
SHELF No. A4 DIVISION F
DESCRIPTION Conveyor wheel
No. OF PATT'S 1 CORE BOXES 0
MATERIAL Mahogany
PATT. MADE FOR J. O. 5101 CHANGED FROM ——
HRS. LABOR 21 COST MATERIAL 1.00 TOTAL COST $12.50
REMARKS (Use for #501)
Cast Iron 20½ lbs.

Fig. 14. Form used in keeping Record of Location of Each Pattern on Shelves

out a specification sheet and a list of all parts which must be provided to fill the order, the proper symbols and numbers being applied to the notation of each part.

In the case of new machines of a type that has not formerly been built in the factory, it is necessary to order the patterns for parts which are made from castings, and special forms are provided for this purpose. In the case of standard machines, it is necessary to look up the old patterns preparatory to issuing orders for castings. The system employed in storing patterns and keeping track of them makes this an easy matter. Each pattern is given a number and bears a symbol of the machine for which the part made from it is intended; and the patterns are stored on numbered shelves. The form shown in Fig. 14 is used to keep track of the location of each pattern. Referring to this illustration, it will be seen that the form gives complete information regarding the pattern, its number, symbol, and location on the pattern storage shelves. The original cost of the pattern and other useful information is also included on


Form 40. 1-5-11

SYMBOL SCM PATTERN No. 401

SHIPPED TO	DATE SHIPPED	DATE RET'D.	REMARKS
Ordered Sharp Bros	4/2/09	4/10/09	
J. T. Clark Co	4/11/09	6/1/09	
"	9/30/09	10/7/09	
"	3/5/10		Repaired 9/24/13.

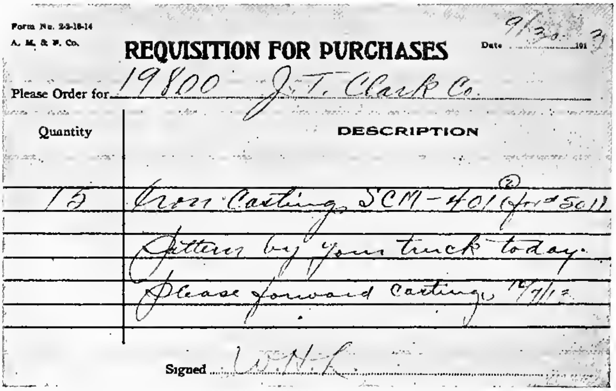
MACHINERY

Fig. 15. Form used in keeping Record of Patterns sent to Foundry when Castings are ordered

this card. When castings are to be ordered, the pattern is drawn from the pattern storage room and sent to the foundry, together with an order for the required number of castings to be made from it. The form shown in Fig. 15 is used to record the fact that the pattern of a certain symbol and number was shipped to the foundry on a specified date. When the castings have been made and the pattern returned, the date of its receipt is recorded on the card opposite the date on which shipment was made, and the pattern is returned to the pattern store-room. When both dates on the card are filled, it shows that the pattern has been returned, but if the space for the return date is blank, it indicates to the production department that the pattern has not come back.

In ordering castings or other material, the form shown in Fig. 16 is sent to the purchasing department requesting the purchase of a specified number of castings.

When the castings arrive at the receiving room, the production department is notified to that effect. The production depart-



Form No. 2-5-18-14
A. M. & F. Co.

REQUISITION FOR PURCHASES

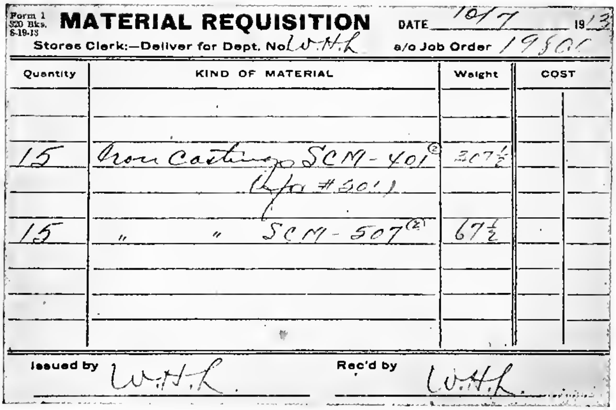
Date 9/30 1913

Please Order for 19800 J. T. Clark Co.

Quantity	DESCRIPTION
15	Iron Castings SCM-401(2) (for #501)
	Pattern by your truck today.
	Please forward castings 10/7/13

Signed W.H.L.

Fig. 16. Requisition Form used in calling upon Purchasing Department for Supplies



Form 1
320 Bks.
6-19-13

MATERIAL REQUISITION DATE 10/7 1913

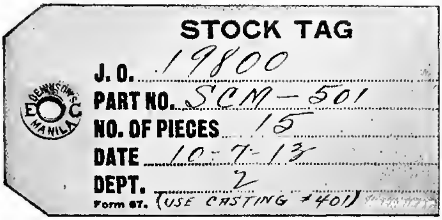
Stores Clerk:—Deliver for Dept. No. W.H.L. a/o Job Order 19800

Quantity	KIND OF MATERIAL	Weight	COST
15	Iron Castings SCM-401(2)	30 7½	
	(for #501)		
15	" " SCM-507(2)	67½	

Issued by W.H.L. Rec'd by W.H.L.

Fig. 17. Requisition Form used in ordering Material sent out to Shops

ment then orders the castings to be sent to whatever department will perform the first machining operation on them, the material requisition form shown in Fig. 17 being used for that purpose. In making delivery of castings or other material, the receiving department uses small tags of the form shown in Fig. 18. These tags are either pink, blue, or yellow, according to whether the material is to be used for a regular order, a repair order, or an experimental order. As a check on the prompt delivery of material by the receiving department, the production department notifies the department in which the first machining operation is to be performed that the material has been received, the form shown in Fig. 19 being used for this purpose.


STOCK TAG

J. O. 19800

PART NO. SCM-501

NO. OF PIECES 15

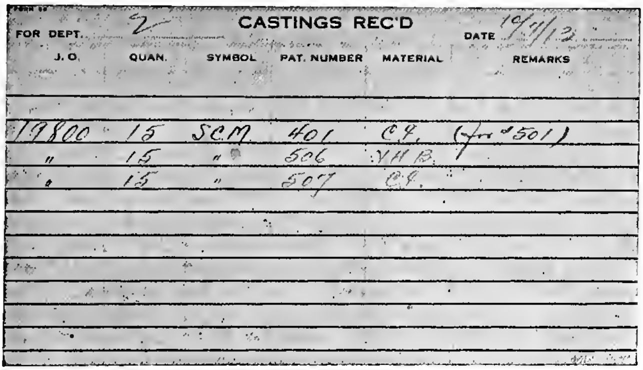
DATE 10-7-13

DEPT. 2

Form 87. (USE CASTING #401)

Fig. 18. Tag used in sending Material to Shops

Method of Accounting for Jigs and Fixtures. — The production department also has supervision over all jigs and fixtures used in the factory. When the blueprints have been made for a given order, and the necessary material to start the order has been

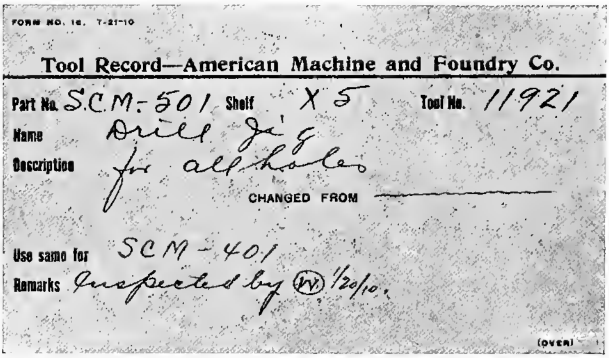

FOR DEPT. 2 — CASTINGS REC'D — DATE 10/4/13

J. O.	QUAN.	SYMBOL	PAT. NUMBER	MATERIAL	REMARKS
19800	15	SCM	401	C.I.	(for #501)
"	15	"	506	V.H.B.	
"	15	"	507	C.I.	

Fig. 19. Form used in notifying Shops that Material is on Hand ready for Use

received, the production department sends out the requisite tools to each department in which work is to be done on the order in question. This is only in the case of jigs or fixtures that are used at more or less infrequent intervals. Those that are in quite general use are kept in the departments in which they are needed to avoid loss of time in transferring them back and forth between the jig-room and the factory. The form shown in Fig. 20 is used for keeping a record of each tool in the jig-room; and it will be seen that spaces are provided for recording the name and number of each tool, and its proper place in the jig-room. The form reproduced in Fig. 21 is used for sending tools out to different shops. As in the case of the pattern records, this form shows, at a glance, what tools have been returned from the factory and what ones are still outstanding. After the work for which each tool is used has been completed, the work and the tool are sent to the inspection room where the tool is examined to see that all its parts are complete and in good condition before it is returned to the jig-room.

Data Recorded on Drawings. — The detail drawings of individual parts are made on large sheets from which tracings and


FORM NO. 16. T-21-10

Tool Record—American Machine and Foundry Co.

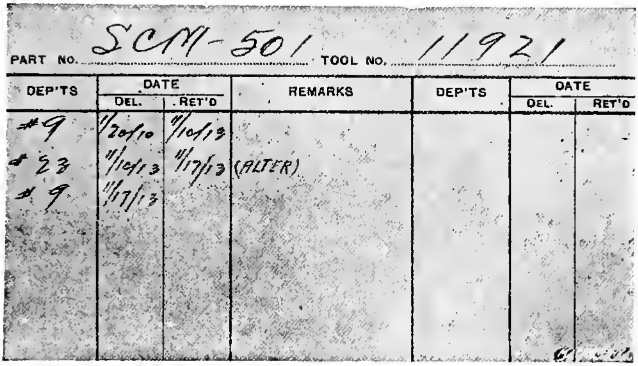
Part No. S.C.M.-501 Shelf X 5 Tool No. 11921
Name Drill Jig
Description for all holes
CHANGED FROM
Use same for SCM-401
Remarks Inspected by W 1/20/10.

(OVER)

Fig. 20. A Card from Production Department's Tool Record

blueprints are made, and the blueprints are afterward cut up into individual sheets. In preparing to send these small sheets, or "cut-ups," out to the factory, the production department stamps them on the back with a rubber stamp. This stamp gives the order number and the color of the tag to be used; *i.e.*, whether the work is for a regular order, a repair order, or an experimental order. The job order, the number of pieces required, and the date on which the print is sent out are also given, together with the department numbers in which the work is to be done. These department numbers are given in the order in which the work is to be sent through them. The blueprints are all sent down to the assistant superintendent, whose first duty is to look over the arrangement of the departments through which the work is to pass, and see that the routing has been specified to the best possible advantage. If it is necessary to make a change in the routing, the blueprint is returned to the production department to have the same change made on the transfer cards. The assistant superintendent also notes the stock to be used in the space entitled "stock req.," after which a clerk fills out the material requisition form shown in Fig. 17, upon which the necessary material is ordered.

Following Progress of Work in Shop. — For use in keeping a record of each order going through the shop, the production de-

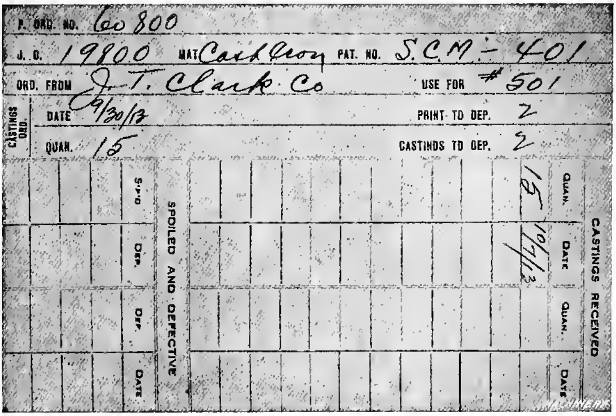


PART NO. SCM-501 TOOL NO. 11921

DEP'TS	DATE DEL.	DATE RET'D	REMARKS	DEP'TS	DATE DEL.	DATE RET'D
#9	11/20/10	11/10/13				
#23	11/10/13	11/17/13	(ALTER)			
#9	11/17/13					

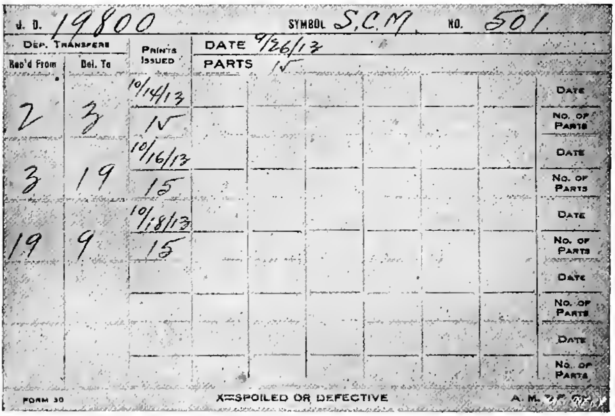
Fig. 21. How Record of Tools sent out to Shops and Those that have been returned is kept

partment maintains a set of transfer cards, the forms of which are shown in Figs. 22 and 23, these forms being printed on the opposite sides of the same card. The form shown in Fig. 22 is used to keep a record of the castings that have been ordered, the number that have been received on various dates, and the number that have either been spoiled in machining or found defective. Fig. 23 shows the form used for keeping a record of the transfer of work from department to department. This form provides a space for entering the part and job order numbers and the symbol and number of the part, together with the date on which the blueprints were sent out to the factory and the number of parts ordered. Spaces are provided for recording the number of parts completed daily in each department, and for the transfer of such work to the succeeding department. These two forms are used for following the progress made in machining castings. For keeping a record of the machining of other parts, such as steel shafts, etc. — where the material is not a casting — a card printed



P. ORD. NO. 60800
J. O. 19800 MAT. Cast Iron PAT. NO. S.C.M. – 401
ORD. FROM J. T. Clark Co USE FOR #501
CASTINGS ORD. DATE 9/30/13 PRINT TO DEP. 2
QUAN. 15 CASTINGS TO DEP. 2
S'P'D DEP. DEF. DATE
SPOILED AND DEFECTIVE
QUAN. 15 DATE 10/7/13 QUAN. DATE
CASTINGS RECEIVED

Fig. 22. Form used for Recording Order and Receipt of Castings



J. O. 19800 SYMBOL S.C.M. NO. 501
DEP. TRANSFERS PRINTS ISSUED DATE 9/26/13
Rec'd From Del. To PARTS 15

Rec'd From	Del. To	Prints Issued	
		10/14/13	Date
2	3	15	No. of Parts
		10/16/13	Date
3	19	15	No. of Parts
		10/18/13	Date
19	9	15	No. of Parts
			Date
			No. of Parts
			Date
			No. of Parts

FORM 30 X=SPOILED OR DEFECTIVE A. M. 7-P.

Fig. 23. Transfer Card showing Progress made Each Day in machining Castings

with the same form as that shown in Fig. 23 is used. This form is printed in black on a yellow card, while the castings record is kept on a form printed in red on a white card. In this way, the production department is able to distinguish between the two classes of work.

Transfer of Work to Inspection Department. — When each department finishes work on a given order, a tag of the form shown in Fig. 24 is filled out and attached to the work, which is then forwarded to the inspection department. The upper part of this form provides spaces for the name of the operation, the order number, the symbol and piece numbers of the part, the number of pieces required, and the date. If the work is required in a hurry, the department doing certain work will not wait until the order has been completed before forwarding it to the inspection department, but will forward a portion of the work with a tag of the form shown in Fig. 24. The inspector counts the work

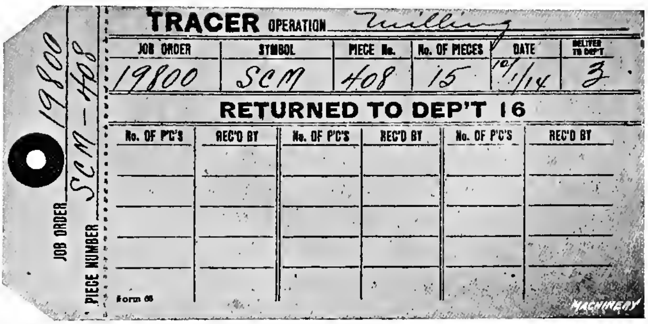
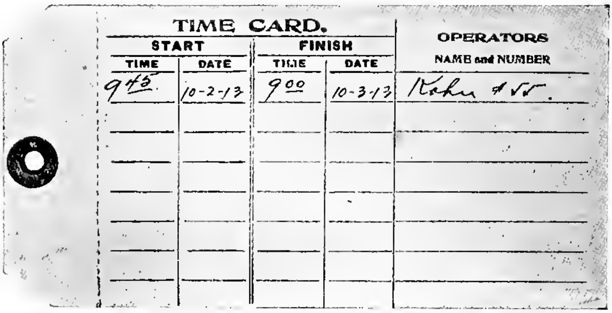


Fig. 24. Card used in delivering Work to Inspection Department

and records in the space on the card the number of pieces received, and then writes his initials opposite this number in another space provided for that purpose. This tag is perforated across the end so that it is easy for the inspector to tear off the card and return it to the department handling the first operation. When the next lot of pieces is forwarded to the inspection department, the card is sent with them and the number of pieces recorded in the same way, this being continued until the complete number of parts has been machined. Each shop foreman has a box on his desk in which these cards are filed when returned by the inspection department. After the inspection department has looked over the work, a new tag of the same form is made out and attached to those pieces which have been found satisfactory; the pieces are then sent on to the next department. This enables work that is required at once to be handled without any unnecessary delay.

Tags of the form shown in Fig. 24 are printed on either pink, yellow, or blue cardboard, according to whether the work is required to fill a standard order, a repair order, or an experimental order, as previously mentioned. The colors of these cards enable the shop foreman to determine, at a glance, to which class the work belongs and advise him as to the method of procedure to follow in handling it. The standard orders are the regular manufacturing operations for which jigs and fixtures are provided. After the jig has been set up on the machine for handling a given class of work, the first piece is made and sent to the inspection department to determine its accuracy. If it is found satisfactory, subsequent pieces are given a more rapid inspection, the jig being



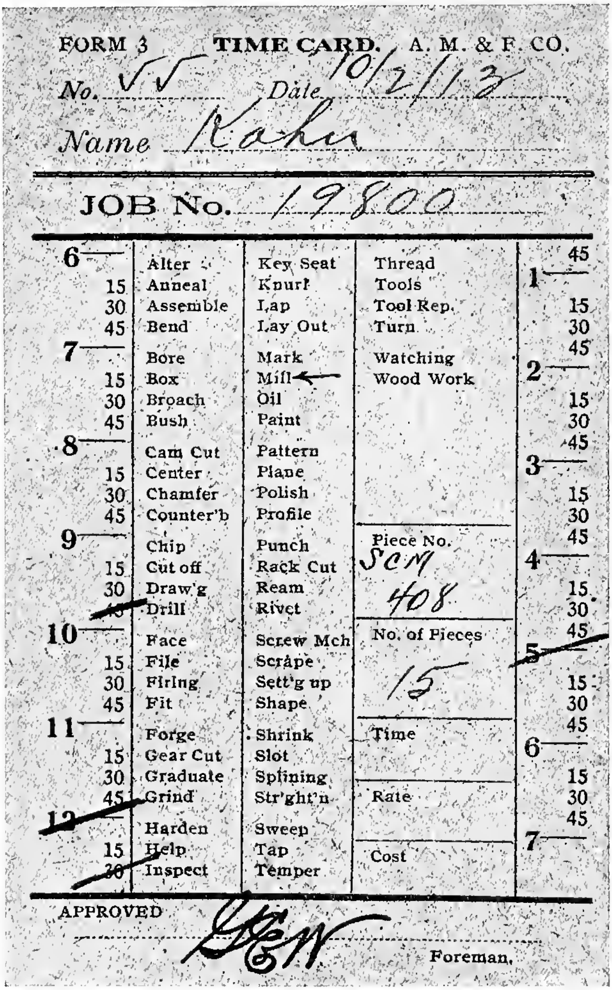
TIME CARD.				OPERATORS
START		FINISH		
TIME	DATE	TIME	DATE	NAME and NUMBER
9 45	10-2-13	9 00	10-3-13	Kohn #55.

Fig. 25. Time Card used by Each Foreman in recording Work done by his Men

relied upon to maintain the necessary dimensions. In the case of repair work, jigs and fixtures are also used, but, as such parts are to be shipped out and absolute reliance must be placed on their interchangeability, each part is given a thorough inspection before being shipped. Parts for the experimental orders are made without the assistance of jigs or fixtures of any kind. This work is usually assigned to the most skilled mechanics, but even under such conditions it is found advisable to have each part subjected to a most rigid inspection before it is sent on to the assembling department.

Time Records. — A time card of the form shown in Fig. 25 is printed on the back of each tracer card. Space is provided for the time and date upon which each job was started and finished and for the name and number of the operator. This card is for the guidance of the foreman in enabling him to keep track of his men. The time-keeping department keeps an independent record of each job on cards of the form shown in Fig. 26. Spaces are provided on this card for the name and number of the operator, for the date and the job number, and the time at which he started and stopped work on a given job. The different classes of operations are tabulated on this card and, in using it, the time clerk draws a line through the figures indicating the time of starting and stopping work and the operation performed. The card is then sent to the foreman and turned over by him to the cost-keeping department. In handling standard orders, little trouble is experienced in maintaining a satisfactory rate of production, but the record of production time on repair and experimental orders is of great assistance in making sure that the work is turned out in reasonable time. The time required for producing any given job is compared with that taken for performing work of a similar nature which was done in the factory at other times, and if an excessive amount of time is taken in any case, the foreman of the department in which the work was done is given an opportunity to explain the cause.

Issuing Blueprints. — The method of issuing a single set of blueprints which follows the work from department to department is adopted where a relatively small number of parts is to be made. In many cases, however, a single order may be received for as many as two hundred machines, and this will keep the factory busy for a considerable length of time. It would obviously be impractical to hold all of an order in a given department until it was completed. To obviate the necessity of such a course, the production department supplies each department in the factory that is to work on the order with a complete set of blueprints, and as fast as the work is completed it is sent on from department to department, the method of recording the work on the transfer cards (Figs. 24 and 25) being that previously described for the case where less than the entire number of pieces called for on the order was forwarded to the inspection department. In this way, the work can be handled in an expeditious manner. If a certain quantity of parts is required ahead of the


FORM 3 TIME CARD. A. M. & F. CO.

No. √√ Date 10/2/13

Name Kahn

JOB No. 19800

6	Alter	Key Seat	Thread	45
15	Anneal	Knurl	Tools	1
30	Assemble	Lap	Tool Rep.	15
45	Bend	Lay Out	Turn	30
7	Bore	Mark	Watching	45
15	Box	Mill ←	Wood Work	2
30	Broach	Oil		15
45	Bush	Paint		30
8	Cam Cut	Pattern		45
15	Center	Plane		3
30	Chamfer	Polish		15
45	Counter'b	Profile		30
9	Chip	Punch	Piece No.	45
15	Cut off	Rack Cut	SCM	4
30	Draw'g	Ream	408	15
~~45~~	Drill	Rivet		30
10	Face	Screw Mch	No. of Pieces	45
15	File	Scrape		~~5~~
30	Firing	Sett'g up	15	15
45	Fit	Shape		30
11	Forge	Shrink	Time	45
15	Gear Cut	Slot		6
30	Graduate	Spining		15
45	Grind	Str'ght'n	Rate	30
~~12~~	Harden	Sweep		45
15	Help	Tap	Cost	7
~~30~~	Inspect	Temper		

APPROVED GEW Foreman.

Fig. 26. Form of Card used by Time-keepers

full amount, an excess amount of parts is started to provide for the possibility of damage or defective parts being found, and this work is pushed along as rapidly as possible.

Defective Work. — In every factory it occasionally happens that work is spoiled in machining or that castings or other materials are found to be defective. When such a condition arises in the work handled by the American Machine & Foundry Co., the job is held up by the inspection department and the production department is notified that a certain number of pieces has been found defective. Certain parts are carried in stock to provide for such contingencies, but if stock parts are not available for replacement purposes, the method of procedure depends upon whether a single set of blueprints is provided, which follows the work from department to department, or whether each department works from a separate set. When a single set of prints is used, the inspection department fills in a form stamped on the back of the blueprint and sends the print to the production department. If the parts are in stock, the required number will be withdrawn and the number of parts called for on the print reduced to correspond. If the parts are not in stock, the blueprint will be returned to the assistant superintendent who will send it to the department that performs the first operation. The inspection department holds up the remainder of the order, until the replacement parts have reached the same stage as the rest of the work. If a separate set of blueprints is issued to each department and the replacement cannot be made from stock, a special blueprint will be issued to follow the work from department to department. When the replacement order has been brought to the same condition as the remainder of the regular order, the inspection department will combine the two and destroy the replacement blueprint.

There are few factories of any prominence that are not capable of turning out work of the necessary accuracy and finish to meet the requirements of their customers; but there are a great many shops that are hindered in the production of their work through lack of system or through the use of inefficient systems which fail to accomplish the results for which they were installed. The system described is one which combines the valuable characteristics of simplicity and efficiency. It was worked out to meet the requirements of a plant dealing with a great variety of special work in addition to standard manufacturing work, and its principal features may be applied in other shops and factories.

Stock-keeping System. — In all manufacturing establishments, a great deal of money can be lost or saved in the stock-room. In many cases, however, this department is placed in some poorly-lighted, ill-ventilated, obscure part of the building and is in charge of a man who has probably secured the position in consequence of a good memory or his inability to become a mechanic, and who is very frequently incompetent, probably due to his being very much underpaid. As assistants, there are usually with him a few boys or old men who cannot be usefully employed in other departments.

The system of stock-keeping to be described has been tried in various plants and proved to be very successful, not only from a production, but also from a pay-roll, standpoint. It must be understood, however, that the success of any system depends largely on the coöperation of the office and accounting departments with the stock-keeper, and any error or misunderstanding between them should be investigated and settled at once; for frequently, even in the best managed plants, the office is obliged to call on the stock-keeper for information, and his prompt attention facilitates matters.

The stock entering into the finished product which is kept in the stock-room should be drawn out, as required, on orders signed by the proper authority — usually the foreman of the department concerned. This stock may be divided into three classes: finished stock, rough stock, and supply stock. Under the classification "finished stock" are included all the parts which are manufactured in the plant. The rough stock includes all purchased materials such as steel, iron, rough castings, etc. Supply stock constitutes such materials as paint, waste oil, small tools, etc., and at times includes such things as advertising matter, letter-heads, envelopes, and office supplies. The first-mentioned of these supplies are frequently included under the "rough-stock" head, but experience shows that, by keeping these supplies under a separate heading, better accounting results may be secured. These divisions may be varied to suit the requirements of the accounting department, but in most cases these three divisions will be found sufficient.

Stock Numbers. — It cannot be too forcibly stated that every article in a stock-room should be known by a number in addition to its name, and, wherever possible, that number should appear on the requisition for material. In good manufacturing systems, the use of names for parts may be entirely eliminated, numbers being used exclusively, the result being better and quicker service

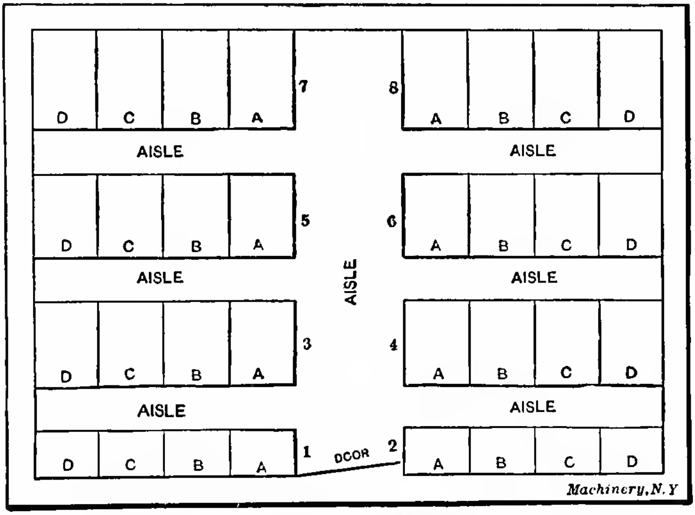


Fig. 27. Plan of Stock-room for Keeping Machine Parts

in the filling of orders. The use of letters in designating material, except where absolutely necessary, is to be avoided, although in some cases a letter is placed before or after a number to show the kind or quality of the material. For example, 211A might mean casting; 642B, forging; and so on, although a system of numbering may be devised that is equally effective. For instance, if the product is a machine consisting of a number of minor assemblies, all numbers ending with 0 would designate an assembled part; 01, a screw; 03, a casting, and so on. By such an arrangement, a parts-list may be made up and mastered after a little study.

Location and Arrangement of Stock-room. — The center of the building seems to be the generally preferred position for the stock-room, although, in many cases, a better location is at the end of the building, as near the office as possible, for in the former case a considerable drawback arises should it ever become necessary to enlarge this department, as other departments would be more or less inconvenienced. Furthermore, firmer and better structures for holding material may be built at the end of the building.

Spindle Arm Attachment				
4250	Spindle Arm Assm	1	a	1
4251	" " Bearing	1	a	19
4252	" " " Screw	1	a	21
4253	" " " Spring	1	a	27
4254	" " " Nut	3	b	4
4255	" " " Lock	3	b	7
4256	" " Pin (See 4118)	7	a	19
4257				
4258				
4259				
4260	Spindle Gear Assm.	5	a	3

Machinery, N.Y.

Fig. 28. Portion of Parts-list

The drawers or shelving for parts that are in constant use should not be more than seven feet above the floor, the space above this being utilized for such parts as are only occasionally called for. In so arranging the parts that they may be readily located, an indexing system has been devised which, with slight variations, may be suited to any special business. Fig. 27 shows the plan view of an arrangement used by a plant manufacturing a number of small machines. This room which is about forty feet square is divided through the center by an aisle four feet wide and is subdivided into sections, tiers, and compartments. The term " section " is applied to the construction on either side of the aisle, that on the right being designated by even numbers and that on the left by odd. These sections are divided into " tiers " which represent spaces between the uprights and are alphabetically lettered to avoid the confusion of numbers. The " compartments " are the drawers or shelving for holding parts.

STORES ORDER

ORDER NO. 1437

DELIVER TO 110 DEPT. H DATE 7/2/10 LOT NO. 2

QUAN	DESCRIPTION	NO.	COST PER UNIT	COST TOTAL
100	Parts to Assemble	4250		

FILLED BY	CHECKED BY	O'K' STOREKEEPER	FOREMAN
616	712	Smith	Brown

Machinery, N.Y.

Fig. 29. Stock Requisition Slip

Sheet steel or heavy tin is the most practical and durable construction material for drawers. They should be made interchangeable, the tiers being fitted with strips to hold interchangeable boards upon which the drawers can rest. In drawers that are of the same width as the tiers, these strips may be fastened to the sides and will be found to work very satisfactorily.

Parts-list and Stock Requisition. — The arrangement for taking care of the stock having thus been attended to, the application may next be considered. Fig. 28 shows a section of a page of a parts-list in common use. A requisition calls for part 4250 which is shown in parts-list as being located in section 1, tier A, drawer 1 (1A1). The stock clerk knows that 1, being odd, is located to the left of the main aisle; A, being the first letter of the alphabet, is the first tier of section 1; and drawer 1 will be at the bottom of a tier. One company has its product divided into sections, parts for which are drawn out, assembled, and then returned to the stock-room and again drawn out combined with other assemblies, completing the finished product. Fig. 29 shows the form of stock requisition slip which is given to the stock clerk, who turns to the card or sheet shown in Fig. 30 of the corresponding number, which readily locates the article desired. This order, after being filled, is checked and forwarded to the

Spindle Arm Assm 4250

PART	QUAN	NAME	SEC	TIER	COMP
4251	1	Spindle Arm Bearing	1	a	19
4252	2	" " " Screw	1	a	21
4253	2	" " " Spring	1	a	27
4254	1	" " " Nut	3	b	4
4255	1	" " " Lock	3	b	7
4256	2	" " " Pin (4118)	7	a	19
4257	1	" Gear Assm	5	a	3

Machinery, N.Y.

Fig. 30. Stock-keeper's Location Card

office, where, after being priced, it is filed against the original order. It is not within the range of this treatise to discuss systems of accounting, but it may be stated that the best results will be obtained where the least time is lost between filling the order and sending it to the accounting department.

Stock Record. — The stock card, Fig. 31, gives a record of the in-coming and out-going material; and the stock clerk, after making deductions, should see that the amount in stock is above the low mark which is indicated in the upper right-hand corner. As soon as filled, these tickets should be forwarded and old cards filed numerically according to part number; but this work should be done by the stock-keeper and not by his clerks. In every case where the ticket is to be forwarded or parts to be ordered, the ticket should be placed on the stock-keeper's desk where a glance at it will at once convey to him a knowledge of the way things stand in regard to this particular article. Every card should be gone over carefully before forwarding on account of arithmetical errors which are always likely to occur; and, if the stock system is used in connection with the so-called perpetual

NO. 4250		LOCATION 1a1	LOW MARK 50	
Spindle Arm Assm				
IN		OUT		ON HAND
DATE	QUAN.	DATE	QUAN.	
6/2	50			50
		6/4	14	36
		"	3	33
6/10	100			133

FRONT

EXAMINED AND FORD 6/2/19	ORDERED 6/2/19
QUAN. 100	ORDER NO. 1437
RUSHED 6/8	ORDER COMP 6/10
OTHER USES	

BACK

Machinery, N.Y.

Fig. 31. Card for Recording Stock in the Stock-room

stock-record system, this is imperative, as any difference between a card and the ledger will cause unnecessary delay in checking for the inventory.

Qualifications of Stock-keeper. — The most important consideration in the organization of a stock department is the selection of the stock-keeper, who must be a high-grade man. This man who has charge of what may be the most valuable department in the plant should be above the ordinary employe as regards both ability and character, and one who is indifferent or incapable should not be retained. Furthermore, he should have sufficient capability to assume full control of his department.

By this it is not to be understood that the stock-keeper is to be allowed to adopt his own methods regardless of the prevailing policy of the management, but that he should be strong enough to fill his position without being constantly called upon to explain errors and accidents, as a man of this type would never be able to manage a department.

Locating Shop Officials. — In many manufacturing plants, especially of the larger sizes, there is some method of locating officials whose duties make it necessary for them to go to different departments. The most common method of locating such officials is by means of electric bells which are placed in various parts of the works. These bells merely serve to attract the attention of the official, who goes to the nearest telephone whenever his particular signal or call is heard. For instance, one ring might be the signal for the shop superintendent; two rings, the signal for the chief engineer, and so on. To avoid large numbers of rings, different combinations may be employed, such as one ring followed, after a slight pause, by two rings, etc. The ringing of these bells may be controlled by a telephone switchboard operator, either by means of an ordinary push-button, or by a mechanical device which repeats the signal automatically. An electrically-operated apparatus of the latter class which has proved effective is known as the "autocall." There is a central station located in the office which automatically transmits audible signals simultaneously throughout various rooms or departments of the plant, thus summoning any one of a number of men by means of a simple code. The controlling mechanism, or "central," automatically makes and breaks the signal circuit, thus causing the signals to sound. The signals are varied by means of a plug board similar to a telephone switchboard. In order to locate an official, the operator inserts the plug in a hole corresponding to that particular official's signal, and by giving the plug a quarter turn, a small electric motor is started. This motor drives a single revolving contact arm that engages various stationary contact fingers, and the desired call is sounded at all signal stations simultaneously, any desired number of times, at brief intervals. As the signals are being transmitted, a colored prism pilot light in the central station cabinet indicates to the operator that the system is in operation. Electric bells are ordinarily used in connection with this apparatus, but either electric horns or air or steam whistles may be installed. In structural steel shops, boiler shops, etc., where there is so much noise that bells might not be heard, the air or steam whistle is used, the former being preferable. If compressed air or steam is not available, electric-horn signals may be substituted.

Another method of signaling is by means of colored lights and numbers. In each department, there is a board having different numbers for every important official, and beneath each number there is a colored light. When one of the lights is switched on by the switchboard operator, the number above that particular light shows what official is wanted. For instance, if the shop superintendent's number is 3, the various lights below No. 3 on each department board are switched on in case the superintendent is in some part of the works and he is wanted. As there is no audible signal, the light may, of course, be on without being seen by the proper official.

Shop Telephone System. — One of the many important time-saving devices developed within the past few years, which merits the careful attention of shop managers, is the automatic inter-communicating telephone. Its installation in a plant means that machine shop superintendents are no longer subjected to the many annoyances occasioned in the past by the crude methods of communication in use, such as unreliable hand-bells, buzzers, unsanitary speaking tubes, etc. The very nature of the modern machine shop organization with its various departments covering a large ground area demands that some quick method of communication be installed that will put every department in close touch with any and every other department. It should not be necessary for the foreman of, say, the milling department to go to the foundry to ascertain why certain castings required for a rush order have not reached him. His time is too valuable to be thus wasted. Again, the shipping department, located perhaps in a remote part of the works, should be in as close touch with the superintendent as the drafting-room just outside his office.

The automatic intercommunicating telephone, of which various forms are now on the market, brings all the departments of the modern machine shop in close touch with each other without involving charges for attendants. With its use, a higher standard of efficiency can be obtained, and almost all the benefits of personal interviews can be enjoyed without the necessity of leaving one's own department. Orders can be transmitted and received almost instantaneously, and many mistakes be avoided on account of the facility provided for readily securing directions and checking up doubtful information. The telephone should not be used to transmit orders of which a record is required. All such orders, requisitions, data, etc., should be transmitted in writing only; but the telephone can be made a most valuable means for explaining points not clear in written communications or which perhaps need modification in some detail to fit a certain condition.

Shop Directory. — The shop directory is being introduced into many of the highly organized systems of modern manufacturing establishments. In practice it constitutes a not unimportant adjunct to industrial management. To have the place of residence of every employe ready at hand must often prove a convenience. In case of fire, certain men might be needed immediately to furnish necessary information concerning the works. It may be the electrician whose services are required to do emergency work. A man may not report for work and it may be necessary to communicate with him. In giving out overtime work, men may be picked more judiciously, so that a minimum amount of hardship may result. There are occasions when the addresses of the men permit of using the mails for distributing literature or other mail matter.

The record goes further than mere residence. Something of the man's history is kept, whether he is married or single, and if he has children — information which is usually sought when it becomes necessary to reduce a working force. It is important to have a record of each man's usefulness as a workman, including the particular line of work at which he is employed, and also any other branch of work in which he has had experience. Where no such record exists — and few works have it — information concerning the workmen is frequently sought for various reasons and is gathered piece-meal, generally at the cost of some time and trouble. Occasionally it cannot be obtained. In large establishments, employing many men, there is no one with even general information concerning all the working force. The superintendent cannot keep track of more than the older employes; his information is usually only that which comes with long contact with his men in the routine of his duties. Each foreman knows his own men pretty well if he has been long enough in his position, but there are always new men of whom no one has much knowledge. When a foreman leaves, his successor has to learn the force all over again. It is safe to assume that few foremen, in large or small establishments, could give the house address of a quarter of their men. The information needed for the shop directory is not difficult to obtain, as blanks distributed for the men to fill out will gather the necessary details, and as new men are employed, each can fill out the same blank, and its contents be added to the general record.

CHAPTER III

GENERAL TOOL AND SUPPLY SYSTEM FOR LARGE PLANT

THE development of an efficient system for the purchase of tools and accounting for them after delivery to the shops is one of the difficult problems which the management of every large factory has to work out. There are various requirements to be fulfilled. In the first place, the men in all departments of the factory must be kept supplied with the tools and supplies needed to carry on their work. Second, the tools must be of the type and quality which will do the greatest amount of work for each dollar expended. Third, they must be purchased in a way that insures obtaining the most advantageous price. Fourth, a careful record must be maintained to see that they are not stolen or needlessly damaged. Fifth, accurate accounts must be kept of all tools delivered to each tool supply room in order that they may be charged up to the department using them, when worn out or broken.

After grasping the different phases of this problem, it will be evident that the man who can administrate the tool service department of a large factory must have a variety of qualifications. He must be systematic, for there are a multitude of details to attend to and records to maintain. It is important for him to be a trained mechanic in order to know which tools are capable of giving the greatest amount of service for each dollar spent, and he should possess a sufficient knowledge of accounting to see that all charges made against all departments and credits in favor of them are correct. The system used in the maintenance supplies and tool service department of the Cadillac Motor Car Co., Detroit, Mich., was worked out to meet the requirements of this company's factory, but it is capable of application, with slight modifications, in any large manufacturing plant.

Function of Tool Service Department. — Before entering upon a detailed description of the work of the maintenance supplies and tool service department, it will be well to know just what relation this department bears to the manufacturing departments of the factory. Briefly stated, it constitutes a central distributing station for all tools and supplies used in the performance of manufacturing operations on parts of Cadillac motor cars, although this department does not have jurisdiction over materials which enter into the construction of cars. The handling

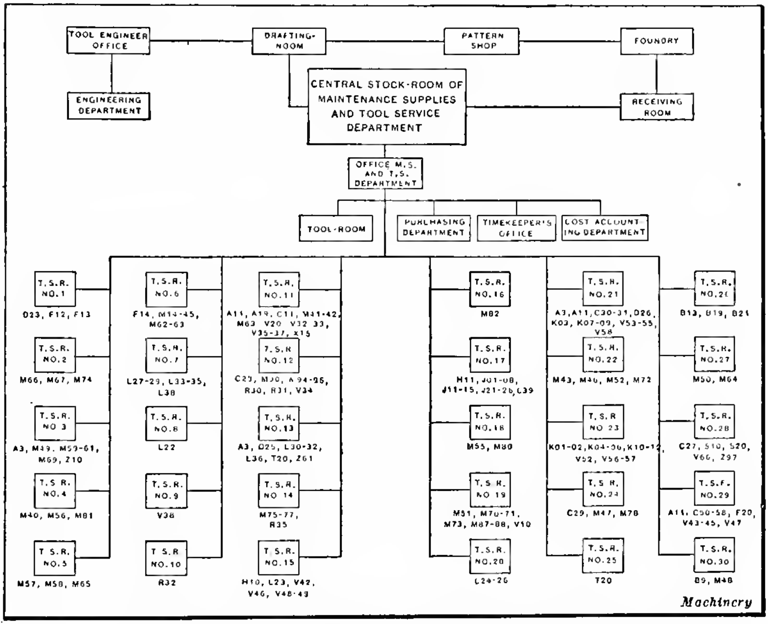


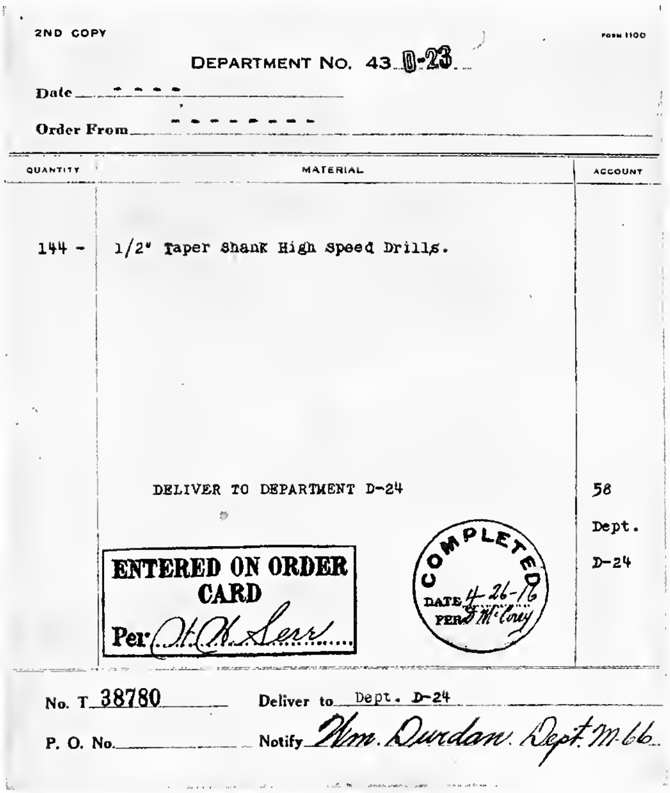
Fig. 1. Diagram showing Relationship of Maintenance Supplies and Tool Service Department to Other Departments of Factory of Cadillac Motor Car Co.

of tools and manufacturing supplies is only a part of the work of this department. In addition, it acts in an advisory capacity to the purchasing department by specifying the classes of tools and materials which are to be purchased. The head of the department is a trained mechanic and is able to order the type of tools or class of supplies which is best suited for the particular purpose to which it is to be put. The maintenance supplies and tool service department is held responsible for the quality of all tools and supplies which are delivered to the factory. For this purpose, it has a corps of inspectors in addition to a fully equipped chemical and physical laboratory; and all tools and supplies are either inspected or tested before being accepted, so that positive assurance is obtained that their quality is satisfactory. The relationship of the maintenance supplies and tool service department to other departments of the factory is shown diagrammatically in Fig. 1.

The material handled by the maintenance supplies and tool service department is divided into three general classifications as follows: 1. "Long-lived tools," which are understood to be tools which have a working life of considerable length. 2. "Short-lived or consumable tools," which is the name applied to a great variety of tools used for manufacturing purposes that are not capable of being used for any long period, drills, taps, dies, files, and hacksaw blades being typical examples. 3. "Manufacturing expense supplies," which include such materials as sand paper or lubricating oils.

How the System is Operated. — For the purpose of giving a detailed description of certain features of this system, assume that the foreman in one of the departments of the factory requires a number of tools of some type which has not been previously used in the factory. To obtain such tools he must make application to the maintenance supplies and tool service department for them, explaining for what purpose the tools are to be used. This application will be turned over to one of the inspectors of the department, who is a mechanic of wide experience, and it is the duty of this man to decide, first, whether the foreman has need of the tools for which he has made a requisition, and second, whether the tools which he specifies are those best suited for the purpose. If the inspector reports favorably on the foreman's application, the maintenance supplies and tool service department will issue a "T-requisition" for the purchasing department, authorizing the buying of a specified number of the tools in question.

In writing this T-requisition, use is made of the form shown in Fig. 2. Six copies are made out which are marked first copy to sixth copy, inclusive, but which are otherwise virtually the same, so that only one copy is illustrated. In the lower left-hand corner of the form there are places for a T-requisition number and a purchase order number, but an arrangement has recently been made whereby the " No. T." is used as the " P. O. No." At the


2ND COPY FORM 1100

DEPARTMENT No. 43 D-23

Date

Order From

QUANTITY	MATERIAL	ACCOUNT
144 -	1/2" Taper Shank High Speed Drills.	
	DELIVER TO DEPARTMENT D-24	58
		Dept.
		D-24

ENTERED ON ORDER CARD
Per H. H. Lerr

COMPLETED
DATE 4-26-16
PER J. McCoy

No. T 38780 Deliver to Dept. D-24

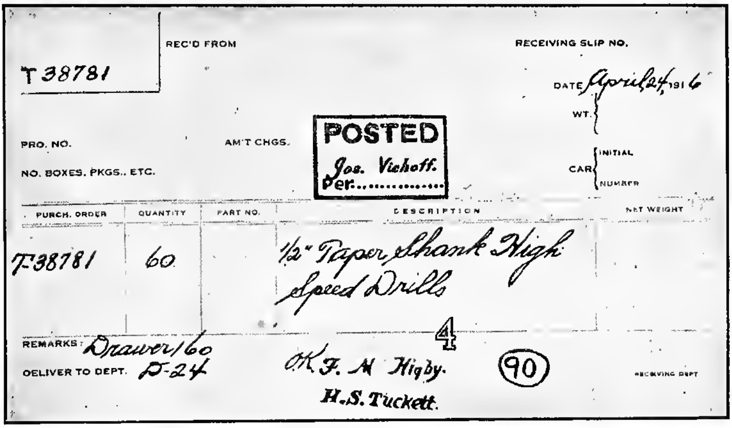
P. O. No. Notify Wm. Durdan. Dept. M-66

Fig. 2. Form used in authorizing Purchase of Tools and Maintenance Supplies

same time that the T-requisition is made out, an entry is made on a white order card, shown in Fig. 4, and the pink copy of the requisition is stamped "Entered on Order Card," to show that the order has been issued. This card also records the receipt of tools.

The use of the six copies of the T-requisition issued on the purchasing department is as follows: The first is sent to the purchasing department as authority to buy. The second copy is filed by the tool tracer in the maintenance supplies and tool service office on a file labeled "unfilled orders" until such time as the order has been completed, as explained subsequently. On the back of this copy the tool tracer records all correspondence, and notes progress being made in filling the order, which information is available to all interested parties. The third copy is held on the inspector's file until the tools are received, to serve as a notice that he has these tools to inspect, and after receipt and inspection of the tools the inspector's copy of the T-requisition is destroyed. The fourth copy is sent to the foreman of the department who ordered the tools to notify him that his order has been taken care of and will be filled in due course. It was stated that the form of all copies of the T-requisition is virtually the same, but in the case of the fourth copy which is sent to the foreman, information is given in regard to the clerks in the maintenance supplies and tool service department to whom written or telephone messages should be addressed in making any inquiries in regard to the tools in question. The fifth copy is given to the tool tracer whose duty it is to follow up the job represented by the T-order to be sure that satisfactory progress is being made in filling it. The sixth copy, which is sent to the cost accounting department, is filed by order number so that the invoice may be properly classified when the goods are received. For the drills called for on the order shown in Fig. 2, the invoice would be classified under account No. 58. The cost accounting department also makes out a cost card which is used for reference in pricing worn-out tools when they are released, as will be explained later.

Receipt of New Tools in the Factory. — At the time that the new tools are delivered to the factory, the receiving department makes out five copies of the receiving slip shown in Fig. 3, three of which are sent to the maintenance supplies and tool service department together with the goods. The first copy is signed and returned to the receiving department, where it is filed according to the date and the name of the firm which supplied the tools, serving as this department's receipt for the goods which it has sent out. The second copy is kept with the goods until they have been inspected. If they are found to be "O. K." and the copy of the receiving slip conforms with the inspector's copy of the T-requisition (Fig. 2), the receiving slip is signed by the inspector and attached to the inspector's copy of the T-requisition. These slips, together with the tools, are then sent to the stock-room where the balance in stock is added to the quantity received, and noted on the receiving slip, as indicated by the 90 in a circle in Fig. 3. This is used as a check against the balance which appears on the stock card. The stock-keeper then signs


T 38781
REC'D FROM
RECEIVING SLIP NO.
DATE April 24, 1916
WT.
PRO. NO.
AM'T CHGS.
POSTED
Jos. Viehoff.
Per..............
NO. BOXES. PKGS., ETC.
CAR INITIAL NUMBER

PURCH. ORDER	QUANTITY	PART NO.	DESCRIPTION	NET WEIGHT
T-38781	60		1/2" Taper Shank High Speed Drills	

4
REMARKS: Drawer 160
DELIVER TO DEPT. D-24
OK F. M. Higby.
H. S. Tuckett.
90
RECEIVING DEPT

Fig. 3. Form used by Receiving Department for Recording Receipt of Tools and Supplies

the receiving slip and notes the location of the tools in the stock-room under the space provided for remarks; and this second copy of the receiving slip, together with the inspector's copy of the T-requisition, is then handed to the tool tracer to notify him that the tools have been delivered to the stock-room. The tool tracer destroys the inspector's copy, attaches the pink copy to the receiving slip, and hands them to the file-record clerk, who is then ready to close the order card, Fig. 4, and make the proper notations on the stock card, Fig. 5. He then stamps the receiving slip "Posted" and files it by the T-requisition number. The third copy of the receiving slip goes to the foreman of the department for which the tools were ordered, to notify him that these tools are in the stock-room. The pink copy of the T-requisition is stamped " Completed " and filed by the T-requisition number for future reference.

How Different Classes of Supplies are Identified. — For the purpose of keeping accounts, each different class of tools or maintenance supplies is charged to a different account, and these accounts are all designated by numbers. Fig. 4 shows the card on which the order is entered at the time that a T-requisition is sent to the purchasing department, authorizing it to buy the

NAME Drills — DESCRIPTION Taper Shank, High Speed — ACCT. NO. 58 — SIZE 1/2"

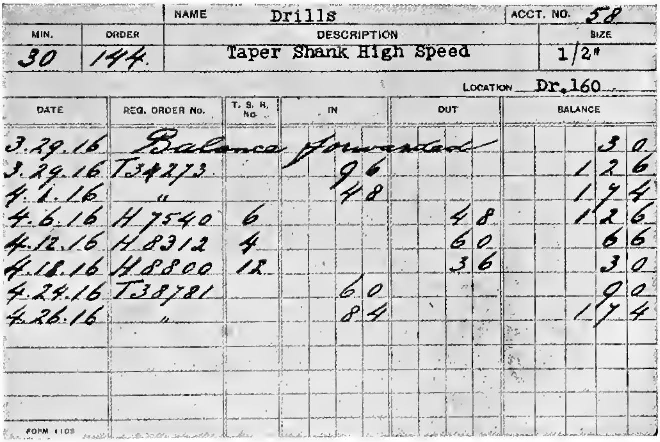
DATE	SENT TO DEPT.	REQ. NO.	ORDERED	RECEIVED	BAL. DUE
- - -		T-38781	144		
4-24-16	D24	"		60	84
4-26-16	"	"		84	0

Form 1107

Fig. 4. Card for Recording Order and Receipt of Tools and Supplies

supplies called for. The order card has spaces at the top for entering the name, description, and size of the tool, and the account number to which it is to be charged; the lower part of this card provides spaces for noting the dates on which the tools are received, the T-requisition number which goes in the column headed " Req. No.," the number ordered, number received, and the balance due. The column headed " Bal. Due " is filled out in cases where a considerable number of tools are ordered and where the immediate necessity for these tools makes it advisable to have them delivered in installments. In any case, this card shows the condition of the last order issued for tools of the particular type to which it refers.

The stock card, Fig. 5, has two spaces on the left marked "Min." and "Order." This refers to the number of tools of this kind which must always be kept in stock, and when the number has been reduced to this minimum, it means that an order must immediately be issued for the necessary number to bring the supply on hand up to the maximum quantity. It will also be noted that the location of this particular tool in the tool stock-room is entered beside the heading "Location." The arrangement of the card will be self-evident with the exception of the columns headed "In," "Out," and "Balance." Each time



		NAME Drills	ACCT. NO. 58
MIN.	ORDER	DESCRIPTION	SIZE
30	144	Taper Shank High Speed	1/2"
			LOCATION Dr.160

DATE	REQ. ORDER No.	T. S. R. No.	IN	OUT	BALANCE
3.29.16	Balance forward				30
3.29.16	T34273		96		126
4.1.16	"		48		174
4.6.16	H7540	6		48	126
4.12.16	H8312	4		60	66
4.18.16	H8800	12		36	30
4.24.16	T38781		60		90
4.26.16	"		84		174

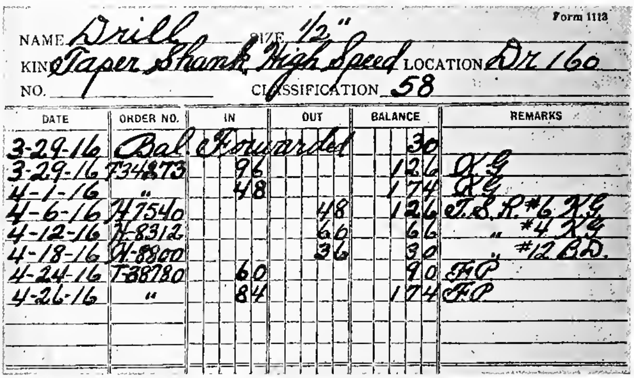
FORM 1103

Fig. 5. Card used for Recording Amount of Stock on Hand in Central Supply Room

new tools are delivered to the stock-room, the number received is recorded in the "In" column, and, similarly, each time tools are sent out to one of the tool supply rooms, the number sent out is recorded in the "Out" column. By adding to or deducting from the previous balance number, the existing balance on hand is found and recorded in the column provided for that purpose.

A record of receipt is made on the stock card shown in Fig. 5 at the time the tools are delivered to the stock-room. The order and stock cards are kept in filing cabinets in the office of the maintenance supplies and tool service department. At the time that the receipt of new tools is recorded on the stock card, a corresponding entry is made on a stock bin card, shown in Fig. 6. Cards of this type are held in clips on each of the bins, and contain a record of the number of tools in the bin. The records on these cards also serve as a check on the records of the balance which appears on the stock cards. The manner in which this card is filled out will be evident from the description of the stock card.

How the Foreman Proceeds in Ordering Tools. — The maintenance supplies and tool service department has a central stock-room to which all new tools and supplies are sent at the time they are delivered to the factory; and distributed around the plant



Form 1113

NAME Drill SIZE 1/2"

KIND Taper Shank High Speed LOCATION Dr 160

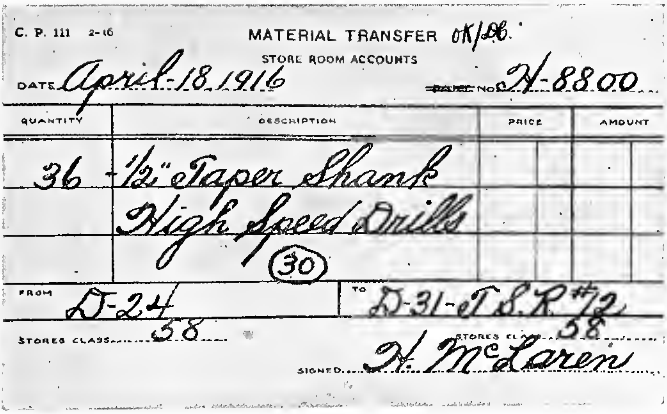
NO. 1 CLASSIFICATION 58

DATE	ORDER NO.	IN	OUT	BALANCE	REMARKS
3-29-16	Bal. Forwarded			30	
3-29-16	T34873	96		126	K.G.
4-1-16	"	48		174	K.G.
4-6-16	H7540		48	126	T.S.R. #6 K.G.
4-12-16	H-8312		60	66	" #4 K.G.
4-18-16	H-8800		36	30	" #12 B.D.
4-24-16	T-38780	60		90	F.P.
4-26-16	"	84		174	F.P.

Fig. 6. Bin Card used to Record Number of Tools in Bins

are a number of sub-departments known as " tool supply rooms " which act as middlemen in the transfer of tools from the main stock-room to the different departments of the factory. The men in the factory go to the tool supply rooms for anything they need; and when the attendant finds that his stock of any tool is running low, which seldom happens due to automatic replacement each week of broken and worn-out tools, he sends up to the central stock-room for more. In making requisition for supplies, use is made of the form shown in Fig. 7, which is made out in duplicate and sent up to the maintenance supplies and tool service department by a messenger. Both copies are handed to one of this department's inspectors, who passes upon the propriety of the requisition, and if found O. K., sends it to the stock-room where an order number is assigned to the delivery of tools, after which the proper entry is made on the bin card and the tools called for are handed to the messenger who takes them back to the tool supply room.

At the time that the tools are removed from the bin, a proper entry is made on the card held in the clip on this bin to show the balance which still remains on hand; and the requisition slip is stamped " Filled " on back. The first copy of the requisition is sent on to a requisition clerk who enters the item in the " requi-


C. P. 111 2-16

MATERIAL TRANSFER OK/

STORE ROOM ACCOUNTS

DATE April 18 1916 NO. H-8800

QUANTITY	DESCRIPTION	PRICE	AMOUNT
36	1/2" Taper Shank		
	High Speed Drills		
	30		

FROM D-24 TO D-31-T.S.R. #72

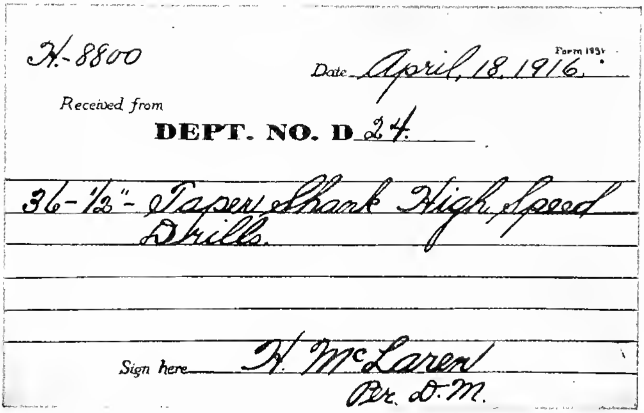
STORES CLASS 58 STORES CLASS 58

SIGNED H. McLaren

Fig. 7. Form used by Foreman in making Requisition for Tools and Supplies

sitions filled " book. This book is maintained to be sure that all requisitions are properly accounted for, and does away with the possibility of lost requisitions. One copy of the requisition goes to the file-record clerk to make the proper entry on the stock card and figure the balance on hand; and finally, the requisition slip goes to the cost accounting department, where the proper adjustment of accounts is made and the slip filed by its order number. The number 30 with a circle drawn around it, on the slip shown in Fig. 7, represents the number of tools that remain on hand after the order has been filled. When the slip reaches the file-record clerk, he calculates the balance on hand from the data on the stock card, and the balance obtained must agree with the number on the requisition slip; otherwise an investigation will be instigated to determine the cause of the discrepancy.

When the tools are given to the messenger to take to the tool supply room, a list of the tools is made on the form shown in Fig. 8, to which has been assigned the same order number as shown on the requisition, and the messenger signs this form with the name of the foreman of the tool supply room to which the tools are going, together with his own initials. This form is filed in the maintenance supplies and tool service office by requisition number and serves as a receipt for the tools that have been sent


H-8800

Date April 18, 1916.

Received from

DEPT. NO. D 24

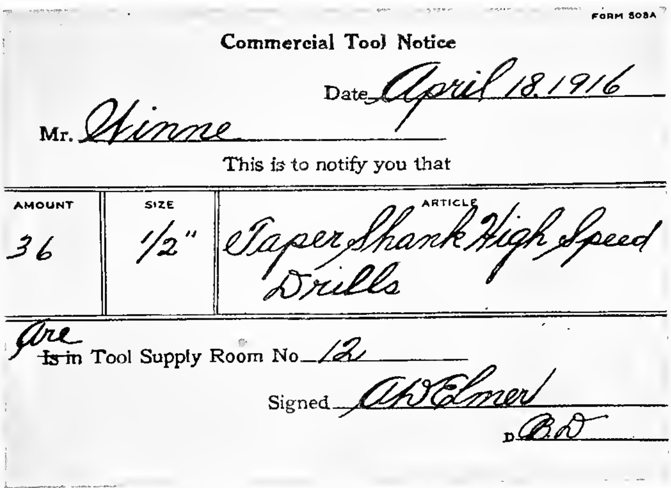
36-1/2"- Taper Shank High Speed Drills.

Sign here H. McLaren Per. D.M.

Fig. 8. Form used by Messenger in signing Receipt for Tools or Supplies sent to Tool Supply Room

out. At the time the tools are sent from the central stock-room to the tool supply room, a slip of the form shown in Fig. 9 is made out and sent to the foreman to notify him that the tools he needs are in his tool supply room ready to be drawn out on the workmen's tool checks. When tools are received in the tool supply room they are entered in a book known as the "incoming commercial tool" book, which shows the date received, requisition number, quantity and description of the tools, and contains spaces to be used by the tool supply room man and clerk for checking when cards are put in the card file and spaces assigned on the check board.

The second copy of the requisition slip, Fig. 7, goes to the tool supply room record clerk who makes an entry on cards of the form shown in Fig. 10. These cards are made out in duplicate on red and white stock; the white copy is filed in the maintenance supplies and tool service department and the red copy, in the tool supply room. On the day following the delivery of the tools, the second copy of the requisition slip is taken to the tool supply room, where the entry is made on a card, Fig. 10, to record delivery of the tools to the tool supply room. At the same time, the clerk checks the "incoming commercial tool"


FORM 808A

Commercial Tool Notice

Date April 18 1916

Mr. Winne

This is to notify you that

AMOUNT	SIZE	ARTICLE
36	1/2"	Taper Shank High Speed Drills

Are ~~Is~~ in Tool Supply Room No. 12

Signed A W Elmer

D BD

Fig. 9. Form used by Central Stock-room in notifying Foreman of Delivery of Tools to His Tool Supply Room

book to show that the proper entry has been made on the card, Fig. 10. Later the man who has charge of the check boards also checks the book to show that a space has been assigned to the tools on the check board.

Report to the Office. — On the day after the tools are sent from the central supply room to one of the tool supply rooms, a clerk takes the second copy of the tool supply room foreman's requisition slip and makes an entry on the card file in the tool supply room. The man in charge of the check board also sees that a space has been provided for the tools so that they may be checked out to a workman. Similarly, if tools are removed permanently, the tool supply room records must show that such tools are no longer available. Each tool that goes out of a tool supply room is entered in a book known as the " outgoing commercial tool " book which shows the date on which the tools were removed and the quantity and description of the tools, together with spaces to be used by the clerk to check when removing cards, check-board man to check when check board has been corrected, and tool supply room man to cross-check when book and work are O. K. Once a week the books of each tool supply room are gone over by the man in charge to see that they are

Form 1112

NAME Drills SIZE 1/2"

KIND Taper Shank High Speed LOCATION T. S. R. #12

DATE	ORDER NO.	IN	OUT	BALANCE	REMARKS
4-18-16	H-8800	36		36	H. M.

Fig. 10. Card used for Recording Transfer of Tools and Supplies from Stock-room to Tool-rooms

checked up to date. In reporting conditions found in each tool supply room, he uses the form shown in Fig. 11. The form used for this purpose provides a space for the number of the tool supply room to which the report refers, and spaces for the date and the signature of the tool supply room man. In the space on the form, information is given concerning the order number and the number of tools, with their size and description, after which a check-mark is placed in one of the three vertical columns at the right to show if a tool has been sent out without being credited, if it has come in without being charged, or if no space has been provided on the check board for the tools in question. In each case, the date is recorded in the column at the extreme right.

Examining Records to Guard Against Shortage. — A minimum number is assigned to each class of tools and supplies, and recorded on the stock card in the space assigned for that purpose.

Form 1452

TOOL SUPPLY ROOM No. 25

Report of Commercial Tools for week ending April 8th, 1916

Signed H. D. Balmer

Order No.	Amount	Size	Name of Tool	Not Charged	Not Credited	Not On Board	Date
H8310	2	#10	Star Hack-saw frame	✓		✓	4-1-16
H8400	4	1/4"	Solid Hand Reamer	✓		✓	4-3-16

Fig. 11. Form used by T. S. R. Foreman for Recording Conditions of Files and Check Boards in Tool Supply Rooms

FORM 1846

No. 2852 NOTICE TO ORDER STOCK

T-38781

INSPECTOR'S REPORT April 18-1916

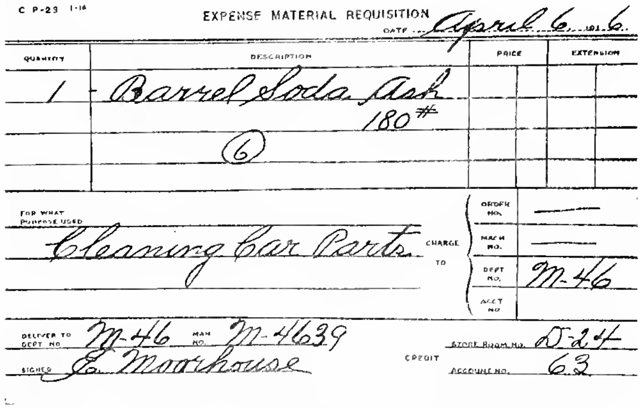
ORDER AMOUNT	SIZE	ARTICLE	AMOUNT IN STOCK	MIN AM'T	AM'T ON HAND	CHANGE MIN AM'T TO	CHANGE ORDER AM'T TO
144	1/2"	Taper Shank High Speed Drills	30	30	30	—	—

LOCATION Drawer 160 SIGNED A. C. Carramore

INSPECTOR L. L. Haskins.

Fig. 12. Form used by Inspector in calling for the Purchase of Additional Supplies

When the file-record clerk, in the course of making deduction for tools sent out, finds that any article has reached the minimum amount, he fills out the form shown in Fig. 12, one copy of which is passed to the inspector to determine whether or not the article is to be reordered. His knowledge of conditions in the factory is such that he can anticipate requirements and thereby control maximum quantities to carry in stock. If he finds that an order should go through, he O. K.'s his copy of the form shown in Fig. 12, and hands it to one of the stenographers to make out a form, Fig. 2, authorizing the purchasing department to buy more articles of this particular class. The form shown in Fig. 12 is made out in triplicate; the first copy is used by the stenographer, as previously mentioned, and is finally filed



C P-23 1-16

EXPENSE MATERIAL REQUISITION

DATE April 6 191 6

QUANTITY	DESCRIPTION	PRICE	EXTENSION
1	Barrel Soda Ash 180#		
	(6)		

FOR WHAT PURPOSE USED Cleaning Car Parts

CHARGE TO: ORDER NO. —— MACH NO. —— DEPT NO. M-46 ACCT NO.

DELIVER TO DEPT NO. M-46 MAN NO. M-4639

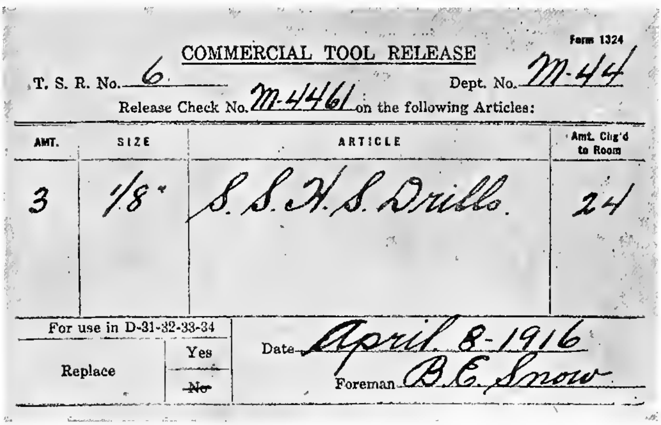
SIGNED E. Moorhouse

CREDIT: STORE ROOM NO. D-24 ACCOUNT NO. 63

Fig. 13. Form used by Foreman in making Requisition for Manufacturing Expense Supplies

by the T-order number, which is written on the form shown in Fig. 2. The second copy is held by the record clerk until the T-order has been written, after which it is destroyed. Before the first copy is filed, it is attached to the T-order form which has just been made out, and sent to the record clerk who makes the necessary entry on the order card shown in Fig. 4. The third copy of the form shown in Fig. 12 is sent to the stock-room for the purpose of checking the balance recorded on the stock card against the number of tools actually in the bin, in order to be sure that these two coincide. The third copy is then returned to the office and filed by its card number " 2852 " for reference.

Obtaining Supplies from Central Stock-room. — The materials used in the factory which come under the classification "manufacturing expense supplies," or supplies which are rapidly consumed, are ordered from the central stock-room on requisition slips of the form shown in Fig. 13. This slip provides for giving a description of the material, amount used, and cost, together with the purpose for which the material is to be used. Spaces are provided on this card for crediting the central stock-room with this amount of material and charging it against the department



Form 1324

COMMERCIAL TOOL RELEASE

T. S. R. No. 6 Dept. No. M-44

Release Check No. M-4461 on the following Articles:

AMT.	SIZE	ARTICLE	Amt. Chg'd to Room
3	1/8"	S. S. H. S. Drills.	24

For use in D-31-32-33-34

Replace Yes ~~No~~

Date April 8-1916

Foreman B. E. Snow

Fig. 14. Form used by Foremen in giving a Release for Tools which have been broken or worn out

in which it is actually to be used. Before any manufacturing expense supplies can be sent out from the central stock-room, the requisition must be O. K.'d by the inspector and an order number must be assigned by the stock-room for purposes of identification. When the requisition is filled, the messenger signs a receipt for it, as in the case where an order is filled for tools, the form shown in Fig. 8 being employed for this purpose. The transaction is entered on the requisition record book by order number and the requisition slip, Fig. 13, is sent to the stock record clerk for adjustment of the stock cards, and then to the cost accounting department, where the proper adjustment of the accounts is made to cover the transaction.

Weekly Replacement of Worn-out and Broken Tools. — If a man has a tool out on check and breaks the tool or wears it down to a point where he finds that it is no longer giving satisfactory service, he takes the tool to the foreman of his department and gets him to sign a tool release slip which will enable him to return the damaged or worn-out tool to the tool supply room and obtain another tool or his check in exchange for it. For the purpose of releasing tools in this way, the foreman makes use of the form

FORM 1706

REPLACEMENT
FOR USE IN DEPT. D-23 ONLY

T.S.R. 6 WEEK ENDING April 6, 1916
DEPT. M-44 PAY PERIOD ENDING April 4, 1916

Amount Charged to T.S.R.	Amount Due T.S.R.	Shortage	Balance in Stock	Stock Keeper's Check	Size	Article	Amount Sent to T.S.R.	Remarks
18	6	0	180	✓	5/16 x 18	Cad. Std Plug Taps	6	
70	12	0	140	✓	1/4"	C.S. H.S. Drill	12	
12	4	0	28	✓	3/8"	Solid Hand Reamer	4	
18	8	0	40	✓	13/16" #9	R.H. H.S. Solid End Mill	8	

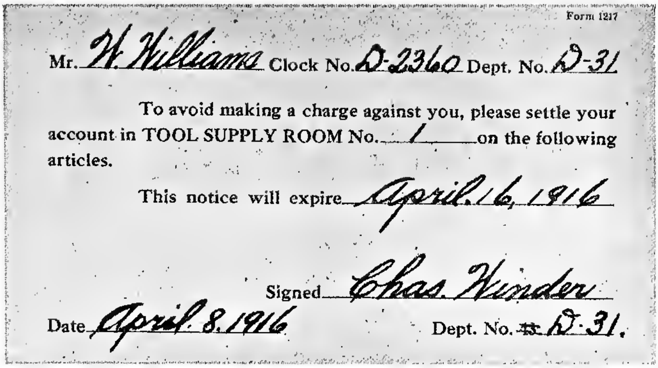
OK L.L. Haskins

SIGNED D. B. McAdam
POSTED BY A. C. Carramore PER J. R. Graham

Fig. 15. Form used by Tool Salvage Department of Central Stock-room in making an Alphabetical List of Broken or Worn Tools

shown in Fig. 14, and when this form is turned in, an investigation is conducted to see if the supply of this particular kind of tool has been reduced to a point where more should be ordered. This work is done by the foreman of the tool supply room, and after he has reached a decision he draws his pencil either through the word "yes" or "no," leaving an affirmative or a negative to express his decision in regard to the necessity of replacement. These damaged tools, together with the foreman's release slips, are placed in a box in the tool supply room, and once a week an inspector goes around to look them over and decide whether or not the damage in each case is of a nature which justifies discarding the tool. In doing this work, use is made of the replacement checking list. The name of the inspector and the foreman of the tool supply room and the name and size of each tool which is found to be damaged beyond repair is entered on this list.

The tools are then sent to the tool salvage department of the central stock-room and an alphabetical list of the tools is made out from the slips, the form shown in Fig. 15, which is made out in triplicate, being used for this purpose. The first copy is a record


Form 1217

Mr. W. Williams Clock No. D-2360 Dept. No. D-31

To avoid making a charge against you, please settle your account in TOOL SUPPLY ROOM No. 1 on the following articles.

This notice will expire April 16, 1916

Signed Chas. Winder

Date April 8, 1916 Dept. No. ~~13~~ D-31.

Fig. 16. Form used by Tool Supply Room in calling upon Workmen for Settlement of Tool Accounts

for the files of the maintenance supplies and tool service department; this is also used in making a replacement of tools in the tool supply room or crediting the room with the number of tools which are not replaced. This first copy is given to an inspector for his O. K., and then it goes to the stock-room foreman, who looks after sending out tools to replace the broken ones; then it is sent to the record clerk in order that the card in his file and the tool supply room card, both of which are of the form shown in Fig. 6, may be corrected for any tools that may not have been replaced. This first copy is then filed in the maintenance supplies and tool service department by order number. The second copy is returned to the tool supply room, where it is checked against the original list to see that the tool supply room has received tools to replace those sent out in a broken or damaged condition. The third copy goes to the cost accounting department in order that the stock-room may be credited with the tools and a corresponding charge made against the department in which they were broken.

If the foreman of one of the tool supply rooms has reason to believe that any man in the factory has checks representing tools which he has broken or lost, it is the privilege of the foreman of the tool supply room to call upon the man for a settlement of his

DEPT. 43-H.—COMMERCIAL TOOL SUB-DIVISION

ISSUE SHIPPING ORDER — YES — ~~NO~~ DATE April, 5th, 1916.

Ship and Charge to T. N. Warren

City Detroit State Mich.

Street and No. 48 Forsythe Ave.

TOOL NAME	SIZE	QUANTITY	PRICE EACH	AMOUNT	CLASSIFICATION	REMARKS
Cad. Std. Tap	5/16 x 18	2			58	Dept D-24

Checked by L. L. Haskins Signed A.W. Elmer

ORIGINAL PARTS SERVICE DEPT. COPY

Fig. 17. Form used in authorizing Shipment of Tools for Use on Work done Outside of Factory

tool account. For this purpose, use is made of the form shown in Fig. 16. This practice of calling upon the men for an accounting at any time tends to avoid disputes.

Records of Tools Lent to Outside Firms. — The Cadillac Motor Car Co. follows the rather general practice of having certain classes of work done by outside concerns in order to benefit by the experience of specialists in unusual lines of manufacture. This is particularly true of certain classes of special tool work, and for handling such work it is occasionally found necessary to lend tools to these outside firms. Of course it is necessary to keep a record of tools which have been sent out this way, and such a record is maintained by issuing the form shown in Fig. 17. The upper part of the card is provided with spaces for the date and for the complete name and address of the firm to which the tools are to be shipped. The lower part of the form has spaces for descriptions of the tools; for the number to be shipped; and for the price, total value, and classification of each kind of tool. After making out the order, it is checked by an inspector to see that everything is correct, after which the form is sent to the head of the maintenance supplies and tool service department for his signature. The form is made out in triplicate, the first copy being sent to the manufacturing sales department, which looks after dispatching the tools to their destination and rendering the invoice, the second copy is held in the maintenance supplies and tool service department until the tools are returned, and the third copy is sent to the firm that does the work. If the tools are "O. K." when returned, they are put in stock and credit is given to the firm that returns them.

Repair of Commercial Tools. — It will be recalled that, when a workman damages a tool or wears it down so that he considers its use is no longer feasible, he takes the tool to his foreman and gets him to sign a tool release slip for it, which he turns in to the tool supply room with the tool in order to obtain his tool check or a new tool, as the case may be. It will also be remembered that at the end of each week these tools are gone over by the inspector and the foreman of the tool supply room, to decide whether or not they have been worn down so that they are no longer fit for service. Some of these tools may be considered capable of giving an additional amount of service after certain repairs have been made on them, and such tools, together with the tools that have been slightly damaged in the shops, are sent to the tool-room to be put back into condition for future service. The making of such repairs involves keeping a record for several purposes. In the first place, the tool supply room must know what tools have been sent out and when these tools should be returned; care must be taken to see that all tools sent out for repairs are finally returned. It is also necessary to give the tool-room instructions as to the nature of the repair that is required, and to keep a record of the cost of the work. For this purpose, the form shown in Fig. 18 is employed. There is a notation "Charge Time and Material to Order No. 63920," which is a blanket order number that is applied on all jobs involving the repair of commercial tools against the department which uses the tools.

Five copies of this form are made out, the uses of which are as follows: The first copy is sent to the maintenance supplies and tool service department with the work, where it is filed by the department order number. The second copy also accompa-


Form 1496

T. S. R. Commercial Tool Repair Order

Charge Time and Material

To Order No. 63920 Date April 6. 1916

From T. S. R. No. 6 To Dept. No. D. 28

Amount 1 Name Hack-saw frame

Remarks: Supply new handle

W. G. Winters Transfer Clerk R. M. Bacon

T. S. R. FOREMAN

Used in Dept. No. M-44 Per F. Irving

FILE RECORD COPY

Fig. 18. Form used by Tool Supply Room in ordering Repair of Commercial Tools

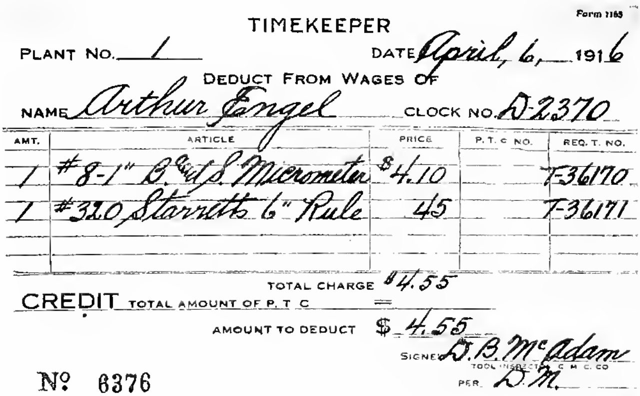
nies the work and goes on to the tool-room, where it is filed as a record of the work which the tool-room did on this particular job. The third copy accompanies the work as far as the office, where it is held during the time that the job is in the tool-room; it simply serves as a reminder to the office that this work is being done and must be looked after to see that it is put through with the customary dispatch. The fourth copy is a receipt that is given to the tool supply room for the tools which they have sent out to be repaired; this copy is sent with the work to be signed by the transfer clerk in the maintenance supplies and tool service department, and is then sent back to the tool supply room, where it is filed until the article has been returned. The fifth copy, which is merely a memorandum of the transaction held by the tool supply room, is destroyed as soon as the receipt is returned.

Twice a month a report is sent to the office of the maintenance supplies and tool service department showing the condition of each tool supply room as regards the tools which have been sent out to be repaired. The upper part of the form used is similar to the one shown in Fig. 11, while the lower space provides columns for a complete description of the tools in question, the number which were sent out to be repaired, and the date of the receipt card for the tools which was sent down to the tool supply room at the time they were received in the tool-room. This report constitutes a check on the work of the tool-room in making repairs, and the distinction between its function and that of the weekly reports of the records kept by the tool supply room foreman should be carefully noticed.

In conjunction with a discussion of the question of handling worn-out and damaged tools, the following description of the method of dealing with files is particularly important, owing to the rapidity with which this type of tool is used up. As in the case of other classes of commercial tools which are worn out, any workman in the shop who finds that his file has been worn down so that it will no longer give efficient service is required to take the file to the foreman of his department and get an order for the exchange of the worn-out file for a new one. For this purpose, use is made of a form which specifies the number, size and type of file which is to be given to the bearer; use is also made of this form when the man has occasion to draw out a new file from the tool supply room.

Buying Tools for Employes. — Every manufacturer recognizes that it is good policy to encourage employes to provide themselves with a good set of tools. The Cadillac Motor Car Co. makes a practice of purchasing any tools which employes need in order that the men may take advantage of the company's wholesale rates from tool manufacturers with whom it has regular dealings. The cost of these tools is deducted from the workman's pay, and for making this adjustment use is made of the form shown in Fig. 19. The form has spaces for the plant number in which the man is employed, the date, and the name and time-clock number of the employe. Below are noted the tools which he has purchased and the price. The form is made out in triplicate; the first copy is sent to the timekeeper for deducting the proper amount from the employe's pay; the second copy is sent to the employe in order that he may check up the deduction; the third copy is filed by the maintenance supplies and tool service department as a record of the tools purchased for the account of employes.

Market Prices and Grades of Materials. — An important factor in the purchasing of maintenance supplies is the placing



Form 1165

TIMEKEEPER

PLANT NO. 1 DATE April 6, 1916

DEDUCT FROM WAGES OF

NAME Arthur Engel CLOCK NO. D-2370

AMT.	ARTICLE	PRICE	P. T. C NO.	REQ. T. NO.
1	#8-1" B.&S. Micrometer	$4.10		T-36170
1	#320 Starrett's 6" Rule	45		T-36171

TOTAL CHARGE $4.55

CREDIT TOTAL AMOUNT OF P. T. C =

AMOUNT TO DEDUCT $4.55

SIGNED D. B. McAdam
TOOL INSPECTOR C. M. C. CO
PER D. M.

№ 6376

Fig. 19. Form used to Charge Employes for Tools purchased for Them

of orders at such a time that advantage may be taken of the best possible price. In order to do this, it is necessary for the head of the department to keep closely in touch with the purchasing department on both present market conditions and the probable trend of the market. Should he see that the price of some commodity for which his plant has constant use is likely to advance, he will proceed to lay in a sufficient supply to last through the period during which producers may ask unusually high prices.

Another important feature is the ordering of the exact class of material best suited for the purpose to which it is put, and the examination of the material when received to be sure that it accurately fulfills specifications. To assist in this work the company maintains a fully equipped laboratory in which chemical and physical tests may be conducted to determine the nature of all supplies that are likely to be adulterated. The experience of these chemists has taught them to know just about what adulterants to look for, and in many cases surprising results have been obtained. For instance, one would hardly expect that the services of a chemist would prove of any great assistance in the purchase of sponges, but experience has proved the contrary to be the case. Sponges are bought at a specified price per pound, and tests conducted on sponges which failed to give satisfactory service revealed the fact that they had been loaded with glucose; as a result the weight indicated that a durable commodity was being obtained, but when the sponges were dipped in water it resulted in washing away the glucose and leaving a flimsy structure that had little durability.

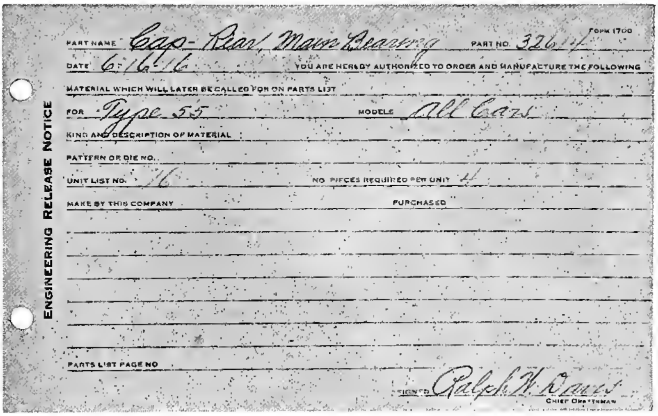
The accurate work of the chemical laboratory may be taken as typical of the entire service rendered by the maintenance supplies and tool service department. In its operation, nothing is left to chance; accurate methods have been devised; and the records of each transaction which are kept, aided by the multiple checks which are applied to be sure that the records are accurate, make the occurrence of errors a matter of extreme improbability. That the benefits resulting from the use of this system have paid many times over for the cost incident to its operation is shown by the reduction in expenditures for tools and maintenance supplies which is revealed by a comparison of inventories over a period of years.

CHAPTER IV

ORDERING, MANUFACTURING, DISTRIBUTING, AND ACCOUNTING SYSTEM FOR SPECIAL TOOLS

IN the preceding chapter, the general system of the Cadillac Motor Car Co. for controlling the purchase of commercial tools and supplies and of accounting for tools in various parts of the plant, was described. This chapter deals with the system used in the Cadillac plant in connection with the ordering, manufacturing, distributing, and accounting for special tools, such as jigs, fixtures, dies, etc. The problem of the maintenance supplies and tool service department in accounting for special tools is somewhat different from that used for standard commercial tools, although the basic problem is the same. As in the case of commercial tools, the point of primary importance is to see that all shops are kept supplied with the tools which they require without any delay in delivery. What was said in the previous chapter in regard to the work of the department in handling standard tools applies equally to the work of dealing with special tools, in so far as commercial considerations are concerned. The chief distinction between the work of the maintenance supplies and tool service department in handling special tools and commercial tools is that the former is largely a problem of manufacturing new tools, while the latter pertains to the purchase of tools under the most advantageous terms.

Procedure when Special Tools are Needed. — In order to explain the operation of the system, it will doubtless be the best plan to start from the point where the engineering department has approved the design of a part for an automobile of a new model, and has authorized the making of tools for use in its manufacture. The authorization of the engineering department for the making of all special tools is issued on one of the forms reproduced in Fig. 1. One copy is sent to the office of the tool engineer, accompanied by a set of drawings of the new car part, and it is his work to design all special tools which will be required in manufacturing this part. The first step taken by the tool engineer is to compare the new part with the car part which it supersedes, in order that use may be made of any special tools by making certain changes in their construction. The points governing the decision as to whether old tools are to be made over or whether it is necessary to design entirely new tools for the purpose are details of the work of the tool engineer which do not properly come within the scope of this chapter.


ENGINEERING RELEASE NOTICE

FORM 1700

PART NAME Cap-Rear, Main Bearing PART NO. 3261-1

DATE 6-16-16 YOU ARE HEREBY AUTHORIZED TO ORDER AND MANUFACTURE THE FOLLOWING MATERIAL WHICH WILL LATER BE CALLED FOR ON PARTS LIST

FOR Type 55 MODELS All Cars

KIND AND DESCRIPTION OF MATERIAL

PATTERN OR DIE NO.

UNIT LIST NO. 16 NO. PIECES REQUIRED PER UNIT 1

MAKE BY THIS COMPANY PURCHASED

PARTS LIST PAGE NO.

SIGNED Ralph H. Davis

CHIEF DRAFTSMAN

Fig. 1. Form used by Engineering Department in authorizing making of Tools for Use in manufacturing Car Parts of a New Model

In any case, a complete set of tool drawings is made, the method of procedure being for the tool engineer to study the part to be machined, decide upon the methods of machining to employ, and then make rough sketches of the tools which are followed by the draftsmen in making the final tool drawings. The decision as to whether new tools are to be made, or the construction of existing tools modified to meet the new requirements, will govern the procedure of the tool engineer in issuing orders for tool drawings. The form which he uses is shown in Fig. 2, and reference to this illustration will make it evident that provision is made for ordering new drawings or making changes in existing drawings by either crossing out the word "make" or "change," so that the order will meet the requirements of existing conditions.

The tool order is made out in quadruplicate. The first and second copies are sent to the drafting-room, and the first copy remains with the work until the tools have been completed. The second copy is a drafting-room memorandum which represents the authority of this department to make the tool drawings; and after such drawings have been completed the memorandum is filed for future reference. The third copy is the tool engineer's memorandum of the transaction; this copy is kept in his "drafting-room file" until the drawings have been completed,

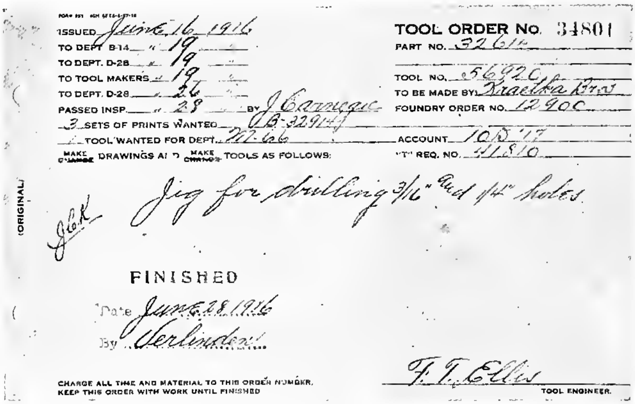
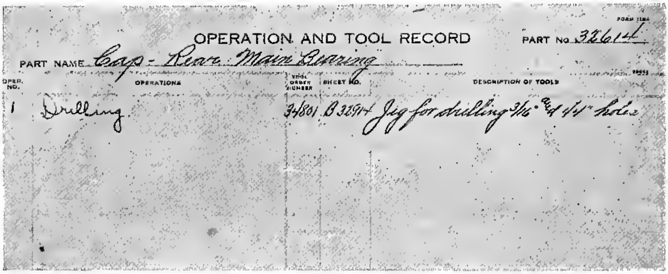

TOOL ORDER NO. 34801
PART NO. 32614
ISSUED June 16 1916
TO DEPT. B-14 " 19
TO DEPT. D-28 " 19
TO TOOL MAKERS " 19
TO DEPT. D-28 " 26
PASSED INSP. " 28 BY J Carnegie
TOOL NO. 56920
TO BE MADE BY Kraetka Bros
FOUNDRY ORDER NO. 12900
3 SETS OF PRINTS WANTED B-32914
TOOL WANTED FOR DEPT. M-66
ACCOUNT 105 17
MAKE CHANGE DRAWINGS AND MAKE CHANGE TOOLS AS FOLLOWS:
"T" REQ. NO. 41810
(ORIGINAL)
J.Co.K. Jig for drilling 3/16" and 1/4" holes.
FINISHED
Date June 28 1916
By Verlinden
CHARGE ALL TIME AND MATERIAL TO THIS ORDER NUMBER.
KEEP THIS ORDER WITH WORK UNTIL FINISHED
F. T. Ellis
TOOL ENGINEER.

Fig. 2. Form used by Tool Engineer in ordering Tool Drawings and Tools

after which it is transferred to the "tools being made file" until the work has been finished. The fourth copy of the tool order is sent to the office of the maintenance supplies and tool service department, where it is classified under the proper account; and the job is then entered on a list of tool order numbers with their classifications, which is sent to the time office for its guidance in classifying time tickets and material orders. The fourth copy of the tool order is then sent to the foreman of the department which will make the car part that requires the use of the special tool in its manufacture, this copy merely serving as a notice to the foreman that future tool requirements are being cared for.

When the tool engineer decides that a tool should either be made or changed for use in machining a certain part, and has written a tool order, an entry is made on a permanent record which is kept on cards of the form shown in Fig. 3. This form is laid out with spaces at the top for the number of the part that the special tools are used to manufacture, and the name of this part; the part number serves as the key by which the permanent record card is filed. The lower space on this form is laid out with sections for the operation numbers, the names of the operations, the tool order numbers on which the tools were made, the tool drawing numbers, and descriptions of the tools. This card represents an outline of the machining operations performed on the part in question, and is a list of all tools used in handling the



OPERATION AND TOOL RECORD PART NO. 32614

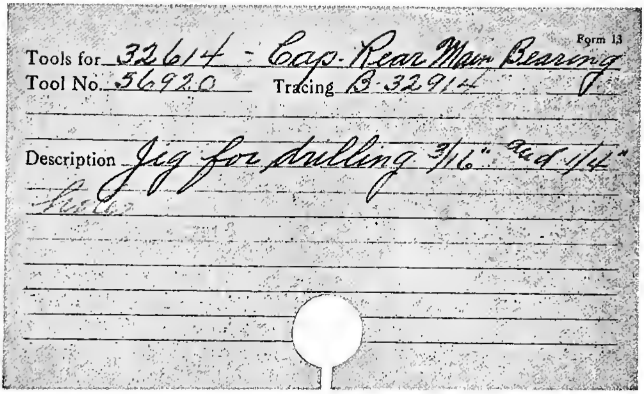
PART NAME Cap - Rear Main Bearing

OPER. NO.	OPERATIONS	TOOL ORDER NUMBER	SHEET NO.	DESCRIPTION OF TOOLS
1	Drilling	34801	B 32914	Jig for drilling 3/16" & 1/4" holes

Fig. 3. Form used by Tool Engineer in maintaining Permanent Record of Machining Operations and Tools on all Car Parts

work, so that, by referring to this permanent record, the tool engineer is able to give information in regard to all operations and tools which he has recommended for use in any given case. A similar record, although less complete than that kept by the tool engineer, is maintained by the drafting-room for the purpose of locating the tool drawings for tools used in manufacturing any given part. At the time the first and second copies of the tool order are received in the drafting-room, a card is made out for the drafting-room file on a form shown in Fig. 4. These cards are filed by the part number, so that tool drawings can be located without delay.

Ordering Patterns and Castings. — The making of such special tools as jigs and fixtures requires a variety of patterns and castings. Ordering these patterns and castings is part of the work of the drafting-room, the orders being issued as soon as a decision has been reached in regard to the final design of the tools. The form used by the drafting-room in ordering patterns and castings is shown in Fig. 5, five copies of this form being required. The first of these is a drafting-room copy which is kept in a temporary file until the patterns and castings have been completed, after which it is transferred to a permanent file where it is available for future reference. The second and third copies are sent to the pattern shop, and the first of these represents an order for making the patterns. The third copy is also kept in



Form 13

Tools for 32614 - Cap-Rear Main Bearing

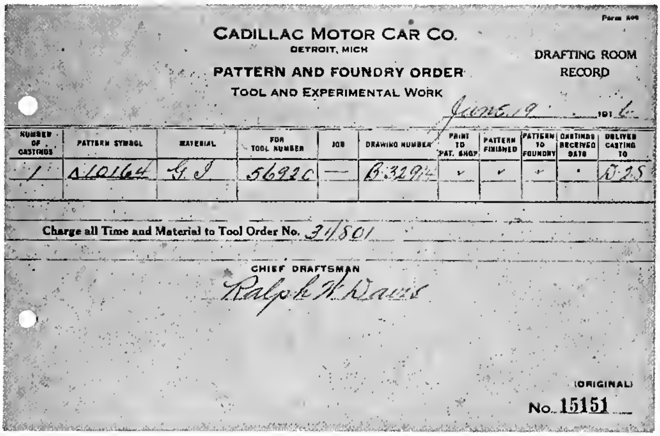
Tool No. 56920 Tracing B-32914

Description Jig for drilling 3/16" and 1/4" holes

Fig. 4. Form used by Drafting-room in keeping Record of Drawings and Blueprints of Tool Drawings

the pattern shop until the work has been completed, and at this time it is sent on to the foundry with the patterns, the form representing an order to the foundry to make the required castings. The fourth copy of the form is sent to the maintenance supplies and tool service department, where it is placed in a "current file" until the castings are received on a shipping order, after which they are delivered to the tool department. The fifth copy is sent to the tool-room, the purpose being to notify the foreman of this department that the castings have been ordered for making the tools; and as soon as the castings are received, the memorandum is destroyed.

Assigning Toolmaking Work. — When the necessary drawings for a tool order have been completed in the drafting-room, the first copy of the tool order, Fig. 2, is returned to the tool engineer, who decides who shall make the tools called for. When a decision has been reached, he makes a notation on the order form in the space provided for that purpose and forwards the form, accompanied by two sets of blueprints of the tool drawings, to the tool order clerk in the maintenance supplies and tool service department. The tool order clerk makes an entry in a "tool order" record book by order number, and also records the blueprint in a "blueprint" record book with a notation of the tool order number. The tool order book is ruled in such a way as to



CADILLAC MOTOR CAR CO.
DETROIT, MICH

PATTERN AND FOUNDRY ORDER
TOOL AND EXPERIMENTAL WORK

DRAFTING ROOM RECORD

June 19 191 6

NUMBER OF CASTINGS	PATTERN SYMBOL	MATERIAL	FOR TOOL NUMBER	JOB	DRAWING NUMBER	PRINT TO PAT. SHOP	PATTERN FINISHED	PATTERN TO FOUNDRY	CASTINGS RECEIVED DATE	DELIVER CASTING TO
1	A 10164	G. I	5692 C	—	B 3294	✓	✓	✓	·	D 25

Charge all Time and Material to Tool Order No. 31801

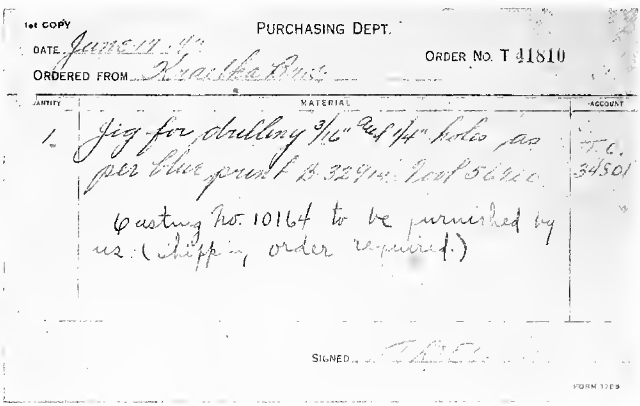
CHIEF DRAFTSMAN
Ralph W. Davis

(ORIGINAL)
No. 15151

Fig. 5. Form used by Drafting-room in ordering Patterns and Castings

provide spaces to show the tool order number, tool number, date on which the order was received by the maintenance supplies and tool service department, quantity required, foundry order number, blueprint number, purchase order number, if ordered from an outside firm, symbol number of car part on which tool operates, description of tool and by whom made, as well as date completed. The blueprint record book shows the sheet number of the blueprint with all order numbers pertaining to that print.

After the entries have been made in the tool order record book and the blueprint record book, the tool order, Fig. 2, with one complete set of blueprints, is turned over to a stenographer who writes a "T-requisition" on the purchasing department if the tool is to be ordered from an outside firm; and, in all cases, the stenographer makes a complete set of record cards to be used as permanent records when the tool has been completed, as outlined in detail later. This set of record cards consists of those shown in Figs. 11 and 13 to 20. These cards, with the exception of the one shown in Fig. 11, are filed in what is known as the "shop box file" and are cross-indexed by tool and part symbol numbers, until the tool has been finished, at which time they are dis-


1st COPY
PURCHASING DEPT.
DATE June 17 [illegible]
ORDER No. T 41810
ORDERED FROM [illegible]

QUANTITY	MATERIAL	ACCOUNT
1.	Jig for drilling 3/16" and 1/4" holes as per blue print B 32914. Tool [illegible]	T. C. 34501
	Casting No. 10164 to be furnished by us. (Shipping order required.)	

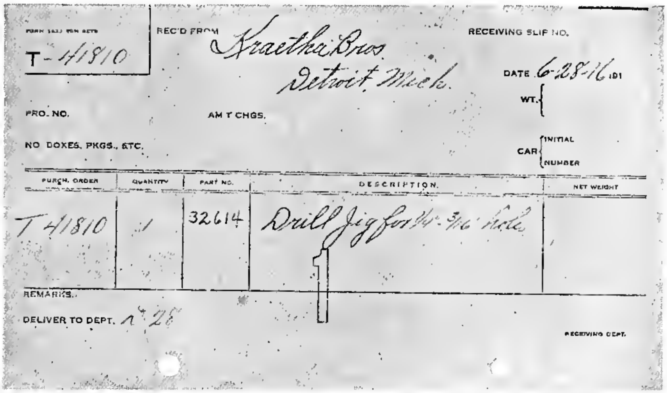
SIGNED [illegible]

FORM 1[illegible]

Fig. 6. Form used by Maintenance Supplies and Tool Service Department to Authorize ordering of Special Tools made by Outside Concerns

tributed to various permanent record files. The card shown in Fig. 11 is filed by the tool order number in what is called the "cost file," and all time, material and invoices pertaining to that particular tool order are posted thereon from time to time.

Ordering Tools made by Outside Shops. — The Cadillac Motor Car Co. has adopted the common plan of having certain classes of work done by outside shops, and some of the tool work is handled in this way. The variety of cases which are dealt with naturally introduces a number of different conditions, but it frequently happens that castings for a jig or fixture will be made in the Cadillac foundry, and these castings will then be sent out for use in making the required tools. For the purpose of discussion, this condition will be assumed in describing the method of procedure which is followed. In connection with the preceding chapter describing the practice in the purchase of standard commercial tools, it was mentioned that the maintenance supplies and tool service department has jurisdiction over all purchases of tools and other manufacturing supplies, the plan being for this department to make recommendations which are followed by the purchasing department in the actual issuing of orders. Assume that it is required to order an outside firm to make a jig for drilling $\frac{3}{16}$- and $\frac{1}{4}$-inch holes in a given part, and


T-41810
REC'D FROM Kraetha Bros Detroit Mich.
RECEIVING SLIP NO.
DATE 6-28-16 191
WT.
PRO. NO.
AM T CHGS.
NO. BOXES, PKGS., ETC.
CAR INITIAL NUMBER

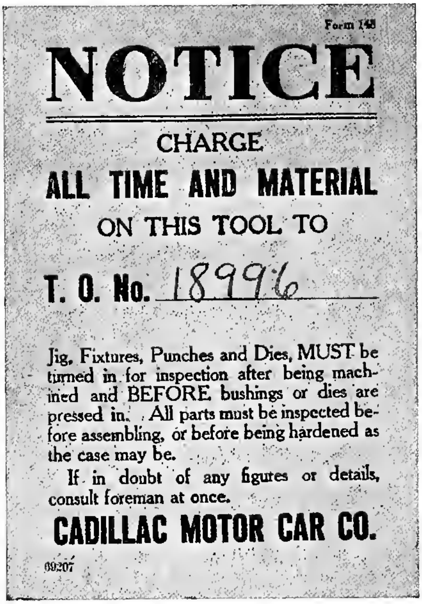
PURCH. ORDER	QUANTITY	PART NO.	DESCRIPTION	NET WEIGHT
T 41810	1	32614	Drill Jig for 1/4-3/16 hole	

REMARKS
DELIVER TO DEPT. No 28
RECEIVING DEPT.

Fig. 7. Form used by Receiving Department in recording Receipt of Tools from Outside Firms and Castings from Foundry

that the casting for this drill jig is to be furnished by the Cadillac company. The maintenance supplies and tool service department will proceed by issuing a " T-requisition " to the purchasing department, calling upon it to order this work done.

Fig. 6 shows the memorandum which is made out, and reference to this illustration will show that, in addition to a description of the tool required, a notation is also made of the fact that the casting is to be furnished by the Cadillac company. Five copies of this form are required. The first is sent to the purchasing department, where it is used in issuing a regular purchasing order. The second copy is held in a " temporary file " on the desk of the tool order clerk in the maintenance supplies and tool service department, and, when the order has been filled, this form is stamped "Filled," initialed by the clerk, and filed for future reference. The third copy goes to the inspector in the maintenance supplies and tool service department to serve as a reminder that the tool is being made and must be inspected in due course. After the inspection has been made and the tool found to be up to specifications in every way, this inspector's copy is destroyed and a permanent inspection card placed on file. The fourth copy is sent to the foreman of the department in which the tools are to be used, to serve as a further notification to him that his requirements are being cared for. The fifth copy is used by the tool "chaser" whose duty it is to follow up each order and see that it is progressing satisfactorily. When the tools are delivered to the factory, the receiving department makes out a receiving slip, using the form shown in Fig. 7, and the tools, together with this form, are sent to the inspector in the maintenance supplies and tool service department. This slip is signed and returned to the receiving room, where it serves as a receipt for the tools which have been delivered to the inspector. When the tools have been delivered, the tool chaser's interest in them ceases, and as soon as he has been assured of the fact, he can destroy his copy of the T-requisition slip.


Form 148

NOTICE

CHARGE
ALL TIME AND MATERIAL
ON THIS TOOL TO

T. O. No. 18996

Jig, Fixtures, Punches and Dies, MUST be turned in for inspection after being machined and BEFORE bushings or dies are pressed in. All parts must be inspected before assembling, or before being hardened as the case may be.

If in doubt of any figures or details, consult foreman at once.

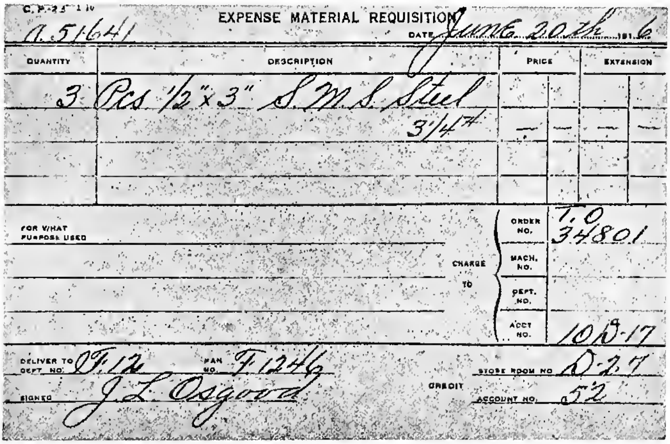
CADILLAC MOTOR CAR CO.

09207

Fig. 8. Form pasted on Backs of Blueprints, constituting Order to Cadillac Tool-room to make Tools

It should be noticed that on the right-hand side of the form shown in Fig. 6, a column is provided to show the account to which the tool is to be charged, and in this column is a notation of the tool order number. This is shown for the guidance of the bookkeeping department, to insure the invoice being forwarded to the maintenance supplies and tool service department to have the price O. K.'d, classified, and posted on the cost card, Fig. 11, which is filed in the latter department.

Procedure when Tools are made in Factory Tool-room. — When an order is issued for making a special tool outside of the



C. P.-23

EXPENSE MATERIAL REQUISITION

A.51641 DATE June 20th 1916

QUANTITY	DESCRIPTION	PRICE		EXTENSION	
3	Pcs 1/2" x 3" S. M. S. Steel				
	3'/4"	—	—	—	—

FOR WHAT PURPOSE USED

CHARGE TO — ORDER NO. T.O. 34801 — MACH. NO. — DEPT. NO. — ACCT NO. 10 D-17

DELIVER TO DEPT. NO. D.F. 12 MAN NO. F 1246

STORE ROOM NO. D-27

SIGNED J. L. Osgood CREDIT ACCOUNT NO. 52

Fig. 9. Form used by Tool-room Foreman in ordering Materials required for Making Tools

factory, the maintenance supplies and tool service department sends a "T-requisition" to the purchasing department, making use of the form shown in Fig. 6, as previously explained; but it does not always happen that tools are sent out to be made. In many cases, the work is done in the tool-room maintained by the Cadillac Motor Car Co., and then the method of procedure is slightly different. Instead of issuing orders to the purchasing department, as soon as the tool order and drawings have been received, the maintenance supplies and tool service department proceeds by entering the proper tool order numbers on gummed labels, shown in Fig. 8, and pasting one of these labels on the back of each tool drawing. The drawings are then sent out to the foreman of the tool-room, and their receipt is regarded as an order to proceed with the making of the tools. The way in which castings have been handled has already been described, and it will be assumed that the castings are available for use in the tool-room. The first copy of the tool order, Fig. 2, is sent to the tool department and kept with the work until completed, after record cards have been made by the stenographer, as mentioned.

Other materials required for making the tools are ordered by the tool-room foreman on requisition slips of the form illustrated

04789 Form 1213-4

TIME TICKET—NON-PRODUCTIVE

NAME Jas M Clarke NO. F1246

DEPARTMENT NO. OF-12 DATE June 20 1916

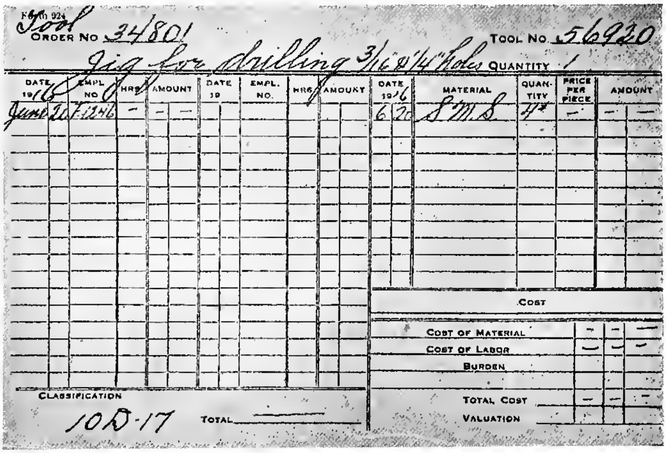
ACCOUNT NAME	FOR DEPT.	Number of Machine, Tool, B. O., Car, etc.	TIME Straight	1½	Double	AMOUNT		
10D-17	—	T034801	8	—	—	–	–	–

NOTE: If work is being done for another department, show number of that Dept. in column headed "For Dept."

Fig. 10. Form used by Tool-room Foreman in reporting Labor Charges on Tools to Cost Accounting Department

in Fig. 9. The requisition is dated, and there are spaces on the form for noting the store-room from which the material was drawn, the department to which it was delivered, and the accounts which are to be credited and debited, together with spaces for noting the tool order number, etc. The clock number of the man to whom the material is to be delivered is noted on the slip, which is signed by the foreman of the tool-room. These requisition slips are left in the store-rooms in exchange for the material, and at intervals of one-half hour they are gathered up by one of the messengers who make regular rounds in such a way that the slips will reach the cost accounting department in not less than one and one-half hour after they were left in the store-room. In the space at the middle of the form, notations are made as to the quantity and kind of material drawn out, the price of this material is entered on the slip by the cost accounting department, and the slip is then forwarded to the cost clerk in the maintenance supplies and tool service department, who posts them on the cost card, Fig. 11.

Record of Toolmaking Labor Cost. — Reports of labor charges on tools made in the factory are also submitted to the cost clerk for use in calculating the total value of the tool. For the purpose of reporting the labor costs on each job, the foreman of the de-


Form 924
Tool Order No 34801
Tool No 56920
Jig for drilling 3/16 & 1/4 Holes
Quantity 1

Date 1916	Empl. No	Hrs	Amount	Date 19	Empl. No.	Hrs	Amount	Date 1916	Material	Quantity	Price per Piece	Amount
June 20	F1246	—	—					6 20	S.M.S	4#	—	—

Cost
Cost of Material
Cost of Labor
Burden
Total Cost
Valuation
Classification 10D-17
Total

Fig. 11. Form used by Cost Accounting Department in recording Labor and Material Charges on Tools

partment in which the work is done turns in daily time tickets of the form shown in Fig. 10. At the top of these tickets, the names and time-clock numbers of the employes are recorded, together with the numbers of the departments in which they are employed and the date. In the space at the bottom of the form, a record is kept of all labor costs to be charged against the tool order, and each day these time tickets are sent to the time office to be classified under their proper account, according to the list furnished by the maintenance supplies and tool service department. The rates are then extended and the slips are forwarded to the cost clerk in the maintenance supplies and tool service department, where the data are entered on the cost cards shown in Fig. 11, after which the time tickets, Fig. 10, are returned to the time office. The clerk who attends to the maintenance of the cost records is under the jurisdiction of the cost accounting department, although he works in the office of the maintenance supplies and tool service department. In addition to recording labor costs in the manner referred to, it will also be evident that the

ORIGINAL FORM 985

TOOL SERVICE DEPT. D-28

To Dept. No. L-39 Date June 24, 1916

Harden as Follows

Material	
2 Slip Bushings	Harden and Temper
S.M.S.	Cyanide
	Pack Harden 3/32" Deep
	Carbonize Only " Deep

Tool Order No. 34801
Dept. " "
B. O. " "
Time Office Job No.

Signed J. E. Vine INSPECTOR

RETURN THIS ORDER WITH PARTS

Fig. 12. Form used by Tool-room Foreman in ordering Heat-treatment of Tools

costs of all materials entering into the construction of the tools are entered on this card, data for the purpose being taken from the material requisition slips shown in Fig. 9.

With these data at hand, the cost accounting clerk is able to figure the total cost and valuation of the tool. On the opposite side of the card shown in Fig. 11, there is a form which provides for maintaining a record of the number of tools of each particular type which are on hand in the factory, and should one of these tools wear out or break, or if another tool of the same type is added to the supply, a notation is made to that effect so that information is available for the purpose of taking inventory. Similarly, if a tool is made outside, the invoice is forwarded from the bookkeeping department to the cost accounting department to be posted on the cost card.

Issuing Orders for Heat-treatment of Tool Parts. — When it is necessary to heat-treat parts of tools, an order must be issued for doing this work, and in issuing such orders use is made of the form shown in Fig. 12. This form is made out in triplicate, the first and second copies being sent to the hardening department

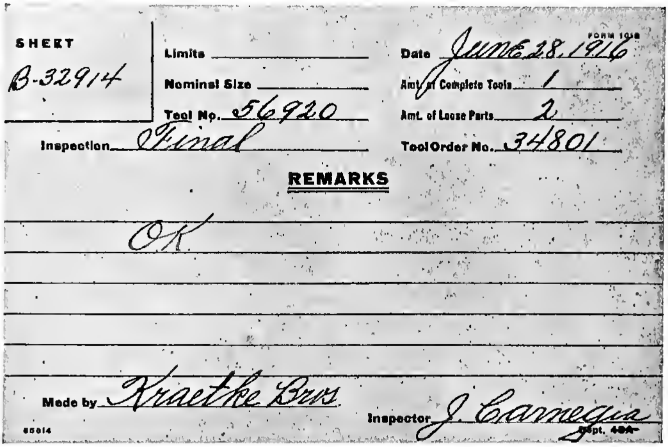
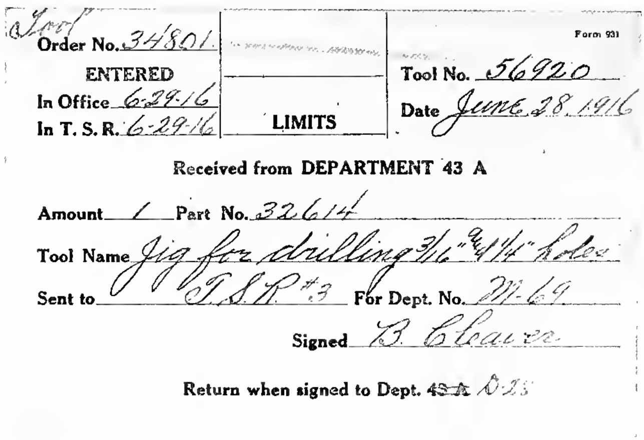

SHEET B-32914
Limits
Nominal Size
Tool No. 56920
Inspection Final
Date June 28, 1916
Amt. of Complete Tools 1
Amt. of Loose Parts 2
Tool Order No. 34801
REMARKS
OK
Made by Kraetke Bros.
Inspector J. Carnegia
85814
Dept.

Fig. 13. Form used by Inspectors in reporting Results of Inspection of New Tools

with the work, and the third copy being kept in the office of the maintenance supplies and tool service department until the parts have been returned. The first copy of the memorandum is returned with the work, and the second copy filed in the heat-treating department as a record of the work done; the first and third copies of the memorandum are then destroyed. In charging heat-treatment against the cost of the tool, use is made of the time ticket shown in Fig. 10 for reporting labor charges to the cost accounting department; and the material expense requisition shown in Fig. 9 is used when ordering materials for the process of heat-treatment.

How Records of Special Tools are Kept. — When all work on the tool order has been completed, the finished tool with the first copy of the tool order, Fig. 2, and the blueprints of the tool drawings are given to the special-tool inspectors in the maintenance supplies and tool service department. These inspectors are practical toolmakers and mechanics of wide experience, and are provided with all the latest improved tools necessary to make an exhaustive and thorough inspection of all special tools used to produce parts for Cadillac motor cars. When they have finished making the inspection, they report their findings on an inspection



Tool Order No. 34801

ENTERED
In Office 6-29-16
In T. S. R. 6-29-16

LIMITS

Form 931
Tool No. 56920
Date June 28. 1916

Received from DEPARTMENT 43 A

Amount 1 Part No. 32614
Tool Name Jig for drilling 3/16" & 1/4" holes
Sent to T. S. R. #3 For Dept. No. M-69
Signed B. Cleaver

Return when signed to Dept. ~~43 A~~

Fig. 14. Form used in obtaining Receipt from Tool Supply Rooms for New Tools

card, shown in Fig. 13, and pass the card, tool, and drawings to the clerk whose business it is to see that the finished tool is delivered to the supply room. When this clerk receives the tool, he immediately stamps the tool order form, Fig. 2, " Completed " and gives it to the tool order clerk who records it as completed, and then forwards the form to the tool engineer. When he has disposed of the tool order, the clerk takes out the set of record cards which have been filed in the " shop box " and removes the card shown in Fig. 14, known as the " receipt card," also a small tag which is used on the tool check board to indicate the hook assigned to the tool, and delivers them to the man in charge of the delivery of tools. A notice, Fig. 16, is also sent at this time to the foreman who will use the tool. The remainder of the set of cards are held on the clerk's desk until the receipt card is signed by the man in the tool supply room and returned.

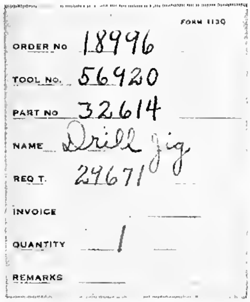
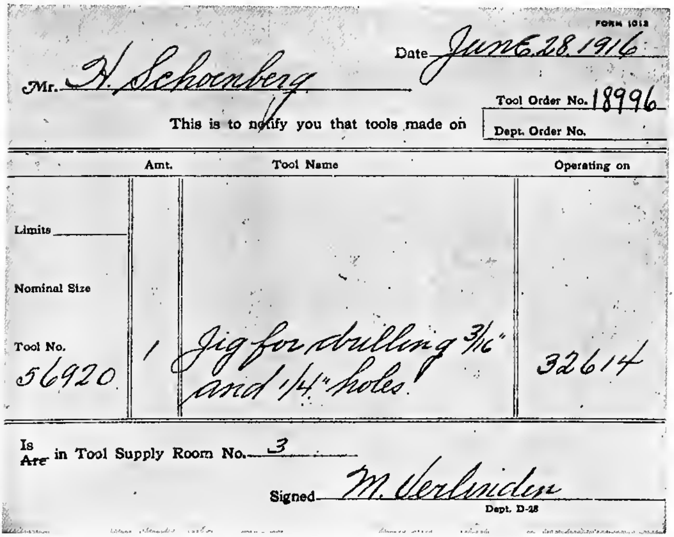

FORM 1130
ORDER NO 18996
TOOL NO. 56920
PART NO 32614
NAME Drill Jig
REQ T. 29671
INVOICE
QUANTITY 1
REMARKS

Fig. 15. Form used in reporting Completion of Tools

When the receipt card is signed and returned, it is attached to the remainder of the sets of cards and given to the finished-tool record clerk, whose duty consists of taking the card shown in Fig. 15 and forwarding it to the cost clerk, which constitutes a notice that the tool has been completed and that he may close his cost card, and file it for inventory purposes. The record clerk next takes the cards shown in Figs. 17 and 18, which are known as the "tool" and "symbol" cards, respectively, and files them in separate files; the tool card is filed by the tool number and the symbol


FORM 1012

Date June 28 1916

Mr. H. Schoenberg

Tool Order No. 18996

This is to notify you that tools made on

Dept. Order No.

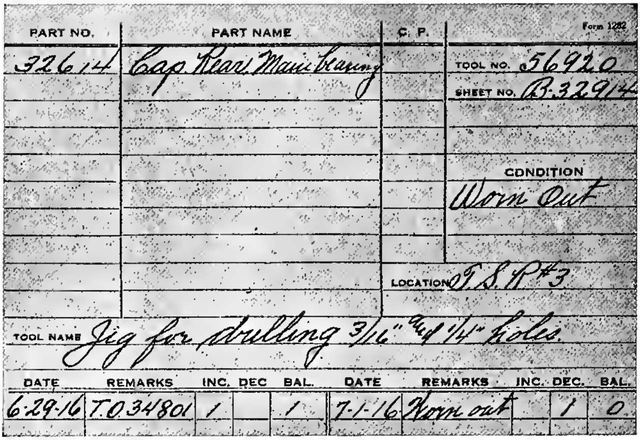
	Amt.	Tool Name	Operating on
Limits Nominal Size Tool No. 56920	1	Jig for drilling 3/16" and 1/4" holes	32614

Is ~~Are~~ in Tool Supply Room No. 3

Signed M. Verlinden
Dept. D-28

Fig. 16. Form used by Maintenance Supplies and Tool Service Department in reporting Delivery of New Tools to Foreman

card by the symbol number of the motor part, thus constituting an effective cross-indexed file. The inspection card and the blue

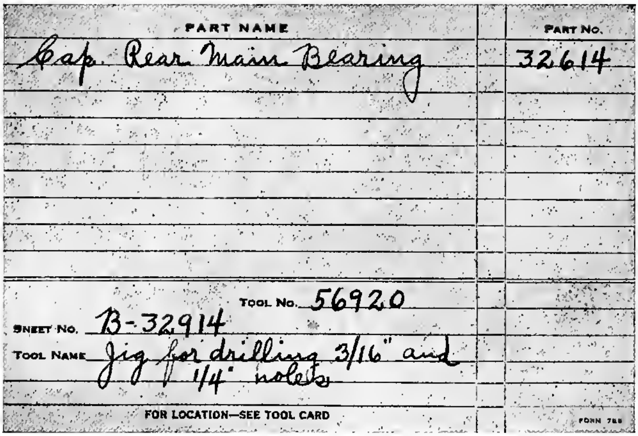


PART NO.	PART NAME	C. P.	Form 1282
32614	Cap Rear Main Bearing		TOOL NO. 56920
			SHEET NO. B-32914
			CONDITION
			Worn Out
			LOCATION T.S.R. #3

TOOL NAME Jig for drilling 3/16" & 1/4" holes.

DATE	REMARKS	INC.	DEC.	BAL.	DATE	REMARKS	INC.	DEC.	BAL.
6-29-16	T.O.34801	1		1	7-1-16	Worn out		1	0

Fig. 17. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Tools by Tool Number



PART NAME		PART NO.
Cap. Rear Main Bearing		32614

TOOL NO. 56920

SHEET NO. B-32914

TOOL NAME Jig for drilling 3/16" and 1/4" holes

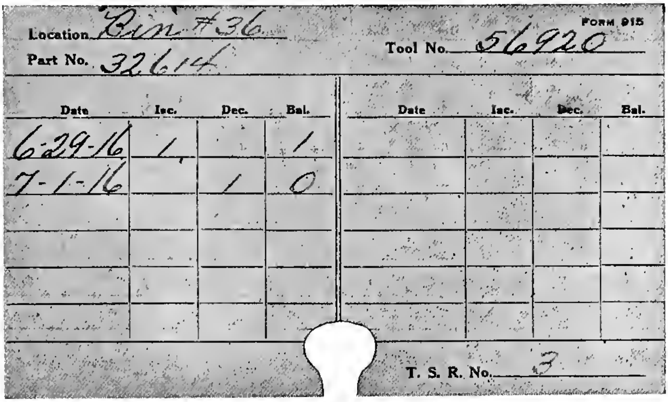
FOR LOCATION—SEE TOOL CARD

FORM 788

Fig. 18. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Tools by Part Number

receipt card, Figs. 13 and 14, are filed together in a file labeled for that purpose. The cards shown in Figs. 19 and 20 are given to a clerk who makes daily trips to each of the tool supply rooms, and files them in filing cabinets for the convenience of the man in the tool supply room.

When the tool is delivered to the tool supply room, an entry is made in the "incoming" record book, which is checked by the



FORM 915

Location Bin #36

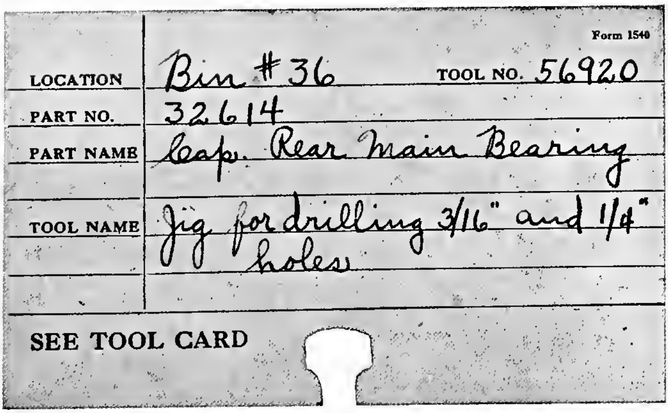
Part No. 32614

Tool No. 56920

Date	Inc.	Dec.	Bal.	Date	Inc.	Dec.	Bal.
6-29-16	1		1				
7-1-16		1	0				

T. S. R. No. 3

Fig. 19. Form used by Tool Supply Rooms in keeping Card File of Tools by Tool Number



Form 1540

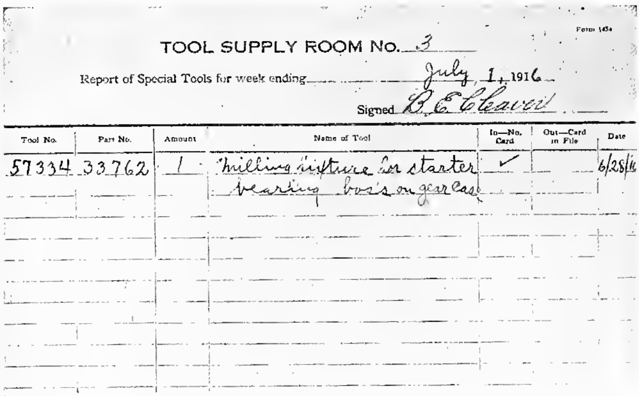
LOCATION	Bin #36 TOOL NO. 56920
PART NO.	32614
PART NAME	Cap. Rear Main Bearing
TOOL NAME	Jig for drilling 3/16" and 1/4" holes

SEE TOOL CARD

Fig. 20. Form used by Tool Supply Rooms in keeping File of Tools by Part Number

clerk who puts the cards in the tool supply room files. The small tool tag previously referred to is also placed on the check board for convenience in checking the tool to a workman; and the placing of this tag is later verified by the man in charge of maintaining the check boards and the checks in order. Entries are also made in the "outgoing" book at the time that the tools are sent up to the tool-room for repair, or when permanent transfers of tools are made from one department to another. Once a week the tool supply room attendant examines both the "incoming" and "outgoing" books, and also makes sure that spaces have been provided on the check board for all new tools delivered to the tool supply room, and that these tools have been properly entered on the card file. The results of this inspection are entered on a form shown in Fig. 21.

Repair of Special Tools. — When the special tools used in any of the shops have become worn or damaged in such a way that they are no longer capable of giving satisfactory service, they are



Form 145a

TOOL SUPPLY ROOM No. 3

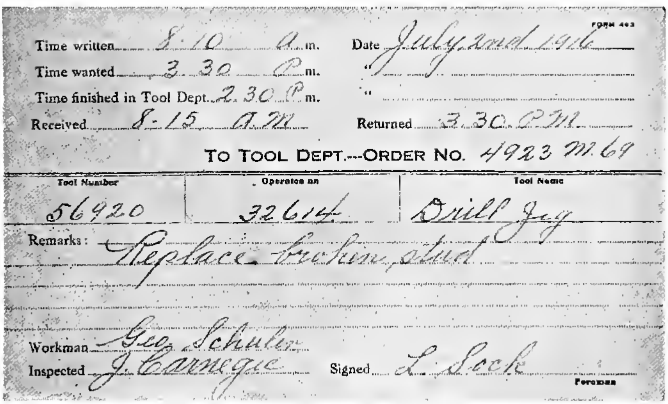
Report of Special Tools for week ending July 1, 1916

Signed B. E. Cleaver

Tool No.	Part No.	Amount	Name of Tool	In—No. Card	Out—Card in File	Date
57334	33762	1	Milling fixture for starter bearing boss's on gear case	✓		6/28/16

Fig. 21. Form used by Tool Supply Rooms in making Weekly Reports

returned to the tool-room for the purpose of making the necessary repairs. The decision as to whether or not the tools require repairing will be made by the foreman of the department in which they are used. When a tool is sent from the tool supply room to the tool-room to have such repairs made, it will be evident that an order must be issued for doing the work, and also that the tool supply room must have a record showing what tools have been sent out for repairs. Fig. 22 shows the form of order made out. In the upper half of this card spaces are provided for not only recording the date on which the work was sent out and the date when the tool will again be needed in the factory, but also for specifying the exact time of day in each case. This is an important matter, because any damage done to a tool of which there is no reserve in stock will result in holding back production until repairs have been made. In repairing special tools, all work is done on a "blanket" order, "No. 4923," and the insertion of this number in the space provided for the purpose shows immediately that the job consists of repairing a special tool. In the lower half of this form spaces are provided for entering the name and number of the tool, together with the number of the part on which it operates. Under the heading "Remarks," the necessary instructions are given to indicate the nature of the repair that must be made.



FORM 463

Time written 8.10 a.m. Date July 2nd 1916

Time wanted 3.30 P.m.

Time finished in Tool Dept. 2.30 P.m.

Received 8.15 A.M. Returned 3.30 P.M.

TO TOOL DEPT.---ORDER NO. 4923 M.69

Tool Number	Operates on	Tool Name
56920	32614	Drill Jig

Remarks: Replace broken stud

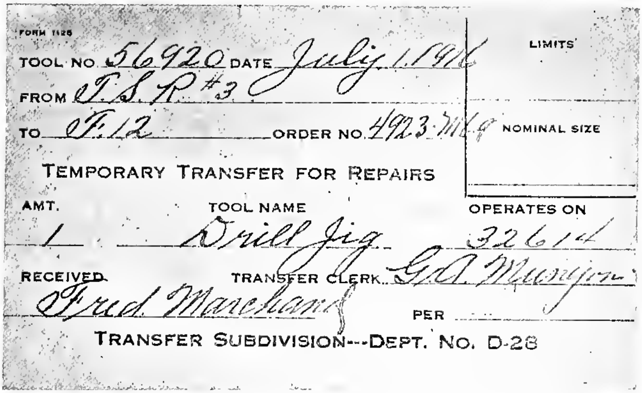
Workman Geo. Schuler

Inspected J. Carnegie Signed L. Sock Foreman

Fig. 22. Form used by Shop Foremen in ordering Repair of Broken or Worn Tools

When tools have been sent out for repair, it is necessary for the attendant in the tool supply room to keep a record of the matter in order that he may not be called upon to deliver tools which are not in his possession. For the purpose of keeping this record, use is made of a form shown in Fig. 23, this form being made out in triplicate. The first two copies are sent with the tool to the maintenance supplies and tool service department; and the first copy goes on with the tool to the foreman of the tool-room in which the repair is to be made, while the second copy is filed in the office of the maintenance supplies and tool service department. The third copy of the form is kept on file in the tool supply room, where it serves as a record of the fact that the tool has been sent out for repairs. When the tool is returned, the card is sent to the tool service department.

Making Repair Parts for Special Tools. — When a tool is in constant use in the factory, a serious delay is caused by sending it out for repair, and such a procedure is avoided as far as possible. One way in which trouble from this source is largely overcome consists of having repair parts for the tool made in advance, so that it is only necessary for the tool to be in the tool-room long enough to have the new parts put in place. For instance, suppose


TOOL NO. 56920 DATE July 1

FROM T.S.R. #3

TO F.12 ORDER NO. 4923-Mfg

LIMITS

NOMINAL SIZE

TEMPORARY TRANSFER FOR REPAIRS

AMT.	TOOL NAME	OPERATES ON
1	Drill Jig	32614

RECEIVED Fred Marchand

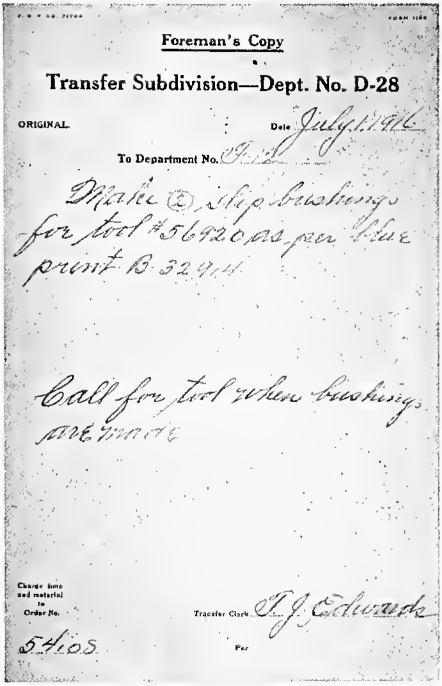
TRANSFER CLERK G.A. Munyon

PER

TRANSFER SUBDIVISION---DEPT. NO. D-28

Fig. 23. Form used by Tool Supply Rooms in recording Temporary Transfer of Tools for Repair

it is found that the bushings in a drill jig have become slightly worn and ought to be replaced. The common method would be to send the jig to the tool-room where the bushings would be made and put into place; but this would involve having the jig out of the shop for a considerable length of time, and production would be seriously delayed by following such a course. The method actually employed consists of sending an order to the tool-room, giving the number of the tool and the number of the blueprint of the tool drawing, together with a statement of what parts need to be replaced. The tool-room then proceeds to make these parts, and when they are finished and ready to put into place, the tool is sent for. In this way, the tool is only out of the shop for a short length of time and the delay occasioned is not serious. Fig. 24 shows the form used in ordering tool repair parts of this nature, this form being made out in quadruplicate. The first and second copies are sent to the foreman of the toolroom and serve as his order for making the parts in question. The third copy is filed in the maintenance supplies and tool service office until the job has been done, and the fourth copy is sent to the foreman of the department who placed the order for parts, to notify him that his order is being executed. These orders are numbered, and all time and material is charged against that order number in the same manner as described in connection with the new tool orders.


Foreman's Copy

Transfer Subdivision—Dept. No. D-28

ORIGINAL. Date July 1, 1916

To Department No.

Make (2) slip bushings for tool #56920 as per blue print B-32414.

Call for tool when bushings are made.

Charge time and material to Order No. 54105

Transfer Clerk T. J. Edwards

Per

Fig. 24. Form used by Foremen in ordering Replacement Parts for Special Tools sent for when Parts are ready to be put in Place

Semi-monthly Report on Special Tool Repairs. — In describing the work of repairing special tools, stress was laid upon the importance of the time taken in doing the work. As a serious delay in the factory is likely to result where the time taken for repairing special tools is unduly long, it is important to check up the time actually required for tool repairing to see that there is no unnecessary loss of time. Semi-monthly inspections of the work of the tool repair department are conducted for this purpose, and the conditions are reported on the form shown in Fig. 25.

Discard of Worn-out Tools. — As long as tools are in good working order they are charged against the maintenance supplies and tool service department; but as soon as they are broken or worn out this department is credited with the amount formerly charged against it, and a corresponding charge is made to the department in which the tools were used. When the usefulness of a tool is destroyed from either of these causes, it becomes necessary to make an adjustment of accounts, and data to form the basis of this adjustment are supplied on a form shown in Fig. 26. At the left-hand side of the form, spaces are provided for the number of the department to which the value of the tool

Form 1459

TOOL SUPPLY ROOM NO. 3

Semi-monthly Report of Special Tools on Repair for two weeks ending July 3rd 1916

Signed H. Kuhn

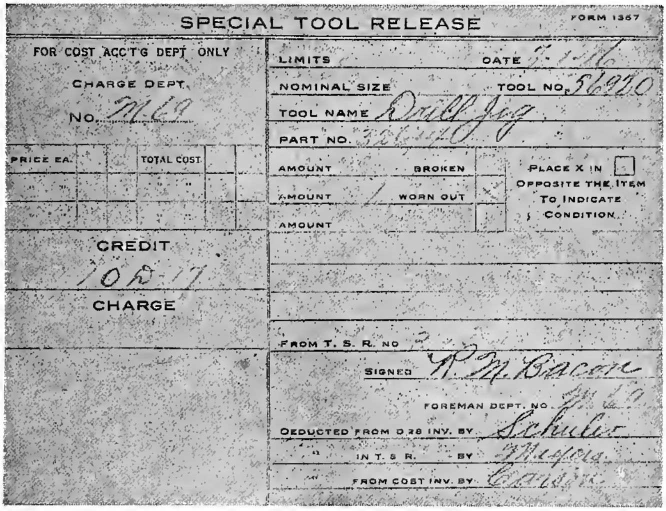
Tool No.	Part No.	Name of Tool	Date of Receipt Card
62794	32673	Jig for drilling 7/16" holes	June 28, 1916

Fig. 25. Form used by Tool Supply Rooms in making Semi-monthly Reports of Special Tools sent out for Repair

is to be charged, and also for the numbers of the accounts which are to be credited and charged with the cost of the tool. The space at the right-hand side of the form is filled in with a description of the tool, a statement as to whether it was worn out or broken, and with information which is used at the time an inventory is taken.

Sets of Tools for Special Operations. — There are certain classes of operations which require the use of a considerable number of tools, and if a workman were required to have each tool out on a separate check, it would involve the necessity of supplying each of the men with an unnecessarily large number of checks.

To avoid trouble arising from this cause, and also to simplify the method of handling tools, the expedient has been adopted of keeping such sets of tools in separate numbered boxes. This makes it possible for the entire set of tools to be delivered to a workman against a single tool check, thus greatly simplifying the work of the tool supply room. For the purpose of recording sets of tools of this kind, use is made of cards of the form shown in Fig. 27. One side of each of these cards carries a list of all special tools required for the operation, and on the other side of the card



SPECIAL TOOL RELEASE FORM 1367

FOR COST ACC'T'G DEPT ONLY

CHARGE DEPT.

NO. M 29

PRICE EA. TOTAL COST

CREDIT

CHARGE

LIMITS DATE

NOMINAL SIZE TOOL NO. 56920

TOOL NAME Drill Jig

PART NO.

AMOUNT BROKEN

AMOUNT 1 WORN OUT

AMOUNT

PLACE X IN ☐ OPPOSITE THE ITEM TO INDICATE CONDITION.

FROM T. S. R. NO

SIGNED R. M. Bacon

FOREMAN DEPT. NO.

DEDUCTED FROM D 28 INV. BY Schuler

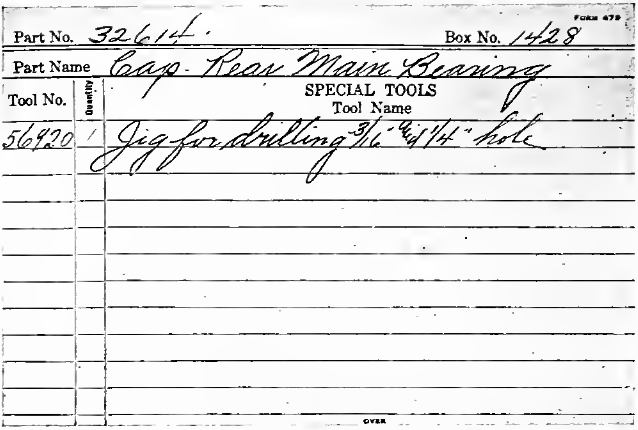
" IN T. S R. BY Meyers

FROM COST INV. BY

Fig. 26. Form used by Maintenance Supplies and Tool Service Department in sending Cost Accounting Department Data on Discarded Tools for Use in Adjustment of Accounts

there is a list of all the standard commercial tools that are needed. At the top notations are made of the number of the part for the manufacture of which the tools are required, and the box number in which the set of tools is contained. The cards are filed numerically by part number. The practice of allowing a workman to draw out a complete set of tools on one check is only followed in cases where the number of tools required for a single operation exceeds eight, and where the workman is looking after more than one operation. When a man is assigned to a job of this kind, he must get an order from his foreman for the tools that he will require in doing the work. This order is made in duplicate, the first copy being held by the foreman and the second copy sent to the tool supply room, where it is filed.

Obtaining Tools from Another Department. — In the factory of the Cadillac Motor Car Co. there are thirty tool supply rooms, and each of these rooms is supposed to deliver tools and supplies to specific departments, the idea being clearly shown in diagrammatical form in Fig. 1 of the preceding chapter. Charts are made out and blueprints of them posted throughout the factory,



FORM 479

Part No. 32614. Box No. 1428

Part Name Cap-Rear Main Bearing

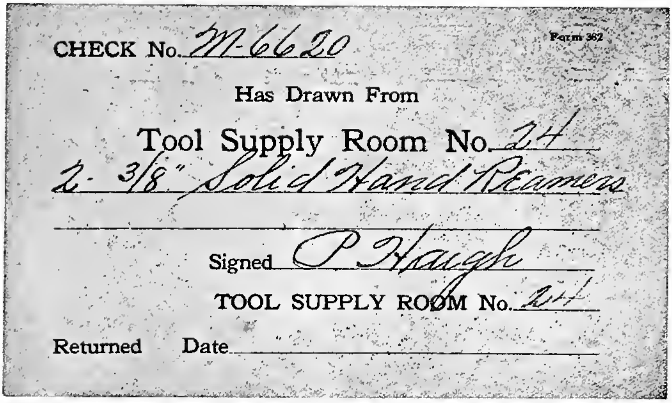
Tool No.	Quantity	SPECIAL TOOLS Tool Name
56420	1	Jig for drilling 3/16" & 1/4" hole

OVER

Fig. 27. Form used by Maintenance Supplies and Tool Service Department in keeping Card File of Sets of Tools used for Specified Operations

showing those departments to which each tool supply room is supposed to deliver materials and tools; but the rule in this connection is flexible, as it may happen that some department in the factory has urgent need for tools or supplies which are not in its proper tool supply room at the time they are required. When such a condition arises, a foreman may send an order to an adjacent supply room for the tools which he needs. Delivery will be made on such an order, but the attendant in the tool supply room from which the tools are withdrawn will fill out one of the forms shown in Fig. 28 and deliver it to the tool supply room which should properly have handled the transaction, advising of the delivery of the tools to one of the departments served by this tool supply room. The purpose of sending this form is two-fold: in the first place, it serves to remind the attendant in the tool supply room that his stock of a given tool is out and must be replenished; and, in the second place, it advises that men from departments which properly come under his jurisdiction have been drawing tools from another tool supply room.

Permanent Transfer of Tools. — Occasionally a readjustment of the work in the factory calls for the permanent transfer of


CHECK No. M-6620 Form 362

Has Drawn From

Tool Supply Room No. 24

2 - 3/8" Solid Hand Reamers

Signed P. Haugh

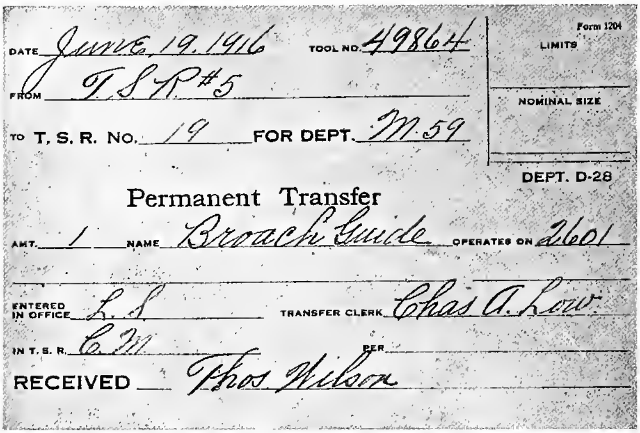
TOOL SUPPLY ROOM No. 24

Returned Date

Fig. 28. Form used by Tool Supply Rooms in reporting Withdrawal of Tools by Men employed in Departments not regularly served

special tools from one tool supply room to another, and, where this procedure is necessary, a record of the transaction is made on a card of the form shown in Fig. 29. Reference to this illustration will show that the card bears the date and tool number, together with the number of the tool supply room from which the tool was taken, and also the number of the room to which it was delivered. At the bottom, spaces are provided for a description of the tool. This transfer, when signed, constitutes authority for removing the tools from one tool supply room to the other, and also for changing the location on the tool card in the maintenance supplies and tool service office, after which it is filed by tool number.

Additional Part Numbers for Special Tools. — All the special tools used in the shops of the Cadillac Motor Car Co. are marked with a tool number, and also with the part number of the piece upon which they operate. When motor cars of a new model are brought out, there will be a considerable number of special tools which can be used without alteration of any kind, but, in order to bring the records up to date, it is necessary not only to add the part number of the new piece upon which the tool operates, but also to correct all records to show this addition. When the engineering department has decided upon a change of model and



Form 1204

DATE June 19. 1916 TOOL NO. 49864

FROM T.S.R. #5

TO T. S. R. NO. 19 FOR DEPT. M-59

LIMITS

NOMINAL SIZE

DEPT. D-28

Permanent Transfer

AMT. 1 NAME Broach Guide OPERATES ON 2601

ENTERED IN OFFICE L.S. TRANSFER CLERK Chas A. Low.

IN T. S. R. C.M. PER

RECEIVED Thos Wilson

Fig. 29. Form used by Maintenance Supplies and Tool Service Department in authorizing Permanent Transfer of Tools

the work of providing the necessary tool equipment has been finished by the tool engineer, reports are sent to the maintenance supplies and tool service department, and a form shown in Fig. 30 is made out and given to the record clerk who adds the part number to all record cards, and then gives the notice to the toolmaker who sees that the tools are properly marked. Only such tools as are required for use on the model being manufactured are kept in the tool supply rooms. A tool storage is maintained in which are kept all obsolete tools. The bins in the storage room are numbered, and the location of each tool is carried on the tool record card filed in the maintenance supplies and tool service office. When it becomes necessary to use obsolete tools for making service repair parts, they are transferred temporarily to the tool supply room and returned to the storage room when the work has been done, as it would be undesirable to obstruct the tool supply room with tools that are only used occasionally.

Controlling Manufacture of Obsolete Parts. — It is necessary for automobile builders to maintain service departments in order to supply repair parts for obsolete models of motor cars which are still in use. A supply of such parts is kept on hand in the various service stations; and when the supply of any part is

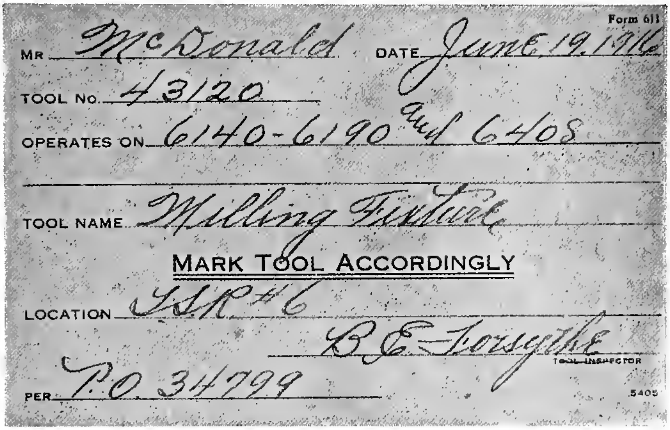
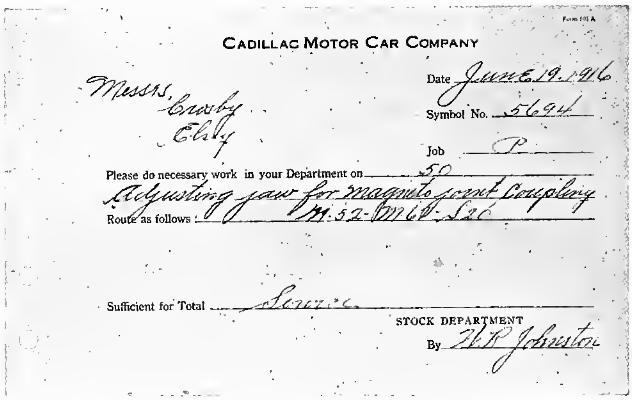

Form 611
MR McDonald DATE June 19 1916
TOOL NO. 43120
OPERATES ON 6140-6190 and 6408
TOOL NAME Milling Fixture
MARK TOOL ACCORDINGLY
LOCATION TSR #6
B. E. Forsythe
TOOL INSPECTOR
PER P.O. 34799
5405

Fig. 30. Form used by Maintenance Supplies and Tool Service Department in ordering Supplementary Marking of Tools

found to be running low, an order is sent in for additional parts of the same type. For manufacturing each part of the current model of a motor car, it is usually necessary to provide a number of tools of the same type; but when the car for which parts are used becomes obsolete, one of the special tools of each type will be set aside for the purpose of manufacturing replacement parts, while the remainder of the tools will either be changed to adapt them for use in the manufacture of parts of the current model, or they will be discarded.

When one of the service departments sends in an order for replacement parts, the stock department issues an order for these parts, making use of the form shown in Fig. 31. This form is then sent to the maintenance supplies and tool service department, which refers to its card file of tools — the form shown in Fig. 17 — which gives a complete list of the tools used in the manufacture of this part. The location of these tools in the storage rooms is then looked up, and all of this information is noted on the back of the form. When the foreman of the department in which the parts are to be made is ready to do the work, the tools are delivered to his tool supply room on a temporary transfer form shown in Fig. 32. This form is made out in


CADILLAC MOTOR CAR COMPANY

Messrs, Crosby Ely

Date June 19. 1916

Symbol No. 5694

Job P

Please do necessary work in your Department on 50

Adjusting jaw for magneto joint Coupling

Route as follows: M.52-M.60-S.20

Sufficient for Total Service

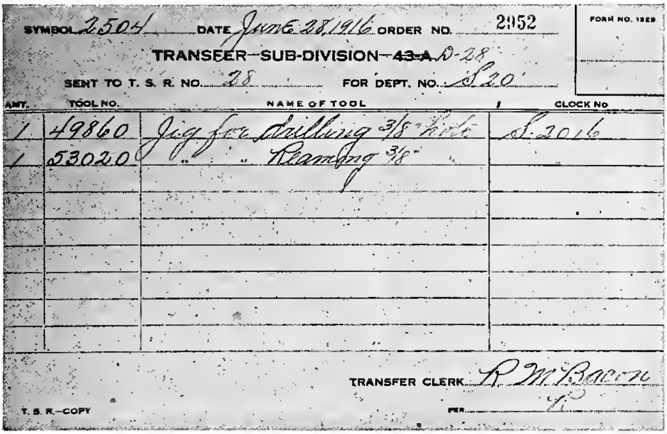
STOCK DEPARTMENT

By H. R. Johnston

Fig. 31. **Form used by Stock Department in ordering Manufacture of Replacement Parts for Service Departments**

quadruplicate, and the "trucker" takes three copies with him when he gets the tools and transfers them from the storage room to the tool supply room, where the first copy is signed as a receipt for the tools and returned to the maintenance supplies and tool service department to be filed with the second copy of the form that was held as a memorandum of the transfer. The third copy is sent to the foreman of the department in which the tools are to be used, serving as a memorandum to advise him that the tools have been transferred to the tool supply room. The fourth copy is left in the tool supply room, and, when the tools are checked out to the workman, this copy, together with the tool check, is put in an envelope bearing the symbol number of the part for the manufacture of which the tools are required. This envelope is kept in the tool supply room until the box of tools is returned, when the check is given back to the workman and the fourth copy destroyed.

Summary of Advantages. — The reader who is familiar with the performance of manufacturing operations on a scale such as that which exists in the factory of the Cadillac Motor Car Co. will be impressed by the fact that, although means are provided for accurately recording all transactions involved in the ordering, making, distributing, and accounting of special tools, the system has been worked out in such a way that there is no unnecessary



SYMBOL 2504 DATE June 28, 1916 ORDER NO. 2952 FORM NO. 1929

TRANSFER—SUB-DIVISION—~~43-A~~ D-28

SENT TO T. S. R. NO. 28 FOR DEPT. NO. S20

AMT.	TOOL NO.	NAME OF TOOL	CLOCK No.
1	49860	Jig for drilling 3/8" hole	S-2016
1	53020	" " Reaming 3/8"	

TRANSFER CLERK R. M. Bacon

T. S. R.—COPY PER

Fig. 32. Form used by Maintenance Supplies and Tool Service Department in authorizing Temporary Transfer of Tools

complication. It may appear that the use of so many forms must inevitably lead to confusion; but the filling in and transmission of many of these forms are merely incidental to the making and distributing of tools, and only a very small clerical force is required to look after all routine work of the maintenance supplies and tool service department. The benefits resulting from this system have made it evident that the expense involved in its installation and maintenance has been offset many times by the saving in lost and damaged tools, and the elimination of unnecessary delays in the manufacturing departments.

CHAPTER V

FOLLOWING PROGRESS OF WORK IN MANUFACTURING DEPARTMENTS

The primary consideration in introducing new methods of management is whether or not an adequate return will be derived from the expenditure involved. Such return may be either direct or indirect, but it must be sufficient to offset both the cost of introducing the new method and the operating and maintenance costs, and still leave the required margin or profit. When the project is of a size which involves a large outlay of money, it is obvious that the most careful study must be given to every detail of the proposed plan.

In this chapter, a follow-up system will be described for keeping an account of the materials used in a factory engaged in small interchangeable manufacture, and also of the progress made by different orders in passing from department to department in the course of manufacture. This system was introduced to remedy certain evils that are likely to arise in any manufacturing establishment, and the man responsible for it was particularly fortunate in that he was not hindered by considerations of expenditure. This fact is mentioned because, had considerations of expenditure been carefully weighed before the benefits derived from the change had been demonstrated, it is probable that the new system would not have been introduced, owing to the large initial and up-keep expenses. Lack of perception on the part of the management is often responsible for the discarding of valuable ideas because of failure to see the advantages which they possess, and unwillingness to bear the burden of what appear to be unreasonable expenses.

Before explaining the workings of this follow-up system, the conditions which were responsible for bringing it about will be briefly described. As previously mentioned, this system was introduced through necessity, and the same may be said of the changes which are made in many industrial establishments. When a factory is engaged in the manufacture of small tools or other products, turned out in large quantities, a great many letters are received containing the vexing question, " When will you ship?" If these inquiries are not answered promptly and truthfully, the people waiting for the shipment of their orders will often be put to considerable inconvenience, as it is likely that they have planned and laid out their work with such promises of shipment in view. If these promises are not kept, the orders will frequently be canceled or repeat orders, at least, will not be received by the manufacturer. It was due to the distrust created among prospective purchasers, through giving evasive answers to inquiries about dates of shipment, and failure to keep promises, which led to the development of this follow-up system. This system is, with some modifications, in use in one of the largest factories of its kind in the United States, and it has proved adequate in eliminating the evils which previously existed, and in improving manufacturing conditions, so that the work of the sales department has been made far more efficient.

Benefits of a Follow-up System. — The benefits derived from this system may be outlined as follows:

1. It enables the management to tell the date on which any order will be finished and ready for shipment, without having to go out into the different manufacturing departments, and with a minimum expenditure of time.

2. To systematically follow up all work — promised and unpromised — from one department to another, and thus receive warning of any delays or mishaps which may occur.

3. To tell at short notice in which department any order is at any time.

4. To tell at equally short notice how long an order has been in any department at a given time, thus making it possible to investigate causes of delay and take steps to remedy them.

5. To find out how many orders a department has on hand, thus making it possible to trace congestion and investigate the cause, *i.e.*, shortage of help, equipment, etc.

6. To afford a means of creating watchfulness on the part of department heads in regard to the time taken in the execution of orders.

As a result, it is impossible for men who are responsible for delays to avoid censure by excuses. As the foremen know that the follow-up system affords a sure method of placing responsibility for any delay that may arise in the execution of an order, they are quite careful to make investigations on their own account before their superiors have been advised in regard to any delays that may have occurred in their respective departments.

To those who are in touch with the details of operating a modern plant, it may seem that any follow-up system is a needless expense, especially if the goods manufactured are of a standard kind (not necessarily size). In most lines of manufacture, however, even standard articles consist of several parts, and, in order to turn out the finished product, these parts must be finished and made ready for the assembling department long before the supply of finished product has been exhausted. In such cases, a follow-up system is necessary for tracing the parts of the completed product through the different departments of the factory. Under these conditions, the system can be reduced to its simplest and most inexpensive form, its chief function being to follow up orders, consisting of a limited number of either parts or complete articles, finishing them before the supply is exhausted.

The system is particularly useful in establishments manufacturing small products of many sizes and many kinds, where a great variety of stock must be kept on hand at all times. It will also prove itself of more than ordinary value to an establishment where the departments have been grouped according to operations. The advantage of this method is that each department is run by an expert who has the machines used in his department operated according to the most economical method, thus making them produce more and better work than would be possible if the product were made complete in a single department. The saving effected by this method may be limited by the loss of time which is involved in moving the work from one department to another, in getting started in each department, and by such necessary operations as counting, inspecting, etc. Where a factory is run without the use of an efficient follow-up system, trouble will be encountered from failure to keep promises in regard to shipment dates, through finding the supply of raw material suddenly exhausted, etc.

Causes of Delay in Finishing Orders. — Among the important features governing deliveries in any manufacturing plant are the stock and store-rooms for either finished parts or the complete product, and it will be well to investigate some of the causes which are responsible for failure to supply these departments with goods in the required quantity and at the specified time. The causes may be outlined as follows:

1. Non-anticipation of large orders and the receipt of a number of small orders at the same time.

2. Shortage of raw material and failure to obtain a fresh supply in time to meet existing requirements.

3. Failure to obtain additional equipment in time to meet existing requirements.

4. Lack of system in ordering stock, resulting in failure to issue orders to the factory in time to allow them to be completed before the stock on hand has been exhausted. The department having this work in hand should have intimate knowledge of the capacity of each department, as well as of the entire factory, so that it is possible to foretell exactly the amount of time required to complete any order which is issued.

5. Delays resulting from resetting automatic machinery to adapt it for a new class of work.

6. Delays caused by premium or contract systems where department foremen evade changing machines from one kind of work to another, in order to secure the greatest possible financial gains for themselves and their men.

7. Failure of the management to see the advantage of investing money in finished material, blanks, castings, and raw material. This condition is most pronounced in times of depression, which are best suited for "stocking up," as labor is cheapest at such times and manufacturing can progress unhampered by special orders that must be completed by a specified time.

Nearly all of these causes of delay were remedied in less than eighteen months by the follow-up system to be described. This was due to the fact that the system automatically calls attention to conditions responsible for delays, and keeps everyone, from the manager and superintendent to the foreman and his assistant, informed of the conditions that have to be met in order for shipments to be made at a specified time. After a careful investigation of the causes of delay outlined in the foregoing, it may be stated that the failure to keep an adequate supply of materials on hand is responsible for the greatest amount of trouble. The other reasons outlined suggest methods of avoiding them, so that little comment is necessary. It is advisable to keep a few surplus machines and a reserve quantity of finished parts, blanks and raw material on hand. This will make it possible to take care of large orders that come in unexpectedly or a number of small orders received simultaneously, without impairing the operation of the factory in any way.

Value of Surplus Stock and Equipment. — There is no excuse for any plant manufacturing a product for which there is a continued demand not providing itself with a surplus supply of finished product. The growth of any industry is dependent upon its ability to meet the demands of its customers, both as regards quality and prompt service. The customer scarcely considers whether his order is too large for the establishment or whether there are other orders on hand which must be filled before his receives attention. The result is that the factory which is able to fill orders promptly usually gets the business. The question of quality is taken for granted, and the manufacturer who neglects this feature will find himself unable to meet the keen competition that exists in practically all lines.

The preceding may be summarized by stating that, in order to meet possible demands of customers for immediate delivery, one of two conditions must exist in the factory. The stock-room must either be well filled with finished product or finished parts of which the product consists, so that it is merely a matter of assembling them for prompt shipment, or else the factory must have an equipment large enough to take care immediately of large orders and finish them without delay. The first condition may be fulfilled by issuing orders to the factory in sufficient quantity and far enough ahead to enable the parts to be finished before the supply of stock on hand is exhausted. (It is suggested, in this connection, that, when the supply on hand has been reduced to an amount equal to the number of pieces sold during any previous year, another order for an equal quantity should be issued immediately. The machine and tool equipment should also be large enough to produce such a number of pieces in a year.) While most manufacturers are willing to invest in reserve equipment, they are unwilling to keep a surplus stock of product on

CUSTOMERS ORDER NO.	OUR ORDER NO.	NO. PIECES WANTED	KIND OF TOOLS WANTED	WILL FINISH DATE
1	2	3	4	5
FILLED IN BY OFFICE OR (STOCK DEPT.)	FILLED IN BY STOCK DEPT. BEFORE BEING SENT TO FOLLOW-UP DEPT.			FILLED IN BY FOLLOW-UP DEPT. AND RETURNED TO OFFICE WITH ORIGINAL LET. OF INQUIRY.

Machinery

Fig. 1. Form used to Follow up an Inquiry Regarding Date of Shipment

hand. It is reasonable to assume that the capital invested in extra equipment provided to meet emergencies is equal at least to that necessary for keeping a sufficient quantity of finished product on hand to meet such emergencies. In most cases, however, the capital invested in finished product is less than that required for a sufficient reserve equipment, and this advantage is further emphasized by the fact that shipments can be made immediately upon the receipt of orders, when the product is on hand in the store-room. In addition, the capital will be turned over more rapidly, as it is not necessary to wait while the product is being made before it can be shipped on a given order. It seems impossible that this fact can escape the attention of the management of so many manufacturing establishments, especially when the product so "stocked" can generally be produced at less expense than when made under average conditions. The solution is seemingly found in the fact that equipment does not show up on the books in the same way as finished product. In considering this subject, it should also be borne in mind that immediate shipment is a means of adding to the list of satisfied customers who will send in repeat orders.

Follow-up System. — Having outlined some of the more important reasons for the use of a follow-up system, and the con-

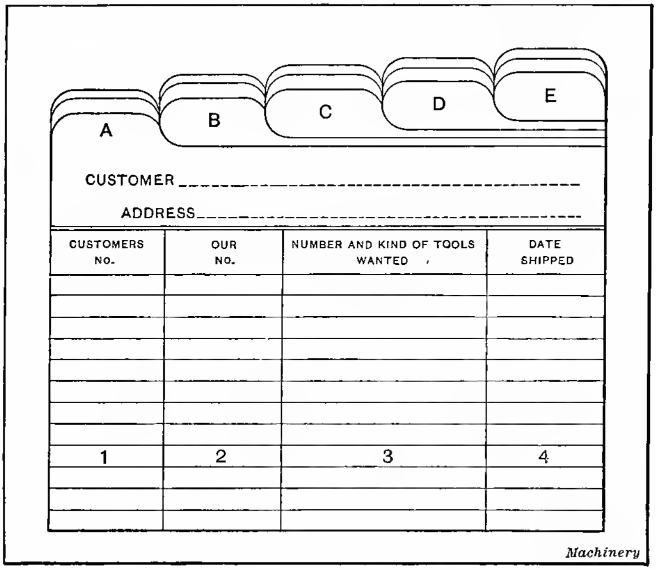


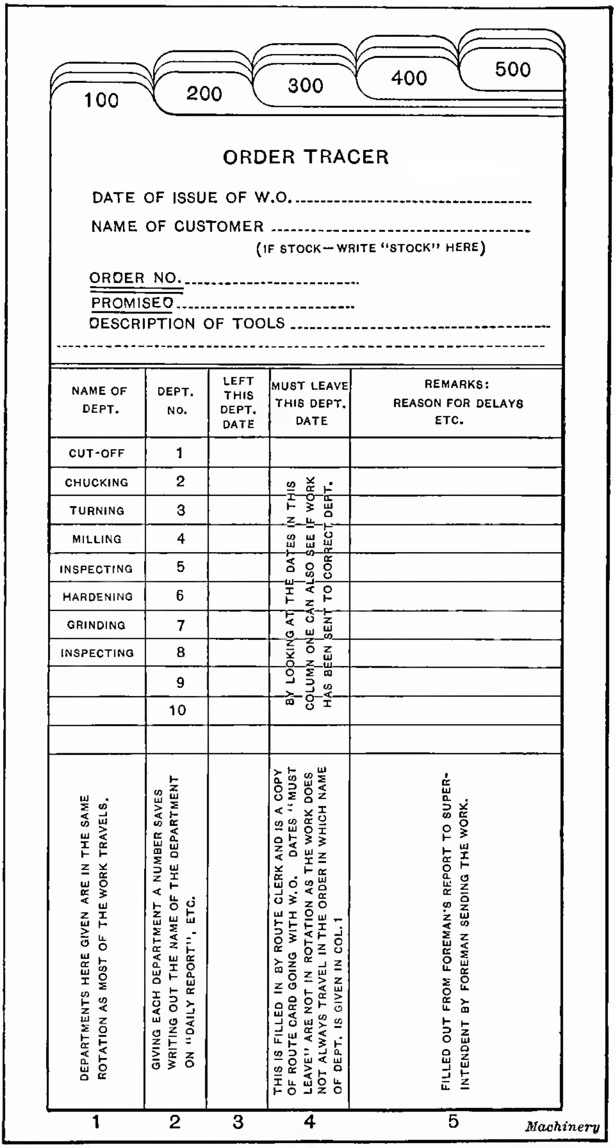
Fig. 2. Card index kept by Stock Department

ditions over which it has control, a system which has many original features, and which has proved very efficient will be described. In order to make the explanation readily understood, certain minor details such as shipping and factory order forms will be omitted, as the forms in general use for such purposes can be adapted to almost any system with satisfactory results. In explaining the workings of this system, it will be assumed that any inquiry as to the date of shipment of an order is received by the office. This inquiry usually carries the customer's order number, and is generally given a factory order number by which it is known until the order has been completed and shipped. The inquiry is immediately turned over to the stock department with the tag shown in Fig. 1 attached to it. The customer's order number is generally filled in by the office, but, in certain cases, where the customer's original order number is on file in the stock department, the tag is filled in when it reaches that point.

Stock Department Card Index. — The stock department keeps a card index, of the form shown in Fig. 2, on which the factory order number is given opposite the customer's order number in cases where the goods are not in stock and have to be made. If no number appears on the card opposite the customer's order number, it signifies that the goods have already been shipped, the date of shipment being recorded in the column marked, "Date Shipped." If shipment has not been made, which is shown by the fact that no notation appears in column 4, and if no number appears in column 2, it shows that shipment can be made from surplus stock on hand. These cards are indexed according to names, and it will be noticed that one or more cards are used for each customer and that each card takes care of several orders.

If the order is special (not in stock and not finished), the inquiry, with the tag shown in Fig. 1 attached to it, is immediately turned over to the follow-up department for answer in regard to the date on which delivery will be made. All of the columns on the tag shown in Fig. 1, except the last one, have been filled out by the stock department, the date being taken from what is known as the shipping order, which includes all details in regard to the items covered by the order.

Order Tracer Card Index. — The follow-up department refers to the order tracer card file, the form of which is shown in Fig. 3. These cards are filed in numerical order, one card being provided for each order number, and show the location of any order in the factory at any specified time; consequently, it is known how far the work has advanced, and also the date on which the work will be finished. A record is also kept on this file of any delay that



100 200 300 400 500

ORDER TRACER

DATE OF ISSUE OF W.O. ....

NAME OF CUSTOMER ....
(IF STOCK—WRITE "STOCK" HERE)

ORDER NO. ....

PROMISED ....

DESCRIPTION OF TOOLS ....

NAME OF DEPT.	DEPT. NO.	LEFT THIS DEPT. DATE	MUST LEAVE THIS DEPT. DATE	REMARKS: REASON FOR DELAYS ETC.
CUT-OFF	1			
CHUCKING	2		BY LOOKING AT THE DATES IN THIS COLUMN ONE CAN ALSO SEE IF WORK HAS BEEN SENT TO CORRECT DEPT.	
TURNING	3			
MILLING	4			
INSPECTING	5			
HARDENING	6			
GRINDING	7			
INSPECTING	8			
	9			
	10			
DEPARTMENTS HERE GIVEN ARE IN THE SAME ROTATION AS MOST OF THE WORK TRAVELS.	GIVING EACH DEPARTMENT A NUMBER SAVES WRITING OUT THE NAME OF THE DEPARTMENT ON "DAILY REPORT", ETC.		THIS IS FILLED IN BY ROUTE CLERK AND IS A COPY OF ROUTE CARD GOING WITH W.O. DATES "MUST LEAVE" ARE NOT IN ROTATION AS THE WORK DOES NOT ALWAYS TRAVEL IN THE ORDER IN WHICH NAME OF DEPT. IS GIVEN IN COL. 1	FILLED OUT FROM FOREMAN'S REPORT TO SUPER-INTENDENT BY FOREMAN SENDING THE WORK.
1	2	3	4	5

Machinery

Fig. 3. Order Tracer Card Index kept by Follow-up Department in which Cards are filed in Numerical Order, one Card being provided for each Order Number

has occurred, the department in which it occurred, and the reasons for the delay, reference being made to the superintendent's "Reasons for Delayed Orders" file for this information. Every foreman is required to report to the superintendent at the end of each day's work in regard to every order which could not be finished and sent on to the next department as required by the schedule. When a department foreman receives an order, he marks the number of the order on his work calendar in the column opposite the date on which the operation must be finished by his

PROMISED

________ 19 ________

DATE	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.
1																	
2																	
3																	
4																	
5																	
6																	
7																	
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26																	
27																	
28																	
29																	
30																	
31																	

Machinery

Fig. 4. Work Calendar showing Dates on which Orders must be finished

department. One of these calendars, shown in Fig. 4, is generally kept by the foreman to insure finishing all orders on time, according to the route clerk's schedule.

The plan of having the foremen report any delinquencies or causes for failure to complete an order in accordance with the schedule is one of the best guarantees that the work will be finished on time. As the superintendent is kept constantly in touch with the progress of each order by this method, he is able to take the necessary steps to prevent a constant recurrence of delays in

ESTIMATE AND ROUTE CARD
(MUST ALWAYS TRAVEL WITH ORDER IN ENVELOPE)

ORDER NO.____________________

DESCRIPTION____________________

CUSTOMER ____________________

NAME OF DEPT.	DEPT. NO.	ROUTE	MUST LEAVE THIS DEPT. DATE	ACTUAL DATE OF LEAVING DEPT.	REMARKS: REASON FOR DELAYS ETC.
CUT-OFF	1	1			
CHUCKING	2	2			
TURNING	3	5			
MILLING	4	4			
INSPECTING	5	6			
HARDENING	6	7			
GRINDING	7	8			
INSPECTING	8	3			
	9				
	10				
		WHEN OPERATION IS DONE SEND WORK TO DEPT. NEXT IN ROTATION.	FILLED OUT BY ROUTE CLERK FROM CAPACITY CARDS.	FILLED OUT BY DEPT. FOREMAN.	FILLED OUT BY DEPT. FOREMAN.
1	2	3	4	5	6

Machinery

Fig. 5. Estimate and Route Card which follows Order through Factory

any department, and this is largely responsible for the success which has been obtained from the use of this system.

Time Estimate and Route Card. — The date on which the work or operation must be completed by any department or foreman will be found on the "Route and Estimate" card shown in Fig. 5. These cards are filled out by the route clerk before the orders for the work are sent out to the factory, and follow the orders for the work from one department to another until the order is completed. These route cards not only show when each operation must be finished, but also the order in which the work

DAILY REPORT

OF ORDERS HAVING TO-DAY LEFT THIS DEPT.

DATE ______________

NAME OF DEPT. ____

NAME OF DEPT.	DEPT. NO.	DATE OF PROMISE OF ORDER	ORDER NUMBER	ORDER SENT TO DEPT. NO.	REMARKS
CUT-OFF	1				
CHUCKING	2				
TURNING	3				
MILLING	4				
INSPECTING	5				
HARDENING	6				
GRINDING	7				
INSPECTING	8				
	9				
	10				
1	2	3	4	5	6

____
(DEPT. FOREMAN)

Machinery

Fig. 6. Form used by Foremen in making Daily Reports

is passed along from department to department, as shown in column 3. For instance, after the chucking operation is completed in Department 2, the work must be sent to Department 5 for inspection, then to Department 4 for the milling operation, and so on until it is completed. Before the work leaves any department, the actual date of leaving is filled out on the route and estimate card by the foreman of the department. This is done

CAPACITY SHEET—PER HOUR—PER DAY OF 10 HOURS

COLLETS #2 SCREW MACHINE

DEPARTMENTS	CAPACITY-SIZE						REMARKS
	½	⅝	¾	⅞			
CUT-OFF							
CHUCKING							
TURNING							
MILLING							
INSPECTING							
HARDENING							
GRINDING							
INSPECTING							

Machinery

Fig. 7. Capacity Sheet for No. 2 Screw Machine Collets

ORDERS IN PROCESS—PROMISED

COLLETS #2 SCREW MACHINE

SIZE	QUANTITY	ORDER NO.	DATE PROMISED									
			CUT-OFF	CHUCKING	TURNING	MILLING	INSPECTING	HARDENING	GRINDING	INSPECTING		
½												
½												
½												
⅝												
⅝												
⅝												
¾												
¾												
¾												
⅞												
⅞												
⅞												

Machinery

Fig. 8. Sheet giving Record of Orders in Process of Manufacture

at the same time that the daily report shown in Fig. 6 is filled out and the foreman receiving the work will be certain to report any errors in these dates to the follow-up department, if the route cards are dated unfavorably to him. This affords a method of checking the accuracy of the daily reports when they are being recorded on the tracer card file by the follow-up clerk.

With the data available through the records kept by this system, it is possible to answer inquiries in regard to the date of shipment immediately and with a reasonable degree of accuracy, without having to go out into the manufacturing plant for the purpose. The tracer card file, shown in Fig. 3, is the key to the whole situation. As previously mentioned, these tracer cards are made out before the orders go to the factory and are checked every day from the daily reports shown in Fig. 6. The route outlined on the route and estimate card, shown in Fig. 5, is also listed on a route card (not shown) which is made out for each class of work. In this connection, it may be mentioned that the routes followed through the factory by many classes of work are practically the same.

Determining the Capacity of the Factory. — The capacity sheet shown in Fig. 7, although not directly connected with the follow-up department, plays an important part in the operation of the factory. These sheets show the capacity of each department for all the different operations which it handles. They are kept in a special loose-leaf binder, so that changes may easily be made in the case of an addition of new machinery or methods in any department. The left-hand pages of the sheets kept in this binder enable the route clerk to determine the capacity of any department for a given operation at a glance, and the right-hand pages, shown in Fig. 8, give a record of all the orders in the factory that must be handled by the different classes of tools, the capacities of which are given on the capacity sheets. The dates on which these operations must be completed are recorded so that, when a new order is issued, an accurate estimate of its date of completion may be made.

The follow-up clerk checks the number of each order which has been passed on to a new department and the departments to

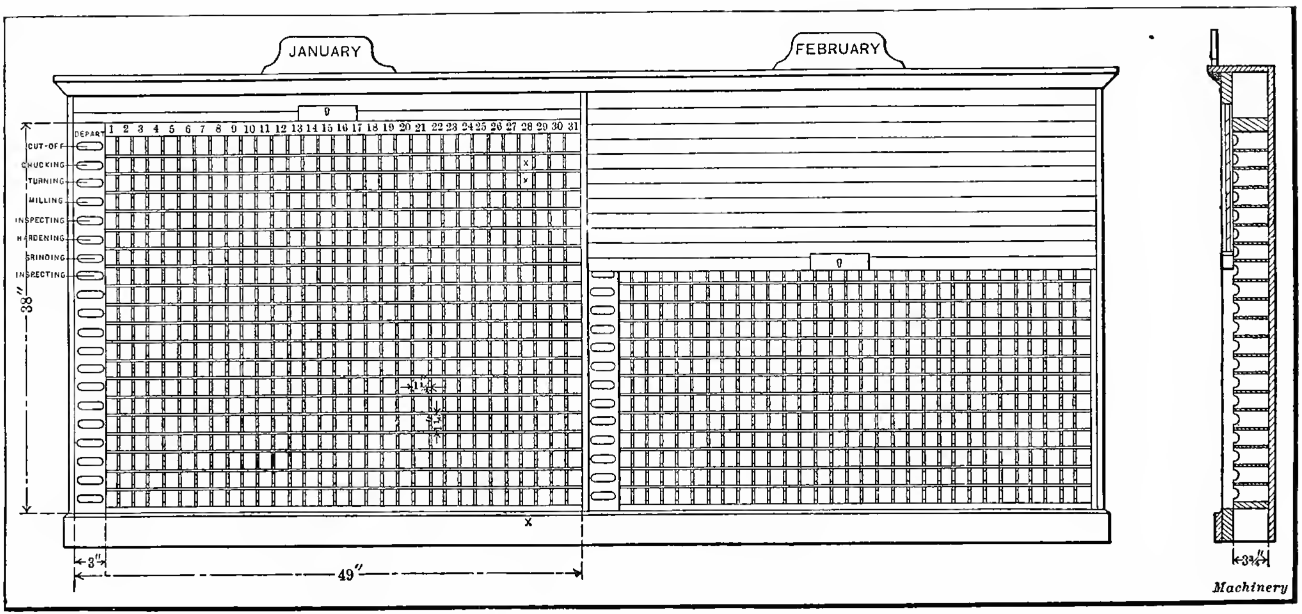


Fig. 9. Follow-up Rack which shows Progress of All Work in the Factory

which the work was sent from the daily reports, when checking up the tracer cards each morning. In so doing, he finds any discrepancy between the date on which the work was finished and the date when it should have been finished, according to the schedule. He may refer to the superintendent's file to obtain the reason in case of delay.

Following Progress of All Departments. — Although this system may be said to fill all of the requirements of following up

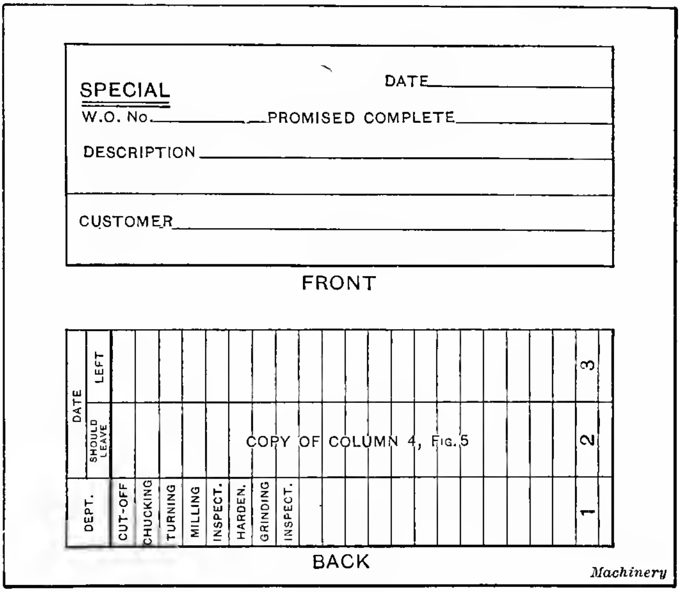


Fig. 10. Follow-up Rack Card for Special Orders

the progress of orders through the factory, and keeping them moving according to schedule, it is lacking in certain respects. For example, how can a factory manager or superintendent determine the number of orders that a certain department has on hand at any time from a card index? How are such officials going to find out (without the assistance of a lot of clerical help) how long an order has been held in a given department? How are they going to know if promises are kept? For this purpose, the " Follow-up Rack " was designed, of which two sections are shown in Fig. 9.

This rack consists of twelve sections, one being provided for each month in the year, and is used to keep a record of progress of the work in the factory. A small card, of the form shown in Fig. 10, is made out at the same time that the estimate card is made out when an order is sent to the factory. One side of this card has spaces for the order number, the name of the customer, the date on which delivery is promised, and a description of the product called for by the order. The opposite side shows the different operations that must be performed on the work, the

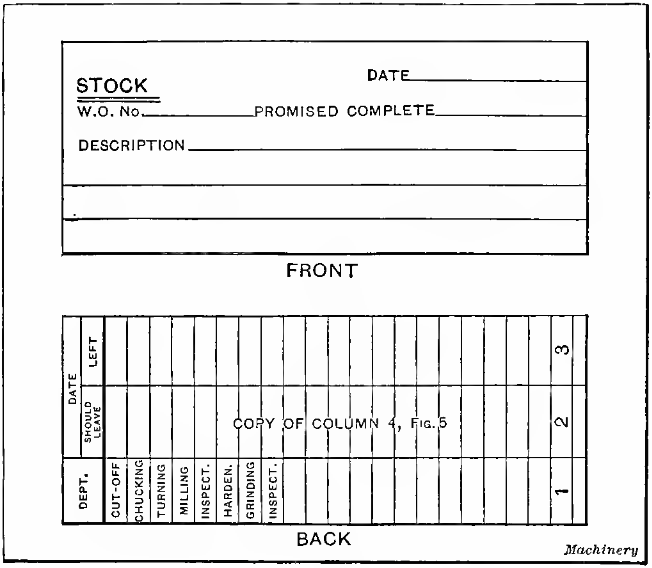


Fig. 11. Follow-up Rack Card for Stock Orders

dates when the work should leave the different departments according to the schedule, and the actual dates upon which it did leave these departments. Fig. 11 shows both sides of the form of card used for stock goods. This card is of a different color from that shown in Fig. 10 which is used for special goods, and the customer's name is omitted. The reverse side is the same as that of the card described in connection with Fig. 10.

How Follow-up Rack is Used. — To illustrate the method of using the follow-up rack, it will be assumed that Order No. 7001 is received from Jones & Co. for 500 collets on September 2, 1917. After the card is filled out in Column 2 by the route clerk, at the same time that he is filling out the estimate and tracer card, the clerk refers to the capacity sheet, Fig. 7, and to the promised order sheet, Fig. 8, to find if the order can be completed by November 28, which is the date specified for delivery. He then files the card in the 28th column of the November rack, opposite the department in which the first operation is performed. The card is then moved up or down in this column, keeping it opposite the department to which the work has been transferred until the work is completed. The proper location for the card is found from the daily report, which not only indicates to which department the work has been sent, but also the date on which the order was promised for delivery. This enables the position of the card in the rack to be immediately found, and also the date on which it was promised.

The card remains in the 28th column until the order is completed, after which it can either be thrown away or filed for future reference. This arrangement enables one to see at a glance just how many orders are promised to be completed, and if they are not finished on time this is immediately indicated by the appearance of the cards in the rack for dates already passed. This naturally causes everyone concerned to push the work along, and constitutes a gage of efficiency for both the department foremen and the follow-up department. This rack also makes it possible to look ahead, and if there appears to be any doubt in regard to a given order being unfinished by the specified date, there is ample time to take the necessary steps to avoid such a contingency.

All twelve racks are arranged in a single horizontal row, and by looking along the row it is possible to form an accurate estimate of how many orders a given department has on hand at any time, which could not otherwise be easily done. By looking at the back of the card, it is possible to see just when the work should have been completed in a given department, and when it actually was finished, the backs of the cards being filled out by the follow-up clerk from the daily reports of the foremen. This information is especially valuable for tracing delayed orders.

The capacity records involve a great deal of expense, not only in getting them up but in keeping them up-to-date. It has been found, however, that these records are an actual necessity, whether

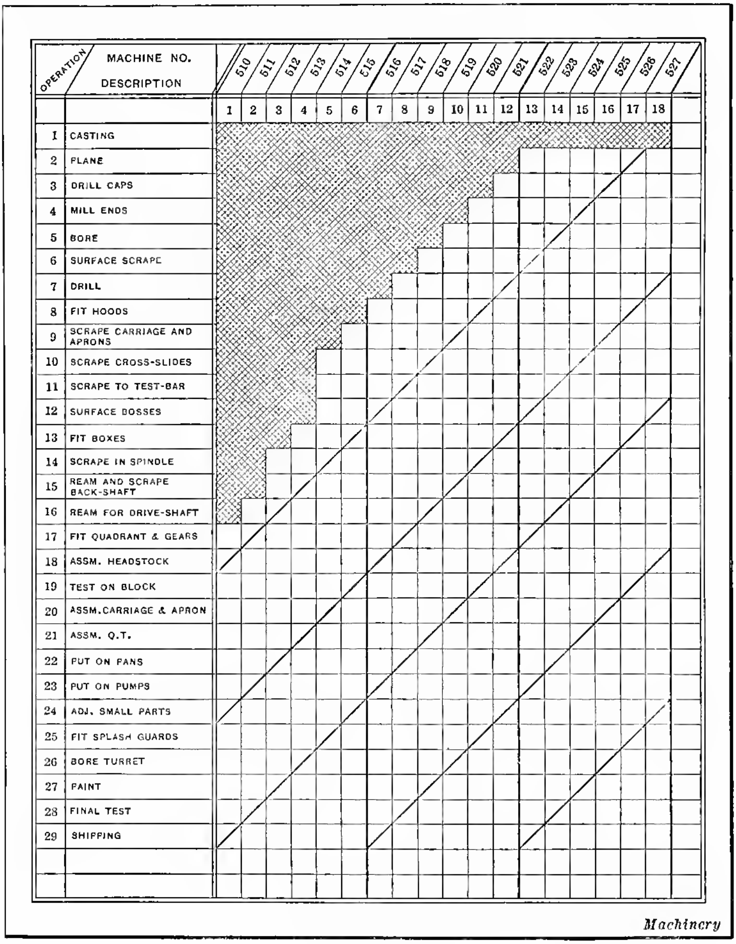


Fig. 12. Production Chart for Recording Progress in Building Machine Tools

a follow-up system is used or not, and consequently this expense cannot justly be entered on the books against the follow-up system. The advantages secured through the follow-up system and follow-up rack which have been described are far-reaching in their results. The heads of manufacturing companies have not generally much time for details, and the use of this system keeps them informed of nearly all the conditions in the plant that are of vital importance. Very little time is required to secure this information, and they can determine just what these conditions are without spending valuable time in going about the factory. Figures and data are often misleading and errors or unintentional deceptions entering into the reports of subordinates are very frequently responsible for serious complications. Where this system is used, however, such deceptions are impossible and the management is thus protected from both deserved and undeserved criticism of customers, which leads to the loss of future orders; hence, this follow-up system is a very productive "non-productive" department.

Charts for Showing Progress of Work. — There are several ways of keeping track of the conditions of production in the shop when building machines in lots, but no matter how good a system is employed, it is desirable to have some graphic means of showing the daily progress to the superintendent or general manager. The board or chart that shows graphically progress and delays from day to day of operations acts as a spur on the manager, who, in turn, is likely to stimulate the activity of the men and thus bring the lagging work up-to-date.

The chart shown in Fig. 12 illustrates the plan of a large blackboard installed in the office of the superintendent of the International Machine Tool Co., Indianapolis, Ind., to facilitate the production of the Libby turret lathes. At the left of the chart are the principal operations arranged in the order in which they are generally done. These consist of casting, planing, drilling caps, milling ends, boring, etc. At the top are the serial numbers of the turret lathes being built.

Suppose that a lot of eighteen lathes is being constructed. It is necessary first to obtain the castings from the foundry, and the chart shows that eighteen castings have been delivered, eighteen of the squares of the chart having been chalked in. The chart also shows that twelve of the castings have been planed, eleven have been drilled for the cap-screws, ten have been milled on the ends, nine have been bored, and so on. If one of the castings develops serious defects after being planed, drilled, milled, or bored, it is rejected and the space on the casting line is erased until a new casting has been obtained to fill its place.

It will be noticed that the last operation that has been filled in is No. 16, " reaming for the drive-shaft," and this has been done on one machine only. The general contour of the filled-in spaces approximates that of a 45-degree right-angle triangle. When the operations go through practically in the order planned and everything follows without serious delay, this plan of progression is carried on throughout. In other words, the operations completed will be about in the order indicated by the diagonal line, and as the operations on a lot are completed they "flow off" the sheet at the lower right-hand corner, shipping being the last job.

The superintendent posts himself each day on the conditions of work in the plant and then fills in the squares of the operations completed. In this way, he impresses upon his mind the condition of work in the plant and at the same time makes a record for reference during the day. The record also acts as an incentive to everyone connected with the production department; when one of the foremen comes into the general manager's office and sees the conditions of the chart wherever his department is concerned, he is likely to make a special effort to increase production if that section shows perceptible lagging behind the general ideal contour of the operation sheet.

The charting system to be described shows, at a glance, the position of finished parts and completed units in an automobile factory. The scheme when modified to suit requirements is also applicable to most branches of engineering. The majority of managers have at some time experienced difficulties brought about by unbalanced production. Suppose an order calling for a production of sixteen chassis per week of a certain type has to be completed in a given time; then, the aim of the management is to get out the chassis at the given rate per week, if possible, but no matter how the weekly production may fluctuate due to various causes, it is up to the management to make an attempt to finish the total number before the final date stipulated.

The chart, Fig. 13, is useful in this connection, as it shows both weekly and total numbers. The dot-and-dash lines indicate the estimated output and the full lines show the actual output. The main object is to arrange production so that the full line showing total output is above or near to the dotted line showing estimated total output. If the full line is above the dotted line, then the

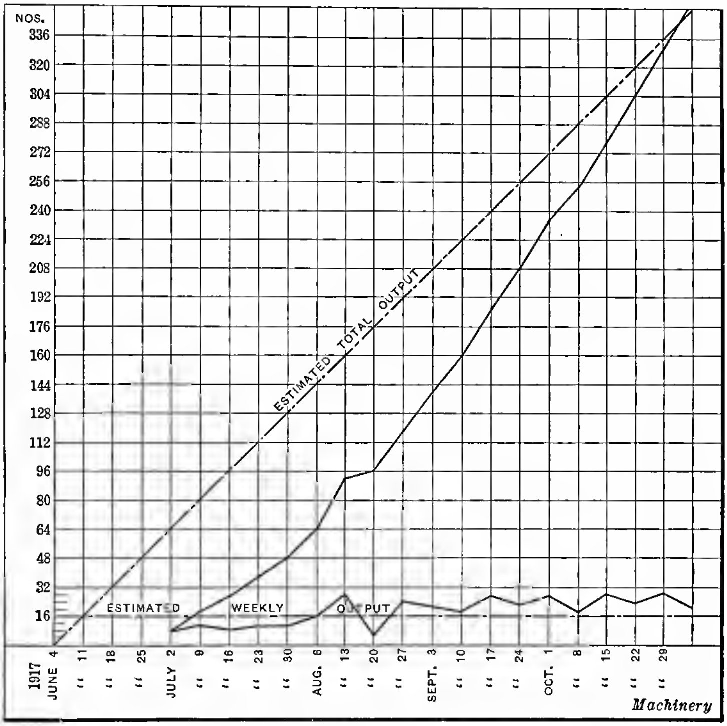


Fig. 13. Chart Comparing Estimated and Actual Outputs

production is safe; but if it is continuously below and shows a tendency to fall away, then the management must take measures to increase the output by overtime or by putting more men or machines on the job. The chart illustrates how a bad start was made, but shows a gradual improvement till ultimately the estimated total is reached.

Before the chassis can be built there must be a supply of detail parts and the chart, Fig. 14, shows a method of recording how these are progressing. Here the main object is to keep all the thick black lines indicating actual output an even height, either level with the dotted lines showing estimated output or in advance of them. If certain details should accumulate much more rapidly than others, then, if the machines are suitable, production may be reduced or stopped on the parts on which there is a sufficient supply and the machines be used for making parts that

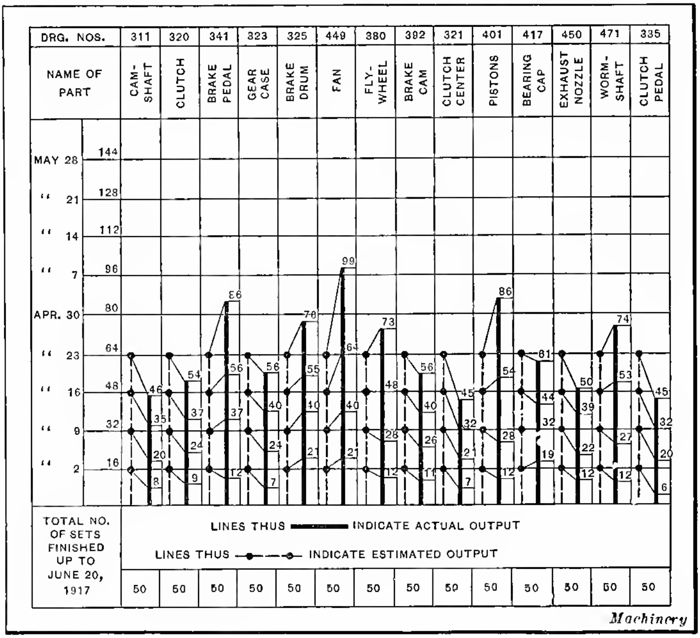


Fig. 14. Chart showing Progress of Various Details

are lagging behind in production. The best arrangement of this chart is in section and numerical order, *i.e.*, one chart for the engine, another for the gear-box, etc., the parts being in the numerical drawing number order. It is then an easy matter to locate any particular detail about which information is required.

Mechanical Charts for Following Progress of Work. — Figs. 15 and 16 show mechanical charts based on the principle of the chart shown in Fig. 14. Fig. 15 shows a portion of the detail board, an enlarged section showing the construction appearing in the lower right-hand corner. It is made of pressed sheet-steel plates backed with dull white celluloid in a wooden frame. A series of celluloid-faced sliding buttons are free to slide in slots provided in the steel plates. On the face of the buttons is printed the number of parts to one engine, gear-box, or set. For instance, on a 6-cylinder engine there would be one crankshaft,

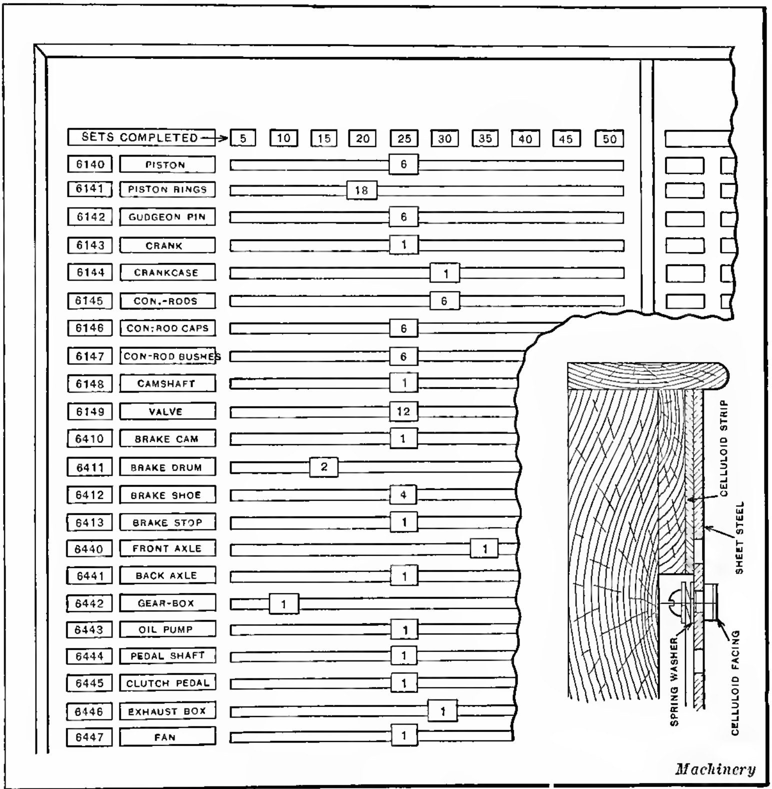


Fig. 15. Mechanical Chart for Following Progress of Work

six pistons, one crankcase, etc. When finished parts or batches of parts have been finally inspected and sent to the "finished stores," the sliding button on the chart representing this part is moved on to the total number then received. As shown in Fig. 15, twenty-five sets of most of the parts are finished. The object of the responsible official is to push forward the parts lagging behind at the expense of the parts that are in front, so that a straight row of sliders gradually advancing is maintained as far as possible.

The numbers at the top of the board, indicating sets completed, can be modified to suit requirements. When the total output reaches about 50 sets, the numbers would be changed from 5–50 to 50–100, and so on. The board should also be arranged in

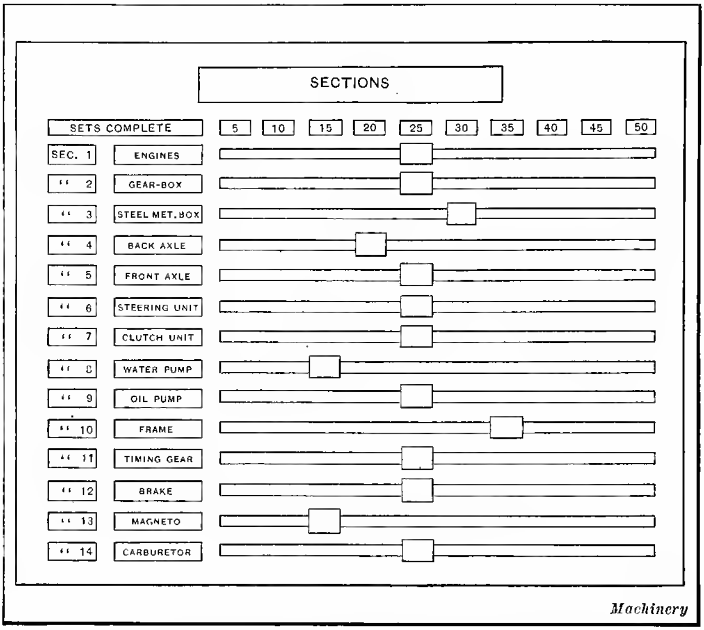


Fig. 16. Section Board showing Number of Sets of Engine Parts, Gear-box Parts, etc., that have been completed

numerical and section order; then when, say, twenty-five sets of engine parts were completed, the slider opposite engines on the section board, Fig. 16, would be pushed forward. The management can see at a glance how the work is progressing, and what parts want pushing forward, without referring to a number of progress sheets or cards. The fitters know how many sets of various sections are available and can arrange accordingly. These charts should be used in conjunction with the progress or follow-up system to obtain the greatest advantage.

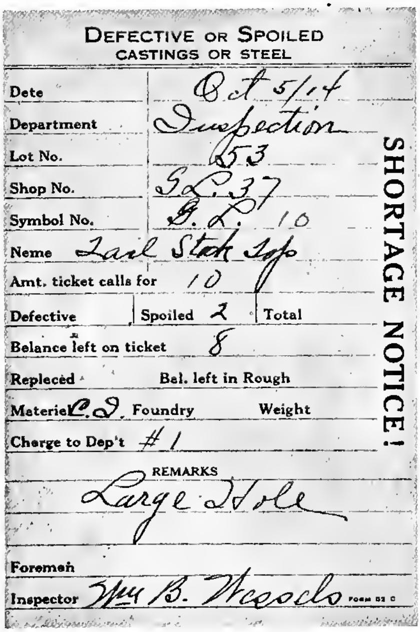
CHAPTER VI

INSPECTION SYSTEM FOR MACHINE SHOPS

THE necessity for a thorough system of inspection and the advantages gained thereby are now recognized by all modern manufacturing concerns, so that whereas formerly inspection was relegated to an inferior position among shop duties, it now occupies a place in the front rank. The business of a consulting engineer is assuming larger proportions every year, due to the tremendous strides being made in manufacturing industries, and if one stops to analyze the functions of a consulting engineer, it will be found that inspection duties now form a considerable part of his work.

As a further illustration of the growing importance of inspection, it may be mentioned that testing and inspection bureaus are being established, which make a business of inspecting and testing factory and mill products at regular intervals. Such products as wire, cable, flexible tubing, hose, bar steel, etc., produced in factories subscribing for the bureau's service, are now marked with a label or other means, showing that they have been inspected and passed by the testing bureau. The general purpose of such an inspection is not only to give customers the fullest possible guarantee of reliability, and to act as a stimulus for the maintenance in the factory of high standards in design and materials, but also to afford manufacturers means whereby their products will be easily recognized in the field in distinction to inferior and unapproved goods. Furthermore, such an inspection will be an aid to manufacturers in keeping up the quality of work and supervision to a point which will best serve the interests of all concerned.

Organization of an Inspection Department. — The organization of an ideal inspection system would mean the employment of enough inspectors so that each piece could be inspected after each operation. In this way, the inspector would find a defective or spoiled piece before any more time was spent on it. In some plants that are not systematized as regards their methods of inspection, jobs that are spoiled by the first operation are sometimes completed before the defect is discovered. Another case illustrating the importance of inspection is when a complete lot of work comes to the inspector who not only inspects it, but also keeps a record of the number of pieces received, so that, in case of a shortage, the previous operator or department must report whether it was spoiled or defective. With one system, if the last operator or department cannot account for the missing piece or pieces, the inspector makes out a shortage slip of the form shown in Fig. 1 against that department, which will be turned in to the cost department where the loss will be figured, and at the end of the month an itemized account is sent to each department showing the heads of departments how much work has been spoiled. Such a record is also kept in the office, and at the end of the year this will be found helpful when taking inventory. In case work is spoiled, the tag shown in Fig. 2 may be attached to the work, which will prevent any further confusion.



DEFECTIVE OR SPOILED
CASTINGS OR STEEL

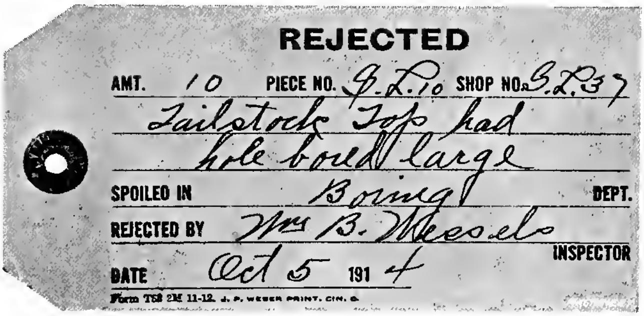
SHORTAGE NOTICE!

Date Oct 5/14
Department Inspection
Lot No. 53
Shop No. G.L. 37
Symbol No. G.L. 10
Name Tail Stock Top
Amt. ticket calls for 10
Defective | Spoiled 2 | Total
Balance left on ticket 8
Replaced | Bal. left in Rough
Material C.I. Foundry Weight
Charge to Dep't #1
REMARKS
Large Hole
Foreman
Inspector Wm B. Woods FORM 52 C

Fig. 1. Form used by Inspection Department in calling Attention to Shortage in Quantity

Further along in this chapter, in connection with a discussion of the inspection of work in the shop and the beneficial results to be derived from working to limiting instead of to exact dimensions, it is pointed out that it would be equally desirable if some method could be devised whereby inspectors of materials could be assisted in handling their work by furnishing them standards such as samples, curves, or other data showing the limits between which materials could be passed, thus reducing to a minimum the possibility of errors in judgment. The idea intended to be conveyed is exemplified in part by maximum and minimum limit gages. Where such gages can be used, the product, when inspected for correctness of size, is supposed to be not greater than the larger nor less than the smaller of the two gages.

Careful records should be kept of materials rejected or found defective in any respect, and steps should be taken to see that



REJECTED

AMT. 10 PIECE NO. 9.L.10 SHOP NO. 9.L.37

Tailstock Top had hole bored large

SPOILED IN Boring DEPT.

REJECTED BY Wm B. Wessels INSPECTOR

DATE Oct 5 1914

Form TS8 2M 11-12. J. P. WEBER PRINT. CIN. O.

Fig. 2. Form used by Inspection Department in rejecting Defective or Spoiled Work

such materials are promptly disposed of in order to prevent any possibility of their becoming mixed with accepted materials. At the same time, those who are responsible for the defective parts should be notified immediately so that the defects may be remedied with the least possible delay. Fig. 2 shows a rejected or defective material ticket used by a lathe manufacturer.

Extent of Inspection. — In factories where the inspection department is well organized, an endeavor is constantly made in each department to inspect the work during the actual making as well as upon the completion of it. When it is remembered that in the stock-room ledger of many factories there are listed thousands of different items, one will appreciate the enormous volume of work that is constantly going through the factory and consequently through the inspection department. It would be a physical impossibility without increasing the force to a disproportionate size, to inspect every individual piece. It would also be equally unnecessary to do so, since many of the parts are made by automatic or semi-automatic machinery, and on all such work it is sufficient to inspect on a percentage basis, a case in point being screw machine products and other repetition work. After the tools are once properly set for work of this kind, it is only necessary to inspect for detecting errors due to the wear of the tools or to a lack of alignment that may develop. When errors from such causes have been guarded against, an inspection of a percentage of the finished parts is quite as effective as an inspection of every piece. On the other hand, parts which are not made by automatic machines or which are not manufactured in sufficient quantities to warrant the making of dies, limit gages, templets, etc., require detailed inspection.

Special Inspection Room. — In some shops, the inspection system is so arranged that the material, after each operation has been performed on it, is delivered with an identification card to a separate inspection room where it can be thoroughly inspected and passed or rejected. If satisfactory, it is retained and, in due course, reissued to another workman for the performance of the succeeding operation. Where the work is small, this method will give excellent results, but in the majority of cases a procedure of this kind is not permissible on account of the large size or awkward shape of pieces, which would require too much labor to handle them. It then becomes necessary for the inspector to go to the work, inspect it and put his special stamp on it or an inspection tag similar to the form shown in Fig. 3. It will be found advisable when the size of piece permits, to stamp it while in the rough state with a serial number, and to check each serial number with the check number of various workmen who perform the work on it. In this way, defective work can always be traced back to the right person, no matter what the lapse of time between the performance of the work and its inspection.

In some classes of apparatus, the nature of work is such that each operation serves as a check on the preceding operation, in which case the workmen act as inspectors. Carrying this idea still further, some concerns hold each workman responsible for any work that may be performed by him on a piece on which any of the preceding operations performed by other workmen have been incorrectly done.

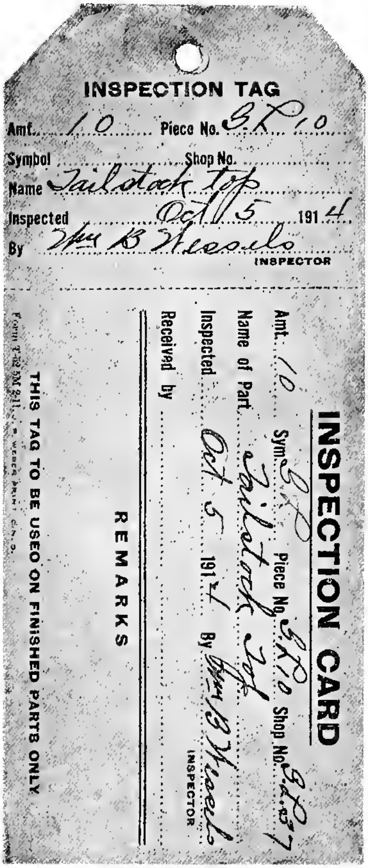


Fig. 3. Card attached to Work after it has passed Inspection

Disposal of Defective Parts. —All defects or deviations from the drawings and specifications, noted by the inspectors during the inspection of materials or the building of machinery, should be given careful consideration to determine whether the piece should be scrapped outright, whether it may be rectified, or if the part happens to be an unimportant one, whether it may be passed without change. A full knowledge of the situation is required before an intelligent decision can be arrived at. If a decision cannot be given by the inspector himself, the matter is at once referred to the head of the department involved. In the meantime, all work which is likely to be affected in any way is stopped, pending a decision as to the disposal of the defective part.

Complaints. — Complaints received from the outside that are either from the erecting department or district offices should, if applying to the works, be referred to the inspection department to be thoroughly investigated. A written report should then be made in each case to the manager of the works and to the erecting department, and also to the office for the purpose of having it forwarded to the proper district office. These complaints should be classified on a monthly basis and treated similarly to expenses due to pieces spoiled in the works. When complaints received from the outside affect the design only, they should be referred to the engineering department where an analogous course of procedure would be followed. A record of all complaints should be maintained by the management.

There is no better field for coöperation, nor one in which either the results of coöperation or the harmful effects resulting from lack of it may be more easily seen, than the work of inspection. The efficiency of inspection depends largely upon the aid received from the engineering, testing and other departments, members of which are more or less in touch with manufacturing processes and are thus enabled to make many helpful suggestions regarding the work. Every letter of complaint from customers should be accepted at its full face value and thoroughly investigated, first with a view to ascertaining the cause of the trouble, and second with a view to preventing a recurrence of it.

When complaints are received involving defective workmanship, it is advisable to send the inspector and foreman of the department in which the apparatus was built to see for themselves the exact cause of the trouble. In this way, their viewpoint will be broadened and they will appreciate more fully the requirements of the machinery built in the works. No matter what precautions may be taken to have nothing but perfect machinery shipped from the works, there will be certain points that can only be learned from actual experience.

Selection of Inspectors. — In choosing inspectors, the endeavor should be made to obtain men who have had the requisite experience in the works. In addition, such men should be selected as are likely to appreciate the responsibility of their position, and who are endowed with an abundance of good judgment, not only for passing upon materials submitted for inspection, but also in dealing with the men about them. As regards their dealings with the men, inspectors should be absolutely fair and impartial.

No discrimination should be made between one workman and another. A feeling of coöperation must also be fostered between the inspectors and the foremen, if the work of inspection is to be carried out effectively, and the inspectors should not be controlled by the foremen of any department, but by a chief inspector. If foremen are given charge of inspectors, the latter, in some instances, may be ordered to pass material to maintain the required rate of production. Better results will ordinarily be obtained if an inspector is under the jurisdiction of none but a chief inspector.

Limits on Drawings. — Many drawings give absolute measurements; that is, they give single measurements to work to, and do not specify what variation in the absolute size will be permitted. As it is not necessary in the vast majority of commercial operations to finish parts to the greatest degree of accuracy possible, the question is one of relative accuracy. In other words, the error should be confined between the limits of variation either way from the exact dimensions. The amount of tolerance or limit depends, of course, upon the nature of the work.

On the blueprints used by the American Machine & Foundry Co., limits are specified in connection with the dimension of every part, no matter what degree of accuracy is required nor how much variation in size is permissible. This is obviously an important point in reducing the cost of machining operations, as the machinist sees, at a glance, whether he is required to work with great precision or whether the part is a rough one that need not be finished carefully.

Relation of Inspection Department to Management. — In any manufacturing company, consideration of the inspection department should begin with a study of the relation of that department to the management of the company and to the various departments of the organization. These relations must be positively fixed and thoroughly understood. In many cases, the inspection department is not rendering the service of which it is capable nor operating at maximum efficiency, on account of lack of coöperation between it and the other departments. It is the primary function of the inspection department to inspect and pass upon the material submitted to it, approving that which meets the requirements laid down and rejecting that which fails to come up to the adopted standard. At the same time, this department is in a position to render valuable assistance to the sales and purchasing departments as well as to the engineering and production departments, if the spirit of coöperation exists throughout the whole organization.

The following is an abstract of a paper on this subject, read by Fred B. Corey before the American Association for the Advancement of Science.

Control of Inspection Department. — In the majority of manufacturing corporations, the inspection department is under the authority of the factory manager or superintendent. In other words, that branch of the organization which builds the apparatus decides whether that apparatus is properly built. It is unnecessary to point out the inherent weakness of this arrangement. The judgment of the inspector may continually be biased by the fact that he is a part of the factory organization and is responsible to the factory management. It is, therefore, evident that the highest standards of quality and workmanship hardly can be maintained continuously if the members of the inspection department are in any degree subject to the control of a factory superintendent or any other executive who is directly responsible for the factory production and has no connection with the engineering or sales organizations. This statement should not be understood as expressing a doubt in regard to the loyalty or honesty of purpose of any factory official. It is a fact, however, that defects, due to drawings or specifications, are often disregarded by inspectors if they know that no criticism can be attached to them by their superiors on account of the latter's approval of the apparatus, especially when a rejection would prevent meeting a promised date of delivery.

Inspection Department under Chief Engineer. — In a smaller number of shops, the inspection department is under the control of the chief engineer. With this arrangement, the judgment of the inspector is likely to be biased by the fact that any defects in the finished product, due to improper specification of materials or any failure of the apparatus to function properly, might be considered as reflecting on the abilities of the engineering department. The inspector will often hesitate to reject a device if he thinks that the objectionable feature may be attributable to his superior officer, as it would imply a difference of opinion that might reflect discredit on the inspector's judgment. Moreover, there is often a tendency among young and subordinate engineers to refuse to recognize slight defects in a design for which they are personally responsible, and to severely criticize an inspector who points out what he considers a defect in such apparatus. Therefore, in most cases the executive head of the inspection department should be as free from control of the engineering department as from the manufacturing department.

Inspection Department under General Manager. — The only logical plan of organization is that in which the head of the inspection department, whatever may be his title, is responsible directly to the general manager of the company or the chief executive in control of the factory output. He should report to the same officer as the works manager or the chief engineer. At the same time, he must be in full sympathy with all other departments. He must command the respect of the other department heads and be ready to coöperate with them to further the interests of his company.

The executive head should exercise a most thorough control over all the activities of the department. To that end, there should be no recognized paths of communication between this department and the heads of the other departments, except through his office. The strict enforcement of this rule is essential to the efficient working of the department and to the avoidance of misunderstandings and duplication of effort. This requirement, if rightly understood, will not be interpreted as limiting the useful activity of any member of the department, but will be recognized as a necessary feature in the conduct of inter-department business.

Duties of the Chief Inspector. — The executive head of the inspection department should be thoroughly familiar with general engineering practice and standards. He should be well informed on all shop methods, including foundry and machine shop practice, and be thoroughly versed in the use of testing machines and gages. He should, if possible, be conversant with chemical laboratory methods and apparatus, so as to be able to direct intelligently that part of his organization. Moreover, he should be familiar with the uses of the factory product and the conditions under which it is to operate after it has passed beyond the control of the factory. He must have absolute control of every inspector in the plant and be held responsible for the quality of material and workmanship of all that the plant produces.

In the majority of manufacturing corporations, all dealings with the customers are conducted by the sales department exclusively, which is the logical arrangement. For this reason, complaints on the part of the customer are made directly to the sales department and usually reach the shop through a more or less tortuous channel. There is sometimes a tendency on the part of the sales department to assume that all of these complaints are justified, to criticize the shop for turning out an unsatisfactory product, and especially to blame the inspection department for failure to prevent the issuance of the material in question. All such complaints should be referred to the executive head of the inspection department for a personal investigation and report, and action on the part of the sales department, except so far as it relates to the replacement of material urgently needed, should be deferred until the report is in hand. This report may entirely change the attitude of the customer with relation to the alleged defective material, as it may clearly show that its failure to meet his expectations was due to no fault of the manufacturer or of the apparatus involved. The trouble may have been due to injury in shipment, rough handling after receipt, failure to install or to apply it properly, lack of proper maintenance on the part of the customer or his employes, or to a misconception of the capacity or function of the apparatus itself.

Coöperation with other Departments. — The inspection department exists for the mutual protection of the manufacturer and the customer. The salesmen should be informed in regard to the methods and practice of the inspection department, as this knowledge may be of great service in promoting friendly relations with a prospective or actual customer. The customer is often much interested in the means employed to insure accuracy in the manufacture of the apparatus he proposes to use.

The relations of the inspection department to the engineering department are most important, especially in the influence that may be exerted on the designs for new apparatus and the improvement of the old. In many places, new drawings, when completed and before their final approval, are submitted to a committee (variously known as "mechanical design committee," "limit committee," "standard committee," etc.) to determine if the limits set by the designers are such as can be met commercially in the factory, and to decide if any changes are desirable on account of methods to be used in the foundry, machine shop, etc. The head of the inspection department should be one of the most important members of this committee; in some instances, he is chairman. His principal duty in connection with this committee is to advise if the dimensions, tolerances and limits called for on the drawings are satisfactory for the various fits, and if the quality of finish called for will be satisfactory to the inspection department. Thus the work of the inspection department should begin even before the designs are approved for manufacture.

The internal organization of the inspection department and the means and methods best adapted to carry out the details of its work are matters that will depend to a great extent upon the management and operation of the larger manufacturing organization of which it forms a part. A plan of organization that may be highly efficient in one factory may be deficient in meeting the needs of another shop producing a different product or producing a similar product by widely different methods. The organization of inspectors that is perfectly suited to a factory having a large output of a few well-standardized articles would be wholly unable to cope with the situations arising in a smaller factory producing a great variety of articles, but making each in comparatively small numbers.

CHAPTER VII

STORAGE AND MAINTENANCE OF SMALL TOOLS

One of the problems connected with the management of machine shops is the care of the numerous small tools used on machine tools and in assembling departments. As the " business end " of a machine tool is the cutting end, it is important to use tools that cut effectively and to keep the machine on the job; and when the parts produced in these machines are being assembled it pays to use reamers that ream, wrenches that are right as to size and fit, and good tool equipment in every department. These are the principal reasons why modern machine-building plants have tool supply rooms and systematic methods of caring for the many different kinds of tools used in machine shops. A store-room for tools of certain classes is found in almost every machine shop, but there is considerable variation in regard to the types of tools that are stored, the coöperation between the tool supply and manufacturing departments and the extent to which systematic methods are applied to insure the prompt delivery of tools in good condition. For instance, the tool supply room may be merely a place for storing small or auxiliary tool equipment when not in use, or it may be so managed that such tools are not only stored but maintained in good condition and delivered to the different manufacturing departments in such a prompt and systematic manner as to add to the efficiency of the entire plant.

Location and Plan of Tool Supply Room. — When a machine shop has only one room or department where tools are stored, this should ordinarily be located in a central position relative to that part of the shop requiring the largest number of tools, provided the general construction of the shop will permit. If the plant is large enough to be divided into separate departments, the usual method is to have a tool crib in each one; frequently the department supply rooms are auxiliaries of the main supply room, which may or may not be a tool-room as well as a place for tool storage. Some shop managers prefer, even for large plants, one main tool storage department from which all tools are obtained. This method, however, has only been adopted to a limited extent and chiefly where the nature of the work is such that many tools are not used exclusively on any one line of work, but are required in various departments. In connection with this plan, as applied to a large shop, the tools should be delivered to the workmen, in which case the accessibility of the tool supply room is not so important as when each employe must obtain the tools required.

The storage of tools is generally under the supervision of the tool-room foremen in plants having toolmaking departments, and, where there is a single tool supply room, this is often a department of the tool-room, but it should be separated completely from it by a grating or partition, and should be under lock and key. One arrangement which has proved satisfactory for comparatively small shops is to have the tool supply room in such a location that one window or opening for the delivery or return of tools is connected with the tool-room and the other window with the machine shop. The tool-grinding department of a medium- or small-sized shop is usually adjacent to the store-room or is practically a part of it. This department usually contains a drill grinder, a tool and cutter grinder for sharpening reamers, milling cutters, etc., and a universal tool-grinding machine for sharpening forged turning and planing tools, provided such tools are kept in the store-room. In the larger plants, where the different departments have separate tool supply rooms, the grinding of such tools as reamers, milling cutters, taps, etc., is generally done in the tool-room.

In locating the bins, drawers, or racks for tools or supplies, it is important to place the sections which are to contain the tools in greatest demand nearest the delivery and receiving windows. The extent to which different classes of tools are used varies in different shops and depends to some extent upon the nature of the manufacturing operations. In general, such tools as drills, taps, reamers, gages, jigs, milling cutters, and files are used frequently. If blueprints are kept in the store-room, these should also be conveniently located with reference to the delivery window. Attention to this matter of tool location prevents needless delay in delivering tools to the workmen.

Classes of Tools and Supplies Kept in Store-rooms. — Tool supply rooms are generally intended for tools such as drills, reamers, taps, milling cutters, form tools for screw machines, box-tools for screw machines and turret lathes, standard and special gages, jigs and fixtures (except those which are heavy and cumbersome), punches and dies, new files, wrenches, lathe dogs, soft hammers, sledges, pneumatic hammers, and many other small tools of the portable class. In addition, there may be a variety of general supplies, such as standard bolts, nuts and washers, taper dowel pins, cotter-pins, brass, copper, iron or steel wire, and so on. In the larger plants, supplies of the general classes mentioned may be kept in a separate department, and the tool supply room be used exclusively for auxiliary tool equipment, such as is required either in connection with machine tool operation or in the erecting department. Another method of handling supplies which is quite prevalent is to keep the principal stock in a supply room and a small stock in the tool cribs, the material which is stored with the tools being of the class that is needed continually by the manufacturing departments.

The variety of tools in any supply room naturally depends somewhat upon the class of work done in the shop or department with which it is connected. For instance, in some machine shops milling machines are used extensively, and consequently a large stock of milling cutters is required; other shops use a relatively small number of milling cutters, but a great many taps, reamers, and drills, and there are many other similar variations.

Storage of Tools on Basis of Usefulness. — When deciding what tools shall be placed in a tool supply room, several factors may be considered. In some shops the store-room is used only for tools which are valuable and which for the most part are products of the toolmaker. Such tools are cared for simply because they are valuable and perhaps easily deranged by careless handling. According to the modern idea of tool-room systems, however, tools are kept in a special store-room not merely because they are expensive to produce, but because of their usefulness and to insure prompt delivery of adequate tool equipment when needed, as well as to eliminate loss of productive time resulting from misplaced tools or fixtures. The rough bolts and clamps used on planers and other machines for holding castings and forgings to the machine table have little value so far as first cost is concerned; but if such equipment is not available when needed, or is in poor condition, the time of setting up a machine may be so delayed as to greatly increase the machining cost, and such delay may affect the work of other departments. In order to avoid difficulties of this kind, it is the practice in the more progressive plants to include in the stock of the tool store-room whatever small tools are essential to machining or assembling operations, even though they may not be expensive or of delicate construction. When the tool store-room is based on this plan, it is closely related to the various manufacturing processes and tends to increase the rate of production and general efficiency of the plant.

Storage of Large Jigs or Fixtures. — While it is generally considered advisable to keep all small tool equipment in a special department, many shops, especially those in which heavy machinery is built, have jigs, fixtures or other tools which are too heavy and cumbersome to be moved to and from the tool supply room each time they are used; moreover, such large tools are often used exclusively in one department, and there is an advantage in having them near the machine to which they belong. Heavy tools that cannot be handled easily are often kept in a definite place on the shop floor, especially if they are used frequently or exclusively in one department; in other plants, auxiliary supply rooms are provided. It is a good plan to have all equipment of this kind, regardless of where it is stored when not in use, under the supervision of the tool supply department. While heavy jigs, fixtures, etc., may not be deranged as easily as smaller and more delicate tools, the fact remains that if no one is responsible for their upkeep, and systematic inspection is not provided for, minor defects often accumulate until, in some cases, the tool is in poor condition.

Storage of Clamps, Bolts, and Packing Blocks. — The clamps and bolts used for holding castings or forgings on the work-tables of machine tools, when special jigs or fixtures are not used, are kept at the different machines in many shops and often are moved from one part of the shop to another as they may be needed by different workmen. Ordinarily when such equipment is not cared for systematically, it is the direct cause of unnecessary delay in setting up machines. Bolts of the right length are often difficult to find and the threads become battered so that nuts must be run on or off with a wrench. Sometimes it will be necessary for a machine operator to recut a bolt with a hand die, and meanwhile the machine is idle.

Equipment of this kind should be kept in the tool supply room and be cared for the same as cutting tools, gages, etc. Where this plan is followed, it is common practice to include, in addition to a stock of clamps and bolts of various sizes and lengths, packing blocks for the clamps. In some plants, a standard wrench is sent out with each set of bolts, clamps and blocks, so that the time for setting up a machine is reduced as far as possible. When bolts are returned to the supply room, each one should be examined to see that the nuts can be turned freely by hand.

Storage of Blueprints. — Tool store-rooms are not only used for equipment of the general classes mentioned, but in many cases for keeping blueprints as well, especially in plants where duplicate machines are constantly being built. When blueprints are kept in this way they are usually given out in exchange for a check the same as a tool. A duplicate set of prints may be filed in the office of the machine shop foreman or superintendent for reference purposes only. These office prints should preferably be bound or filed together in sets, so that the foreman always has a complete set for his own use, instead of being obliged to refer to those which are scattered about the shop.

One method of handling blueprints which has proved satisfactory is to mount them on thin steel plates, heavy cardboard, or wood. A thin material is preferable, owing to the relatively small space required for storage. Blueprints mounted in this way are protected while in the shop and they can be easily filed for future use.

In a great many machine shops, blueprints are destroyed when they are no longer needed in the shop for a certain job. The reason for destroying them instead of filing them away for future use is that, in many cases, the blueprints are either soiled or torn to such an extent that it is preferable to make new ones when they are needed again. Naturally the extent to which blueprints are soiled varies with the length of time they are kept in the shop, and may depend considerably upon the kind of work done, so that the practice of destroying them might not always be justified.

Storage Fixtures for Tools. — The fixtures, such as racks, shelves, bins, and drawers in which various kinds of tools are stored, should, as far as possible, be compactly arranged, in order to economize in space. The light should also be distributed evenly so that there are no dark shelves or bins, and it is important to arrange each fixture in such a way that the tools may be removed without difficulty. Each tool or tool set should have a definite place in the tool cabinet and provision be made for identifying and locating different classes of tools. A common method of marking different sections of a tool supply room is by means of letters and numbers, the letters indicating main sections and the numbers showing the location of racks, bins, drawers, or other storage places in each section.

General Arrangement of Storage Fixtures. — When designing storage fixtures of any kind, it is advisable not to conceal the tools any more than is necessary, although drawers or trays are often considered preferable for small drills, taps, reamers and other tools that might be lost or misplaced if kept in open bins or shelves. Shelves or box-shaped enclosures should be large enough to permit the hand to be inserted without interference. Trays or open shelves for small tools should have shallow or low partition strips for separating different sizes of tools, and if such receptacles slope toward the front the tools may be seen better and more easily removed. Edged tools, such as reamers and milling cutters, should be separated so that they will not strike against each other. Reamers, taps, etc., are sometimes held vertically by inserting the shanks in holes made in a special rack; such tools are also kept in trays or drawers having low partition strips to prevent direct contact between different tools. Fig. 1 shows reamer and drill cabinets in a tool supply room of the Cadillac Motor Car Co. The reamers are placed in separate

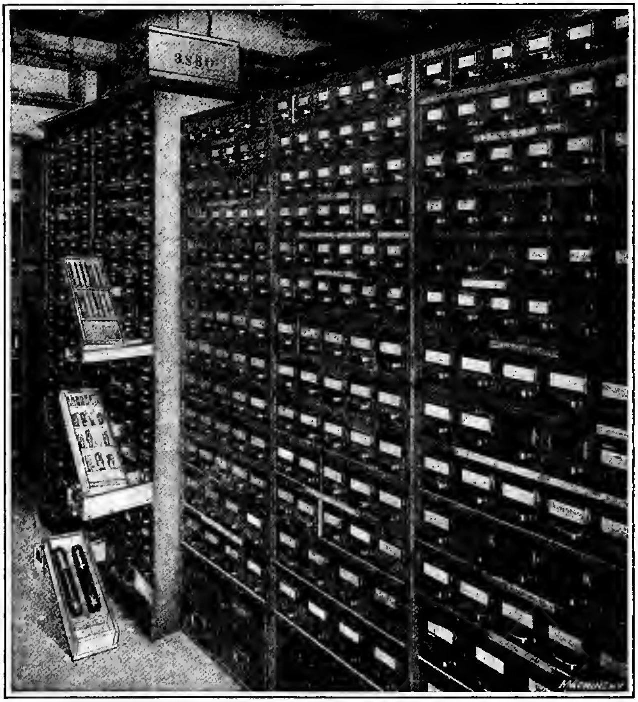


Fig. 1. Drill and Reamer Cabinets

pockets formed in crosswise strips so that they do not roll against each other and thus injure the cutting edges (see the three drawers to the left which have been removed).

The height of tool racks and cabinets usually varies from five or six feet to the height of the tool supply room ceiling. Low racks (Fig. 2) are usually found in shops having plenty of space. A ladder supported by a track and rollers is convenient for high racks such as are found in many city shops, located where land and space have a relatively high value. (See Fig. 11.) Wood is generally used for tool racks and cabinets in tool supply rooms, although many of the new plants have steel shelving.

Unit System of Cabinet Construction. — Most tool store-rooms have cabinets or fixtures which are of permanent construction.

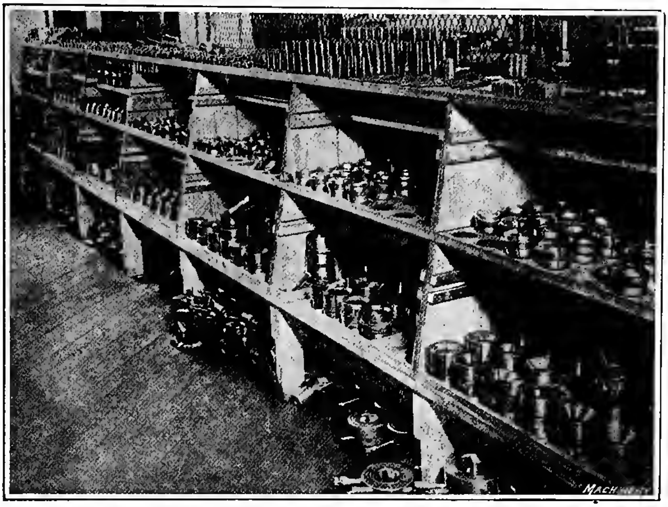


Fig. 2. Collet Rack

It is desirable, however, to so construct the storage equipment that it can be rearranged and expanded to accommodate a larger stock of tools, if this should be necessary on account of the growth

Dimensions of Standard Boxes and Trays[1]

Number of Box	Outside Dimensions, Inches	Number of Box	Outside Dimensions, Inches
1	24 by 24	9	12 by 4
2	24 by 12	10	8 by 8
3	24 by 8	11	8 by 6
4	24 by 6	12	8 by 4
5	24 by 4	13	6 by 6
6	12 by 12	14	6 by 4
7	12 by 8	15	4 by 4
8	12 by 6	....	....

[1] The length or depth is 17 inches or less in all cases.

of a plant. This unit system of construction, as applied to the tool supply room of the Tabor Mfg. Co., Philadelphia, Pa., is illustrated in Fig. 3. The tool cabinets consist of a main rack having square sections which may be subdivided for storing different types of tools by means of boxes, trays, and drawers of

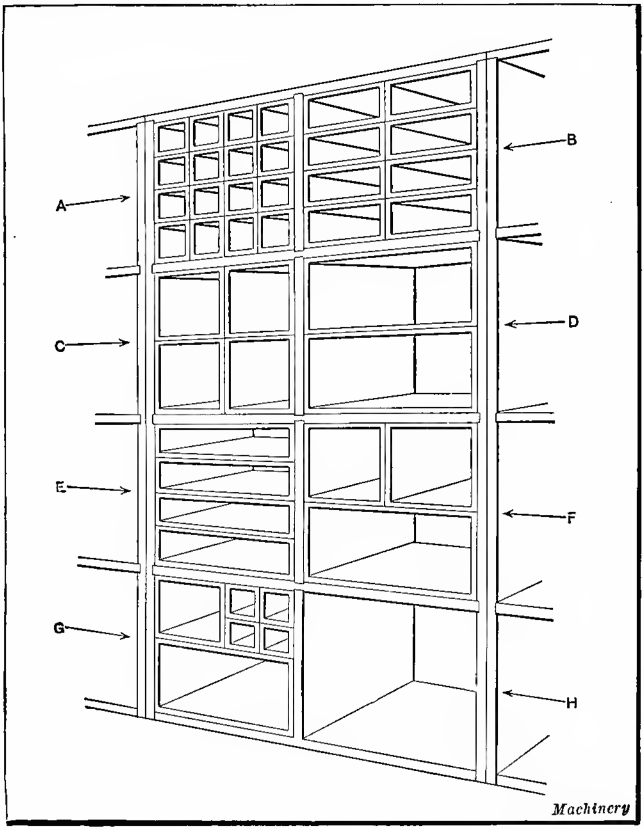


Fig. 3. Diagram illustrating Unit System of Construction for Tool Racks

standard size. The sections or compartments of the main rack are $24\frac{5}{8}$ inches square and 17 inches deep. These racks are made of wood and are rigidly constructed, as they sustain heavy loads when filled with tools. The boxes which are inserted in these square compartments for holding the tools are made in fifteen standard sizes, as given in the table on the preceding page.

Fig. 3 shows some of the combinations that are possible with this construction; thus, section A is fitted with sixteen square sections or boxes; section B has eight rectangular boxes; sec-

Fig. 4. Rack for Clamping Bolts of Various Lengths

tion C, four square boxes; and so on. The compartments are fitted with whatever combination of boxes is best adapted to the size and number of tools they are to contain. When drawers can be used to better advantage than open boxes for the storage of small tools, cutters, etc., these drawers are inserted in double vertical rows which fit into the standard compartments.

Racks for Clamping Bolts and Packing Blocks. — Fig. 4 shows the form of storage racks used by the Tabor Mfg. Co. for clamping bolts such as are often required for holding castings or forgings on the work-tables of machine tools. The bolts are suspended from T-slots formed in the standard storage boxes used at this plant. The symbol for each size of bolt and the hooks for the workmen's checks are placed adjacent to the various com-

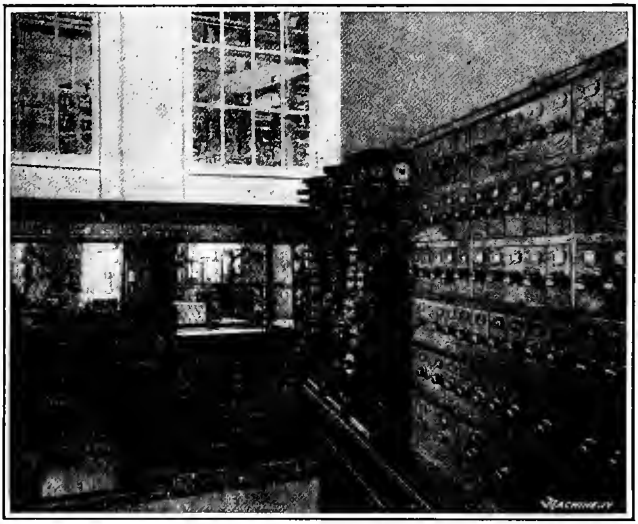


Fig. 5. View in Tool Supply Room showing Revolvable Racks for Milling Cutters

partments. Standardizing equipment of this kind is of especial importance in shops doing general work for which special fixtures have not been constructed.

Cabinets and Racks for Milling Cutters. — Many tool supply rooms have cabinets of the general type shown near the delivery window in Fig. 5 for storing milling cutters. These particular cabinets are of octagonal form and each of the eight sides is covered with cutters suspended on pegs. As the cabinet can be revolved about a vertical axis, any side may be easily reached.

The swinging or folding door type of cutter rack illustrated in Fig. 6 is now used quite extensively. These swinging doors are hinged to a vertical shaft and each door provides two sides for the storage of cutters. Another compact design is similar in construction to the familiar sliding barn door. Each door of the

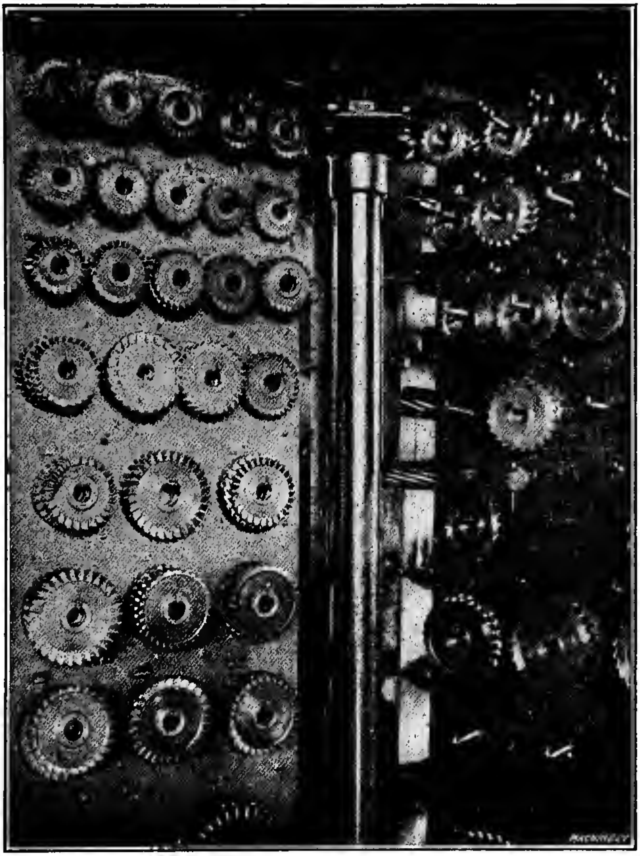


Fig. 6. Swinging-leaf Type of Milling Cutter Rack

cabinet has wheels above and below it which engage horizontal tracks for guiding the doors as they are rolled in or out. There are several parallel doors arranged in a group with a space of about twelve inches between them. The cutters are suspended upon pegs or hooks. Fig. 7 shows milling cutters stored on shelving. Different types are grouped together, and these groups are plainly marked. Instead of placing the cutters loosely on the shelves, they are provided with removable holders consisting of base blocks and vertical pegs which pass through the cutter-arbor holes.

Racks for Taps and Dies. — The rack for taps shown in Fig. 8 is so arranged that the taps are held in position by their shanks, which are inserted in holes of suitable size. This form of rack (which is used by the Cleveland Automatic Machine Co.) pre-

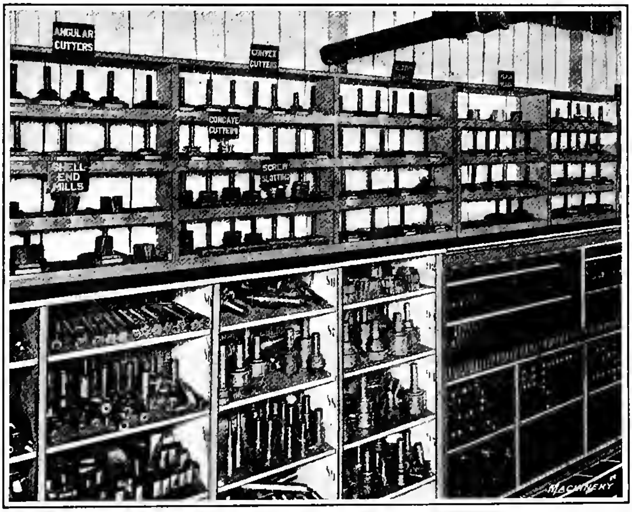


Fig. 7. (Upper Section) Method of Storing Milling Cutters on Shelves by Means of Special Holders

vents taps from being nicked or otherwise injured by striking against one another. Each tap has a label indicating its size, and there is also a hook for receiving the workman's check when the tap is in use. A rack for spring screw-threading dies is shown at the left of Fig. 8. The hollow shanks of the dies fit over pegs on the rack which hold them in position.

Racks for Snap Gages. — A good type of rack for snap gages is shown in Fig. 9 (see upper part of cabinet). Metal partitions are used to separate different gages, the height of these partitions and the space between them being varied in accordance with different gage sizes. These partitions extend across the shelf at the bottom, but curve backward toward the top, so that the upper ends of the gages project far enough to be easily gripped for removing them from the cabinet. This form of rack is found in the tool supply rooms of the Cadillac Motor Car Co. Incidentally, this illustration shows how steel partitions can be used to form compact bins or compartments of the general type shown just below the gage rack. The consecutive numbers of the bins

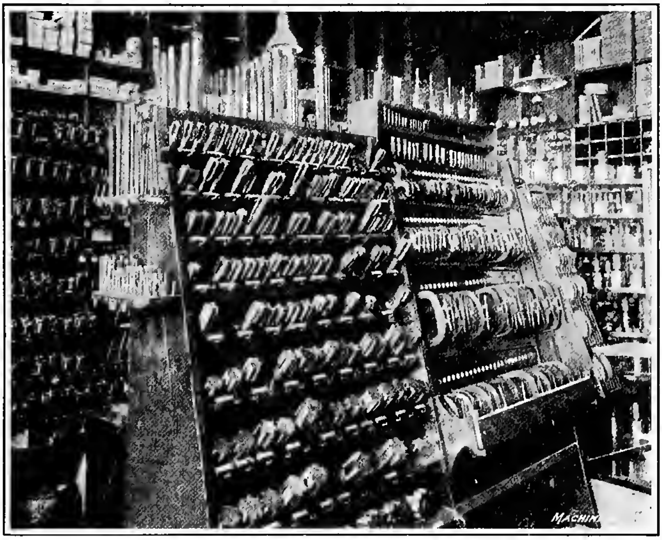


Fig. 8. Racks for Taps and Snap Gages

are stamped on circular checks or tags suspended from rings so that they are free to swing and do not interfere with the insertion or removal of the tools. Fig. 8 shows (at the right of the tap rack) a form of snap gage rack used by the Cleveland Automatic Machine Co. The gages are held in place by boards having slots on the edges into which the gage jaws are inserted.

Rack for Storing Blueprints. — When blueprints are kept in the tool store-room they are often filed in drawers, but this is an inconvenient and troublesome method and requires more room than is necessary. When the drawers are filled with blueprints, it is difficult to prevent them from curling up and catching when the drawer is pulled out, and occasionally a blueprint will slide out at the rear end. In a shop where considerable trouble had been experienced with blueprints stored in shallow drawers, the rack illustrated in Fig. 10 was installed and proved very satisfactory. This rack is made of 2- by 4-inch timbers to which are secured a large number of sheet-steel strips upon which the blue-

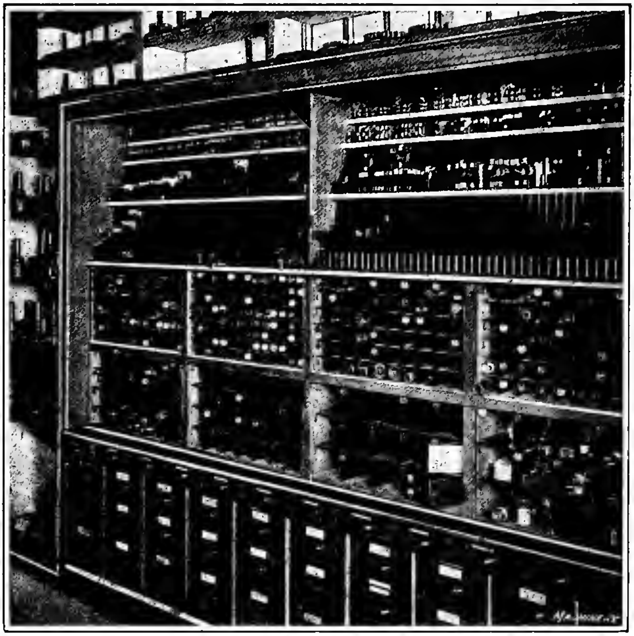


Fig. 9. (Upper Section) Rack for Snap Gages. (Lower Section) Bins formed of Steel Partitions

prints are suspended as indicated by the illustration. The lengths of these steel strips are varied in accordance with the size of the blueprints, the largest prints being at the bottom of the rack and the smallest ones at the top. The numbers of the prints are written on labels and pasted on the steel strips or arms.

Tool Grinding in Supply Room. — The grinding of the class of tools used on turning and planing machines is considered an important function of the tool store-room in many plants where this system has been put into use. There are a number of reasons why machine operators are not permitted to grind those tools that are adapted to be ground by hand. In the first place, numerous experiments have proved that slight changes in the shape of a tool of the type used for turning, planing, etc., may have a decided effect on its cutting qualities and upon the length of time that the tool can be used before regrinding is necessary; therefore, it naturally follows that these tools should all be given whatever shape has proved to be most effective. In other words,

Fig. 10. Rack for Storage of Blueprints

tools should be standardized, especially as regards the shape of the cutting ends. The development of special tool-grinding machines and the establishment of tool-grinding departments in many shops has made it possible to have all the cutting tools uniform and ground according to approved principles.

Disadvantages of Grinding Tools by Hand. — When each man is independent as to the grinding of tools, the results depend upon his experience, skill, or interest in doing things the right way. Some workmen grind their cutting tools properly and others violate every principle of tool grinding. Correct grinding is not always done even when the workman knows how different tools should be formed. Sometimes the shape of the tool is sacrificed in order to grind it quickly or easily. The way an old shopmate used to grind thread tools illustrates this point. The plan followed was to bevel the top of the face downward toward the front, because the narrow point of the tool could easily be ground away. The scheme worked well and the edge was sharp, but the "negative rake" neither improved the cutting qualities of the tool nor the form of the thread cut with it.

Another important reason why hand grinding by machine operators is not regarded favorably by many manufacturers is that machines are frequently idle while the tools are being ground. The amount of productive time lost in this way varies with different classes of work and also with the ability of the operator. Some operators grind dull tools while cuts are being taken, but the extent of this practice depends upon conditions. The time taken to sharpen a tool is sometimes increased considerably because the grinding wheel is naturally more or less of a social center.

Tools that lie about machines deteriorate in many instances, their condition often depending upon the initiative of the man operating the machine; moreover, in many shops where individual sets of tools are found, there is little incentive for keeping tools in good condition. For instance, an operator who understands tool grinding may, as the result of his own efforts, secure a set of lathe or planer tools that have been carefully forged and ground, but such tools are often borrowed permanently by other workmen, so that attempting to keep up a set of tools is rather discouraging.

When tools of the class referred to are kept in the tool supply room with the other tool equipment, but the grinding of such tools is done by the machine operator, the results may depend largely upon conditions. In comparing this system with the one which provides for grinding all tools to standard shapes by means of a special grinder, instead of by individual workmen, the size of the plant and general nature of the work should be considered. In a relatively small shop where a great variety of work is done by competent machinists, the tools are often ground to suit different operations and there may be advantages in allowing the workmen to grind their own tools. Whether or not the size of the plant will warrant the installation of a special tool-grinding department for forged tools is another point to be considered, some contending that such machines should be used in small shops as well as in those of larger size.

Location of Tool Grinder. — The grinding machine used for sharpening forged turning and planing tools is usually located either in the tool supply room or in a separate section of this room; it is also sometimes put in the tool-room or out in the shop. If there is not enough tool grinding to keep one man busy, the grinder is generally located where it will be convenient for the operator whose time is partly given to other work.

In some shops the grinding of forged lathe and planer tools is done in the department where the tools are forged and dressed. One method is to first forge the tools to standard shapes and then rough-grind them on a universal tool grinder before hardening; after the hardening operation the tools are finish-ground and are then stored in racks until needed in the shop. This practice of grinding forged turning and planing tools in the forging department has been adopted by the American Machine & Foundry Co. with satisfactory results. All dull tools are collected daily and one man grinds nearly all the tools of the class mentioned. The shops are equipped with grinding wheels so that the employes may grind their own tools, although this practice is not encouraged by the management. It might be assumed that hand grinding would prevail generally, but the fact is that the wheels in the shop are only used occasionally by men operating the machines, because they consider that the tools ground to standard forms in a tool grinder designed for that purpose are superior to those ground by hand; consequently, the wheels are used principally for sharpening tools that have been dulled slightly or for making slight changes in tools to adapt them to special operations.

Stock of Sharp Tools. — When sharpened tools are issued from the tool store-room, it is advisable to have a sufficient number of each size and shape to last, say, two days before the supply is exhausted. As the dull tools are returned, they are allowed to accumulate so that a number can be ground at one setting of the machine. Tools of the same size and form should be ground successively in order to reduce the time required for adjusting the tool grinder. Fig. 11 shows the rack in which sharp tools are stored in the tool supply room of the Tabor Mfg. Co.

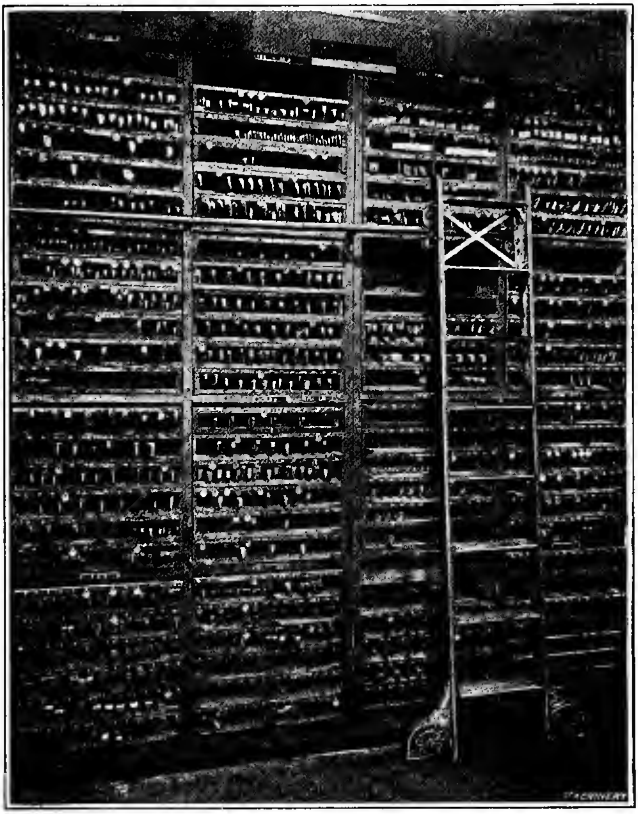


Fig. 11. Rack in which Forged Turning and Planing Tools are kept in Tool Supply Room

Maintenance of Tools. — A tool store-room where tools are merely kept while not in use soon contains many tools that are not fit for service or that, at least, seriously interfere with the efficiency of manufacturing processes. One of the important functions of the tool supply department is to see that all tools are kept in good condition and that there are enough tools of each type requiring duplicates to meet the demands of the shop. This involves sharpening dull cutting tools and replacing or repairing any tools that may be partly or entirely deranged, either because of wear or breakage. In large shops, especially, it is also important to have some systematic method of investigating defective tools to determine whether or not they are worth repairing and the cause of tool breakage, so that the design or construction may be altered if it is apparent that such changes are necessary.

A tool maintenance system which has proved satisfactory in a large manufacturing plant is so arranged that the replacement and repair of tools is done on as systematic a basis as the regular manufacturing work. If a tool needs to be replaced because of breakage or excessive wear, the employe must first have his foreman sign a " tool release card "; the employe may then return the tool to the tool crib, where he either receives another one or the tool check, if another tool of the same kind is not needed. The release card and the damaged tool are kept together in the store-room, pending a weekly examination by an inspector who determines whether or not the tools should be repaired or discarded. In many cases, the tools become defective on account of long usage, but if it is apparent that the damage is the direct result of faulty construction or gross carelessness on the part of the user, steps are taken either to modify the design or to stop the careless practice.

In case regrinding or repairs are necessary, it is essential to record in the tool supply room what tools are sent out and to see that they are returned to the right place. The card or form used in such cases gives the number of the department in which the tool is used, the name of the man in charge of the tool crib, the name of the tool, the nature of the repairs or operation required, the number of the tool crib, and the order number against which the time needed for the repairs and any material that may be required is charged. A copy of this form accompanies the defective or dull tool and is kept in the tool-room where the repairing or sharpening is done, as a record of this work; a second copy is kept in the tool crib to show what tools have been sent to the tool-room, and the office also receives a copy, which is held temporarily as a reminder that the work is being done.

When files need to be replaced as a result of wear, a special order is used. The worn file is taken to the department foreman, who examines it and then makes out an order for another file, if in his judgment the old file should be replaced. On this order is written the name of the file, the size, the number of files needed, the department number, the tool crib number, the date, and the number of the employe to whom the file should be delivered. This order also bears the signature of the department foreman. The same order is used to obtain new files.

Determining Causes of Tool Breakage. — The number of tools which must be replaced because of breakage can often be reduced considerably by instituting a systematic method of determining the cause of breakage in each case. A plan which has proved successful requires the use of printed forms or slips (see Fig. 12) which are given to all foremen. When an employe breaks a tool, he must obtain one of these slips from the foreman in order to secure another tool or the check which has been deposited in the tool supply room. The printed slip contains a list of tools commonly used and blank spaces in which the names of other tools may be written. If a $\frac{1}{2}$-inch tap, for example, is broken, the size of the tap is marked in the space opposite the word "tap" on the card. The cause of breakage is indicated by a cross made by the foreman opposite whatever term on the card indicates the cause. These forms are filed back of each man's "record card" and are examined at the end of each week or month to determine what workmen are breaking the most tools and the causes for such breakage.

Tool Supply Systems in General Use. — In order to determine what tool supply room system has been adopted most widely by manufacturers in various parts of the United States, information pertaining to the more important features has been obtained from a great many machine-building plants which differ widely in size and also as regards manufacturing conditions. This investigation shows that, while details vary considerably to suit local conditions, there are certain methods of handling small tool equipment which have been employed quite generally. A brief review of the system which seems to be the most prevalent will be given.

When a man is first employed he is given a set of tools which is kept permanently. This set may include files, cold chisels, bench brushes, or whatever equipment the employe uses in connection with his daily work. A record is kept which shows what equipment should be in the possession of any employe, especially if he is about to leave.

Check No. 45 Foreman John Smith Dept. 17

All Broken Tools Must Be Returned

Name of Tool	No.	Size	Name of Tool	No.	Size
Drill			Wrench		
Tap	1	½"	Milling Cutter		
Reamer					
File					
Hacksaw Blade					

Cause of Tool Breakage

____Carelessness ____Defective Construction
X Accident ____Defective Machine
____Defective Design ____Defective Jig

Fig. 12. Form used when Tools are broken by Workmen

The tools which are kept in the tool supply room are accounted for when out in the shop by means of brass checks, in 93 per cent of the shops previously referred to. Ordinarily a certain number of these checks (usually ten or fifteen) are given to each employe requiring tools, the number being recorded on the tool record previously referred to. When these checks are exchanged for tools they are usually placed where the tool belongs when not in use. In some of the shops the checks are filed on check boards, in which case a tool tag may be placed with the check to show what kind of tool is out; a double set of checks is also employed in a few shops, different methods of using them being explained in the following chapter. In 7 per cent of the selected list of shops, some form of written receipt is given in exchange for tools.

When tools are called for at the tool supply room, special tools, such as jigs, fixtures, dies, etc., are ordinarily identified by a number or a letter and number combined, which represents either a part number or a tool number; the operation number may also be included if separate operations are necessary. Sets of tools such as a jig with its drills, etc., or a milling fixture and the necessary cutters are commonly delivered to workmen in single boxes. The special tools of a set are usually kept together, whereas the standard commercial tools, such as twist drills, standard taps, reamers, and so on, are kept with other tools of their class and are collected (in advance of the time needed in some shops) to form a set when necessary. In many shops that are continually manufacturing duplicate parts, all the tools of a set, whether special or standard, are kept together permanently in suitable boxes, and a list shows what tools form a complete set.

When a shop is large enough to have a tool-room (where new tools are made) and one or more tool storage rooms, most cutting tools, such as milling cutters, reamers, drills, etc., are sharpened in the tool-room. Drills are frequently sharpened in the tool storage room even when there is a separate tool-room. In the shops of the selected list previously mentioned, 22 per cent of the drill grinding is done by the machine operators, either by hand on an ordinary grinding wheel, or by means of a drill-grinding machine. The tools for general turning and planing operations are ground by the employes using them in 84 per cent of the shops. The grinding of tools to standard shapes in universal tool grinders is done in the remaining 16 per cent of the shops. In most cases where tools are ground by hand, individual sets of tools are kept at the different machines, although the practice of keeping the main stock of tools in the supply room and issuing them in exchange for checks is quite prevalent. When tools are ground by the employe, the practice varies somewhat in different shops. For instance, in some cases, sharp tools are obtained from the supply room and are ground by men until they need redressing when they are exchanged for other sharpened tools. In other shops, rough tools are delivered to the workmen to be ground. In the three following chapters, some of the more important variations in practice are explained.

CHAPTER VIII

TOOL CHECKING SYSTEMS

In every tool store-room it is essential to have some systematic method of determining what tools are in use and where they are located in the shop, to prevent loss of tools and to enable any tool to be readily found, if necessary. The method which has been adopted almost universally is to use brass checks which are numbered to correspond with numbers given to different workmen. These checks may be placed in the store-room tool cabinet where the tool belongs, or they may be filed on a board in the store-room, so that the number of tools in the possession of any particular workman may readily be determined. There are various modifications of this checking system which are intended either to simplify the system, or to make it a more effective means of accounting for tools and of preventing mistakes or fraudulent practices.

Single Check System. — The single check system, as commonly applied to tool-rooms, is so arranged that each workman has a certain number of checks which he receives when first employed. These checks, as previously mentioned, are stamped with the employe's number, and whenever he obtains a tool from the store-room, a check must be given to the tool-room attendants as a receipt. This check, according to the usual method, is placed on a hook located where the tool belongs in the bin, rack or drawer of the cabinet. When the tool is returned to the tool-room, the check is given back to the workman. If the tool should be sent from the tool-room to the grinding department or forge shop, a special tool-room check is either put in its place or a written record is kept; consequently, the location of every tool not in the store-room is shown either by the number of the workman's check or by a tool-room check or a separate record.

Use of Checks and Tool Tags. — Instead of placing the employe's checks in the tool racks where the tools belong when not in use, they are placed on a check board in some tool supply rooms. One system which has proved satisfactory in a large plant where there are many tool supply rooms for the different departments is as follows: The bins or other storage places for all tools are numbered consecutively and for each special tool there is a card in the tool supply room and also a tool tag. These tags and the cards are used in connection with the delivery of the tools to the employes. The cards show the names and numbers of the parts on which the tools are used, the names and numbers of the tools, and the bin numbers for locating the tools in the supply room; these cards are filed numerically according to the part numbers. The tool tag for each special tool is marked with the name of the tool and its number. There is a check board for special tools and another for commercial or standard tools. The tool tags are filed on the check board for special tools. Whenever an employe receives a special tool, his check is placed on a hook of the check board over a tool tag marked to correspond to the number of the tool. Numbers stamped on the different tools may be used to identify them or determine their location in the supply room by referring to the card file. The commercial tool check boards are arranged in alphabetical order according to the names of commercial tools, using the noun in each case; different hooks may represent different sizes, as in the case of drills.

All Checks Kept in Tool Supply Room. — The most common objection to giving checks to workmen is that they are sometimes lost or borrowed. A lost check may cause considerable trouble, especially if it is found by some other workman who uses it in a fraudulent way. Deception might be difficult in a small shop, but in a large plant the store-room attendants might not know whether the proper check was received or not. In order to prevent checks from being misplaced or lost, it is the practice in many plants to charge a certain amount for each check that is missing when the workman leaves the employ of the company.

In order to avoid the difficulties resulting from losing them, checks are not given to the workmen in many shops, but are permanently kept in the tool store-room. Each man is allowed a certain number of checks, which are usually kept on a check board in the store-room. This board has a hook or slot for each man who may require tools, and there is some kind of record or card file showing the names of the workmen corresponding to each check number. The names, in many cases, are on the check board. When a man calls for a tool, one of his checks is removed from the board and is put in the place occupied by the tool, for which a hook is usually provided. When the tool is returned by the workman, the check is removed from the tool cabinet and is replaced on the tool-room board. While this system prevents the loss of checks by workmen, it is not faultless, as carelessness on the part of the tool-room attendant will sometimes result in misplaced checks, or failure to return checks to the board when the tools are returned by the workmen.

There is another method of keeping all checks in the tool-room which differs from the one just described in that the checks are placed on the check board when the tools are delivered instead of being hung in the vacant places of the tool cabinet. A board large enough to receive tags bearing the names of all the men requiring tools is placed in a convenient location and opposite each name there is a hook for receiving checks whenever tools are delivered. The tools are all numbered and the checks are numbered to correspond. When a tool is delivered, the check which bears its number and hangs near it is removed and placed on the board opposite the name of the man to whom the tool was delivered. When this tool is returned the check is removed from the board and hung in its place in the tool cabinet.

Checks having Different Exchange Values. — When a number of tools are required by one workman, special checks are sometimes used, one arrangement being to have the workman's number on one side and numerals on the other side indicating the number of tools received. For instance, the reverse side of checks may be numbered 2, 3, 4, 5, etc. If the workman's number is 50 and he should require four tools, the check given to the tool-room attendant would have the number 50 on one side and 4 on the reverse side, the latter number showing that he has four tools of the kind belonging in that particular section of the tool cabinet where the check is placed. These special checks should be of a different size and shape from those ordinarily used so that the attention of the tool-room attendant will be directed to the numeral on the reverse side of the check when the tools are returned. The exchange value of the check may depend entirely upon the shape instead of numbers.

Double Check Systems. — When a single check is exchanged for a tool and is placed where the tool belongs in the tool cabinet, it might be impossible for the man in the tool supply room to determine how many tools a workman has in his possession without examining the entire stock of tools, providing there were no separate record. The double check system shows the number of tools received by each workman and for that reason is preferred in some plants. Double check systems vary somewhat as to details, but the methods here described cover the general principles.

With one system, there is a board in the tool store-room which has two check hooks for each employe and near each pair of hooks there is a label giving the name of the employe and the corresponding check number. When a man is engaged by the concern he is given a certain number of round checks, and a corresponding number of square checks are hung on one of the hooks opposite his name on the store-room board. Whenever a workman receives a tool, he gives a round check in exchange for it and this check is placed on the hook adjacent to the man's name and number. At the same time, a square check from the opposite hook is removed and inserted in that part of the tool cabinet from which the tool was taken. When this tool is returned, the square check is replaced on the board and a round check on the other hook is given back to the workman. With this system the number of round checks hanging opposite each name shows how many tools that particular man has in his possession, without searching through the tool cabinet. The square checks, which are also numbered, show who received the tools that are not in the tool racks.

Another double check system, which is a modification of the one just described, differs from it in regard to the method of filing the checks. Each employe receives a certain number of checks bearing his number, and there is a check for each tool in the store-room which hangs near the tool when the latter is not in use. In the store-room there is a board with each employe's number on it and a single hook adjacent to each number. Upon the receipt of a tool from the store-room, the workman gives a check which is placed on the hook in the tool cabinet where that particular tool belongs. At the same time, the tool check from the cabinet is hung on the hook adjacent to the employe's number on the tool-room board. When the tool is returned, the exchange of checks is made in the reverse order. If a tool that is out in the shop is wanted by some other workman, the man in the store-room can readily tell who received it and the tool-room board also shows how many tools are in the possession of each employe, which information might be of considerable importance in case a man were leaving the employ of the company. A double check system is sometimes preferred in large shops, especially where men are leaving constantly.

An Exchange of Checks. — There is another modification of the double check system which is based on an exchange of tool checks and employe's checks. Each workman is provided with a certain number of checks, the same as in the system just described. Near each tool in the store-room, checks of special shape are kept on suitable hooks. The name and size of the tool is stamped on each of these tool checks. When a workman requires a tool he exchanges his check for the tool, which is also accompanied by the tool check. This system is intended to prevent mistakes on the part of the store-room attendant, such as placing the wrong check on the hook of some missing tool and holding the wrong man responsible for it, because the check accompanying each tool is a receipt for the man who obtains the tool.

Double Check System with All Checks in Tool-room. — The double check system, as well as one requiring a single set of checks, may be so arranged that no checks are allowed in the possession of the employes who are thereby prevented from losing them. One method requires the use of two check boards, each having a number of hooks corresponding to the number of employes using tools. Each hook on what is known as the "in-board," contains the same number of checks, the number usually being ten or fifteen. The hooks on the "out-board" are intended to receive checks representing the number of tools delivered. As each man is engaged by the company, he is given an identification number which establishes his identity in the tool supply room. Every tool in this room is identified by a small check which is kept with the tool when the latter is not in use. If, for example employe No. 50 is given a reamer, a check from hook No. 50 on the "in-board" is transferred to hook No. 50 on the "out-board," and on the same hook on the "out-board" is placed the check for identifying the tool. With this system, the man in the tool-room can readily determine how many tools are out, the type of tool, and to whom they were delivered. When a man leaves the employ of the company, a receipt from the tool-room showing that all tool have been returned must be presented to the time-keeper before the man is paid.

Checks which show how long Tools have been out. — In order to determine the length of time tools are kept by workmen, special checks may be used in conjunction with the regular checking system. These checks, which are of special form and kept in the store-room, are numbered from 1 to 31 to correspond with the days of the month. When an employe receives a high-grade or expensive tool, such as a standard gage, his check is filed where the tool belongs and a special check showing the day of the month on which the tool was delivered is placed in the tool cabinet. If the tool has not been returned at the end of the month, the workman is notified, and if he still needs the tool it must be taken back to the store-room before he uses it again; another "date check" is then placed in the tool cabinet, thus indicating that this particular tool was again delivered on the first of the month.

Written Receipts for Tools. — Written receipts are preferred to metal checks in some shops. One method is to place printed slips or forms in suitable boxes which are conveniently located about the shop. When a tool is required, the workman writes the name of the tool on the slip, his check number, the date, and his signature. When a tool has been received, the slip is given to the store-room attendant. One method is to file these slips in numerical order according to check numbers, back of guide cards showing the various classes of tools. When the tool is returned, the slip is removed from the file and given to the workman who destroys it. A sample order blank for tools used in connection with a system of this kind is illustrated in Fig. 1. The names of tools most commonly used are printed on the order and the names of other tools are written on the blank lines provided.

ORDER FOR TOOLS

Tool Supply Room. Dept. M

Please furnish me the following:

____Drills ____	1 Arbors 2" Lathe
____Files ____	____Brushes ____
____Taps ____	____
____Die ____	____
____Reamer ____	____
____Gage ____	____

Name John Smith Check No. 210

Date 2/26/17

Fig. 1. Written Order for Tools which is used instead of Brass Checks

In some plants the receipt is not given back to the workman when the tools are returned, but is transferred from one file to another and is kept as a permanent record. In case the workman receives supplies which are not returnable, such as pipe fittings, etc., a different order blank is used, and instead of transferring it to a permanent file, as is done with the receipts for returnable tools, the order or requisition is sent to the accounting department so that the supplies can be charged against the particular department which receives them.

Check Boards for Tool Supply Rooms. — When employes' checks are placed on a board in the tool supply rooms as a record of tools in use, the board usually has hooks which are numbered consecutively to correspond with the numbers given to different workmen. The board or cabinet illustrated at *A*, Fig. 2, has vertical rows of inclined slots for receiving the checks. While this cabinet is more expensive than a plain board with hooks, the design is compact and a door is provided so that the cabinet may be locked if desired. There are ten vertical rows of slots which are numbered along the top, as the illustration shows. Each horizontal row of slots is also given a number. By combining these numbers at the left-hand side of the board with those at the top, any check may readily be located. For instance, check

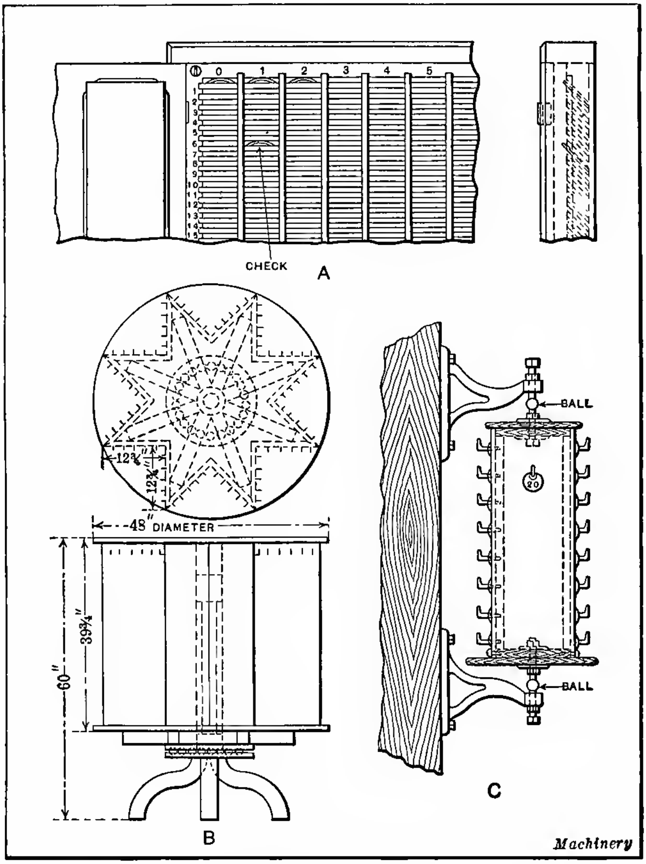


Fig. 2. Three Forms of Check Boards or Cabinets for Tool Supply Rooms

No. 61 is placed in column 1, opposite 6 at the left-hand side of the board. In a similar manner, the number of any slot may be determined quickly. This method eliminates a confusing mass of numbers and permits placing the check slots close together so that the board requires a relatively small space. As the end view shows, the check slots are at an angle of 45 degrees, so that all checks will be retained in their respective positions. The slot should be somewhat less in depth than the diameter of the check so that the latter may easily be lifted out of the cabinet.

The check board illustrated at *B* has sixteen sides arranged as shown in the plan view. This board or cabinet is provided with hooks and will hold 1600 checks of ordinary size, when made to the dimensions given on the illustration. It is mounted on a ball bearing so that any one of the sides may easily be turned to a con-

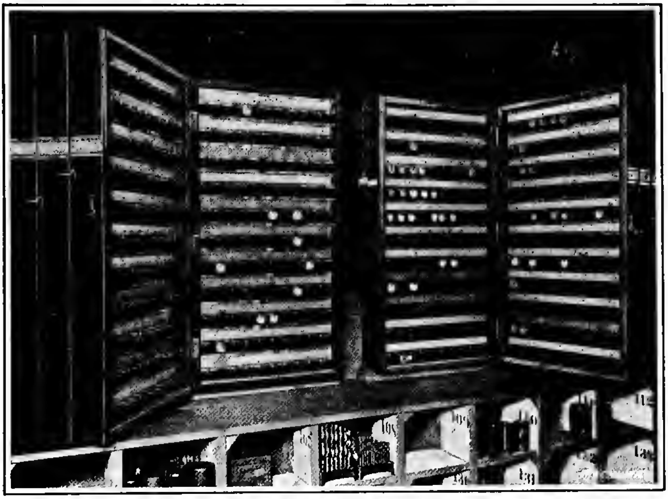


Fig. 3. Check Boards of Folding Type

venient position for removing a check. Another check-holder of the revolvable type is shown at *C*. This is simply a wooden cylinder 6 inches in diameter by 24 inches long, provided with 100 hooks.

The cabinet for tool checks shown in Fig. 3 is the type used in the tool supply rooms of a large automobile factory. This cabinet is composed of several check boards which are hinged together. One board remains in a fixed position and the others are opened like the leaves of a book. All employes' checks are placed on the hooks when tools are obtained instead of being deposited in different parts of the supply room.

CHAPTER IX

METHODS OF DELIVERING AND IDENTIFYING TOOLS

In most machine shops, tools are obtained from the supply room by the workmen who use them, but tool-room boys are sometimes used for delivering the tools and returning them to the supply room. In connection with this system an annunciator or other electrical signaling device should be used. An annunciator is placed in the tool supply room and connected by suitable wiring with push-buttons located throughout the shop. When an employe wants a tool he presses the nearest button and may hang his tool check on a hook near this push-button. The annunciator shows which one of the buttons was pressed and a tool-room boy goes to that part of the shop and finds out what tool is required. If the tool is of special design, it is the general practice for the workmen to designate it by a number or symbol of some kind which is found either on the blueprint or on a list of operations accompanying the blueprint. This number or symbol enables the man in the tool supply room to locate the tool or set of tools, as the case may be, either directly or by referring to a card file or other record.

Delivery of Tools in Sets. — In shops where machines and parts are manufactured in duplicate, it is economical to provide some systematic method of issuing tools in sets which include all the tools required for a series of operations on any part. In some cases, special tools are kept in sets permanently, but usually such sets are made up of both standard and special equipment and the standard or commercial tools are used singly as well as in sets. For instance, a set of tools may consist of a drill jig, several drills and reamers, and one or more taps. In this case, the jig and possibly a reamer might be special and the other tools of standard or commercial forms and sizes. When a great many duplicate parts are produced, if sets of tools are kept together permanently, obviously a large stock will be necessary. To reduce the stock of tools, the standard types are often used either separately or in conjunction with the different special tools to form sets which may be needed for manufacturing operations.

In connection with the delivery of tools in sets, it is essential to have records that will enable the man in the tool supply room to collect the tools quickly for any regular manufacturing operation. If the operations are on a new part or on a series of parts, the department which decides what tools are to be used should provide the tool supply room with a list which may be used as a guide in collecting that particular set of tools, provided they are

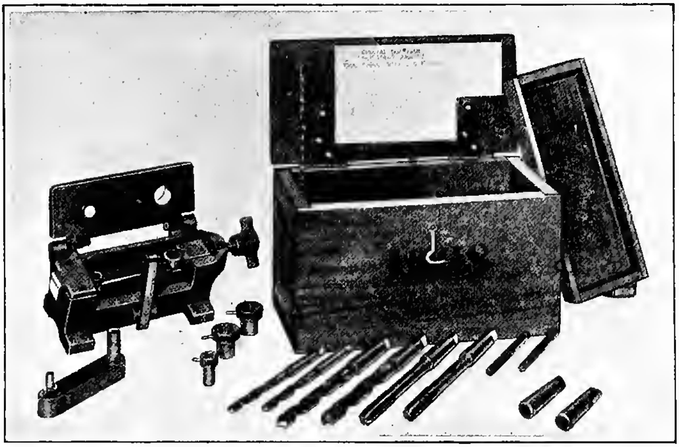


Fig. 1. Set of Tools and Box in which they are sent to Manufacturing Department

not kept permanently in sets. The tools used for screw machine operations, such as box-tools, form cutters, etc., are often kept in sets with a record of the " set up " for future reference. In the plant of the Tabor Mfg. Co., the planning department, which decides the kind of tool equipment for each job, issues a list of tools which is sent to the tool supply room prior to the time that these tools will be required in the shop. With this system, the set of tools is made up in advance so that no time is lost when the tools are actually needed in the shop.

Special Boxes for Sets of Tools. — With the system of issuing tools in sets adopted in the plant of the Cadillac Motor Car Co., many sets of tools for different manufacturing operations are placed in boxes (see Fig. 1) which are delivered to the workmen in exchange for checks. If the special and commercial tools for operations on any part are of such a nature that the use of a box is

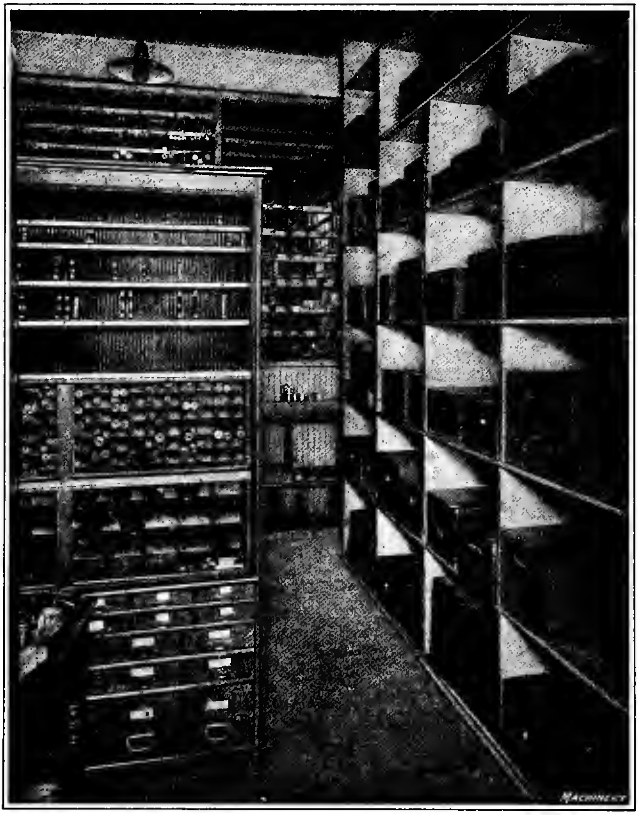


Fig. 2. (Right-hand Section) Storage for Boxes in which Sets of Tools are delivered to Manufacturing Department

practicable, this box is given a number and a list of its contents is placed on the inside of the cover. These box numbers are listed upon cards representing special tools which are arranged in files under the part numbers. Part numbers are given to every part of the automobile and are used, in conjunction with tool numbers, to identify different special tools. For instance, if the foreman of the drill press department wants to begin work on part No. 12,800, this number is given to the man who goes to the tool supply room after the tools for whatever operations are to be performed on this part. The attendant in the tool supply room refers to a card in the file of special tools which is marked with this part number and shows the number of the box containing the set of tools. These boxes are stored in numerical order and on racks built for the purpose (see Fig. 2) so that any box can be found readily. The tool list on the box lid shows what tools remain in the box and what tools belong in the regular tool racks. Ordinarily, the special tools are kept in the boxes while in storage and the commercial tools are distributed, although some of the commercial tools are also kept in the boxes permanently.

Form 1478

Part No. 32460 Check No. M 4690

Operation No. 42 Machine No. 2409

T. S. R. No. 22

Please give to bearer the following Special Tools:

Tool No.	Amount	Tool Description
53040	2	Jig for tapping

Also the following Commercial Tools:

Amount	Size	Description of Tools
2	5/16 × 18	Plug hand taps
2	5/16" × 18	R.H. adj. dies

These tools to be covered by one check and all to be accounted for before check is released.

Date 2/27/17 Foreman E. Moorhouse Dept. M-46

Use this form only when the number of tools on one job exceeds eight or when one man has more than one job.

T. S. R. Man J. A. Stroyan

DEPARTMENT FOREMAN'S COPY

Fig. 3. List showing what Special and Commercial Tools are required for Operations on a Given Part

If it is not practicable to keep a set of tools in a box, a tool list is used which shows all the special and commercial tools required for any part number or operation number. These lists are made out in duplicate, one copy being for the tool supply room and the other for the department foreman. (See Fig. 3.) The tool lists which are on file in the tool supply room (arranged under the part numbers) are kept in linen envelopes, and, when tools of any list are in use, the employe's check is placed in the envelope with the list. All the tools on a list may be covered by one check and all must be accounted for before this check is given back to the workman. The tools handled in this way are asked for somewhat before they are actually needed, so that the tool supply room attendant will have time to collect the tools in a tray before they are called for.

Many of the tools (probably half) are not handled by either of the methods previously referred to. To illustrate, assume that a drill jig and a drill are required. The part number on which the jig is to be used would be given and the drill would be called for by simply giving the name and size.

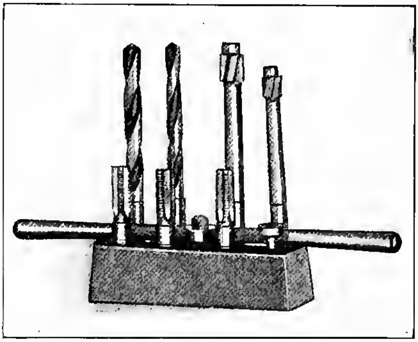


Fig. 4. Block containing Set of Tools for Drilling, Counterboring, and Tapping

Sets of Tools for Tapping Operations. — The tools used for tapping operations are commonly kept in sets and are given in exchange for one check, the same as a single tool. A typical set of tools of this kind is illustrated in Fig. 4, which shows the form of "tap block" used by the Brown & Sharpe Mfg. Co. These tap blocks equipped with tools for tapping holes of all sizes are kept in the tool supply rooms. They contain a tap drill; a "size drill" for drilling a clearance hole; a set of three taps; a counterbore to enlarge the hole, if desired, from the tap size to the body size of a screw; a counterbore for the screw head; a gage showing to what depth the screw-head counterbore should be sunk; and a tap wrench. If a workman desires to drill and tap holes of a certain size, he asks for a tap block corresponding to that size, which is delivered in exchange for one check.

Portable Cabinets for Sets of Tools. — The portable cabinet or cupboard of the form shown in Fig. 5 is used by the Brown &

Sharpe Mfg. Co. for delivering tools in sets. The particular cabinet shown in the illustration contains the jig for a 10-inch spiral head and the necessary cutting tools, such as drills, reamers, etc. This cabinet is mounted on casters so that it can easily be rolled along the shop floor to whatever machine is to do the work. The jig is kept in the bottom part of the cabinet and is on a plat-

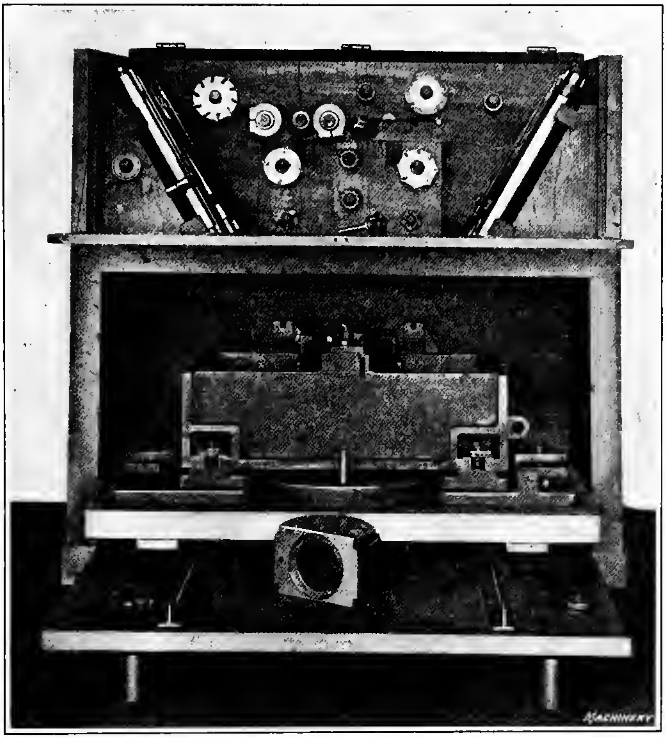


Fig. 5. Portable Cabinet containing Jig and the Necessary Cutting Tools

form that runs on a track, so that, when the door is lowered, the jig can be pulled out easily, after which it is hoisted from the platform and placed on the table of the machine. The upper section of the cabinet, which is shown with the door open, contains all the drills, counterbores, reamers, etc., that are used in connection with the jig.

Storing Heavy Sets of Tools on Skids. — Sets of tools for certain machining operations are kept together in boxes in the shops of the T. B. Wood's Sons Co., Chambersburg, Pa., and the larger and heavier sets are placed on skids when not in use so that an elevating-platform type of truck can be pushed under the tool box when it is to be moved. The boxes rest on a platform which has skids on each side that are high enough to permit rolling the truck beneath the platform. A view of the storage place for these tool boxes is shown in Fig. 6, which also shows a truck in

Fig. 6. Sets of Tools stored in Boxes with Heavier Boxes on Skidded Platforms to Facilitate Removal with Elevating-platform Type of Truck

position beneath one of the boxes. The lighter boxes are placed on shelves.

Tool Lists Stamped on Jigs and Fixtures. — The record of the small tools used with jigs and fixtures, such as drills, reamers, milling cutters, etc., is generally on a blueprint or separate list of operations, for the guidance of the foremen or to enable the tools to be selected readily by the attendant in the supply room. At the Newark works of the Westinghouse Electric & Mfg. Co., all jigs or fixtures have stamped on them the sizes or names of whatever small tool equipment may be required, and this practice has been adopted in various other plants. For instance, if a jig is used for drilling a number of different size holes, the diameter of the drill for each hole is either given directly or is indicated by a number or letter, in accordance with the different methods of indicating commercial twist drill sizes. The size of each drill is marked near the hole in the jig to which the drill belongs. If a jig is needed for drilling a certain part, the employe gives the item or part number and the tool number, which may be obtained from the blueprint. A card index file in the tool supply room shows where this particular jig is located. When the jig is obtained, drills of the different sizes stamped upon it are collected and any other tools, such as counterbores, reamers, etc., that may be included in the list. With this method, the jig or fixture itself serves as a permanent record of all the small tools required.

Storing Special Tools Separately. — The practice of keeping special tools permanently in sets for duplicate manufacturing operations is not followed in some shops, especially when the work is diversified instead of being confined to the manufacture of a standardized product. At the works of the American Machine & Foundry Co., where a variety of work is done, the tools for different series of operations are stored separately in whatever part of the tool supply room each type of tool belongs. This method is followed regardless of whether the tool is special or a standard commercial type. For instance, a special reamer which may have been intended primarily for use with a certain jig is not kept with that jig, but with other reamers, because, even though the reamer is special, it may, in many cases, be used for other parts that are designed later; therefore, the special reamer, tap, or other tool is not regarded as a special type in the sense that it is to be used exclusively for any one part. The prompt delivery of tools to each machine is insured by the following system: Each machine manufactured by the company is given a symbol and all the parts of this machine have numbers assigned to them. The foremen of the departments receive cards for the different parts which they are required to produce. These cards are marked with the machine symbol and the part number, and give a complete list of the tools needed for machining each part. To illustrate the method, assume that a drilling machine will soon be ready for drilling part No. 1726. Before the machine has finished the work on which it has been employed, the department foreman refers to the card file and removes the card bearing the part number 1726. This card, together with the blueprint for the job, which has the same symbol and part number on it, is taken to the tool supply room by one of the men who attends to the delivery of tools to the machine. All the tools listed on the card are then collected by the man in the supply room so that they are ready for use when needed and there is no delay at the machine. If a special tool such as a drill jig is required it can be located readily in the storage rack by the jig number on the card.

Tools that are to be used exclusively for one operation are marked with a tag. For instance, a reamer which must be kept to a certain diameter within close limits has a tag tied to it which indicates that it is not for general use.

Sets of Tools Kept by Workmen. — In every shop, there are employes who use certain tools daily, but these tools are of the class usually furnished by the company. If they were kept in the tool supply room, it would be necessary in many cases to obtain them every morning, which would mean loss of time. In many shops, it is the practice to give out sets of tools of the class needed continually and these are kept by the employe permanently or until they need to be replaced. A record of the tools that are given out is kept in the tool supply room and, when a man leaves the employ of a company, the stock of tools he returns must agree with the record, which is modified from time to time to suit any changes which have been made during the period of employment. Such tools as cold chisels, files and file cards, scrapers, bench brushes, oil-cans, etc., are commonly issued in this way. The number of tool checks originally given to each employe is usually marked on his card and if, for any reason, this number should be either increased or decreased, the number on the card is changed accordingly. When a man leaves the employ of the company, if the number of checks turned in to the supply room does not agree with the number on the record card, an investigation is made and the lost checks accounted for, if possible, before the employe is paid. If the missing checks are found in the tool racks, thus indicating that the employe still has tools in his possession, the cost of these tools, or some part of the cost, may be charged against him.

The method adopted by one manufacturer is to provide a printed list of tools which may be kept permanently by employes. Each foreman has a conductor's punch and the shape of the perforation serves to identify the foremen of different departments. Before tools are issued to a new employe, a punch mark must be made by the foreman in the space provided on the card opposite each tool which may be needed by that particular workman; if more than one of the tools is required, the number is marked on the card. This tool list is given to the tool-room attendant in exchange for the tools, and is kept as a permanent record so that, if the man should leave the employ of the company, the card shows what tools should be returned to the tool supply room. Tools that are worn out, such as files, are exchanged for new ones, which does not interfere with the record on the card.

Identification of Special Tools. — When an employe calls for a tool at a tool supply room, the tool may be identified either by name or in some other way, the practice varying in different shops. The necessity for a systematic method of identifying the tools needed for various operations depends, to some extent, upon the class of work manufactured and the extent to which special tool equipment is needed. Standard commercial tools such as reamers, drills, and taps may readily be identified by the name and size, but the use of names for special tools would, in many instances, cause confusion and mistakes and result in a waste of time. For instance, if several special tools were used on some part, it might be difficult to give these tools names which would clearly distinguish one from the other, even though the men in the supply room were familiar with the various classes of tools.

Special tools may be identified either by a number given to the tool, by a number assigned to the part on which the tool is to be used, or by a part and tool number combined. If a part requires only one special tool, the part number and name of the tool might be used to identify the latter, but when several special tools are needed both part and tool numbers are preferable. In some cases the part number and the operation number are used. With the Taylor system of classification, all tools are given symbols composed of letters (with numbers added when necessary to indicate tool sizes) which indicate the type of tool and its location in the tool supply room (this system will be referred to under the heading " Tool Classification "). The number or symbols used to indicate the tool equipment may be on the blueprints or on special sheets or cards that contain a list of all the operations.

Tool and Operation Lists Kept by Department Foremen. — At the plant of the Intertype Corporation in Brooklyn, N. Y., the tools required for operations on different parts are shown by cards which are sent to the foremen. The card in each case gives the part number, the name of the part, the name and number of the assembled unit to which the smaller part belongs, the various operations in their successive order, and the tools required for these operations. These cards are kept permanently by the department foremen who refer to them in order to determine what tools are needed for different operations. For example, if part No. S-60 is to be machined, the foreman refers to this particular card in the file, finds out exactly what the different operations are and the name of the special tools, such as gages, arbors, fixtures, etc., which may be needed for the different operations. The employe who is to do the work is given the part number and the operation number, so that the tools may be located in the tool supply room. There is one of these tool supply rooms for each separate department. A card file in the tool supply room contains a card for each part that is machined in that particular department. These cards are filed consecutively by the part numbers, so that it is a simple matter to locate any of the tools by referring to this card file. For instance, if a workman calls for the tools for machining part No. U-47, operation 6, card No. U-47 is located in the file for operation 6, and on this card is found the name of the tool or tools and the shelf number. All the tools, such as drill jigs, dies, special milling cutters, etc., have heavy cardboard tags attached to them. These tags, which are plainly visible, are marked with the part number, the name of the tool, the operation number, and also the equipment number which is used when taking an inventory of the tool stock. When the tool is located by referring to the shelf number shown on the card file, the tag is removed from the tool and, together with the employe's check, is left where the tool belongs. The check identifies the workman and the tag shows what tool is out and also exactly for what operation it is used.

Tool Symbols Based on Class of Work. — The method of identifying tools, such as jigs, fixtures, dies, etc., at the factory of the Ellis Adding-Typewriter Co., Newark, N. J., is by means of symbols on the tools and blueprints which are based on the general class or part of the mechanism for which the tools are used. The symbol, except in the case of special tools, is composed of a letter and number; the letter indicates the general section of the typewriter or adding mechanism to which the part belongs, and the number shows whether this part is a shaft, screw, collar, casting, drop-forging, punched part, spring, or a miscellaneous piece not belonging to the more common classes mentioned. The meaning of the symbols will be more apparent after referring to the following list of some of the letters used and the general classes of mechanism they represent: A, accumulator mechanism; B, base, frames, case, spring barrel, carriage ways; C, carriage (non-shift parts); D, left-hand operating parts, governor; E, escapements; F, tabulating mechanism; G, tally roll and carriage return.

The different parts which the numbers represent are as follows: 0-9, shafts; 10-29, studs, pins, and screws; 30-44, collars (screw machine parts having holes); 45-49, castings; 50-74, punched parts; 75-79, drop-forgings; 80-89, springs; 90-99, miscellaneous parts not in above classification.

To illustrate the method of using these letters and numbers, assume that a symbol is required for a shaft in the accumulator mechanism. The symbol for this shaft would be composed of the letter A and some number between 0 and 9. If the part were a stud, pin, or screw for the accumulator mechanism, the letter A would be followed by some number between 10 and 29, as shown by the list previously referred to. This symbol or part number is marked both on the blueprint and on any special tool that may be required, such as a jig, fixture, or die.

The symbol or part number makes it possible to locate readily a special tool in the supply room. To illustrate, suppose a jig is required for part A8. This tool will be found in section A of the supply room, and, as the tools are filed numerically in that section, tool A8 can readily be located. If a tool is used for one of a series of operations, the particular operation, in each case, is shown by another number which is added to the symbol. For instance, if a die is marked E55–2, the letter E shows that it is for some part of the escapement, the number 55 indicates that it is a punched part, and the figure 2 following this symbol shows that the die is used for the second operation. Similarly, the die for the preceding operation would have 1 after the symbol, and if the third or fourth operation were required, the additional dies used would be marked 3 and 4, respectively, after their classification symbols.

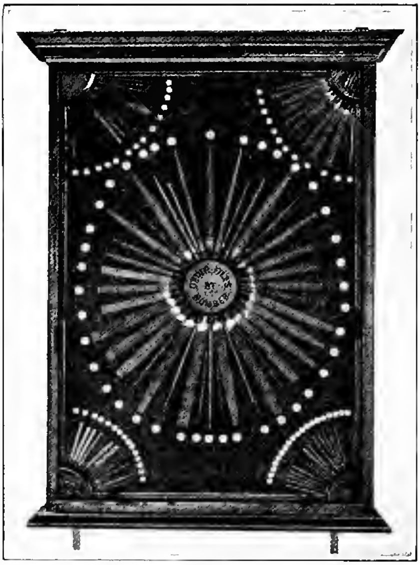


Fig. 7. Cabinet containing Sample Files which are identified at Tool Supply Room by Number instead of by Name

As it has been necessary to manufacture many special parts which differ from the standard parts of the adding typewriter, a different method of marking the blueprints and tools is used for the special pieces. The part number consists of a whole number and a decimal. The whole number is used instead of a letter to avoid confusion or interference with the regular symbols, and the decimal has the same meaning as a whole number preceded by a letter. For instance, No. 25.7 represents some kind of special shaft, whereas 25.46 would represent a special casting, since 7 comes between 0 and 9 which, according to the preceding list, are numbers assigned to shafts, and 46 is between 45 and 49 which are the casting numbers.

Cabinets for Identifying Files. — When files are obtained from the tool supply room, the usual method of identifying them is by the names given to different classes of files. This method of identification frequently results in confusion and delay, owing to the fact that the correct names are not always given by the employes. In some cases the man receiving the file asked for, but not the kind wanted, does not like to admit that he was in error and the result is that a file is frequently used when it is not exactly what is required for the job. In order to insure prompt delivery of files of the size, form, and grade wanted, sample boards or cabinets are used in some shops. A cabinet in the tool-room of the Taft-Peirce Mfg. Co. is shown in Fig. 7. Every size and shape of file in the tool supply room is represented in this cabinet, and each file is numbered so that the workmen, after determining the size and style required, can order it by number instead of using a name, or a manufacturer's number in the case of toolmakers' files. On some sample boards, the name of the file is given instead of the number.

Numbers for Identifying Lathe and Planer Tools. — Forged tools, such as are used for turning and planing operations, are sometimes identified by numbers to insure the delivery of a tool of the required shape. The different forms of tools are shown on a chart, and each form is given a number which may be used instead of a name when an employe obtains tools from the tool supply room. In one shop where such a tool chart is used, the names of the different tools corresponding to the numbers are also given.

CHAPTER X

TOOL SUPPLY SYSTEM UNDER SCIENTIFIC MANAGEMENT

THE ideal tool supply room system does not exist, if by system we mean a complete plan or organization which, without modifying any of the details, may be applied universally. A system that would be ideal in one plant or machine shop might require some modification in another shop to suit local conditions. The variation may be a slight change of detail or a reduction of the entire system to a more simple form, whenever the manufacturing conditions and problems are relatively simple and do not require the more complex system necessary when a great variety of work is produced. While such changes are often essential, there is a tool supply room system which may be considered ideal in principle. Such a system would include not only the care, maintenance, and accounting for all tool equipment of the classes previously referred to, but prompt delivery of such tools to various manufacturing departments before the tools are actually needed.

While systematic methods of issuing tools and of maintaining them in good condition are common, the tool supply rooms of a great many machine shops are either partly or entirely independent of the manufacturing department, instead of being so interwoven with the entire system of shop management that they are controlled the same as any other department. If turning, planing, and milling operations are necessary in manufacturing a certain machine, the departments doing the work will be so controlled in a well organized shop that they will act in unison, so that the maximum output of the finished product may be obtained. Inasmuch as the efficiency of any department or of an entire plant may be affected considerably by the condition of the small tool equipment, it is also important that the tool supply room be controlled with reference to the work of manufacturing, instead of placing this department in the same class as a safety deposit vault and regarding it merely as a place of storage.

If a certain machine will soon complete a job, considerable delay may be avoided if the tools for the next successive job are collected in advance and placed at the machine. It is evident, however, that these tools will be useless to the machine operator unless the parts to be worked upon are also at the machine, together with the necessary blueprints and whatever additional instruction regarding the sequence of operations, etc., may be necessary; therefore, it is apparent that there should be some form of centralized control to insure prompt delivery not only of tools but of raw material, such as castings, forgings, or bar stock. Naturally the details of any special system will be subject to more or less variation and may be affected by such conditions as the arrangement of the shop or factory and the uniformity or divers ty of the product.

The method of controlling the delivery and maintenance of tools adopted by the Tabor Mfg. Co., of Philadelphia, will be described as a practical example of a system based on the principle that all the departments of a manufacturing plant should be so closely allied that they are like the different parts of a machine which move in perfect unison and accomplish results by concerted action. The control of the entire plant is centralized so that every department, including the tool supply room, is governed with reference to the work of the entire manufacturing organization. As explained in Chapter I, the planning department not only decides how and when work should be done, but provides for supplying the necessary tools and materials in advance so that all delay is avoided.

Classification of Tools. — While it is the general practice to place tools of the same class together in the supply room to facilitate finding different tools as they are called for by the workmen, the classification ordinarily is not intended to include the system of identifying tools. In most shops, the part number or tool number on a drawing or list of operations is simply given to a certain machine part or tool arbitrarily, but does not of itself indicate to what class the tool belongs.

With the system of tool classification devised by F. W. Taylor and adopted by the Tabor Mfg. Co., the symbol for each tool is composed of letters, each of which indicates something definite about that particular tool. When the tool cabinet is arranged to correspond with this system of classification, it is easy for anyone to locate a tool readily in a large supply room, after a brief explanation of the system, due to the fact that the location of any tool depends upon the system and not upon the memory of the man in the supply room. This system is based on a general classification for all tools and the dividing of these general classes into divisions and subdivisions, down to a tool of a certain type, form, and size. For instance, the symbol might be composed of letters which show that the tool is used for turning, has a round nose or cutting end, and is bent to the left. A number added to this combination of letters would show that the tool was made of stock of a certain width.

General Classification. — The general classification of each tool is indicated by a letter forming part of a symbol. The various classes of tools represented by these letters are as follows:

A — Miscellaneous tools, not elsewhere classified.

B — Bending tools. All tools for producing changes in shape by bending, folding, spinning, etc.

C — Clamps and holding devices of all kinds, including bolts and screws.

D — Drilling and boring tools. Tools that remove metal from the interior, such as drills, boring-bars, cutters, and all appliances relating to them, and lathe boring tools, etc.

E — Edge tools. Edge tools for working wood, and tools for working plastic materials, such as clay, molding sand, putty, etc.

F — Heating tools. All kinds of tools used for heating, lighting, melting and molding, oil tempering, annealing, drying, cooking, etc.

H — Hammers and all tools that work by striking or being struck, such as sledges, tups, etc., chisels, sets, flatters, etc.

L — Transportation tools. All tools used in moving materials from one place to another, such as buckets, boxes, etc., trucks, shovels, wheelbarrows, bogies, brooms, riggers' tools, slings, chains, etc.

M — Measuring tools. All instruments of precision, weights, measures, gages, etc., electrical instruments, etc.

P — Paring tools. All tools that remove metal from the surface by cutting, except slotter and milling tools. (See class D for lathe boring tools.)

R — Milling tools. All tools for milling or sawing metal.

S — Slicing tools. All parting tools and slotter tools.

T — Templets and all instruments for duplicating work, including jigs and fixtures.

U — Abrading tools. All tools used for rubbing, scraping, filing, grinding, shearing, punching, breaking, etc.

W — Wrenches and all tools used for causing rotation.

X — Painting tools. All tools used for covering a surface with an adhesive foreign material, and any for removing same.

Sub-classification. — The general classes of tools listed in the foregoing are divided and subdivided, and as each division and subdivision is represented by a letter, the combination of letters indicates the exact type and form of tool, although the man in the shop or tool supply room does not need to know the meaning of the various symbols because the list of tools previously mentioned insures the delivery of the proper tool equipment. The man in the tool supply room, however, should understand the system of classification so that he may readily locate any tool by means of the symbol. In connection with this system, there is a record in the form of a loose-leaf book which contains symbols for the general classes of tools, as well as all sub-classes. This book is not needed for locating tools in the supply room, but it shows what symbols should be given to a new tool and enables a tool, the symbol of which is unknown, to be located if the name is given.

The accompanying table illustrates the arrangement of the different classes of cutting tools under the general class designated as "paring tools," and by the letter P. The symbol for a turning tool having a blunt round nose and a cutting end bent 30 degrees to the left will illustrate the principle of this system of classification. Turning tools belong to class P, since they are included, as shown by the previous list, in the general group used for removing metal from a surface by cutting, except slotting and milling tools; therefore, P would be the first letter of the symbol. The next letter is found by referring to another sheet indexed under the letter P. On this sheet is a list of the different shapes of the cutting edges (see table), and as R represents a round nose or cutting edge, the symbol becomes PR. Each symbol on this sheet P has another sheet marked PC, PR, and so on. Sheet PR would be referred to, in this case, and it would show what

Key for Sub-classifying Standard Shape Cutting Tools

First Letter	Second Letter	Third Letter	Fourth Letter
Class	Shape of Cutting Edge	Sub-classification of Second Letter, Shape of Nose	Straight, Bent, and Hand
Paring .....P From general classification	Parting ....C Round ....R Square .....S Side ....U V-shape V	Sharp ......S Blunt........B Broad .....W Beveled ....A	Straight ....A Straight... right B, left C Bent 30° to right D, left E Bent 45° to right F, left G Bent 60° to right H, left J Bent 90° to right K, left L

letter should be added to PR to indicate that the round cutting edge is of blunt form. This letter is B, so that the symbol is now PRB. Sheet PRB is next examined to find the letter for a tool having a cutting end bent 30 degrees to the left. Letter E represents such a bend, and the symbol PRBE thus obtained is completed by adding a figure to it, which, in the case of forged tools, shows the width of the tool shank as measured on the long side. For instance, the symbol $\frac{7}{8}$ PRBE shows that the tool is a $\frac{7}{8}$-inch blunt, round-nose tool bent 30 degrees to the left. The classification sheets show definitely that this symbol is complete, because no sheet will be found indexed under PRBE, which indicates that there is no other subdivision.

Arrangement of Tools According to Classification. — The tool racks are of standard form, as previously explained in connection with Fig. 3, Chapter VII. All tools are placed in the different compartments of these standardized racks in the exact order indicated by the symbol. For instance, the symbol $\frac{7}{8}$ PRBE for

Fig. 1. View in Tool Supply Room of Tabor Mfg. Co.

a turning tool would be used for locating this tool in the rack in practically the same way that the name of the tool would be determined by referring to the book of tool classifications. Symbols at the end of each rack along the aisle illustrated in Fig. 1 show the first and last symbol included, so that a glance at these "keyboards" enables one to determine whether or not a certain symbol or tool is in that particular rack section. (One of these keyboards may be seen above the tool rack in Fig. 11, Chapter VII.) On one of these boards will be found the symbol DBG–DDTT (up to $1\frac{17}{32}''$). This particular symbol shows that all tools listed in the inventory between these letters are in this rack. For example, tools having the symbol DCBG are in this rack, because DCBG comes between DBG–DDTT, according to the alphabetical order; a symbol like DDTS would also be included in this rack, because S precedes the last letter T of the symbol DDTT.

Each twenty-four-inch unit or compartment of a rack also has a symbol which serves the same purpose for this department as the keyboard previously mentioned does for the entire rack. Thus, if the symbol DDTT is over a twenty-four-inch unit, it shows that only tools of this classification are in that particular department, although there may be different sizes of these tools, as in the case of drills, reamers, etc. If there were two symbols over a twenty-four-inch compartment, as DCBG–CFN, this would mean that all tools between DCBG and DCFN were in this twenty-four-inch section, although part of the tools included under the end symbols might, in some cases, be in the preceding or successive compartment of the tool rack. Boxes or drawers within the twenty-four-inch compartments are labeled with brass tags (painted black with letters filled in with white), each bearing the symbol and size of the tools in each box, tray, or drawer. For example, a drawer marked 1″ DDTT means that only one-inch taper shank twist drills are in it.

Locating a Tool by the Classification Symbol. — In order to locate a tool quickly when its symbol is given, it is essential to know the order in which the racks are arranged. The general classes of tools represented by various letters from A to X, according to the list previously given, are stored in the racks in alphabetical order. The tools in the general class A are followed by those in the B class, and so on. The standard twenty-four-inch compartment at the upper left-hand corner of a rack at one end of the tool supply room corresponds to the first page of a dictionary. The next rack, or the second one to the right of the first, represents the second page; the third is directly below the first; the fourth to the right of the third, and so on as shown by the order of the letters on the diagram, Fig. 3, Chapter VII. These twenty-four-inch units are read from left to right down to the eighth or last rack of a standard section. In this particular tool supply room most racks are composed of two sections, each containing eight twenty-four-inch compartments, and the second section is read like the first one, beginning at the upper left-hand corner and reading each horizontal pair of units or compartments from left to right. When the twenty-four-inch units are subdivided with boxes or drawers, these are also read from left to right, as in reading a book.

To illustrate the method of locating a tool from the symbol, assume that the tool having the symbol DDTT1″ is required. (This happens to be the symbol for a one-inch taper shank twist drill.) The main rack is first located by looking for the letter D the same as when locating a word in a dictionary. This leading letter D may not always locate the right rack, because more than one of the racks may have symbols beginning with D. The two symbols on the keyboard at the end of the rack containing this tool will be such that the first one precedes the tool symbol and the second one follows it, according to the alphabetical order. The rack marked "DBG–DDTT up to $1\frac{17}{32}$″," shows that it contains the tool DDTT1″. The symbol on the twenty-four-inch compartment containing this particular tool is next located, this serving the same purpose as the word at the top of the column in a dictionary, which shows that the word is somewhere in that particular column. The keyboard at the end of the rack indicates that symbol DDTT is not at the beginning of the rack, so that the first few sections are skipped and the heading DD is looked for, the same as "de" or "dee" would be in searching for the word "deed" in a dictionary. If the symbol DDTS is found, evidently DDTT is farther along. After finding DDTT above a twenty-four-inch division, the box, drawer, or bin containing one-inch tools, in this particular case, is found. Whenever tools of one kind or type are kept in a variety of sizes, they are arranged according to the size, the small tools coming first. By this plan the tools can be located without delay.

Procedure in Obtaining Tools. — The exact method of obtaining the tools for a certain operation in the shop will be explained. The tools are shown by the symbols on the tool list which is sent out with the instruction card by the planning department. Assume that these tools are intended for a certain operation on machine L-10. As explained in connection with Fig. 3, Chapter I, the foreman or gang boss is guided in assigning work to the men under him by the shop bulletin board in his department. The foreman waits until machine L-10 is two or three jobs ahead of the particular operation under consideration; the tool list for that particular operation is then sent to the tool supply room by one of the boys who transfer tools.

The tool list is accompanied by enough brass checks to cover the number of tools required. These checks bear the workman's shop number, and there are four different shapes representing a corresponding number of exchange values, the same as four coins of different denominations. For example, a round check may be given in exchange for one tool, a square check for two tools, an octagonal shaped check for four tools, and a scalloped edge check for six tools. The use of these different shapes reduces the number of checks to be handled.

Method of Collecting Sets of Tools. — When the tool list and checks covering the number of tools required are brought to the tool supply room, one of the attendants, using the tool list as a guide, starts to collect the tools, beginning first with those which are farthest from the delivery window. In connection with this work, an "issuing truck" is used which has three shelves. (This truck may be seen in Fig. 1.) The two lower shelves contain the tote boxes in which different sets of tools are placed, and the upper shelf is for holding the tool lists, which are temporarily attached to suitable boards having spring clamps. With this arrangement, several tool lists may be made up at one time, the tools called for on each being placed in a separate box. Each tool that is removed from a box, drawer or rack is replaced by a workman's check, which is placed either on a hook or in a pocket provided for that purpose, in the case of a drawer. As each tool on a list is obtained, it is checked off the list by extending a pencil line or mark along a heavy white line at the left of the column showing the number of tools required. (These tool lists are small blueprints, so that the heavy checking line is white against a blue background.) This checking of the tools is done to insure the delivery of the complete set called for on the list. When a set of tools is made up, the tool list is placed in a pocket of the metal tote box and then the tools are ready to be sent out to whatever machine or other part of the shop is marked on the tool list. Wooden boxes fitted with compartments to protect the cutting edges are used for tools that might be injured if placed together in a metal box.

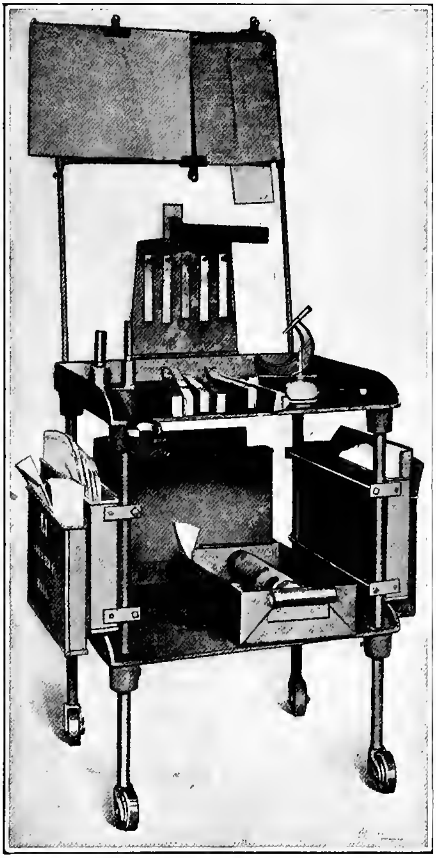


Fig. 2. Shop Tool Stand for Holding Tool List, Instruction Card, Blueprints, and Sets of Tools

Signal Lights for Tool Delivery. — Inside the tool supply room window there are three red lights arranged in a vertical row, which represent the three floors of the machine shop. Each of these lights is connected with a similar light on the first, second, and third floors, so that they can be used for attracting the attention of the boys who deliver and return tools. For instance, if a set of tools is ready for some machine on the first floor, the lower light is turned on and one of the boys comes for that set of tools.

Tool Stands for Machines. — When the box containing the set of tools is brought to a machine, it is placed on the lower shelf of one of the portable tool stands illustrated in Fig. 2. The particular tool stand shown has only one box of tools, but ordinarily there are three boxes containing the tool equipment for a corresponding number of jobs which are to follow the one on which the

Fig. 3. Receiving Bench where Returned Tools are examined and sorted

machine is working at the time. In this way, all delay due to waiting for tools is entirely eliminated, and as soon as one job is finished, the foreman or gang boss sees that the machine is properly set up for the next operation. This tool stand is provided with pockets for holding the necessary blueprints, tool list, and instruction card. When these lists and cards are brought from the planning department, they are placed in the pocket marked "jobs to be done," and when the work is done, they are put in the pocket on the opposite side.

Return of Tools to Place of Storage. — As soon as a certain operation is completed, all of the tools, including any clamps, bolts, or blocking that may have been needed, are returned to the tool supply department with the list used in making up the tool set. Even though some of the tools are to be used on the next successive job, they must first be returned to the tool supply room for inspection to show that all the tools are in proper condition. If this plan were not followed, tools might be used that were not up to the required standard. When the tool box reaches the delivery window, the tool list is removed and placed in a small compartment near the window provided for that purpose. The tools are then taken to the "receiving bench" shown in Fig. 3, where they are carefully examined so that all dull tools may be separated and placed in boxes on a shelf just beneath the receiving table. All tools that are to be sent out for sharpening are replaced by checks marked to indicate the department to which the tool has been sent. The remaining tools, after being assorted to facilitate distributing them, are placed on the "putting away truck."

The truck used when distributing tools is similar to the one employed for collecting them in sets, except that the two upper shelves are spaced or partitioned so that, when tools are assorted on the table, they can be transferred to these spaces, which will keep the different types in order. As each tool is returned, the workman's check is removed from the tool rack and placed on a check ring which keeps the checks together and prevents their being lost. For each tool that is sent out to be ground or repaired, the workman's check on the tool rack is replaced by one of special form showing to which department the tool is sent.

When the tools of a set have been put away, the workman's checks and the tool list are sent back to the place where the work was done, the tool list being placed in that pocket of the tool stand representing jobs that have been finished. These lists are then removed and filed away in the planning department for future use.

Outgoing Grinding and Repair Racks. — All tools that have been dulled in use and need grinding or sharpening are transferred from the receiving table to a nearby compartment marked " outgoing grinder rack." The boxes for such tools as dull drills or forged turning and planing tools are kept at the receiving table until enough tools have collected to warrant issuing an order for grinding them. They are then transferred to the " outgoing " rack and are taken from this rack by a " move man " to whatever machine or department is to do the work.

The " outgoing repair rack " serves the same purpose as the other rack referred to, except that it is for tools requiring repairs other than grinding. There is also an " incoming tool rack " for holding tools which have either been ground or repaired; new tools are also placed in this rack before being filed away in one of the regular compartments. At the time tools are ordered, the proper symbol is given to them according to their class and subclass and this symbol is stamped on the tool. The forged tools used for turning, planing, etc., have symbols stamped on the shanks, which show the size and classification, the name of the steel, and the lot number in which the steel was received. The brand of steel is represented by letters which are an abbreviation of the trade name. These symbols are stamped in a definite place, the classification symbol being on the top of the shank near the end, the lot number on one side, and the symbol for the brand of steel on the opposite side. Incidentally, the grinding of dull tools is controlled by the planning department the same as manufacturing operations.

CHAPTER XI

TOOL ENGINEERING DEPARTMENT

SUCCESS in any line of interchangeable manufacture depends, to a large extent, upon the care that is taken in planning machining operations and designing jigs and fixtures. This fact is shown by the unusually high rates of production and large returns from labor and investment in plant obtained in the automobile industry. Probably there is no line of manufacture in which the performance of machining operations along preconceived lines has found such wide application, and in which the work is done according to the actual requirements of the operation, regardless of what may be current practice on similar work. Therefore, the general procedure referred to in this chapter is based largely upon methods common to the automobile industry, although the methods referred to may be applied generally.

Qualifications of Tool Engineer. — The man who looks after the work of planning operations and designing jigs and fixtures is generally given the title of "tool engineer," and, in order to handle this work successfully, he must have certain well defined qualifications. It is of the utmost importance for him to possess a wide knowledge of machine tools and methods of performing machining operations; and he must keep constantly posted in regard to the latest equipment used in the manufacture of interchangeable parts. The tool engineer must also be thoroughly familiar with the physical properties of all classes of metals used in constructing the product of the company by which he is employed, and with the cutting speeds and feeds which can be employed in machining these materials. The tool engineer should also be an experienced draftsman, and he should have sufficient knowledge of free-hand sketching to enable him to express his ideas rapidly on paper.

First Step in Design of Special Tools. — When the design of a new car has been passed by the engineering department of an automobile factory and a decision has been reached to place it on the market, the first step in taking up the manufacture of this car will be to send blueprints of all parts to the office of the tool engineer so that he may study the design of each part, lay out the order in which the machining operations are to be performed, and design jigs and fixtures for these machining operations. Assume a case in which a factory previously engaged in automobile manufacture has adopted a new design of engine to be used in a car that this company is about to place on the market. In such a case, the factory will be provided with practically all of the machine tool equipment required for the machining operations, so that the work of the tool engineer will be confined to the planning of operations and the design of the necessary jigs and fixtures.

When blueprints of the motor parts have been received by the tool engineer, and he has been given instructions to proceed with the design of jigs and fixtures for these parts, he should first refer to the design of corresponding parts of the preceding type of motor and the tools used for machining them. This is done to ascertain whether or not any of the tool equipment formerly used can be changed at a moderate cost to adapt it for use in the manufacture of parts of the new engine. It often happens that many of the tools can be utilized in this way, but attention must be paid to the fact that all automobile manufacturers are continually called upon to furnish repair parts for obsolete types of motors of their manufacture. Such parts are generally made in lots of about one thousand, and are distributed to the service departments of the company, which are maintained in most important cities. For use in the manufacture of these parts, at least one complete set of jigs and fixtures is kept on hand. Card files are maintained to show the position of these tools in storage bins, and the bins are conspicuously numbered so that any particular lot of tools can be easily located.

Coöperation between Tool Engineer and Chief Designer. — The first point that should be considered by the tool engineer is the character of the parts to be machined and the method of holding which appears to be most suitable for each particular case. In order to secure the most satisfactory results, the tool engineer and the chief designer of the engineering department should work together. The reason for this is that the designer is not usually an expert on the performance of machining operations, and, therefore, he should secure the advice of the tool engineer in order to be sure that the design of all parts of the motor shall not only be perfectly suited to the service required of them, but that they shall also be made in a way which will enable them to be machined on an economical basis. A few minutes devoted to conferences between the designer and tool engineer at specified intervals would often be the means of effecting large savings in the cost of manufacture, as it sometimes happens that many castings are made before it is found that they are of such a form that special means should have been provided for holding them. Had such a conference been held before the castings were made, it would have been an easy matter for the tool engineer to suggest the provision of lugs or recesses on the castings to engage clamps provided on the fixture. These conferences should be held before the drawings are sent to the pattern shop, so that, after the design has once been approved by the chief draftsman and tool engineer, they may be circulated through the factory with the assurance that no subsequent trouble will develop.

Order of Tool Engineer's Work. — It is a general principle of tool design that the method of procedure must be governed by the number of pieces to be produced, because it is obvious that a certain relation should exist between the cost of a jig or other special tool, and the amount of work to be produced in it. While the tool engineer in an automobile factory pays a certain amount of attention to this point, it is not a matter which concerns him so vitally as it does the tool designers employed in some other lines of manufacture, because the average automobile factory has such a large production that any reasonable expenditure is warranted, provided it furnishes a means of handling the work with the maximum efficiency.

The order in which the tool engineer handles his work is as follows: 1. Planning the order of operations. This includes a consideration of the effect of the design of each part to be machined upon the method of machining. 2. Deciding on what type of machine each operation is to be performed. 3. Selecting locating points on the work for each operation. 4. Designing the necessary jigs, fixtures, and tools. 5. Making the tool drawings. 6. Estimating the rate of production that can be obtained for each operation, in order to determine the number of machines and tools that must be provided to produce the required number of parts. As each motor part is taken up, the tool engineer decides upon the best order in which to perform the machining operations, and then makes out an operation and tool list. Each operation and tool list gives all necessary information concerning individual machining operations, the types of machines used, the tools with which these machines are equipped, and the estimated hourly production per machine.

After planning the order of operations and deciding upon the type of machine on which each operation is to be performed, the tool engineer is ready to take up the design of jigs and fixtures. When he has decided upon the best method to follow in performing each machining operation, he calls in draftsmen from the tool designing department and explains the general requirements for each tool. The tool designers are experienced men, and much of the detail work is left to their judgment. For instance, the tool engineer will not specify the form of clamping mechanism to employ in each case, as he knows that his assistants in the tool designing department are thoroughly competent to handle this part of the work. But in many cases, where the method of machining is somewhat complicated and the tool engineer feels that there is a possibility of misunderstanding his instructions, he will make a free-hand sketch while he is explaining his ideas to the tool designer. This sketch is taken back to the drafting-room and constitutes the best possible form of memorandum for the designer in carrying out the instructions of the tool engineer.

In connection with the work of the tool engineer, the ability to make good free-hand sketches rapidly is a valuable asset, as previously stated. Much time that would otherwise be required to explain his ideas can be saved by a judicious use of free-hand sketches. These can go into more or less detail, according to the complexity of the idea; but they should always clearly show the principle involved, so that the designer will not be obliged to come to the tool engineer with too many questions.

Organization of Tool Designing Department. — The usual practice in designing tools for use in machining motor parts and similar work would be to turn over to one tool designer the operation and tool list, and allow him to proceed with the designing of all tools for machining a particular piece, following the sequence of operations in their proper order. This is the ideal method, but it is subject to variation, depending somewhat upon numerous conditions, such as the number of jigs and fixtures required for machining the piece. When there are a large number of jigs and fixtures to be designed for any one piece, such as the cylinder block, it will be found advisable to have several designers working on the tools simultaneously in order to avoid delay. Another method which is sometimes used in large factories where a number of tool designers are employed is to divide the various men into groups of three, four, or six, and place each of these groups under the control of a capable designer who is also an experienced draftsman. This arrangement works out very nicely in practice, and relieves the tool engineer of the necessity of answering numerous questions in regard to points on which the tool designers want additional information. Such a group of draftsmen can be assigned to designing the tools for machining one piece for which a number of jigs or fixtures are required, and these men can work together and complete the designs very rapidly.

Special Tool-designing Experience Essential. — It is well to note that a mistaken idea of economy exists in some factories in regard to the method of handling the work of tool designing. At certain seasons of the year, when a great number of new fixtures are to be made, a proportion of the drafting-room force is switched off to assist with the tool designing, although these men may or may not be adapted to the requirements of this particular class of work. A man may be a good designer of automobile parts and still be utterly incapable of giving satisfaction on tool design, because of lack of knowledge in regard to the most efficient methods of conducting machining operations and the conditions that must be fulfilled by jigs and fixtures. Such features as the provision of chip clearance, selection of the best locating points, and many other details which would be taken care of instinctively by an expert tool designer would puzzle the draftsman unfamiliar with this class of work, with the result that he is likely to neglect them. On this account it is advisable to secure the services of men on tool design who have had a number of years' experience in the shop, followed by the necessary drafting-room experience to make them proficient. It is not economical for any concern to employ its regular drafting-room force for this purpose, unless it is well aware of the capabilities of certain of the men along these lines. In addition, the average designer on automobile work does not like to be shifted to tool design, as he prefers to specialize on his own particular line of work. However, this is a mistaken idea on the part of a designer, as he will find that the knowledge gained in tool design will be valuable to him in many ways in connection with other work.

Points to be Considered in Tool Designing. — In making the tool drawings, the designer is governed entirely by the operation and tool list and the tool engineer's sketches, together with verbal instructions which he may have received in going over the matter with the tool engineer. In the first place, the design of each tool must provide for securing the required degree of accuracy in the work. When the number of parts to be produced is quite large, it is essential for every possible refinement to be incorporated in the design of the jig or fixture in order that there may be as little delay as possible in setting up and removing the work. For instance, the provision of quick-acting clamps may be the means of making a noteworthy reduction in the time occupied in setting up the work. The question of cleaning the fixture or jig should also be carefully studied and no deep pockets should be left in which chips will accumulate and cause trouble in obtaining correct locations. Whenever possible, the parts most subject to wear should be so designed that new parts can be quickly substituted when the old ones have worn beyond the required limits of accuracy, as the time lost in repairing tools is otherwise likely to be a serious matter. The provision of means for clamping the work and holding it in the correct position while being machined should also be very carefully studied; and all clamping devices should be both rapid and convenient to operate, as well as so designed that there will be no possibility of the piece being cramped or thrown out of its true position when clamping. Many of these points are considered, and methods suggested, at the time that the tool engineer outlines his ideas to the tool designer. In making up each drawing, the position of the work should be indicated by either a dotted or a red line, so that the purpose of each part of the jig or fixture will be evident to the toolmaker.

There are a number of important details in connection with the making of tool drawings which are taken care of in various ways, according to the system in vogue at the particular factory where the work is being done. To facilitate the work of tool-making, it is essential to include on the completed drawing a bill of material, which gives the amount of stock required in making the jig or fixture, with the necessary allowance for finish. When this is done, the completed drawing goes to the ordering department, where the order is issued for the various materials needed in the construction of the tool. A still better way to handle this matter is to have the tool designer issue orders for the stock on regular stock cards, which are attached to the tool drawing by clips after the drawing has been completed, thus showing the tool-room foreman what stock is required for the job.

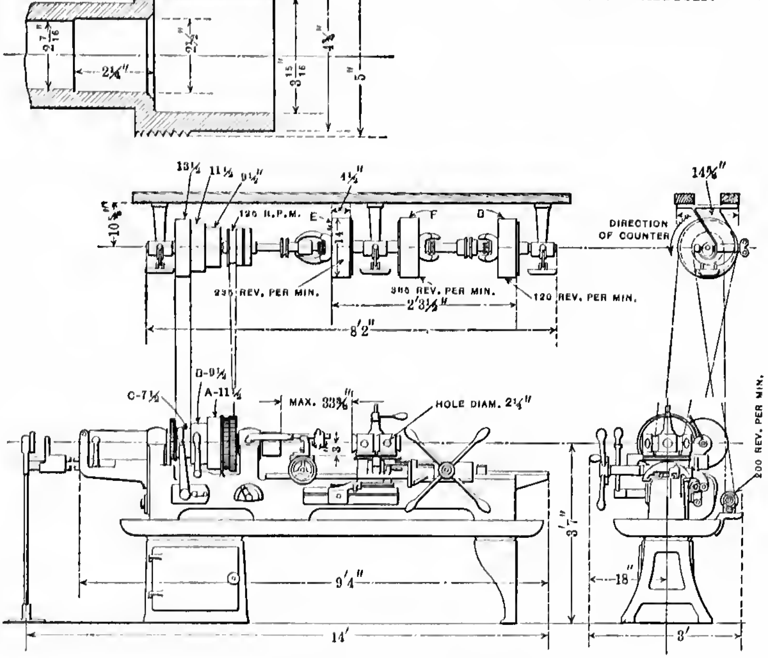
Importance of Checking Drawings. — Upon completion of the drawing, it goes to the tool engineer, who looks over the general points of construction and features of design, and makes any suggestions which he may deem advisable. After he has approved the drawing, it goes to the checker, who carefully goes over all dimensions to be sure that there are no errors when it is sent to the tool-room accompanied by an order to make the tool. Just exactly why this precaution is frequently omitted in connection with tool drawings is not apparent, but the fact remains that many of them are allowed to go directly to the tool-room. It follows, therefore, that any errors which occur are either discovered by the toolmaker while doing his work or else they go through without discovery until the fixture is finally checked before it is sent into the shop. Even then, an error may not be discovered unless the work which has been machined in the fixture is inspected to see that it conforms to the requirements of the blueprint of the engine part. In cases where several jigs or fixtures are to be made for machining the same piece of work, it is especially important for the drawings to be carefully checked in order to see that no errors occur. In this particular instance, assume that the drawings have been checked and O. K.'d by the tool engineer, after which they are ready to be sent to the tool-room.

Materials for Tool Drawings. — Several methods are employed by different factories in making their tool drawings. One of these is to make the drawings in lead pencil on manila paper, and send them out to the tool-room after they have been varnished and attached to a board. Another method is to use tracing cloth (not paper) on the rough side of which the tool drawing is carefully laid out in pencil. A No. 3 pencil gives very good results in printing and will not smudge appreciably. The objection may be raised that the use of tracing cloth for making tool drawings is too expensive; but it will be found that, although the first cost is somewhat greater than when manila paper is used, the convenience and time-saving features will more than offset this difference in cost. It may also be said that a pencil drawing made on tracing cloth will be smudged and made illegible, or that the blueprints taken from such a drawing will not be sufficiently clear. But several of the large machine tool builders in the United States are securing excellent results from this system at present, which should be sufficient to vouch for its practicability. The use of tracing paper is not to be commended on account of the wear and tear to which it may be subjected in handling.

There are a number of advantages secured through the use of tool drawings made on tracing cloth. One of these is that blueprints can be made which can be sent to the pattern shop and to the toolmaker, while additional copies can readily be made if, for any reason, other departments may require them. Another advantage is that in redesigning or making over a jig or fixture to meet the requirements of a new model or design, the pencil marks on the tracing can be easily rubbed off and the necessary

LATHES, TURRET

TYPE AND SIZE OF MACHINE
P. & W. CO., ---- 2 BY 26
SWING OVER BED ------ 16
SWING OVER C. S. ------- 8¾
WIDTH OF C. S. --------- 6



SPEEDS IN REVOLUTIONS PER MINUTE									
	D			E			F		
	A	B	C	A	B	C	A	B	C
SLOW BACK GEARS	15	21	30	28	41	60	45	67	99
FAST BACK GEARS	44	56	83	75	111	164	124	183	269
OPEN BELT	114	145	213	194	285	423	319	466	692

FEEDS IN INCH PER REVOLUTION								
	TURRET-SLIDE				CROSS-SLIDE			
FEEDS	0.007	0.011	0.015	0.020	0.0012	0.002	0.0028	0.0035

Fig. 1. Sheet from Tool Engineer's Loose-leaf File of Machine Tool Equipment, giving Available Speeds and Feeds and Important Dimensions affecting Design of Tools and Fixtures

changes made with very little labor. In addition to this, it may be desirable to keep a record of the original tool drawing, which can be easily done by making a blueprint and marking it "record print." This can be filed in its proper place and referred to at any time.

Filing Systems and Care of Tool Drawings. — An excellent system for filing tool drawings and lettering them so that they can be easily found is to standardize the various sizes of sheets; for example, 9 by 12, 12 by 18, 18 by 24, 24 by 36 inches, etc. Each of these sizes is designated by a letter, such as "A" for the 9 by 12 size, "B" for the 12 by 18 size, etc. It is also advisable to have one letter to designate extra sizes which may be necessary in the design of a special machine or an exceptionally large fixture. "X" answers very well for this purpose, and a separate filing drawer should be used for these odd-sized drawings. It is a good idea to put the letter and the accompanying number of the drawing in the lower left-hand corner and again in the upper right-hand corner upside down, so that no matter which way the drawing happens to be placed in the drawer, the number will always be easily seen. A drawing record book should be prepared containing consecutive numbers under each size and letter; and these numbers should be checked off as they are used. A card file system should also be devised, the cards being arranged numerically by piece number or alphabetically by the name of the piece, according to the system in vogue in the factory, and the numbers of the drawings which apply to the tools and fixtures on any piece can then be entered on these cards. In this way, a double file is available so that any required tool drawings can be located from their tool drawing numbers or from the name or piece number of the part on which they are used.

List of Machine Tool Equipment. — In the tool engineering and tool design department, a complete list of the machine tool equipment of the factory will be found useful. The requirements will vary according to the machine tool equipment in the factory; but in any case the list should be as complete as possible, and should include the capacity of all machines. In many factories, the tool designer, when at work upon a fixture or jig, is obliged to go out into the factory and measure up the machine on which the fixture is to be used. This is entirely unnecessary when a reference list is kept in the tool engineer's office, as such a list may easily be made to contain all the necessary information for any of the machines in the shop. This list of machine tool equipment may be conveniently kept in a card file; Fig. 1 shows one of the cards from such a file, which gives the dimensions of a horizontal turret lathe. Reference to this illustration will show that the form is so arranged as to give the necessary data on all machines of this type, together with the available feeds, speeds, and general features of construction. There are few ideas which can be

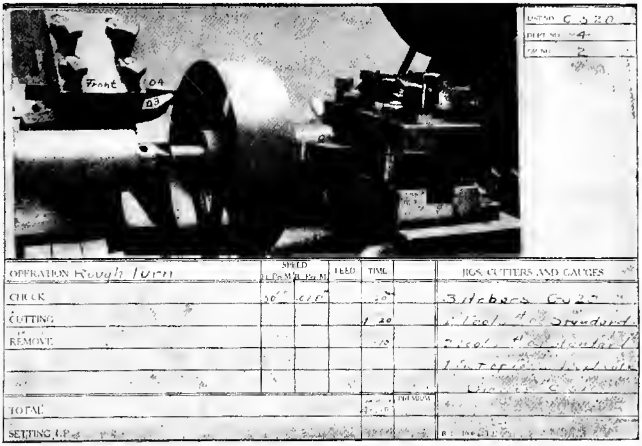


Fig. 2. Shop Operation Sheet for Rough-turning a Pulley

applied to tool designing that are capable of saving more time than this system of recording the mechanical equipment of the factory. It requires a certain amount of time and care to compile such a list, and a little work is necessary from time to time to keep it up to date, but the expense involved will be more than offset by the time saved. In the preparation of an index of this kind, outline drawings of different types of machines can usually be found in machine tool builders' catalogues. These outline drawings can be cut out and pasted on a good sized card, say 8 by 10 inches, so that they can be handled without difficulty. If desired, the reference index can be extended to include much other data of value to the tool engineer. These data may take the form of trade journal clippings referring to new developments in machine tools, special tools which have been designed for work similar to that done in the factory, and other valuable data.

Photographic Shop Operation Sheets. — The Jones & Lamson Machine Co., Springfield, Vt., uses photographs in conjunction

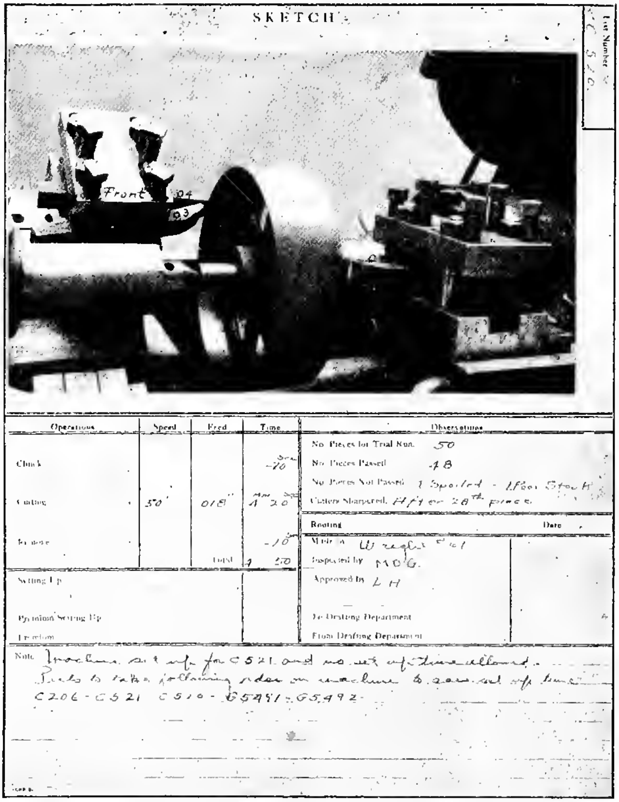


Fig. 3. Efficiency Department Record of Operation Sheet Fig. 2.

with tabulated data, to show the tool equipment employed for different machining operations. Fig. 2 shows a photograph and instructions mounted on cardboard as given to the machine operator, while Fig. 3 shows the shop operation sheets or records retained by the efficiency department and filed away for future reference. The machine operator is given a photograph of the proposed method of setting up the machine for a given job, and on the same sheet instructions are given as to the speed and feed to use and the time required for the job. The object of the photograph is to record accurately the tools to be used, how they are used, what clamps and holding-down screws are used, and to show clearly all special arbors and fixtures. The photograph is superior to a drawing, especially when used by more or less unskilled operators. In general, it is far easier for the shop man to set up work in a machine from a photograph than from a drawing.

In order to determine the proper speeds and feeds and the time required, the work is first done in a special department, which determines what methods are to be used. The job is started at a speed which experience has shown to be as rapid as possible for the work in hand. Ten pieces are made and the operations timed. No time of less than a second is considered, and usually on a job of several minutes' duration the time is taken to the nearest multiple of five seconds. Sometimes reference letters are marked with ink on the photographs, in order to more clearly indicate the requirements to the operator.

CHAPTER XII

ORGANIZATION OF AN ASSEMBLING DEPARTMENT

An investigation of the conditions existing in many manufacturing establishments will show that obsolete methods and processes in the assembling department nullify, to a large extent, the savings made in machining. The adoption of up-to-date methods of assembling may easily be expected to increase the efficiency of the average assembling department from 100 to 150 per cent, and if the department is in a run-down condition, even greater savings may be anticipated. Of course, to expect such large increases in all cases would be unreasonable, but there are many instances where such results are possible.

While the need for system in the assembling department is becoming more widely recognized, there are many manufacturers to whom the word "system" is invariably linked with "red tape." "Organization" is not their idea of economical management, because it means additional "non-producers"; and the leaks continue unchecked until some well-organized competitor forces the condition to their attention. This condition, however, is generally due to lack of sufficient experience or data enabling a concern to determine, with any degree of accuracy, whether or not economical results are secured from foremen, workmen, or processes.

It should be fully understood that there is no infallible system which will fit all cases alike; methods must be suited to the circumstances under consideration, since the first thought in regard to any plan must relate to its adaptability to existing needs. The reorganizer can rely but to a small extent upon any established system, and his initiative and common sense must bring a working result from a mass of conflicting conditions.

Necessity for Analysis of Existing Conditions. — Before introducing innovations in a department, it is necessary to analyze existing conditions and methods with regard to the men in the present organization, for invariably a certain amount of ignorance, prejudice, false pride, and stubbornness must be met and overcome. To win success, all plans must recognize, primarily, the human element of the men affected; methods should be instituted that are likely to elicit the support, develop the latent ability, and bring out the best that is in the workers. The best system in existence will not bring complete success without securing the support of the foremen and workmen. If these points are ignored, the tendency of the workers to gradually abandon methods with which they are not altogether familiar will cause a partial failure of the system.

The most arduous task, next to training the workmen, is that of progressing along new lines and at the same time not interfering with the regular output. This should be accomplished gradually as the old system may possess a momentum not easily overcome. However, when once a general line of procedure is outlined and progress begun, there must be no lessening of effort. Everyone must be impressed with the idea that every day must show some progress, however slight.

The machine and the assembly departments are so closely connected that the introduction of new methods of assembling must begin with an investigation of the production conditions in the machine departments. This investigation will include the quality and quantity of work, whether or not provisions are made for inspection in the machine departments, methods of routing the work, what delays are encountered in getting work to the assemblers, whether the work is sent directly to the assembling department or duplicated in large quantities and kept in a store, etc. It is apparent that any defects in the processes just enumerated will have an immediate effect on the efficiency of the assembling department.

In the assembling department may be found faulty judgment regarding assembling methods, lost time in looking up work, hunting for tools, and running after drawings, or to the stockroom for screws and pins — mistakes due to oversight, lack of proper instructions to the workmen, etc. The faults in organization and methods mentioned in this outline must be eradicated before any effective improvement can result.

Stock-tracing System. — Where there is constant trouble in getting out machines or repairs in a reasonable time, it usually will be found that some one or two departments are responsible for practically all of it. The first step to remedy the trouble, then, is to locate it. The assembling department is often blamed, but an investigation will generally show that the difficulty lies in not getting work promptly to the assemblers. Many manufacturers are so accustomed to delays in getting finished parts to the assemblers that they regard the matter as unavoidable, even though the consequent losses show clearly that a remedy is imperative. A well-organized stock-tracing system is an important factor in overcoming this defect. Some of the more important features of the assembling department of a large machine-tool plant will be described.

The functions of the stock-tracing system are: Directing the transportation of all parts in the factory; pushing the work through the foundry and machine departments in such a manner as to prevent delays to the assemblers; keeping up records that will show the location of parts in the foundry and shop, the time required by the various departments, the labor cost, and all losses, with proper explanations. The sole authority and responsibility for this work should be vested in the head of the stock-tracing department. It is obvious to the experienced shop manager that such duties cannot be left to the department foremen if the shop is to be run advantageously. The foremen's attention should be concentrated solely upon improving their methods and their output, and their duties should be confined strictly to their own departments.

Experience has demonstrated that it is necessary to give the stock tracer absolute control of all parts in the process of manufacture; in addition, he should be given such authority that the foremen will understand that his requests for stock must be complied with under all circumstances, and he alone should have authority to secure parts from any department in the factory, either for any foreman or for the assembling department.

Having under his charge all the records for stock in the course of manufacture will enable him to locate all stock with certainty and dispatch. Another advantage is that the superintendent always knows where to get any information regarding the location of work in the factory, and the time it may be expected to reach the assembling department.

If the work is allowed to remain in any department after it is finished, it is apt to be forgotten, and is difficult to find when wanted. Therefore, the advantages of having the work placed in central depots as soon as finished by each department will amply compensate for the time consumed in hauling the work to one of the depots, putting it on a platform, checking it up and then taking it to the next department. This plan is especially advantageous where any system of inspection is followed; no stock can be lost; each foreman can see at a glance how much work there is ahead of him; and it aids the superintendent in getting a conception of the conditions of the work. The central depots can be located at any number of points and should contain suitable platforms for the storage of stock. These remarks apply to the smaller parts; it would not be practicable to carry out this plan in the case of large work.

Transfer cards showing delivery of work from one department to another form a ready record which shows the date on which the articles have been received, the length of time they were retained, and the date they were passed on to the next department. A glance over this record shows if the work is pushed through with all the promptness possible. The question of giving certain orders priority over others is one upon which the stock tracer will need to exercise his best judgment. If any work is behind time, the card made out when the order was first sent to the shop may be replaced by a similar card of bright red color containing exactly the same information, and also the required date of delivery. An order with the red card always has precedence over those with cards of the ordinary color. Care must be taken, however, not to use these "rush" cards to such an extent that they become so familiar as to be ignored. One form of transfer card is shown in Fig. 1.

Instead of allowing each foreman to have his own gang of truckers, the trucking force throughout the factory should be centralized and placed under the supervision of the stock tracer. This force of men should deliver work to all departments in the factory as it is called for, and upon their returning to the respective depots they should bring in the work that is on the machine room floors already finished. The fact that this work is finished is indicated by " Move It " cards, which are placed in the boxes by the workmen. These remarks apply to the handling of small parts; in handling large work, cranes are almost universally used.

RECEIVED OF

____________________Foreman.

on Machine__________Lot__________S.O.__________

No. Pieces	Name of Piece	Piece No.	Sent to	Date	Punch Here	
					Insp.	Dept.

Machinery

Fig. 1. Transfer Card

Inspection. — The inspection of work in the machine departments is essential in order to secure economical assembling. This is one of the essential preliminary steps in the revival of a rundown assembling department. Two important advantages to be gained by an efficient inspection department are as follows:

1. Imperfect parts are eliminated before the work reaches the assemblers. If the parts come to the assemblers properly inspected, so that they can be put together without unnecessary filing and fitting, the saving of time in assembling may easily reach from 60 to 75 per cent.

2. The fact that the parts are interchangeable will result not only in ease of assembling, but in case of repairs the parts can be

sent out with the assurance that they will fit properly without adjustment. The last-named feature is important in that it is a good advertisement to any concern.

Any system of inspection must be thorough, and the limits given to the work must be adhered to uncompromisingly. Weakness on the part of the inspector will immediately be noted by the workmen. The inspector's authority to reject work should be unquestioned, and the superintendent should never, unless when absolutely necessary, reverse his decision. An inspector should be placed upon as high a plane as any of the foremen in the factory, and to be successful, he should possess good judgment, firmness of character, and familiarity with the business.

A thorough system of inspection effects large economics in every direction, but principally in the assembling department. The parts can be assembled more quickly and accurately, and the saving in this department alone will pay for the cost of inspection; besides, the machines built will be much more accurate. In many cases it is not necessary to establish an elaborate system.

There is another phase of this question which is important from an economic standpoint; this relates to fair and consistent inspection — *commercial* inspection. Unless an inspector has sufficient intelligence to discriminate between vital and unimportant dimensions, and unless he possesses enough judgment to know when a job is commercially satisfactory, he causes a waste of time and imposes unnecessary hardships upon the men who do the work. Good judgment in inspection is a vital factor, and it is advisable to employ first-class men on this work.

Reports should be made by the inspectors at least once a month, showing the amount of work scrapped by each department, together with the reasons. The effect of this upon the foremen is marked; when they realize that they are liable to censure for the excessive amount of scrap coming from their departments, they will soon give the matter their personal attention. Fig. 2 shows a blank report of this character, while Fig. 3 shows a card or tag which is placed on all defective work by the inspector.

The inspectors' duties on the assembling and erecting floor consist primarily in examining the fit and alignment of the various shafts, gears, slides, guiding surfaces, etc., and to see that every part of the machine functions properly. This necessitates the constant and watchful attention of the inspectors as the work proceeds, so that faulty workmanship is discovered in its early stages. Even the matter of looking after such seemingly unimportant details as the proper tightening of nuts and bolts should receive attention. Steel stamps bearing a distinctive character should be furnished the inspectors for marking all work passed upon by them — these stamps, under no circumstances, to be

INSPECTOR'S REPORT TO CHIEF INSPECTOR
ON DEFECTIVE WORK AND MATERIAL

Supplementary to Report No._____ Date________ 19___

Quantity____________ Inspector____________________

Article______________________________ No.________

Pattern or Forging No._______ Dwg.No. & Part_______ Mat'l______

From_______________________ Rec'd on Req. No.__________

Location__________ Dept. For Ship. on Req. No.__________

Defects, etc.______________________________________

Oper. Done________________ Date Corrected__________ 19___

Fault of________________ Employed in________________ Dept.

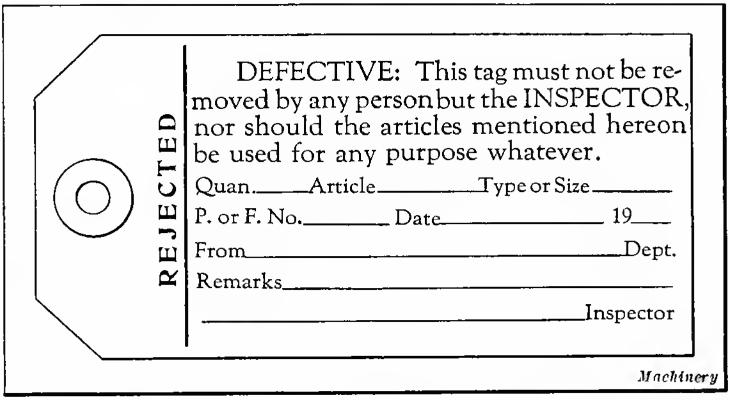
Machinery

Fig. 2. Inspector's Report from which the Monthly Report is made

out of their jurisdiction. This acts as a check upon the inspector, for if any defective work passes his hands and bears his stamp, he is responsible for any future trouble arising therefrom.

In connection with the question of determining just what limits of error are allowable, in modern machine tool practice the tendency is to allow greater limits in running fits than was thought advisable a few years ago. Thus, for all rotating members, except main spindles carrying the work or tools, the general practice is to allow from 0.002 to 0.004 inch for running fits, for diameters of from $\frac{3}{4}$ to 3 inches, according to the requirements of the case; to have a lateral clearance, or endwise motion, of 0.005 inch for shafts, gears, or pulleys, running between bearings, sleeves carrying gears, etc.; and to cut the teeth of all gears thinner than standard, so that two gears when in mesh will have a slightly perceptible amount of backlash.

The advantages of this practice are at once apparent; it not only results in ease and quickness of assembling, but the main feature to be considered is the fact that, when the bed of a machine is under the severe strains of a heavy cut, the distortion likely to occur may cause the rotating members to bind in their bearings, if fitted too closely, and thereby consume an excessive


REJECTED

DEFECTIVE: This tag must not be removed by any person but the INSPECTOR, nor should the articles mentioned hereon be used for any purpose whatever.

Quan.____ Article________ Type or Size______

P. or F. No.______ Date____________ 19___

From____________________________ Dept.

Remarks____________________________

____________________________ Inspector

Machinery

Fig. 3. Card or Tag for Rejected Work or Material

amount of power, besides overheating in the case of high rotative speeds; moreover, so much time will be saved in assembling these parts, that an extra amount of time is allowable for obtaining accuracy in the alignment and fit of vital members, such as main spindles, slides, and guiding surfaces.

Men for Assembling Department. — As a general proposition, first-class, well paid machinists are the cheapest in the end on assembling work. This is especially true where the work varies in character. The amount of work that will be turned out by a highly skilled assembler, when compared to that of a cheap man, is astounding. An important feature to consider is also the fact that the workmen's pay is only one part of the total cost, because a largely increased production per square foot of floor area decreases the proportion of overhead cost per piece.

Where work is duplicated in large quantities, so that there are constant repetitive processes, it is possible to so train the cheaper and less experienced workmen that they in time become expert on their particular class of work. It is advisable to provide for a rigid subdivision of labor; thus, the more particular work at the vise or bench is handled by special men who do no other class of work. These high-priced mechanics perform no work that can be done by cheaper men or apprentices, and, in this way, the average rate is kept normal.

Arrangement and Equipment of an Assembling Room. — A large number of concerns machine a part of the work in the assembling room, even though regular machine departments have been established for the machining operations. This leads to inefficient methods of machining in the assembling room, as the machines can generally be used to better advantage if installed in the proper machine department. The average assembling room is small, and the space taken up by operating machinery is generally needed for assembling work or for storage. In most cases, the reason given for having machine work done in the assembling room is that difficulties arise in getting the parts promptly to the assemblers; if the machines are in the assembling department, delays will be avoided. While this may be true, yet, with an efficient stock-tracing system, there should be no difficulty in obtaining the work from the machine departments in time. Occasions will also arise in the assembling when it is necessary to adjust some of the parts, and it is then advantageous to have machines convenient to the assembler. Upon investigation it will generally be found, however, that much of this work is unnecessary and can be eliminated by the employment of a few simple gages.

In describing the arrangement and equipment of the machine tool assembling department, assume that the operations involved will include the cleaning and chipping; drilling; filling, rubbing down, and painting; assembling the small units; scraping; and erecting. As these operations differ widely, each being performed by a different class of workmen, a proper system requires their segregation. In large shops devoted exclusively to building one article, these operations usually are carried on in separate departments, each under a different foreman. The usual plan where the product is of a varying character is to have a separate assembling department for each class of machines; thus, in the machine tool line, the lathes are erected in one department, the planers in another, etc. The last-mentioned plan is the one that will now be considered.

In some shops the cleaning and chipping is done in the assembling room, although it is more economical to clean the castings in the foundry, owing to the cheaper class of labor employed and the better facilities for this work. However, when this work is done in the assembling department, a suitable space should be provided. As all castings should be cleaned thoroughly before any drilling or assembling operations are started, this work should be located near the receiving depot and convenient to the drilling machines, as nearly all castings require some drilling operation.

The filling, rubbing down, and painting can be done to advantage in the cleaning space; these operations should be completed immediately after the drilling, and before the assembling operations are commenced. In many shops, however, the painters are allowed to fill and rub the finished or partly finished machines, to the annoyance of the assemblers, and with the certainty of getting dirt in the bearings. Of course, some of the painting and touching up with filler must be done on the assembling floor, but, in most cases, it can be confined to one place. If special shop conditions render it advisable to have the drilling machines in the assembling department, they should be located near the place where the work is received.

Assembling. — Even when the assembling and erecting processes are carried on in one department, it is best to provide a separate location for each, because the equipment for each differs widely. For assembling the small units, it is convenient to have long benches on which to place the parts; these benches are provided with vises, in addition to the regular wall benches, and should be arranged convenient to the latter and with aisles between them for trucking the work. These aisles should always be kept clear. When the parts are made in large quantities, fixtures should be provided for holding the parts that cannot be conveniently clamped in the ordinary vises during the assembling process. For holding the heavier pieces, as, for instance, lathe headstocks, trestles or wooden horses are required, which may be made of sufficient length to hold three or four headstocks. The space under the trestles can be utilized for keeping the smaller assembled units until needed.

The practice of allowing the benches to be littered up with small parts and stock supplies, such as screws, pins, keys, etc., is a source of loss and waste. One difficulty is due to the fact that the workman soon forgets what members the stock supplies belong to, with the result that screws are used that are either too long or too short, or not of the right type. This defect may be overcome by providing boxes of uniform dimensions for keeping the small parts. These boxes should be made with a partition at one end for the stock supplies, and with a tin pocket on the side in which to place cards giving the necessary information.

Much time will be saved in the assembling department by having a specific place for such tools as wrenches, pneumatic drills and hammers, clamps, etc. When there is a departmental tool supply room, it is better to keep all tools there. Incidentally, ratchet wrenches with removable sockets fitting different sized nuts, bolts, and screw-drivers are most convenient for assembling work.

All parts to be assembled should be arranged in logical order and placed convenient to the workmen, so that their sole attention can be concentrated upon the assembling operations, thereby making it unnecessary for them to waste time in searching around the shop for parts. Every facility should be provided for the quick handling of the work.

Scraping Operations. — The work of scraping usually does not receive the attention that its importance demands. It is essential that a proper equipment of straightedges, surface plates, test indicators, squares, etc., be provided for testing the truth and alignment. Each individual member should be tested separately, and it is often advisable to have special straightedges or surface plates which can be used both for testing the planing and scraping. Then the planing is easily tested, and if not within the allowable limits, the part can be sent back for replaning before any scraping is done. This is an important feature, since it is far more economical to plane work true than it is to scrape it.

Without the aid of such devices for gaging the work, errors may exist in the machining that may necessitate the use of a file before the scraping operation. These special straightedges or surface plates are, however, not intended to make the parts interchangeable in all respects. It is practicable only to carry out this feature in the planing process and up to a certain point in scraping, after which the pieces are scraped together and numbered accordingly.

In addition to trestles for the heavy parts, scraping trucks are convenient for supporting the movable members during the scraping. These trucks are portable benches mounted on castors, so that they can easily be moved about and turned around to any position that will secure good light on the work. Motor-driven, rotary oilstones should be provided for sharpening the scrapers. Simple and inexpensive pulling devices for moving heavy parts when testing scraped surfaces will greatly facilitate this work and enable the workmen to devote their energy to the actual operation of scraping.

Erecting. — The arrangement of the erecting floor will vary with the character of the work; however, a few general principles may be stated. Where it is the practice to build machines in large lots, the beds are placed in rows with aisles between. Crowding should be avoided; in case there is not sufficient room to arrange all the beds in a lot on the erecting floor at one time, fill the available space without crowding, and store the remaining beds in some convenient place.

Suitable erecting pits are required for such machines as large boring mills and planers, which have driving works reaching below the floor line. The bottom of the pits is usually lined with concrete, with sides of the same material or brick, while cast-iron plates are placed all around the mouth. These pits are generally provided with movable girders or supports, to accommodate various sizes of machines. When a pit is not in use, it is covered with a plank floor made in sections, supported upon the girders set in pockets in the sides of the pits.

Emery-wheel stands, speed lathes, small drill presses, and portable vise stands should be located at convenient points on the erecting floor. Chalk, emery cloth, machine oil, and all special appliances used by the workmen should be handy so as to avoid running to the tool-room. Many shops are now abandoning waste for cleaning purposes and using raw silk towels which can be washed in a machine, and, besides being cheaper in the end than waste, are far more sanitary.

The relative importance of handling facilities, such as electric cranes, hoists, etc., varies according to the character of the work. What may be the most important feature for one class of work may not be essential in another class. In some cases it pays to have specially designed jib cranes with power hoists, so that the workmen need not wait for the overhead crane after the work is once placed within reach of the former.

In the handling of light work, there are several points of importance that must be considered. Whenever possible the stock should be carried in boxes. These boxes should be of some standard sizes. For very small work, it pays to arrange the boxes with removable trays so that the stock can be easily handled and better protected in carrying it through the shop. Erecting trucks with one or more shelves and ordinary two-wheeled trucks are necessary for moving the light pieces. The features mentioned in this brief outline apply to the entire assembling department and are of vast importance, because an astonishingly large proportion of lost time can be attributed to lack of proper facilities and methods for handling work.

As all power-driven machinery should be run or operated when completed, some convenient source of power is necessary. This problem is easily solved in the case of motor-driven machines, but for belt drives, instead of moving each machine under a countershaft, it is more convenient to provide portable electric motors, which can be moved to any machine by the crane. If required, these motors may be back-geared and provided with different-sized pulleys, and in the case of small units the entire outfit can be mounted on a truck. When the machines to be run require the application of power to more than one pulley, a suitable countershaft can be supported above the motor by braces bolted to the truck. Each outfit should be provided with a controller, as variable-speed motors are best adapted to this work.

Departmental Stock-supply and Tool-room. — One of the principal factors in the efficiency of an assembling department is the stock and tool supply room. Added to the loss of time in looking for lost or missing parts, due to haphazard methods of checking up and taking care of the parts as they are received, it is the usual custom in run-down assembling departments not to provide any regular place for keeping the work, but to dump it down anywhere. Frequently the only place provided for the small parts is under or on top of the vise benches.

In equipping a stock and tool supply room, adjustable metal shelves and bins can be used, and for storing many of the small parts carried in the boxes, already referred to, racks can be so arranged that any box can be placed directly into the rack in the same manner as a drawer. This arrangement saves extra handling of the work, and is better than piling boxes one on top of another, as any box is instantly accessible. The shelves and bins in the stock-room are only for keeping the smaller parts, such as can be easily handled by the stock clerk; the larger pieces, not being so apt to get lost or misplaced, can be taken directly to the assemblers without passing through the stock-room, although care should be taken in checking up this material when received.

Sufficient space should be assigned in the tool-room for storing all tools used in the assembling department. Some simple system must be inaugurated for keeping track of the work and avoiding delays in giving it out, for taking proper care of the tools and keeping them in good condition, and for charging up to the workmen the tools in their possession.

Methods of Routing the Work. — In shops without established methods of routing the work, it frequently occurs that work reaches the assembling department without having all the machining operations completed, and if this is not discovered before the parts are put away, time will be lost when the work is finally delivered to the assembler, and, in addition, unnecessary trucking is required. This is likely to happen where there is no system of inspection and the sequence of operations is not mapped out in the beginning on cards or tags, as shown in Fig. 4, which accompany the work in its course through the shop.

The receiving depot in the assembling department should consist of a long bench about the height of the moving trucks, for convenience in placing the small parts; the truckers who bring the work to the assembling department are merely required to put it on this platform, as the stock-room clerk may not always

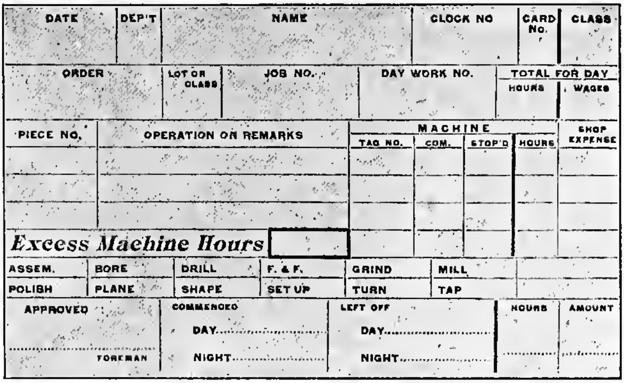

DATE | DEP'T | NAME | CLOCK NO | CARD No. | CLASS
ORDER | LOT OR CLASS | JOB NO. | DAY WORK NO. | TOTAL FOR DAY: HOURS | WAGES
PIECE NO. | OPERATION OR REMARKS | MACHINE: TAG NO. | COM. | STOP'D | HOURS | SHOP EXPENSE
Excess Machine Hours
ASSEM. | BORE | DRILL | F. & F. | GRIND | MILL
POLISH | PLANE | SHAPE | SET UP | TURN | TAP
APPROVED .... FOREMAN | COMMENCED DAY .... NIGHT .... | LEFT OFF DAY .... NIGHT .... | HOURS | AMOUNT

Fig. 4. Card which accompanies the Work until it reaches the Stock Room. The Necessary Operations are numbered consecutively and checked off as completed

be in a position to immediately check up and dispose of the parts. He should, however, give a receipt for all work entering his department, these receipts being returned by the truckers to the respective machine departments to be placed on file as evidence that the work had reached its destination. Cards for this purpose must accompany the work, and the receipt may be given in the form of a distinctive punch mark or with a rubber stamp. This card should be similar to the one shown in Fig. 1.

As soon as possible after the work reaches the assembling department it should be disposed of in a proper manner. All small pieces that require cleaning and painting are sent to the cleaner's bench; those requiring drilling and no cleaning or painting are sent to the drilling machine and piled in a convenient place; all other small parts are placed in the stock-room bins. After being cleaned, the work is sent to the drill presses, and all small work, as soon as drilled, is delivered to the stock-room; thus no work enters the stock-room until ready for the assemblers. Large, heavy pieces are sent directly to the drilling machines and from there to the assembling or erecting floor. A regular place should be provided also for the large parts, as otherwise much unnecessary handling will result. It is advisable to mark or tag these parts, for identification, with their group number in addition to the piece and order numbers.

Delivery of Work for Assembling. — When work is to be delivered to a workman who is nearly ready for his next job, the foreman or the "job-boss" sends a helper to the stock-room with a work card properly filled out. This card contains the date, workman's name and number, group number, piece numbers, names of the parts to be assembled, operations, contract price, and the estimated time for assembling. The stock-room clerk delivers the parts to the helper, who, in turn, delivers them to the workman together with the card just mentioned, any shortages being noted on the card. All small pieces are carried in the boxes mentioned, which remain with the workman until empty, when they are returned to the stock-room.

After each group is assembled, any parts requiring scraping are taken apart and sent to the scraper-hands, while all the remaining pieces are taken directly to the erecting floor and placed convenient to the bed of the machine to which they belong. Thus the erectors are supplied with work as soon as it is assembled. The parts that require scraping are immediately sent to the erectors upon completion of the scraping operations. This, of course, applies to the smaller members; the heavy members and beds of the machines are scraped on the erecting floor to save extra handling. The scraper-hands and erectors are furnished with contract tickets similar to those given to the assemblers.

On some classes of work, such as, for instance, large lathes and planers, it is the practice to duplicate only the parts in quantities, because machines of this character have beds made to order, the lengths varying considerably. In this case, the parts when assembled are sent to a stock-room for finished work, and kept there until a machine is ordered, when they are sent to the erectors to be fitted to the bed. The completed machines having passed final inspection are then placed in the hands of the shipping department. The tag which is placed on each machine on the erecting floor is shown in Fig. 5.

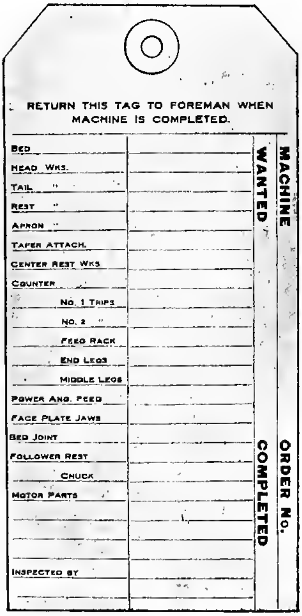
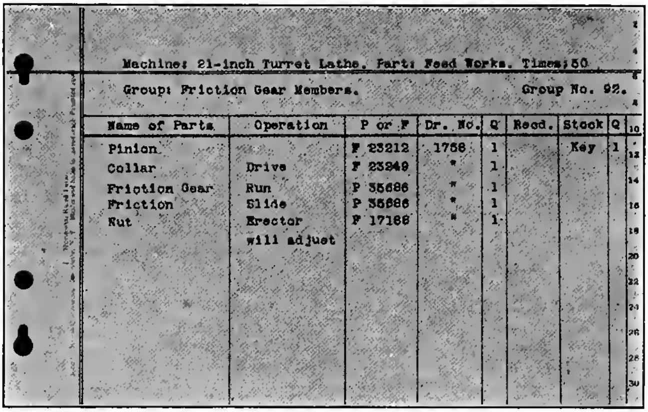


Fig. 5. Tag used in Erecting Engine Lathes

Method of Assigning the Work. — Two fundamental principles of economical assembling must be recognized in the apportioning of the work among the workmen so as to secure a rigid subdivision of labor, and in the avoiding of unnecessary delays in getting work to the men, before they are ready for it. In fact, if nothing more were accomplished in reviving a run-down department than the constant supplying of the workmen with plenty of work and the necessary tools, and having the jobs classified and arranged in logical order, the productive capacity of the department would be considerably increased. Yet, in average cases, the foreman gives these matters little consideration, resulting in work being assigned to high-priced workmen that could as well be performed by cheaper men, and in wasted time while the foreman hurriedly chases around looking up jobs for men who are out of work. In this way, work is often assigned and commenced without regard as to whether or not it is wanted first, and without ascertaining whether all the parts belonging to any particular job have been received and are ready for the assembler.

It now remains to formulate plans whereby the work can be assigned and distributed with the least amount of attention on the part of the foreman. At the outset it will be necessary to group or classify the parts which are to be assembled. The most convenient way to make the classifications is to take the assembly drawings and thoroughly analyze the operations necessary to assemble the machine. The classification of grouping of the parts and assembly operations will be made with reference to the correlated members, *i.e.*, members which can be assembled or



Machine: 21-inch Turret Lathe. Part: Feed Works. Time; 50

Group: Friction Gear Members. Group No. 92.

Name of Parts	Operation	P or F	Dr. No.	Q	Reqd.	Stock	Q
Pinion		F 23212	1758	1		Key	1
Collar	Drive	F 23249	"	1			
Friction Gear	Run	P 35686	"	1			
Friction	Slide	P 35686	"	1			
Nut	Erector	F 17166	"	1			
	will adjust						

Fig. 6. Sample of Specifications for Turret Lathe Part

fitted independently of other parts. In making these classifications, it is advisable to make as large a number of divisions or groups as possible; for instance, a large semi-automatic turret lathe easily would comprise from 150 to 200 groups.

The primary objects in making such a large number of groups are to provide for a rigid subdivision of labor, and to enable the rate setter to arrive at a more accurate determination of the time required to assemble the various parts. The secondary advantages derived from the system are that excessive time spent on any particular operation can be detected at once and the cause located; there is likely to be less discrepancy between the estimated time and actual time; all the small members constituting each group may be kept in a separate bin in the stock-room so that the parts can be delivered to the workman in logical order, thereby avoiding the necessity of sorting over a large number of pieces when giving out the work; the task of assigning the work becomes a comparatively simple matter, as only a small number of parts are in each independent group; and a subdivision of this character facilitates the assembling operations by permitting different jobs to be started as soon as a few parts are received.

In mapping out this work, effective use can be made of a loose-leaf book which enables rapid arranging and indexing of the

21-inch Turret Lathe Driving Works

Name of Group	Wk.Recd.	Wk.Assem.	Assem.by	Index
Inter. Driving Gear Members				I 25
Inter.Driving Gear Stud Members				I 26
Sliding Pinion Clutch Members				I 27
Clutch Yoke Members				I 28
Clutch Handle Members				J 29
Rack Sleeve Pinion Members				J 30
Back Gear Shaft Members				J 31
Back Gear Clutch Members				J 32

Fig. 7. Part of a Group Index Page from which Work is Assigned

groups. The general classification of the data may be seen from Fig. 6, which shows the tabulation for friction gear members. The parts are arranged in logical order the same as they are to be assembled, which is the plan that should be followed in preparing the part lists for all the groups. The column marked "Recd." is to be filled in with lead pencil, so that the same page can be used for any number of machine lots, provided no changes in design are made.

After tabulating all the groups belonging to one machine, they should be arranged in logical order, classified, numbered consecutively, and a list compiled for ready reference. In the specimen page shown in Fig. 7, columns are provided for "Wk. Recd," and "Wk. Assem.," which furnish the foreman with a continual record of the condition of the work, and enable him to ascertain instantly just what groups are ready to be assembled, and when the work is ready for the erectors. This record is kept up-to-date from data secured from the stock-room records and piece-work tickets. As occasion requires, the foreman fills in the column marked "Assem. by," from which his clerk is enabled to make out the proper contract, which should accompany the work when it is delivered to the workman. Another index is required giving the pattern and forging numbers in numerical order together with their group number. This is to facilitate putting the work into the proper stock bins. A copy of this index, together with a list of parts belonging to each group, is needed for the stock-room, but the loose-leaf record book must always be kept in the foreman's office.

Good results can be secured from a simple yet thorough system of reports by the assembling foreman, based upon his actual experience in carrying through his department a newly designed product. These reports should contain criticisms and suggestions either regarding the design or other features affecting production. This will result in establishing comprehensive and business-like coöperation between the designing department and the assembling foreman.

CHAPTER XIII

SYSTEM OF PURCHASING DEPARTMENT

PURCHASING material and supplies is one of the first, if not one of the greatest, functions in the activities of that complex structure called "business." The purchasing of materials, supplies, and equipment includes materials that have to be shaped into products; those that are to be sold again; those that are required to handle manufacturing materials or goods; and all supplies that are needed in connection with the daily requirements of business. This branch of an industrial organization or other business enterprise is considered one of the first great steps in distribution.

The first step in the creation of a successful purchasing department consists in selecting the right man as purchasing agent. He should be a man of strict integrity, and capable of taking care of the administrative work as well as the detail work. It is impossible for the successful purchasing agent to avoid details entirely, since it is of paramount importance that he should keep his hand on the pulse of the entire organization. The purchasing agent should have good judgment, and be able to forecast market movements and price fluctuations. His duties are diversified; his acquaintance among business men should be broad and comprehensive as his field of action may extend over the entire country. The purchasing agent should be a man of personality, and should be able to impress the salesmen who come to him with the fact that he knows his business thoroughly and that he cannot be persuaded to buy except when the proposition is good. There is a surprising difference in the cost of raw materials which are bought by the shrewd purchasing agent, possessing the qualities enumerated, and the cost of the same material which is purchased by a man without these qualifications. In order to secure the right sort of man, it will be necessary to pay him a good salary;

not for the purpose of insuring his honesty, but because his work is valuable and his vocation is such that it requires years of careful training and study.

No one department of any business can be considered without some reference to the other departments, because the complex organization of the modern plant requires coöperation between different departments; therefore, while this chapter deals primarily with the purchasing department, there will be some digression for the purpose of emphasizing the importance of the various elements, which, when properly arranged and coördinated, constitute the system.

Requisition or Supply Order. — Before describing the details of the methods and system of a purchasing department, it may be well to make a few general observations on the practice to be followed, if the department is to render the best service to the organization. The requisition or supply order which is issued by the storekeeper or department head is considered the nucleus around which all the departmental functions are centered. These supply orders should convey complete information, including a correct technical description of the material wanted, as well as shipping instructions in certain cases, with a statement of the quantity on hand, the time it will last, and the earliest date when the material will be required in the plant.

Standards for Materials. — As far as possible, uniform standards should be adopted for all materials and supplies. When this is done, it lessens the work of the purchasing department, and it also enables the better placing of long time contracts and the securing of much lower prices. When manufacturers are furnished with minute specifications, and when the specifications are standard, they can always figure more closely on prices. Where standards are not uniform, or where materials ordered are of special character, the manufacturer will always make a liberal allowance for uncertainties, and this operates, naturally, to the detriment of the purchasing agent.

Importance of Authority for Purchasing Agent. — The importance of giving the purchasing agent a free hand is recognized by the most progressive firms. If the manufacturers and supply men are given to understand that the purchasing agent is the "court of last resort" in all matters affecting purchases, this authority enables him, in many cases, to buy to better advantage. Otherwise, if it becomes known that salesmen can go over the head of the purchasing agent, or if they can go into the office of the purchasing agent, confident that they will receive the order, and with the assurance that it is practically given to them, they will never quote their lowest prices, and the purchasing agent is at their mercy. This operates to the lasting disadvantage of the organization, and the position of purchasing agent becomes a mockery. Therefore, it is necessary that the purchasing department should be recognized as the one department having charge of such matters. This does not mean that the purchasing agent should entirely ignore recommendations made to him from time to time by department heads, or by the engineers in the employ of the organization.

All information regarding specifications and requirements should come through the purchasing department. This should be made a strict rule. Sometimes it is advisable to have department heads make recommendations, and the committee system is sometimes used to great advantage in aiding the purchasing agent in his duties. In the matter of purchases, however, department heads should not be allowed to go beyond recommendations. The following rules regarding purchases, which were taken from the regulations of a prominent railway company, are pertinent:

1. In making contracts and purchases, the purchasing agent will be guided by his best judgment, taking into consideration quality, prices, and the recommendations of responsible heads of departments.

2. Negotiations regarding contracts and purchases and the correspondence relating thereto will be conducted by the general purchasing agent; requests for information about articles, the use of which may be contemplated, will be made through him.

3. Information relating to the quality and performance of materials, supplies, tools, track appliances, etc., will be furnished

to outside parties by the general purchasing agent only, and all requests for information made by such parties, either verbally or in writing, will be referred to him.

Classes of Purchasing Agents. — No universally applicable system has ever been formulated for any branch of business activity, because every organization and every industry has its own individual peculiarities, which must be taken into consideration in developing a system to fit the business; therefore, in the consideration of any business activity, all that is possible is to present the general outlines of a typical system. It is difficult to go even this far in the case of a purchasing department, because the duties of purchasing agents, as a class, have not been clearly defined, and, in some organizations, the authority of the purchasing agent may be much more extensive than in others. Generally speaking, however, purchasing agents can be divided into the two following classes:

1. Those who confine themselves strictly to placing and tracing orders, and have no supervision over the store-room.

2. Those who, in addition to placing and tracing the orders, are in charge of the material after it arrives and are responsible for its distribution in the factory or office.

It is evident that some of the activities of the second class are not concerned strictly with purchasing, but are only incidental. In other words, the determination of what materials are to be purchased and their storage and distribution after receipt are not necessarily purchasing functions. They have been frequently added to the duties of the purchasing agent simply because they are more directly connected with his activities than with those of any other member of the average organization; because they are incidental, however, and not fundamental duties, they will not be considered in detail in this chapter which includes only the systems that will guide the purchasing agent in his relations with his sources of supply — systems that will help him in his essential duties of placing and tracing orders.

Purchasing Department Records. — The accumulation of reliable records is essential for the purchasing department. A substantial proportion of these records can be compiled from the actual transactions which take place in the department itself, but there are other facts which are necessary accessories and which can be obtained from the other departments and also from outside sources.

Subject Index. — The first essential in a purchasing system is an accessible record of every article that may be called for to be purchased. This can be kept on what is usually called a "subject index," similar in form to that shown in Fig. 1. This record should be filed alphabetically with suitable index cards to enable

SUBJECT

NAME OF FIRM	ADDRESS	SEC. NO.	CAT. NO.	PAGE

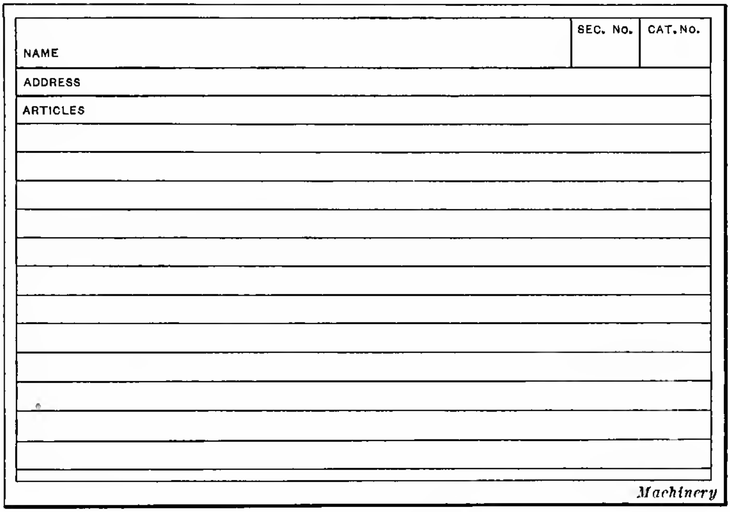
Machinery

Fig. 1. Subject Index Card

the purchasing agent to find quickly any desired subject. Each kind of article and each grade or size should have a permanent stock number, which should appear on all records in connection with the name or other reference to the material.

Index of Firms. — To supplement the subject index, there should be a file that is usually known as a firm index, similar in form to that shown in Fig. 2, which is a typical arrangement. This record should be filed in the same manner as that which comprises the subject index. One is merely a cross reference for the other. It is advisable to have these two records of a different color, as a precaution against their being placed in the wrong filing drawer.

The record of sources from which materials, goods, and supplies can be obtained should be revised constantly and kept up to date. It is not sufficient to keep a list of manufacturers from whom purchases are regularly made. They may be the ones who have been best able to supply requirements in the past and are in the best position to do so at present, but changes are continually taking place and new manufacturers are coming into the market


NAME | SEC. NO. | CAT. NO.

ADDRESS

ARTICLES

Machinery

Fig. 2. Firm Index Card

who are better equipped perhaps than the old ones. If the market seems too restricted for purchases to be made to the best advantage, it is advisable to obtain further information to rectify this. A great deal of valuable information regarding different firms can soon be accumulated which can be collected on cards, if the market is assiduously searched.

Quotations Received. — Some means should be provided for the recording of quotations received. Ordinarily, quotations are made by letter, unless specification blanks are provided to the bidder. It is common to file such quotations in the correspondence file under the name of the bidder, but in order to provide a comparative record of all estimates received for the supply of certain material, it has been found advisable to use a card or form which may be arranged like the one shown in Fig. 3.

Catalogue File. — In addition to the above records, the purchasing agent should be able at all times to locate catalogues received from various firms. For this purpose, a catalogue file should be maintained. A satisfactory method of filing catalogues is to divide them into groups according to size. There are five main sizes of catalogues. Each group should be given the sym-

QUOTATIONS RECEIVED

ARTICLE ______ UNIT OF MEASURE ______ CATALOG NO. ______

QUANTITY	LIST	DIS-COUNT	NET COST	TRANS-PORTATION	TOTAL COST	DELIVERY	TERMS	NAME AND ADDRESS

Machinery

Fig. 3. Quotations Received Record Card

bolical letter A, B, C, D, or E. If a catalogue belonging to any group arrives, it should be given a number; these numbers are consecutive under each group. For example, a 3 by 5 catalogue may be given the number A-36 (the letter indicates its group); a 4 by 6 catalogue might have the same number preceded by the letter B, and so on. The comparatively small catalogues should then be filed in drawers and the larger bound volumes in bookcases.

Material Purchased. — The information that is recorded in the subject index, the firm index, and the quotation file is not all the purchase data that a purchasing agent should have in the form of permanent, accessible records. He should also maintain a record of all previous purchases. A simple form for this purpose is shown in Fig. 4, which can be elaborated on as much as necessary, so long as useful information is being recorded, but duplication should be avoided. In small establishments, the store's perpetual inventory can be used for this purpose, if it is kept in the purchasing office.

It has been stated that the first essential of any purchasing system is to provide for classified purchase information. The four forms that have been described ordinarily give this data in sufficient detail. With such a system in operation, the pur-

RECORD OF MATERIAL PURCHASED

MATERIAL ____________

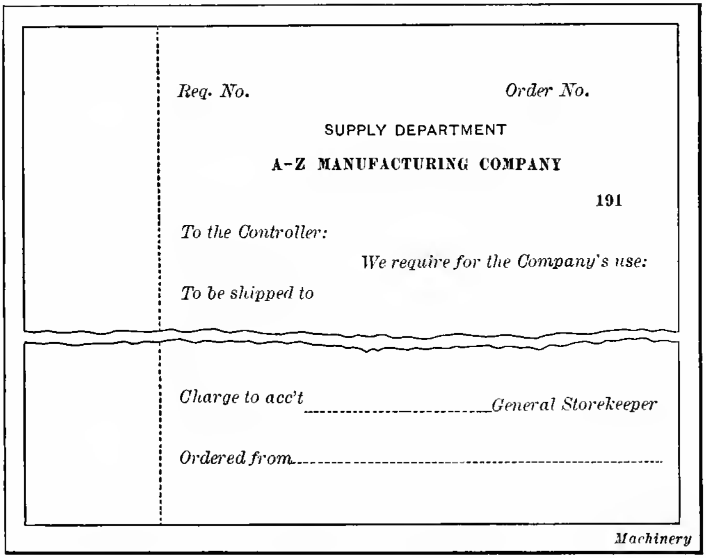
DATE	ORDER NO.	PURCHASED FROM	QUANTITY	PRICE	PER	F.O.B.	VALUE		

Machinery

Fig. 4. Record Card for Material Purchased

chasing agent knows what materials he requires, where they can be bought, the prices at which they are offered, and where, when, for what, and in what quantities they have been purchased in the past.

Placing and Tracing Orders. — A method of placing and tracing orders is another important requirement in a purchasing department. In the elementary system covered in this chapter, the purchasing agent does not have to determine when and what to order. The supply order or requisition originates either in the store-room or in the department, and, as previously stated, this requisition or supply order is the nucleus around which all the departmental functions are centered. Each department or store-room from which orders originate should be furnished with forms in duplicate; the original is forwarded to the purchasing agent; the duplicate is retained for departmental information. A suitable form of requisition or supply order is shown in Fig. 5. Each department or store-room should be given a symbol to be used in identifying its orders, which should be numbered consecutively. This order should have the approval of the head of


Req. No. *Order No.*

SUPPLY DEPARTMENT

A-Z MANUFACTURING COMPANY

191

To the Controller:

We require for the Company's use:

To be shipped to

Charge to acc't ________________________ *General Storekeeper*

Ordered from ____

Machinery

Fig. 5. Supply Order Form

the department desiring the material and, in addition, the superintendent or factory manager should place his approval on it before sending to the purchasing agent.

Quotations and Purchase Orders. — When a requisition or supply order covers material for which there is no agreed price with whoever supplies the material, or when the price agreement expires, new quotations must be obtained. For this purpose a form similar to that shown in Fig. 6 can be used. Reference should be made to the files previously referred to, showing sources of supply, and the inquiries sent to as many firms as are necessary to obtain the lowest prices, best material, and suitable delivery.

A copy of this inquiry with a list of all firms it was sent to should be kept with the requisition until finally disposed of, when a purchase order is issued, which may be similar in form to the one shown in Fig. 7. Purchase order forms vary considerably; in

REQUEST FOR QUOTATION

To...

....

....

Please quote on this sheet in space indicated below for the articles described.

No charge will be allowed for packing or cartage.

This is not an order.

Quotations must be in this office by

....

PURCHASING AGENT

ITEM	QUANTITY	DESCRIPTION	LIST PRICE		DISCOUNT	NET PRICE		

To...

We quote you as above F. O. B..............................*Shipment can be made in*.............*days from receipt of order.*

Terms..............................

Date..............................

Machinery

Fig. 6. Style of Form used when New Quotations must be obtained

fact it would be difficult to find two with exactly the same wording, but there are essential features in all which are intended to convey the same interpretation.

The description of the material on this order should not only be exact, but definite, and free from ambiguity, as any errors in execution resulting from such conditions affect in more ways than one any department whose material or supply the order covers. Some purchase orders are sent out with an attachment for acknowledgment, but this is not to be recommended. It is generally treated in a very perfunctory manner. A very good practice, and one that has given good results where used, is to enclose a post card, similar in form to the card in Fig. 8, because it receives more recognition. This card has a space for writing down a promised date of shipment.

A–Z MANUFACTURING COMPANY

Requisition No. 10000 ________________ 191___

Messrs ______________________________

____

Please ship us via ______________________________

QUANTITY	CATALOGUE NO.	DESCRIPTION OF ARTICLES

SEND INVOICES WITH BILLS OF LADING FOR THE SAME TO

☞ *Mark cases with our Requisition No.* ....

A–Z MANUFACTURING COMPANY

By ______________________

PURCHASING AGENT

Refer to the above REQUISITION Number in all correspondence.

Compared with Invoice dated ________________ *191*____

No charge will be allowed for Boxing, Packing, or Cartage.

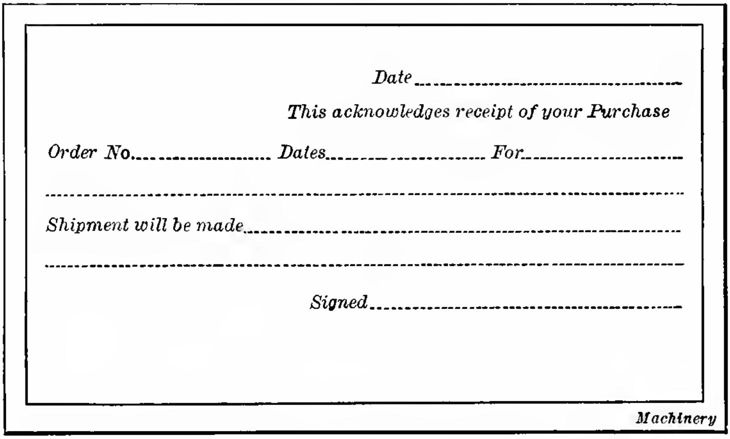
Machinery

Fig. 7. Purchase Order Form

Several copies of the purchase order have to be made. One copy is usually sent to the department which made the requisition and sometimes a copy is sent to the storekeeper and to the accountant, depending upon the methods in vogue. All copies should be distinctive in color, as this facilitates distribution and identifies the different orders. The copy that is kept in the purchasing office is used to trace the order and to check the invoice when the material arrives. For this purpose, the back of the copy should have spaces provided for four classes of information, as follows:

1. Correspondence sent. 2. Correspondence received. 3. Materials received. 4. Invoices received and checked.

Receiving System. — In order to insure against the payment of bills for material which has never been received, or which is not in accordance with specifications, a receiving system should be adopted. Here, again, the nature and size of the business will affect the system to be used. The form shown in Fig. 9, which



Date......................................

This acknowledges receipt of your Purchase

Order No...................... *Dates*...................... *For*......................

....

Shipment will be made..

....

Signed......................................

Machinery

Fig. 8. Acknowledgment Post Card sent out with Purchase Order Form

can be made in as many copies as desired, according to the organization of the business, is comprehensive enough to fit almost any condition. As soon as the receiving clerk receives a shipment of material he goes to his file of notices to ascertain where the material belongs. He then fills in this receiving report. The original copy is immediately sent to the general accounting department, where it is attached to the invoices which, in most cases, have been received; if not, the report is held until the invoices do come in. This notifies the accounting department that the material is no longer in transit. If a bill should remain in the office for an unreasonable length of time before a report showing the receipt of the material is turned over to the accounting department, investigation is immediately made and a request to trace sent to the shipper, if necessary.

The duplicate copy goes with the material to the inspection department, from there to the store-room, and from there to the stock clerk, where its receipt is recorded on the stock records. It finally goes to the accounting department as notification that the

Form 406

A–Z MANUFACTURING COMPANY

Goods received by Stores Department

*From*____________________

______BAGS ______BUNDLES ______REELS

______BARRELS ______COILS ______

______BOXES ______CRATES

WEIGHT______ CAR NO.______ WAY BILL______

191 A

Order No.

*Via*____________________

*Charges*____________________

QUANTITY	DESCRIPTION	HOW USED		
		LOT NO.	WORK ORDER	ACCOUNT NO.

IMPORTANT
Full details of all Shipments received must be given above, and this form sent to Audit Dept. within 24 hours after receipt of goods.

*Received by*____________________

*Correct*____________________
STOREKEEPER

Machinery

Fig. 9. Form to be Filled in by Receiving Clerk when Shipments are received

material is in accordance with specifications. This form is also attached to the original invoice. The triplicate copy goes to the purchasing department, where record is made on the back of the copy of the original order. It is sent from there to the accounting department as notification of the purchasing department's approval. The last copy is retained in the receiving department as record of material received. There it serves as a basis for the furnishing of statistical reports to the officials of the company.

This system of receiving does away with the ordering of material for personal use and obviates the necessity of the bookkeeper having to go through the plant to find out whether material billed has actually been received and if it is satisfactory.

The approval of invoices from shippers should not be one of the functions of the purchasing department. It adds a burden to that department which can better be placed elsewhere, and it has numerous other disadvantages. Inasmuch as the purchasing department has already sent to the invoice desk a copy of its order on the shipper stating the price as well as the terms, the comparison should be made by the invoice clerk.

The details of a purchasing system may differ greatly in individual cases, but most of the features that have been described are in general use. Whatever may be the changes in detail, due to the requirements of the individual business, the general nature of the buying data to be recorded remains approximately the same in all instances; and there are few industries in which the demand for a suitable method of systematizing the purchasing cannot be met by some application of the fundamental principles that are the basis of this chapter. On the whole, the purchasing field may be said to be one that requires the exercise of good common sense and business acumen, the faithful performance of duties, and the installation of a thorough but simple system for departmental organization, capable of being developed and enlarged as the business increases.

Ordering Small Tools and Supplies. — Practically every manufacturing plant has a different method of handling requisitions for tools and supplies for the various departments. In many factories there is too much "red tape" in the ordering of small tools and supplies generally. In fact, there is more red tape in the ordering of the less expensive materials and tools than in the case of the more expensive machines. The reason for this is probably that in a large factory small tools and supplies are ordered by a great number of individuals holding subordinate positions in the organization, while the orders for the larger and more expensive equipment generally come from men of greater responsibility. It is, therefore, assumed that a more careful supervision is necessary over the orders for minor tools and supplies than in the case of the orders for larger machines.

Few machine-building plants have in the tool-room an adequate supply of tools for the needs of their shop force, but depend to a large extent upon the fact that many skilled mechanics have many tools of their own. New men added to the force are, therefore, often handicapped by the lack of suitable tools for the work they are expected to do. The small tools, however, should be considered just as vital a part of a modern shop equipment as any of the machine tools.

The difficulty which arises in the ordering of small tools and supplies is to formulate a system by means of which it can easily be determined what should and what should not be ordered. If every requisition is too closely questioned and the system is too rigid, a foreman will hesitate about asking for necessary tools and supplies, because he feels that his judgment is questioned; hence, many necessary supplies may be neglected. On the other hand, if every request coming from the foreman was passed without comment, abuse of the privilege would in many cases become a source of unnecessary expense.

The best way to take care of this matter is to let all the requisitions pass through the hands of a properly trained man capable of exercising judgment in the matter of standard supplies and small tools, and who should keep records which would indicate whether the consumption at any one time exceeded the regular consumption of similar supplies, in which case he would investigate the matter and take steps to correct the trouble. When requests are made for articles which are not regularly purchased, then the facts relating to the matter should be ascertained by the person in charge of the purchasing, and he should place these before the chief executive for his decision. In this way, the executive can be relieved of the routine of approving a needless number of regular orders, and yet feel that when any department calls for something that is not part of the regular equipment he will have an opportunity to decide whether or not the expense is warranted.

Purchase of New Machines. — One of the most difficult problems with which the shop manager must grapple is that of determining when to replace old types of machinery with new. Judging from statements sometimes seen in the daily and semi-technical press, one would think that engineers in general consider it economical to throw out an old machine and install a new one if it can merely be shown that the new machine will perform a certain operation at less cost than the old one. This, however, is not the only consideration. If the old machine is still in good condition and can be used for several years without any additional capital outlay, then it might prove advantageous to retain it, even though the cost per piece were slightly higher than on the new machine.

If the same operation is performed throughout the greater part of the year, and if it is possible to determine the exact reduction in cost of output by the new machine in comparison with the old one, the problem will be one of simple arithmetic, as the only factors to be taken into consideration will be the number of pieces to be made per year and the additional interest charges on the capital invested in the new machine. In most cases, however, the problem is not so simple. The machine is not used for making the same parts throughout the year, but is changed from one class of work to another. For some work the new machine may not be more economical than the old one — for other work, the economy may be very marked. Exact comparisons are then impracticable, and keen judgment, rather than calculation, is required on the part of the shop manager. Should he decide to install the new machine and sell the old one for junk, merely because some particular piece for which the new machine is especially well adapted can be made with marked economy, he may make a mistake and incur considerable loss.

On the other hand, it is likely that a greater number of people err on the side of keeping old, worn-out machinery when a new equipment would reduce their costs considerably. Especially is this true of long-established firms whose reputation and well-cultivated markets make them feel the keenness of competition less severely. It is a well-known fact that the most modern machinery is often found in the smaller, comparatively inconspicuous shops. The retention of old machinery long after its term of usefulness has expired is probably a greater mistake than that of scrapping tools and devices prematurely. The question of when to install new machinery and scrap the old equipment is, therefore, one that calls for better judgment of the requirements of shop practice than almost any other the shop manager has to consider. In order to decide it successfully, a comparative study of the capacities of new and old machines extending over long periods of time is often necessary. In that way only is it possible to decide with reasonable accuracy whether it be more economical to retain old equipment or to install new.

Balancing Production with Sales. — One of the dangers in a factory manufacturing a large variety of products is the possibility of accumulating too much stock, thus tying up working capital. In a plant where nearly a hundred different machines are made and carried in stock, an examination of the balance sheet for the previous year indicated that there was considerable danger of overstocking. The first step in analyzing conditions was to obtain an estimate of sales. The sales manager was called into a conference and asked to give a fairly optimistic estimate of the probable sale of each kind of machine for the ensuing year. Statistics had been gathered, showing the sales of each kind of machine over a period of ten years, and graphic charts had been made to emphasize the tendencies in sales. This information, which the sales manager should always have had at hand, proved of the greatest assistance in checking up his estimates.

The sales manager considered each machine and gave an estimate of the probable sales for the ensuing year; and this figure was then analyzed from the statistics. In a number of cases it was shown that the sales manager's estimate was too large and that he was not aware of the dropping off in sales. In other cases the sales had increased and he increased his estimate after reviewing the sales statistics. The next step was to call for an inventory of finished stock, machines in process, and parts on hand. The estimating department was then asked to compute the labor cost to complete the machines in process. These estimates served to show roughly the amount of labor required to complete the machines in process. A comparison of the year's requirement for sales, the finished stock on hand and machines in process brought out the fact that, by the addition of labor to work in process to a value equal to four weeks' payroll, there would be enough machines to fill the estimated sales for the next nine months.

Analysis also brought out the fact that the finished stock on hand of one or two types was sufficient to last several years. Only in one or two cases, where the machines were small and inexpensive, was it found that the stock was too low, but these machines could be produced so quickly and at such a small labor cost that they did not serve to compensate for even a small part of the other stock. In order to prevent a similar occurrence in the future, a clerk in the sales department was assigned the duty of graphically recording the sales of each kind of machine on a separate sheet. Another " graph " curve on each sheet shows the number of machines in process, while a third shows the machines in process, plus the machines in stock, minus the machines on order. A quick review of these sheets now informs the sales manager at all times as to the sale of each kind of machine. It would be impossible now to surprise him by the statement that one machine is not selling well or that another machine is coming into demand. He can see the tendency and forecast the probable sale of each kind of machine. Where the tendency appears to be downward and in his judgment it should be upward, he is quickly informed and can take the matter up with his salesmen. Other records have been devised to supplement this particular one and the whole plan is used by the planning department to balance production and keep the investment in raw materials, work in process, and finished machines at the lowest point consistent with the prompt delivery and service that the sales policy demands

Efficient Buying Methods. — The real salesman is the man who discovers live prospects and sells goods. The real buyer is not the man who merely places orders, but the one who discovers live prospects among those concerns who are able to sell him what he wants and at the right price. The educational efforts made to improve the conditions of buying have not yet reached the stage or been given sufficient prominence to correct many of the evils that still exist, but much is being accomplished. Selling has been governed too largely, perhaps, by the natural ambition of every salesman to increase his sales and of every manufacturer to see his business grow, with insufficient consideration of the economic aspects of the situation. The present disproportion between the buying and selling expenses of a concern should be brought into the proper relation to each other, not that the expenses of buying will be materially increased, but the application of better methods should make an appreciable difference in selling expenses.

First it is absolutely essential to know where to buy to the best advantage; promiscuous requests to manufacturers for quotations will work to the disadvantage of the purchaser. It is important that every buyer should collect accurate information regarding the available sources from which he can make his purchases, and it is not sufficient for this to be just a list of manufacturers or firms dealing in the particular commodities he may be called upon to buy. By a process of selection and elimination he can make this list accurate, complete, and confined to those concerns which are in the best position to supply his requirements, and he can then practically concentrate his entire efforts upon them. This method cannot fail to secure for the buyer the most efficient results, and the business will go to the seller with the minimum amount of wasted effort on the part of competing concerns.

In compiling and tabulating information regarding sources of supply, there are several factors to be taken into consideration. Not only must the firms to whom the business is given, and with whom negotiations are conducted, be able to make the goods, but they should also be geographically located so that an unfailing supply is assured. Freight embargoes have demonstrated to many concerns the wisdom of distributing their purchases in such a manner as not to be dependent upon one manufacturer or one transportation line. Scientific buying precludes the possibility of failure to obtain delivery of goods at the time required and where required. The serious losses that might ensue if proper precautions were not observed are obvious, and provision must be made for keeping records of the character, reliability and financial responsibility of the concerns dealt with.

Another source of unnecessary expense to manufacturers and wholesale houses caused entirely by inefficient buying methods arises in those cases where requests for quotations are worded in such an ambiguous manner that there is some perplexity on the part of the bidders as to what is actually required. Sometimes a size is incorrectly given or the careless specification can be interpreted to cover two entirely distinct articles. This involves requests for additional information by telephone or letter, or sometimes salesmen are sent to make inquiries for the purpose of clearing up uncertain points. This also happens with orders when issued, and it is a fault which is entirely too common.

Any betterment of these conditions would tend to reduce the selling expense and consequently lower the selling price. Thus the buyer would be likely to derive a material benefit, but such a benefit could only be brought about by scientific methods. Scientific salesmanship cannot cope with certain phases of unscientific buying. The remedy lies with the buyer, and the economic advantages will not only be secured for his own concern but for all those with whom he does business. If one considers the wide ramifications of business, and the successive buying and selling from the raw material to the finished product, it will be realized that this question of right buying has a broad significance and that its influence on business is universal.

CHAPTER XIV

WAGE SYSTEMS

THE wage system of an industrial organization may have a decided effect upon its general efficiency or the unit cost of production. Before the introduction of scientific management, practically all attempts to decrease the cost of production were based on some system of payment. Extra financial rewards have been offered in different ways as an incentive for increasing the amount of work done. When attempts have been made, however, to obtain the higher rate of production without the payment of a suitable reward, except during a short "speeding-up" period, the resulting labor trouble has demonstrated in many cases that the system is poor. A wage system cannot properly be classified as good unless it is fair both to employer and employe, and this principle has been generally recognized in the development of modern wage systems. The two fundamental methods of paying for labor are (1) to pay the workman according to the amount of time expended or (2) to pay him according to the amount of work that is done. All wage systems are either based directly upon the time or amount of production, or they are combinations of these two methods of payment. There are five well-known methods of payment which may be defined as follows: 1. The day-wage system. 2. The piece-work system. 3. The premium system. 4. The differential system. 5. The bonus system.

Day-wage System. — The day-wage or day-rate system is simpler than any of the others mentioned and is also very common. With this system, the workman is simply paid at a certain rate per hour or per day. In other words, payment is made entirely upon the amount of time expended on the work, but the amount of work done bears no direct relation to the financial reward, although it is assumed that a fair amount of work will be done. Ordinarily, the pay is based on an hourly rate, which varies according to the class of labor, with more or less additional variation in different localities. If every employe worked diligently and if it were possible to base the rate of pay upon the actual productive value of each man's services, the day-wage system would be fair to both the employe and employer. The principal objection to this system, however, is that there is no incentive for the employe to make any special effort to increase production. On the contrary, many workmen try to accomplish as little as possible, which not only decreases the efficiency of a plant, but causes dissatisfaction among other men of the same class receiving an equal rate of pay and making an honest attempt to give a fair day's work in return for it. While the day-wage system is in very general use at the present time, it has been replaced in many industrial organizations by other systems of payment to be described.

Piece-work System. — The piece-work system is based upon the plan of paying a workman who is producing or operating on duplicate parts a certain amount for each piece of work that is completed. The object, of course, is to pay each man for what he actually accomplishes, the fast workman earning more than one who produces less, either because he is naturally slower or less inclined to exert himself. One not familiar with the actual working of this system might consider it fair and just both to the employe and employer. It has been the cause, however, of many labor troubles and frequently has proved inadequate as a means of increasing the efficiency of workmen or of justly rewarding them for their services. One of the fundamental difficulties with the piece-work system, as ordinarily installed, is in determining how much should be paid for a given operation, or the price per piece. The usual method of determining the piece-work rate involves more or less guesswork, especially in the production of new parts. Frequently the rate is entirely too high at first, in which case the usual result has been that the workman made an exceptionally high wage until the rate was reduced. On the contrary, a rate that is too low makes it impossible for the employe to obtain a fair daily wage until an adjustment is made and this change may be delayed unnecessarily. If the rate enables the workman to earn much more than he could under the day-wage system, he may be allowed to do this temporarily or until the management has definitely determined just how much it is possible for the workman to produce; the rate per piece is then reduced and, in many cases, the final result is that the workman receives about as much as he did formerly, but produces a great deal more; consequently, this system of payment is not regarded favorably by most workmen and its theoretical advantages as a means of decreasing production cost are modified in practice because many employes, instead of attempting to earn as much as possible, aim to produce just enough to earn a moderate wage in order to avoid a reduction of the piece rate. For instance, if a piece rate, which has been established largely by guesswork, enables an employe to earn seven dollars per day by working as fast as possible, he may consider it wise to so regulate the production that the daily wage is four dollars or whatever amount is considered low enough to prevent a reduction of the piece rate. The ordinary piece-rate system is opposed to modern or scientific methods of management because it is not based on definite knowledge as to what constitutes a fair amount of work. The cost of inspection is also relatively high with the piece-work system, as a general rule, because there is a tendency to slight the work, although trouble from this source may not be very serious when each man is held strictly accountable for rejected parts.

Premium System. — The Towne-Halsey premium system was developed to overcome the inherent defects of the piece-rate system. It is based on the principle that a fixed daily wage should be guaranteed and that extra payment should be given whenever a job is finished in less than the alotted or standard time, the amount of extra pay depending upon the amount of time saved. The plan is to record the quickest time in which the work has been done and use it as a standard. If the workman succeeds in finishing the operation in less than the standard time he receives, in addition to a regularly hourly rate, a premium, which may vary from one-quarter to one-half the difference between the wages actually earned and what would have been earned if the full time had been utilized. In order to illustrate the practical working of this system, suppose an employe receives thirty-five cents an hour, so that his minimum guaranteed wage for an eight-hour day is two dollars and eighty cents, and that a premium equal to 40 per cent of the difference between the actual working time and the standard time is given. If the standard time for a given job is six hours and the work is finished in five hours, the employe receives the regular hourly rate of thirty-five cents for five hours, or one dollar and seventy-five cents, and, in addition, 40 per cent of the difference between the pay for six hours' work and the pay for the actual working time. The difference in this case is thirty-five cents ($2.10 - 1.75 = \$0.35$) and 40 per cent of thirty-five equals fourteen cents, which represents the premium. Therefore, the total wage for five hours equals $1.75 + 0.14 = \$1.89$, and during the three remaining hours of the day the employe will earn, in addition, at least $1.05, and more than this, if he continues to do the work in less than the standard time.

One fundamental defect of this or any other wage system requiring a standard time for a task, when applied in conjunction with an ordinary system of management, is in determining with accuracy just what the standard time should be. In one case, the time may be based on favorable conditions or upon the performance of a fast workman, whereas another standard time for a task may be determined under less favorable conditions, unless time studies are resorted to and the standard time is based on a careful analysis of the conditions. The premium plan, however, is simple and easily introduced and it has proved successful in a great many shops and factories.

Rowan Modification of Premium Plan. — With the premium system previously described, it is to the advantage of the workman to have the standard time as large as possible, because the greater the difference between the standard time and the actual working time, the larger the premium; therefore, the tendency of the workmen, when new work is being started, is to make the standard time larger than is necessary. One method of meeting this difficulty is to make the premium a percentage of the amount received for the actual working time at the regular day rate. This percentage, according to the Rowan plan, is equivalent to the percentage of standard time that is saved.

If A equals the amount received for the actual working time at the regular day rate; B equals the standard time in which the work should be completed; and C equals the amount of time saved, the premium may be computed as follows: Premium = $A \times \frac{C}{B}$. For example, if the standard time is eight hours and the actual working time, six hours at thirty cents an hour, the premium equals $180 \times \frac{2}{8} = 45$ cents, and the total amount received in this case equals $180 + 45 = \$2.25$.

With this system, the premium is decreased as the amount of time saved increases, and if it were possible to save 90 per cent of the standard time, the premium would be the same as when the saving was only equal to 10 per cent of the standard time. The workman, however, receives a more liberal premium for a moderate change in time than he does with the Towne-Halsey premium system. The Rowan plan has been objected to on the ground that it discourages honest efforts on the part of workmen to obtain maximum production, but, on the other hand, there is less tendency on the part of the employer to reduce the basic rate. This system has been applied quite extensively in England.

Bonus System. — The straight bonus system differs from the previous system in that the workman receives, in addition to a daily wage, a fixed amount or bonus whenever a piece of work is finished within or less than the predetermined time. Assume that the bonus is equal to one-third the amount that would be earned in the time set for a given job; then, if the work is supposed to require nine hours and it is done in eight hours, a bonus equal to three hours' pay would be given in addition to the regular rate of pay for the actual working time. For instance, if in this case the hourly rate were thirty cents, the total amount received for the job would equal $2.40 + 0.90 = \$3.30$. If the work had been done in seven hours, the total amount received would equal $2.10 + 0.90 = \$3.00$. The time saved by doing the work more quickly is, of course, expended on the next successive job. In case the time set for the job is exceeded, the wage is then based on the regular hourly rate.

Gantt Task and Bonus System. — The task and bonus system, introduced by H. L. Gantt, differs from the "straight bonus system" previously referred to, in that the workman is paid the full time allowed for the task and, in addition, a bonus equivalent to one-third of the full task time, when work is finished within the task time. For instance, if the task time is three hours; the regular fixed rate, thirty cents per hour, and the work is done in two hours, the workman would receive pay for the full time, or ninety cents plus a bonus of thirty cents. Thus, in effect, the hourly rate was increased from thirty to forty-five cents by doing the work in less than the task time, in addition to the bonus received. With the straight bonus system, he would receive thirty cents an hour for the two hours of actual working time (instead of pay for the entire task time), and, in addition, a bonus. If the bonus were one-third of the task time as before, the total amount received would equal $60 + 30 = 90$ cents, as compared with \$1.20 under the Gantt system. If the work is not done within the task time under the latter system, the regular hourly or daily rate is received.

The Gantt system has been extensively applied, especially in shops operating according to the Taylor system of scientific management. It should properly be utilized in conjunction with such a system of management, so that the task time can be based on a careful study of the conditions. When this plan is followed, what seems to be the best methods of performing each element or detail of various operations are carefully determined and then the minimum time that should be allowed for each detail is recorded. The results of these numerous analytical observations are recorded for all kinds of work, so that it is possible to correctly estimate the time that should be allowed for other jobs involving the same general elements or details. In conjunction with this work, it is necessary to have all the machines and appliances in the proper order, and arrangements should be made for supplying the necessary tools and materials. Specific instructions are also necessary so that the workman will know just how to proceed in order to perform a given operation in the precise manner upon which the standard or task time is based.

Almost every operation may be performed in several different ways, but obviously these methods are not equally efficient; in fact, some of them are so obviously inefficient that they would not be considered, but it is often a difficult problem to determine the best method and it is only by a scientific investigation of all the controlling elements that even an approximate solution may be obtained.

Differential Wage System. — The differential wage system introduced by F. W. Taylor depends upon accurate knowledge as to the length of time required to do the work as determined by the methods connected with scientific management, and it is intended to reward liberally the efficient workmen and to penalize the inefficient who produce less than the required standard, by giving them a relatively low rate of pay. The important feature of the original plan is that there are two piece rates, one being high and the other low. The higher rate applies when the work is completed within the prescribed time as determined by careful observation and study, and the lower rate, when this standard time is exceeded. In order to illustrate this system by a practical example, suppose a careful investigation has shown that ten pieces per day represents a maximum number. Then, under the differential system, if a workman finishes ten pieces per day and all of these pieces pass inspection, he receives, say, 35 cents per piece. On the other hand, if the work is done too slowly and only eight pieces are finished, then, instead of receiving 35 cents per piece, the rate might be reduced to say 30 cents per piece. If ten pieces are finished but some of them are imperfect and will not pass inspection, the low rate of 30 cents may be still further reduced, the amount of reduction depending upon the circumstances.

As the preceding example shows, whenever a workman is producing the maximum amount, either for a day or a shorter period, he receives the higher wage rate, but when there is a reduction, either in quantity or quality, the pay is also reduced and becomes less than the ordinary rate of pay.

One important principle upon which this system is based is that men will not do an extraordinary amount of work for an ordinary amount of pay. In Mr. Taylor's paper, "A Piece-rate System," the two following facts were given as the basis for harmonious coöperation between employer and employe: First, that the workmen in nearly every trade can and will increase their present output per day providing they are assured of a permanent and larger return for their time than they have received before; second, that the employers can afford to pay higher wages per piece, even permanently, providing each man and machine in the plant turns out a proportionately larger amount of work. The second statement is based upon the generally recognized fact that in most lines of manufacture the indirect expenses equal or exceed the wages paid directly to the workmen, and that these expenses remain approximately constant whether the output of the establishment is large or small. From this it follows that it is always cheaper to pay higher wages to workmen when the output is proportionately increased, the diminution in the indirect portion of the cost per piece being greater than the increase in wages.

Many manufacturers in considering the cost of production fail to realize the effect that the volume of output has on the cost, because they lose sight of the fact that taxes, insurance, depreciation, rent, interest, office expenses, sales expenses, and frequently the cost of power remain about the same whether the output is large or small. In the paper previously referred to, it was pointed out that where large and expensive machines are used and a large output is dependent upon severe manual labor as well as upon the skill of the workmen (while the chief cost of production lies in the expense of running the machines rather than in the wages paid), it has been found of great advantage to establish two or three differential rates offering a higher and higher price per piece or per unit of production as the maximum possible output is approached. The differential piece-rate system was not intended to be applied until thorough time studies have been made of all the elements of the work and the other accompanying conditions have been perfected and completely standardized. The differential system requires a high standard of management, and it is considered particularly useful where the same kind of work is completed day after day and the maximum possible output is desired.

The differential system and task and bonus system both give the workman a large extra reward when he accomplishes his full task within the given time. With the differential rate, if, for any reason, the workman fails to do his full task, he not only loses the extra large premium which is paid for complete success, but, in addition, the direct loss of the piece price for each piece by which he falls short. Failure under the task and bonus system involves a corresponding loss of extra premium or bonus, but the workman receives his ordinary day's pay. In principle, the two systems appear to be almost identical, but the slightly milder nature of the task and bonus system is sufficient to make it much more flexible, and, therefore, applicable to a large number of cases to which the differential system could not be applied.

Emerson Wage System. — The plan of the Emerson system of payment is to reward workmen who are reasonably efficient and to increase the reward or bonus as the efficiency of the workman increases. Each workman is assured of a fixed daily wage and has an opportunity of earning, in addition, a bonus depending upon the relation of the actual production to a certain fixed standard. The standard performance is first established by making a careful study of all the controlling factors the same as with the Taylor and Gantt systems. The workman receives a bonus equivalent to 20 per cent of the daily wage for work done in the standard time, as his efficiency would then be 100 per cent. If the standard time were eighteen hours and the job were completed in twenty hours, the workman's efficiency, as compared with the standard time, would be 90 per cent and he would receive a bonus of 10 per cent; if his efficiency were 80 per cent, the bonus would be reduced to $3\frac{1}{4}$ per cent, and, if the efficiency were less than 67 per cent, there would be no bonus at all. In case the work were done in less than the standard time, so that the efficiency were over 100 per cent, the bonus would increase until it was equivalent to 60 per cent of the wages for an efficiency of 140 per cent. In the practical application of this system, the bonus is calculated with reference to the work for some period such as a week or a month, and not for individual jobs. For instance, if the standard time on all the different jobs handled by one man in a month amounted to 200 hours, and the actual working time had been 220 hours, the efficiency of that particular workman would equal $\frac{200}{220}$ = 90 per cent, approximately; therefore, the bonus in this case would be about 10 per cent. If the hourly rate were thirty-five cents, the regular daily wage would equal $220 \times 0.35 = \$77.00$ and as the bonus is 10 per cent of the wages, the total amount would equal $77 + 7.70 = \$84.70$.

This progressive method of rewarding efficiency is intended to hold the interest of the workmen even when conditions for any one job are not favorable, and it is apparent that the work cannot be done within the standard time. The standards are established after careful and reliable investigations have been made, including time and motion studies. It may be necessary, of course, to change the time standards to suit new conditions or equipment, and the rate of pay may also be varied, but the time standards should not be changed to affect wages as they are based strictly upon analytical observations of the different factors affecting production.

A modification of the Emerson system advocated by C. E. Knoeppel differs from the former in the amount of bonus paid at the beginning and also when an efficiency of 100 per cent has been obtained. The workmen who are over 67 per cent efficient receive a larger bonus than with the Emerson system, especially during the earlier stages from 67 to 85 per cent, and when an efficiency of 100 per cent is exceeded, there is an additional bonus of 5 per cent added to the 20 per cent received under the Emerson system. This 5-per-cent premium is an extra incentive for increasing production beyond the 100 per cent mark. With either of these systems, the cost per piece decreases slightly instead of remaining constant as with the straight piece-work plan.

Contract System. — The contract system which has been applied in quite a number of the larger industries, such as locomotive works, shipyards, etc., both in the United States and abroad, differs from the other systems referred to in that the employer does not deal directly with the workmen, but with contracting foremen. The foreman agrees to do the work for a certain sum or at a certain rate per piece in the case of duplicate manufacturing operations. All materials and tools are provided by the employer, but the hiring of men and the system of paying them is controlled entirely by the contracting foreman. Apparently, with this system, labor difficulties are shifted from the employer to the contractor and a definite manufacturing cost is obtained. This system, however, is liable to cause unsatisfactory labor conditions unless the contracting foremen are disposed to deal fairly with the men under them. The chief difficulty has been that the men ordinarily do not receive uniform treatment because they work under different foremen, and, in some cases, different wage systems are in use in the same plant. As a rule, the tools are also used more severely and carelessly under the contract system than in a shop where the employer is in more direct control. A coöperative plan whereby profits over a certain amount are divided with the workmen has proved successful in connection with the contracting system.

Profit-sharing Methods. — The history of profit-sharing has, on the whole, been disappointing. Companies engaged in profit-sharing have been no more free from labor troubles than companies not so engaged. Many firms have given up the idea after a lengthy experience with it. There are some cases in which profit-sharing has been a conspicuous success, but they are few in number. The simplest method of apportioning profits, and one which has often been used, is to pay each employe sharing in the profits the same per cent of his year's wages as is paid to the stockholder in the form of a dividend. Thus, if a six-per-cent dividend is declared on the stock of the concern, every employe participating in the profits receives at the end of the year an amount equal to six per cent of his wages for that year. The division of profits is not necessarily deferred until the end of the year, but may be made quarterly or semi-annually.

A second method of profit-sharing divides the net profits of the business into two equal portions, one going to the stockholders and the other to the employes. The half apportioned to the employes is usually divided in proportion to their earnings. Suppose that a firm having a capital stock of $500,000 has a wage roll of $1,000,000, and that the net profits for the year are $100,000. $50,000 of this is apportioned to capital, and the stockholders receive a dividend of 10 per cent. The other $50,000 is apportioned to labor, the employes receiving a dividend of 5 per cent of their wages.

A third method of profit-sharing is quite different from either of these. It is assumed, first, that labor is entitled to the current wage, and second, that capital is entitled to the current interest rate. After labor has received its wages and capital its interest, a surplus may remain. This surplus is then apportioned between the stockholders and the employes in proportion to their earning power. Thus if the current interest rate is 5 per cent, a man who receives wages amounting to $1000 per year has the same earning power as $20,000 worth of stock. (Strictly speaking, this is not true, if it is considered that a man, like a machine, has a limited life and is, therefore, subject to depreciation. Allowance for depreciation reduces the value of a man's earning power by almost one-third. The introduction of this element of depreciation complicates the matter so greatly, however, that it gives the method an appearance of unfairness in the eyes of the average employe, and is best avoided.) The following case will illustrate the application of this method of profit-sharing. Assume that the wage roll for the year is $1,000,000, that the capital stock is $2,000,000, and that the total profits of the business are $320,000. Labor has already received the current wage. Assuming an interest rate of 5 per cent, the $2,000,000 of capital stock is entitled to $100,000 in interest. The earning power of the employes, *i.e.*, their annual wages capitalized at 5 per cent, is $20,000,000. Adding the earning power of the employes to the amount of the capital stock gives $22,000,000, upon which a dividend of $220,000 will be declared. This amounts to 1 per cent and, accordingly, the stockholder will receive a dividend of 6 per cent upon the par value of the stock, and the workmen will receive a dividend of 1 per cent upon their earning power, which will be 20 per cent of their annual wages.

If the profits realized in different industries were apportioned between capital and labor by any of the three methods which have been outlined, it would be found that, in some industries, the portion available for labor would be exceedingly small, probably only two or three per cent of the annual wage roll. In other industries, the profits would be very great, sometimes being sufficient to double the employes' incomes. Unfortunately, as a general rule, the profits are the smallest in those industries where the wages are the lowest. There are a few industries of special character or in newly established lines of manufacture where the margin of profits is large, and where it is possible to pay unusual profits to the employes. The Ford Motor Co. of Detroit makes a highly standardized product in enormous quantities, and sells it at a relatively low price for a good profit. In consequence, the profits of this company have been so great that an enormous plant has been created out of the surplus profits of the business, and, at the same time, an unusually liberal profit-sharing system has been installed.

In testifying before the Federal Commission on Industrial Relations, Henry Ford stated that the regular wages received by the men working in the Ford plant were about 15 per cent above the usual wages paid for similar services by other manufacturers. In addition, anyone who qualified under certain rules was entitled to a certain part of the profit so that the minimum daily income under the plan (wages plus profit) would be \$5.00. The profit-sharing rate which is added to the wages is so arranged as to give to those receiving the lowest daily wage the largest proportion of the profits. For example, a man receiving 34 cents an hour receives a profit of 28½ cents an hour in addition, making a total income of \$5.00, while a man receiving as his regular wage 54 cents an hour receives a profit-sharing rate of 21 cents an hour only, making the total daily income \$6.00. The wages and the profits are paid in currency every two weeks. Those qualified for participation in the profits are of three classes: 1. Married men living with and taking good care of their families. 2. Single men over twenty-two years of age who have proved to be of thrifty habits. 3. Young men under twenty-two years of age and women who are the sole support of some next of kin. In order to be entitled to profit sharing, six months' employment with the company is required.

From one point of view, the Ford profit-sharing system is a great success. The money distributed to the employes has, for the most part, been wisely used by them and has procured for them a much larger measure of social welfare than they could otherwise enjoy. However, there are many industries which, like the Ford plant, are efficiently operated but which would find it impossible by the most careful management to divide among their employes profits that would increase the wage rate 15 per cent above the normal. These industries are so thoroughly standardized and so keenly competitive that there is a sharp and definite limit to their profits.

CHAPTER XV

DRAFTING-ROOM SYSTEMS

THE relation between the drafting-room and the manufacturing department of a machine-building plant varies greatly. In some drafting-rooms the work is confined almost exclusively to originating new or improved designs, whereas other drafting departments are so organized that they not only plan new developments but have considerable to do with the control of manufacturing operations, the aim being to relieve men in the shop from the work of planning, so that they are able to concentrate their efforts on the actual work of production. The drafting-room really bears a double relation to the shop. When considered as a place where designs are originated, it is the head of the shop, furnishing it with the ideas which are reproduced into concrete forms of iron and steel. On the other hand, the drafting-room may also be regarded as the " servant " of the entire works, because it is here that the preliminary planning, calculating, and similar work is done. In conjunction with the organization and work of the drafting department, some system is essential, since, in large drafting-rooms especially, there are thousands of tracings and records which must be cared for and, in addition, considerable routine work that must be done in a systematic way. The exact details of a drafting-room system must conform to the conditions existing in each plant and may vary considerably according to the type of plant and its size. Some of the more important features common to drafting-room systems will first be outlined.

Standard Drawing Sizes. — In order to simplify the handling and indexing of drawings, it is desirable to have a single standard size for the sheets. The blueprints that are used in the shop, however, should not be larger than is necessary, for reasons apparent to anyone who has had occasion to use the unwieldy barn-door sizes. The requirements of both the shop and office may be met by making the tracings of standard size and cutting the print up afterward into as many smaller sheets as may be necessary when the tracing has on it two or more separate drawings. While there is no generally accepted standard, tracings measuring 24 by 36 inches are very common. This standard sheet may be divided into 18- by 24-inch half-sheets; 12- by 18-inch quarter sheets; or 9- by 12-inch eighth sheets; the latter are sometimes referred to as "sketching sheets," and are especially suitable for drawing small parts made on the screw machine, etc. If an extra large sheet is needed for an assembly view, a 36- by 48-inch sheet, or larger, may be made and folded to the standard sheet size for filing.

Numbering the Parts and Drawings. — In numbering parts and drawings, each type of tool may be given a distinctive letter. For instance, in a plant building machine tools, "A" might represent a universal milling machine; "B," a plain milling machine; "C," a vertical type; "D," a shaper; and so on. The size of the machine would be indicated by a number accompanying the letter. Thus, "A3" is a No. 3 universal milling machine, and "L16" might represent a 16-inch engine lathe. Each separate part is also given a serial number. Thus, L16–32 might represent the cone-pulley for a 16-inch lathe. This symbol would also be marked on the pattern in order to identify it.

The title of the drawing is placed in the lower right-hand corner, usually in a ruled off space 2 or 3 inches high and 4 or 5 inches wide. The exact arrangement of the title varies considerably, but, as a rule, it contains the symbol of the machine, the lot number, which is filled in on the blueprint, the part number or numbers, a title descriptive of the part drawn, the name of the machine to which the part belongs, the firm name, the date, the initials of the draftsman and of the one who checked the drawing, and a space for recording changes that may subsequently be made. In the margin at the lower right-hand corner of the sheet, it is well to place the numbers representing all the details on that sheet for convenience in filing the tracing. In assigning numbers to parts, it is also advisable to omit a few numbers in the beginning so that these omitted numbers can be given to the assembly drawings when they are made.

Lists of Machine Parts. — There should be accurate lists of all machine parts for which drawings are made. The parts may be classified according to the materials of which they are made, the different classes being listed on separate sheets. Fig. 1 shows a form used for listing castings. This same form may also be used for forgings by substituting the word "forging" for "casting." The form shown in Fig. 2 is intended for parts made from bar-stock. Another list should be made up for purchased parts, such as bolts, nuts, screws, and similar articles. These part lists may be traced and blueprinted, but, if the machines are a regular

LIST OF PARTS Date________

Machine Name________Size______No.________Symbol________

CASTINGS. Material________________

Part No.	Part Name	Number Wanted	Weight, each	Date Ordered	Order Completed

Machinery

Fig. 1. List of Parts, as arranged for Castings

product, it may be advisable to print the forms since quite a number will be required. From these part lists, orders for materials, lists of materials, and similar records may be compiled. When a new lot of machines is to be constructed, the stock-keeper can use the part list in order to see that every purchased part such as screws, washers, etc., that will be needed, is in stock. The man who orders the castings can also check the supply on hand with the number that will be required according to the part list. These lists are also of value to the shop foremen who have a record of just what is required.

Dimensioning Drawings. — A drawing like a machine may be efficient or inefficient. As the purpose of a drawing is to show by lines and dimensions the form and size of the required part, it is important to make the drawings clear and self-explanatory as far as possible. In placing the dimensions on drawings, it is well for the draftsman to keep in mind the operations that will have to be performed on the piece. The dimensions should be given in such a way that the workman will not have to add or subtract or make other calculations in order to obtain the necessary dimensions. Notes are frequently of considerable assistance in indicating exactly what is required. The determination of limits requires good judgment and experience on the part of the draftsman.

Dimensions that may be required by the patternmaker should not be on shop drawings, since they are used but once and are

LIST OF PARTS Date__________

Machine Name__________ Size________ No.______ Symbol__________

BAR STOCK PARTS.

Part No.	Part Name	Length, One Piece	Number Wanted	Material	Form of Section	Total Length

Machinery

Fig. 2. List of Parts made from Bar Stock

objectionable in that they complicate the drawing. The extra pattern dimensions may be placed on the paper drawing from which the tracing is made or they may be marked with a yellow pencil on a blueprint made especially for that purpose. If it is necessary for a finished surface to be located relative to a rough surface, a dimension line should, of course, extend from the rough surface, but otherwise the shop drawing should show only the dimensions of finished surfaces.

Checking Drawings. — The checking of drawings to ascertain whether or not they are accurate should be done after the tracings are finished and preferably by someone other than the man who made the drawing. It is well in checking to make out a list of the possible errors and always refer to this list. The general design represented by the drawing should be examined to see that it is well-proportioned, adequate as to strength, and, in the case of a part, in general harmony with the remainder of the machine. Changes that might reduce the cost of molding in the case of castings and of machining should also be carefully considered. All surfaces that require finishing should be so marked that there will be no confusion regarding this point. It should be possible to obtain directly from the drawing and without calculation each dimension that will be required by the machinist. In checking a detailed drawing its dimensions should be compared with those of every related part in the machine, whether the related part is detailed or given in the list of stock parts. Titles and stock dimensions should be compared with entries in the list of detailed parts. If the drawing is not self-explanatory, notes should be added so that it will not be necessary for the workman to ask questions. The title of the drawing should also be checked to see that it is correct in regard to the name, part numbers, etc.

Changes in Design. — In shops where the product is in a constant process of improvement, it is necessary to make provision for changes in design in a good drafting-room system. The men in the shop should never be allowed to make an erasure or addition of any kind to the shop prints and drawings. If an error is discovered or an improvement found advisable, it should be reported at once to the drafting department. In general practice, however, it will be found best from the drafting-room standpoint, and that of cheapness of production as well, to delay radical changes until a new lot is begun. In some places, the foremen and other prominent men are furnished with books of forms on which they write suggestions for the improvement of the different lines of machinery. The form is filled out in duplicate with a stub in the book, and is sent to the drafting-room, where it is considered either immediately or when a new lot is ordered, according to the urgency of the case. This method gives the draftsman the advantage of having all the suggestions in a tangible form, for ready reference, and also gives the credit to the men who hold the duplicate stubs.

It will be found advisable to make out a list of everything which might require attention in making alterations of any kind. The following outline would cover about everything: Detail tracings; assembly tracings; list tracings; all prints (detail, assembly, and lists); patterns; special tools; and record of changes.

In making a change, if it is at all elaborate, it is best to sketch it out on detail paper before making changes on the tracing. Cases sometimes occur in which a comparatively simple change, like shortening the overall length of a complicated casting, would entail a considerable amount of labor. To avoid this, the dimensions only may be changed, and a small heavy circle be drawn around the dimension. This gives notice that the dimensions are out of scale, so that the drawing will not measure correctly.

The assembled drawings should be kept up-to-date if they are to serve any purpose at all. In some cases it might be permissible to introduce circled dimensions on these tracings as well, where an otherwise small change would require much erasing.

Patterns and special tools must be looked up for each individual case, and duplicate written orders made out for changes, one to go to the toolmaker or patternmaker, and the other to be kept in the office as a record until the work is reported finished.

After each change is completed and checked up, the person making the change should enter his initials and the date in a space provided on the drawing. A " Record of Changes " book should be kept. Under the date in the " Changes " column, there should be entered a brief description of the alterations, giving exact dimensions, and perhaps the reason for them as well. A separate book should be kept for each line of machines manufactured. By comparing the last change date on a print with that on the tracing, it can immediately be determined whether or not the print is up-to-date. By referring to the given date in the " Record of Changes," the exact scope of the alteration can be found at any time. This will be found a great convenience.

In cases where an error has been made in the shop on a machine, and a deviation from the drawings in that particular case will save a large amount of costly labor and material, such change may be made; but it must be recorded for convenience in making future repairs and attachments. The machines of a given kind and size should be numbered serially, beginning, for instance, by numbering the first 20-inch lathe built, No. 1, the next one, No. 2, and so on, as long as the machines are built. This number should be stamped in a prominent place, and attention called to it in the catalogues and other printed matter of the firm.

Record of Machines Shipped. — A book for a "Record of Machines Shipped" should be kept, with a page for each individual machine. This page should be numbered with the serial number of the tool, and contain the name of the firm to whom the machine was sold, a record of the inspector's tests, a description of any change from the standard drawings used on other machines in the same lot, and a record of all attachments furnished, repair parts sent, complaints from user, etc. It is easy to see the value of such a record as this in furnishing new parts, remedying defects, and estimating the values of various designs. After each lot of machines has been approved ready to ship, all the blueprints — detail, assembly, and lists — should be returned to the office.

Drawings and Lists of Tools. — Drawings of tools should be numbered with the symbol and part number of the detail for the manufacture of which they are used, adding a serial number as well. This serial numbering should be common to all tools made, no matter for what purpose, and is to be given them in the order the drawings come from the office. Thus, if L22–75 is the part number for the spindle of the No. 4 vertical milling machine, the finishing taper reamer for the hole in the spindle might be numbered L22–75–193. These numbers should be stamped or etched on the different tools as soon as they are made.

All special tools should be listed in a suitable book, the tools being entered serially as fast as drawn. With one arrangement, the first column of the tool-list book gives the date of the tool drawing, the name and number of the tool, and symbols representing a list of parts for which this tool is used other than the one for which it was made. These tool and jig sheets should be filed in a drawer of their own, divided into compartments of suitable size, and all arranged with serial numbers in order, the lowest at the bottom. The jigs and tools themselves are best arranged with the serial numbers in order, since this will avoid constant rearranging as the stock increases. To find them readily, an index list should be prepared, giving the standard machine parts in numerical order, and listing under each one all the special tools used in its production, whether those tools were originally used for it or not. Much of this system of keeping track of special tools is required only in shops where such tools are used in large numbers.

In cases of special machines or outside work of any kind, which does not come under the head of standard product, the system previously described may be followed as a whole, with the exception of the symbol for the machine, which should be given a serial number instead of the letter and size number of the regular product. A record of these serial numbers should be kept in the office, and the drawings filed away, if the job is important, in the same manner as the standard blueprints. Attachments to regular machines, made up separately, may follow the entire system for standard parts. The symbol describing them may be formed by adding a letter to the symbol letter of the machine. Thus AA-3 would be "Vertical Milling Attachment for No. 3 Universal Miller."

In place of record books, it might be better to use loose leaves, with punched holes, and held in suitable binders. These leaves could then have proper entries made on them with a typewriter, and thus save hand work.

Index System for Drafting-room. — The greatest difficulty in devising a satisfactory index system is met with in shops having to deal with a great variety of work. For drafting-rooms in shops where the product is limited to only a few standard machines, or articles, which are turned out in great quantities, the problem is a comparatively easy one. The main factor to be taken into consideration when planning a system is the rapidity with which a thing looked for can be found. The somewhat greater care needed to keep up a complete system will hardly amount to anything compared with the time wasted in trying to locate things looked for in an incomplete and patched up card index system.

Definitions of the terms "drawing," "shop sketch," and "customer's sketch," as applied in the following, will be given first:

Drawing. — Any tracings or drawings for machines, tools, and devices manufactured by the firm as a standard article or used in the shop.

Shop sketch. — Any drawing, made in the drawing-room, of special tools that are ordered in small quantities by customers.

Customer's sketch. — Any drawing, tracing, sketch, or blue-print that has been sent to the firm by customers or others not connected with the firm.

The drawings are indexed on cards (see Fig. 3) which are numbered, when they are blank, with the drawing numbers in rota-

Drawing No. A-612 **Date** March 6 **1905**

Drawn by M. C-r **Checked by** Potter

Casting Detail:
Special head for #2
Brown & Sharpe Milling Machine.

Piece No. 656

Remarks: For construction see A-109.
For milling hexagon nuts.

Fig. 3. Index Card for Shop Drawing

tion, and are kept in numerical order. As soon as a drawing is made, the first blank card is filled out and its number stamped on the drawing. The card is then placed in the index, according to the following rules: In the first place, tools and machines should be indexed in general classes, and all general attachments for the machines should be indexed under the heading of the machine with which they are used. For example, cutters of every description should be indexed under the word "cutter," and sub-headings should be provided in the index if the number of cutters of different descriptions make a subdivision necessary.

Jigs and fixtures that are to be used for certain operations in manufacturing parts of standard machines and tools are indexed in the same divisions as the parts on which the operation is to be performed are indexed under. If it is difficult to decide under which heading to place a certain tool or fixture, it is advisable to make out two or even more cards under headings that are most likely to be looked for. The files for the cards should be kept in the most accessible place in the drafting-room, where everybody having to use them can do so with convenience.

The drawings should be filed in drawers in the drawing-room, and a " record blueprint " of each tracing should be kept in a fireproof safe or vault. These " record blueprints " should be replaced every time a change is made on the original tracing or drawing.

As sketches are ordinarily used only a limited number of times, they should not be traced, but be drawn either in copying ink or copying pencil, and then be copied in a special copybook used for the purpose. The sketch is marked with the page number of the copybook where it is copied. These sketches could be indexed on the index pages of the copybook, but when one copybook after another is filled out, it would be a waste of time to have to go through the index of each one in order to find what is wanted; therefore, a card index is provided for these sketches also, where the cards are put in order according to the names of the customer.

There is also an additional card index for these sketches where the cards are put in order, not with reference to the name of the customer, but according to the name and the kind of tool drawn on the sketch. Customer's sketches are not listed in any card index, but are kept in proper order in a common letter-file.

There is no need of providing a card index for patterns, as the pattern numbers are always marked not only on the drawing itself but also on the index card for the drawing. However, it is both convenient and necessary in many cases to be able to tell from the number of the pattern what machine or tool this pattern applies to. Therefore, a book is provided with pattern numbers in rotation, where the patterns are entered as soon as a drawing is made.

Drafting-room System of American Locomotive Co. — The American Locomotive Co., in its Schenectady plant, has a highly developed drafting-room system which was originally based on the method employed by the Baltimore & Ohio R. R. for many years in the filing of drawings, correspondence, etc. Under the Baltimore & Ohio system, everything in connection with the drafting-room was arranged in such a manner as to be filed along the lines of the alphabetical system to be explained. The system in use by the American Locomotive Co., however, has been changed so materially, due to the numerous improvements that

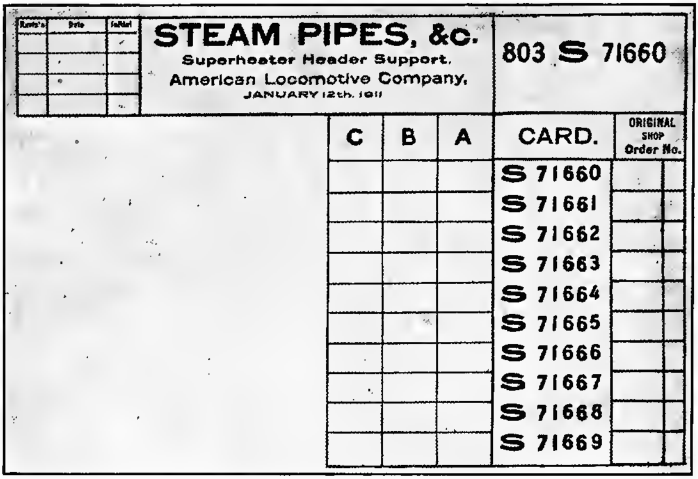


Fig. 4. Tracing Imprint, showing Method of Grouping into General and Subdivisions

have been instituted from time to time, that it is practically a new system with nothing but the basic principle of the old system left.

Classification of Drawings. — The manner of classifying the drawings, or " cards " as they are called, will first be explained. This is the principal feature of the system and is one which, with slight modifications, might be advantageously adopted for a wide range of work. In this method, the parts of a locomotive are divided into ninety general groups, each group being given a number, the numbers ranging from 10 to 99; thus, group 10 is " ash-pans," 11, " axles," and so on up to 99; every part of the locomotive has a number. As before mentioned, the drawings were originally made in the works where the order was to be completed. As the system was to be uniform throughout the works some distinguishing mark had to be given to the drawings from the different plants, so for that reason the initial letter was chosen. Thus "S" stands for Schenectady, "B" for Brooks, etc.

There are eleven sizes of drawings. The following table gives the number of sheet, size, and the details for which each sheet is to be used:

No.	Size	Use
1	12 × 9	Small details and brass work.
2	12 × 18	Small details and brass work.
3	24 × 18	Details.
4	24 × 30	Cylinders, boiler sections, grates, ash-pans, and tanks.
5	12 × 42	Engine frames, etc., and small designs.
6	12 × 60	Engine frames, etc.
7	24 × 42	Cylinders, tender frames, and tanks.
8	24 × 60	Boiler elevations and small erecting cards.
9	25 × 66	Ordinary erecting cards.
10	25 × 84	Double-ender erecting cards.
11	25 × 102	Mallet erecting cards.

The previously mentioned general groups are further subdivided. For example, the "steam pipe, etc.," group 80, is subdivided into steam pipe, tee-heads, joint rings, etc. The "tee-heads" subdivision is given a series of numbers ranging from 2000 to 3000; joint rings, 3000 to 4000, etc. Each drawing when completed is given one of these numbers, say, 1000, and, at the same time, all the numbers from 1000 to 1009 are allotted to it, permitting nine further tabulations to be made. Another feature of interest is the manner in which certain sized sheets are allotted to certain work. For example, "steam pipe tee-heads" can be made on sheet size No. 2 only; "steam pipe joint rings," on sizes 1 and 2, etc. Experience has shown that these sizes are the best for that particular line, thereby keeping the work uniform. This classification and numbering is looked after by a special drafting-office system index which tabulates all the groups, etc., giving all the details in connection with it. The majority of drawings, however, are made on size 3.

The general group number, size drawing, works at which the drawing was made, and number of the drawing in that group represent four different factors, seemingly with but little connection; it remained to combine these groupings in some simple, logical manner that they might be readily understood. Consider group 80, card size 3, Schenectady works, card number 71,660. In the system adopted, this would be written as follows: 803S71,660. This is readily understood, the first two figures giving the general group number; the third, the size drawing; the letter, the works; and the final group of figures, the drawing number in that group. This arrangement is shown in Fig. 4 where the drawing number is placed in the upper right-hand corner. Below, as shown, are placed the ten tabulations allotted to the drawing as previously mentioned, and, opposite to it, the original shop order number. Should any dimensions be lettered, the space to the left would be ruled to suit, as indicated; however, these tabulations are usually additions.

Immediately to the left of the drawing number is a space containing the name of the group and the sub-group, the company, and the date. In the example, "steam pipes, etc.," corresponds to 80 and "superheater header support" corresponds to the subgrouping 71,000 in general group 80. Further to the left in the small tabulations shown is a space to be filled in case of any future revision of the drawing. All this corner piece of the drawing is printed in the local press room so that the work is absolutely uniform. Electrotypes of the different headings and subheadings are kept in stock, so that no mistake can occur in giving the titles.

Record Prints and Blueprint Folios. — As is customary in most drafting-rooms, the tracings were used for reference purposes until a new system of record prints was introduced. It was found that the constant handling of these tracings had a very bad effect, in many cases requiring their renewal long before it should have been necessary. Under this new method, an extra blueprint is made from each tracing, on which, during the blueprinting process, a large " R," two inches high, is printed, with this legend directly below in good-sized letters:

This is the Record Print
Must be treated as an Original
Return to Vault promptly

In this way, the tracings are saved; they cannot be taken from the vault except when absolutely necessary for changes, retabulating, etc. These record prints, being kept automatically up-to-date by the blueprint department, are authoritative and serve their purpose equally as well as the tracings. While additional expense is incurred from having to make this extra print, it is more than compensated for by the diminished wear and tear on the tracing.

Further records are kept in the form of blueprint folios, which are loose-leaf books of the blueprints arranged according to their general groups and sizes. These are very convenient for the draftsmen in looking over previous records of what has been done in any particular line.

Storage Vault. — All permanent records and tracings are kept in a vault. The main vault has two floors containing tiers of shallow drawers in which the tracings are kept with respect to group, different sized drawers being used according to tracing sizes. In this vault are also kept any permanent records, such as specifications and the books for castings, patterns, cards, and material. The reference prints previously mentioned are kept in tiers of drawers in a room adjoining the vault. Not being of a permanent nature, they do not require to be kept in the fireproof vault, from which they are excluded by reason of the lack of space. The card, pattern, casting, and material books are kept in the vault, arranged according to order number.

Anything in the vault or its adjoining room is let out on an order such as shown in Fig. 5. Everything kept in the vault is included on this one order card; for example, in the upper left-hand corner, either a tracing or reference sheet may be called for by striking out the one not desired, or a folio may be taken out by marking its number; the " old " column has reference to prints made previous to the installation of this new system. Any of the record books may be taken out by checking the one desired. On all forms, whenever possible, checking is used instead of writing a name; this proves to be more expeditious in nearly all cases, as well as obviating confusion from poor writing. At the bottom of the card are shown the transferring arrangements, whereby the charge may be removed from the one against whom it is posted to any of the departments listed, by checking the proper department. As these orders come in, they are filed verti-

803	Tr. S Ref.	71660	Sept. '10 E. D. 96
			CHARGE TO: Brown — DATE: 1/12
FOLIO GROUP NO. New / Old		PLACE ALL CARD, SKETCH OR DATA NAMES HERE: Steam Pipes	ENG. ORD. NO. 5708

IF AN ENGINE RECORD BOOK IS REQUIRED ✓ THE ONE WANTED

CARDS	CASTINGS	FORGINGS	MATERIAL	TENDER	O. R. SPEC'S

TRANSFERS Data charged out to one must not be transferred to another unless re-charged by the department ✓ed below who holds the permanent file.

Tracing Vault		Gen. Des., S. M.		Calculating		Special Design		Detail Design	
Record Vault		Gen. Des., H.C.P.		Material		Office Inform'n			
Tender Vault		Gen. Des., J. K.		Clerical		Superheater			
Correspondence		Gen. Des., G. D.		Die		Sch'y Local			

Fig. 5. Vault Slip, for Use when taking Drawing from Vault

cally in boxes according to group and their order in the group, where the vault clerk has a record of the location of any particular tracing or reference sheet should it happen to be out of the vault. Upon the return of the tracing, the charge is removed and the slip destroyed.

Each of the principal draftsmen has a light wooden box 20 by 28 by 5 inches deep, in which all tracings are kept while being made, as well as drawings that are awaiting inspection. Each night these boxes around the drafting-room are collected and placed in the vault so that no records of a permanent nature are left around where they may be destroyed.

Specifications. — The best way to obtain a clear understanding of the workings of the system is to follow an order through the engineering department. The engineering department in New York draws up a contract specification between the purchaser and the company; as a rule this is general in its nature and does not enter very deeply into detail. Each order is given a number; thus, "B783" means Brooks, order number 783. A similar plan is adopted for the other works. A copy of the contract specification with an order to construct is forwarded to the chief engineer at Schenectady, who appoints one of his assistant engineers to look after the design. Just previous to this, however, the specification is given to an assistant engineer in charge of office specifications and scheduling. This engineer compiles more definite data from the contract specification, elaborating thereon in a special form supplied for that purpose; this form consists of a number of printed pages arranged in the same group order number as previously explained; complete data, as regards material, size of parts, etc., are given in this drafting-room specification. On its front page there is a table containing all of the vital data in connection with a locomotive, such as type, size, and kind of cylinders, wheels, etc. As in general these specifications differ but slightly from those to be seen in any engineering office, no further explanation will be given.

Scheduling. — While the specifications are being compiled, the process of scheduling the work is under way. The contract specification usually states a time delivery for the locomotives. The form for scheduling is shown in Fig. 6, which shows the schedule card for the locomotive on an 80-day basis; similar cards are made out for the tender. On this schedule form, complete information is given, but the principal feature to be noted, however, is the scheduling. All the productive work is divided into three general groups: "A," material and specifications; "B," new and old patterns and flanging dies; and "C," cards and sketches.

Different lengths of time are required for making any particular part, depending upon such factors as the amount of machine work, whether it is purchased on the outside, and other equally important considerations. From long experience, the company has been able to form a general schedule showing how long previous to the delivery date it is necessary to have the different details ready. This has been prepared in the department for various delivery periods, ranging from 105 down to 40 days, the former length of time being generally required for new designs, while a repetition order may be completed within the latter time period, from the fact that in the latter case all drawings, patterns, etc., are ready. Consider an 80-day delivery: From this general schedule the engineer knows just how much time any part re-

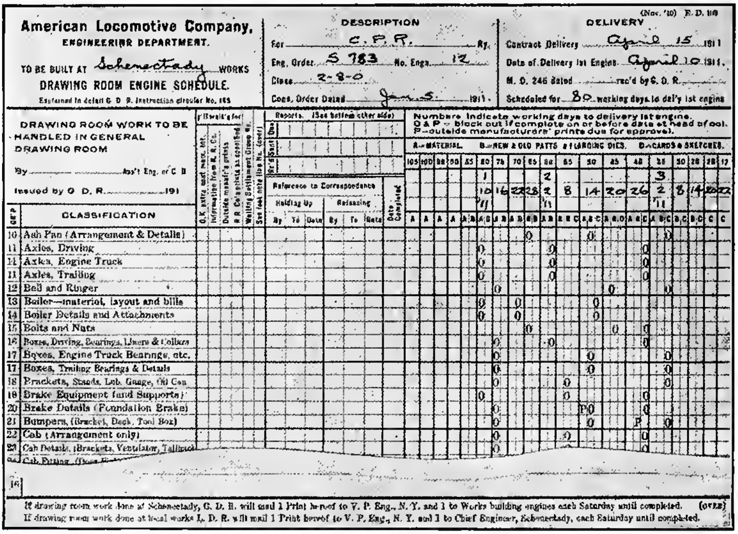


Fig. 6. General Schedule showing when it is necessary to have Different Details ready to Insure Delivery at Specified Time

quires; from a computing calendar, a date for any number of working days ahead can be readily determined. Take, for example, " axles " on an 80-day basis; the material for these must be ordered among the first things. This is shown by the cipher opposite " axles " under list " A " of the 80-day column. The date is placed in the vacant space just above, under the squares containing " 75, 70, 65, 60," etc.; these dates are 5, 10, 15, and 20 working days ahead. All cards and sketches must be gotten out on the date corresponding to 40 days. This schedule is kept by the scheduling department, which keeps in touch with all the other departments and sees that the schedule is lived up to. When the allotted time elapses, if the schedule is broken, inquiries are set on foot to ascertain the cause of the delay. When notification of the completion of each of the scheduled events occurs, the square is blocked out; the unblocked squares are the ones to be watched.

Minor cards, such as are shown in Fig. 7, are made up for distribution to the different drawing departments. For example, the one shown is given to the section working on groups 13, 14, 36, and 57. It shows the day on which their work is expected, and that department is held responsible should the order fall behind on that date. These are usually dated a day or more

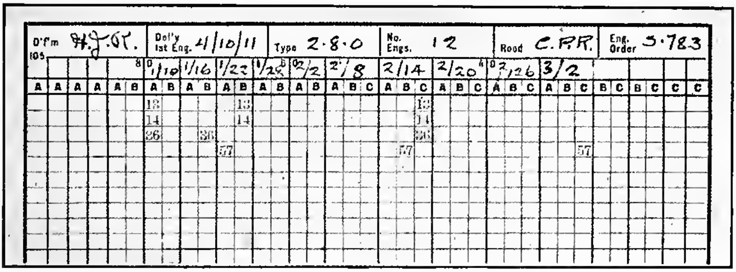


Fig. 7. Schedule Card for Different Departments

ahead, in order to give that department time to transfer the drawings, etc., to the next.

Long cards, 22 inches in length, sections of which are shown in Fig. 8, are given to the material department — a separate strip for each order. When each part is completed, as with the other cards, the space is blocked out. The unblocked spaces on the date for which it is specified are then followed up to ascertain the cause of the delay. The work in all departments is, therefore, automatically kept moving through at the proper rate.

Elevation and Detail Department. — During the time that the work is being scheduled, the assistant engineer of elevation who has charge of the particular order is making the elevation drawings of the locomotive, which usually include a side view, end view, and several cross-sectional views, as well as a partial view from below. This design is purely tentative until passed upon by the calculating engineer.

When well under way, the engineers in charge of detail are called in; they prepare detail drawings of the parts that come under their respective departments. Such details as the frames, grate arrangements, and erecting cards are looked after by the elevation engineer, as the whole arrangement of the locomotive must be considered more particularly in the preparation of these parts.

	80
Draftsman	Smith.
Schedule Delivery	4/10/1911
Class	2-8-0
Number of Engines	12
Name of R. R.	C.P.R.
Engine Order No.	5 783

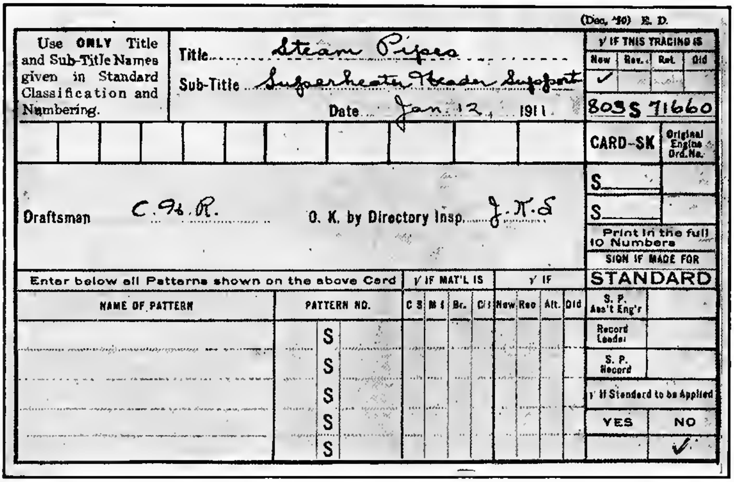
GROUP	ENGINE DETAILS	1/10	1/16	1/22	1/28
10	Ash Pan (Arrangement and Details)				0
11	Axles, Driving	0			
11	Axles, Engine Truck	0			
11	Axles, Trailing	0			
12	Bell and Ringer		0		
13	Boilers—materials, layout and bills	0			
14	Boiler Details and Attachments	0			
15	Bolts, Studs and Keys				0
16	Boxes, Driving, Bearings, Liners & Collars		0		
17	Boxes, Engine Truck Bearings, etc.		0		
17	Boxes, Trailing Bearings and Details		0		
18	Brackets, Stand [illegible] Can		0		
	[illegible] Painting, etc.				

GROUP	TENDER DETAILS	SCHEDULE DATES			
11	Axles	0			
17	Boxes (Bearing, Wedge, Dust Guard, Lid)		0		
19	Brake Equipment	0			
54	Headlight, Shelf, Flag and Signal Fixtures				0
54	Tank Capacity and Ownership, Plates				0
62	Pilot, Bumper Knee, Rail Guard, Snow Plow		0		
63	Pipe Fittings, Train Line & Sig. Pipe Elbows			0	
90	[illegible] Arrangement & Details			0	
95	Wheels, Tender, Centers and Tires	0			

Fig. 8. Schedule for Material Department

In the detail department, when a drawing is completed, a slip such as is shown in Fig. 9 is attached to the card or tracing; on this slip are written the title, sub-title, and the date. It is then passed to a clerk whose duty it is to record the tracings and give the drawing a number. It is then sent up to the printing department where a title as shown in Fig. 4 is printed on the drawing in the manner before explained. The drawing is returned to the detail department and there checked, and, if found correct from its standpoint, is passed to the elevation engineer. The elevation engineer, when it reaches that stage, re-checks the drawing as regards clearance with other parts, etc.; he is then through with it. This checking need not be further explained, being common to all drawing-rooms.

As the elevation engineer passes upon the drawings and finds them to be correct, before sending them on from his department, he enters the drawing numbers in what is called the "Card Book." This card book has the order number in large letters on the cover and is printed throughout with names of parts in the group order number just explained. All that is necessary then is to enter the drawing number opposite the name of the part.


(Dec, '10) E. D.

Use ONLY Title and Sub-Title Names given in Standard Classification and Numbering.

Title Steam Pipes

Sub-Title Superheater Header Support

Date Jan. 12, 1911

✓ IF THIS TRACING IS: New ✓ | Rev. | Ret. | Old

803S 71660

CARD-SK | Original Engine Ord. No.

S

S

Draftsman C. H. R.

O. K. by Directory Insp. J. H. S.

Print in the full 10 Numbers

SIGN IF MADE FOR STANDARD

Enter below all Patterns shown on the above Card		✓ IF MAT'L IS				✓ IF			
NAME OF PATTERN	PATTERN NO.	C S	M I	Br.	C/I	New	Reo	Alt.	Old
	S								
	S								
	S								
	S								
	S								

S. P. Ass't Eng'r

Record Leader

S. P. Record

✓ If Standard to be Applied: YES | NO ✓

Fig. 9. Imprint Order Card to be sent to Press Department with Tracing

Calculating Department. — All calculations come under a distinct department, so that the draftsmen have no computations to make. The work of this department commences immediately after the first lines of the locomotive are laid down. When the outlines of the locomotive have been drawn in by the elevation engineer, the calculating engineer goes over this outline and by comparison with drawings of locomotives of a somewhat similar type is enabled to determine just how the weight of the locomotive is going to be distributed over the wheel base, and whether this distribution will conform with that specified in the contract specification. The elevation engineer cannot proceed with the design until this matter has been determined. If, for example, the boiler must be moved back, or other similar changes made, the extent of this movement is determined by the calculating department so that the elevation engineer has no figuring to do in the matter, merely following what has been laid down by the calculating department.

While the principal work of this department is to regulate the distribution of weights, other work is also done such as determining the strength of different members — as, for example, axles, piston-rods, and connecting-rods — and the determination of counterbalances, coal and water capacities, strength of springs, and designs of brakes. This department must keep in touch with the work all the way through, from the time the order first comes into the drafting-room until the last drawing is completed. Special forms are supplied for all the calculations, so that they are retained in permanent form for future reference.

Inspection of Drawings. — The drawings, as they leave the elevation and tender departments, are inspected by shop men attached to each of the different departments, who examine the drawing in order to determine whether the part can be improved from a manufacturing standpoint, noting in the case of a casting whether improvements might not be made to facilitate molding. This inspection is made with the sole purpose of facilitating manufacture and merely forms a re-checking of the drawing.

In the detail department, in addition to the usual cards made of all parts, small cards called " sketches," which are not as complete in detail as the regular drawings, are made of all parts that must go through the blacksmith shop. All sketches on being passed by the elevation men and inspectors come to the die department where they are examined by the assistant engineer in charge of this department, who determines whether or not it would be possible to produce this part by some machine-forging process, such as drop forging, bulldozing, etc. If practicable, drawings are made of the necessary dies, such as flanging dies, etc. This is not necessary in the case of drop-forging work.

All plate-work drawings also pass through this department to see if flanging dies cannot be preferably used to facilitate work. A very complete system of adjustable flanging dies is employed by the American Locomotive Co., which are very convenient in such places as the firebox shell, where on different locomotives varying amounts of slope are given to the walls; having adjustable dies saves the making of many new dies for the purpose.

Most of the drawings that have to pass through the machine shop come under the inspection of the assistant engineer of the die department, and he also determines the practicability of producing tools and jigs to increase machine shop production.

A special series of office information sheets is kept for the tools, dies, and jigs. These are made out on standard M.C.B. letter-size tracing linen and are given a group number similar to the larger drawings. The principal difference is in the numbering. For example, with " tools," a " T " is added to the works signification; thus, 932ST510 means the tools on a Schenectady drawing; " D " and " J " are similarly added for dies and jigs. These office information sheets give the die or jig number and also the drawing number on which the die or jig has been designed. This gives a complete record in convenient form of all auxiliary appliances used in producing the work. These office information sheets are kept by this department and are filed away, a card index system, indexed according to the order number and road, being used for this purpose.

Material Department. — The material department in charge of an assistant engineer makes a record of all the material required on any order; everything ordered on the outside must be recorded in a special material book. This material book is a specially printed book resembling the previously mentioned card book and is arranged in the group order number with all the principal names of parts printed therein. Complete information for the purchasing department is there given. This information is obtained from the designing draftsman in various ways. Some, depending upon the nature of their work, compile bills of material which are handed over to this department to be entered in the material book, while a large part of the information is obtained directly from the cards. The results are carefully checked over by the department, so that no omissions or duplications are possible. Owing to the large amount of material obtained on the outside for the boilers and tanks, there are special material bills prepared for these, which obviate the necessity of drawings for all these parts, as the material book usually orders by drawing number.

The material book is posted with the new material requirements that come in day by day, until the time allotted on the schedule is fulfilled; at this point, from 75 to 80 per cent of the material has been entered, as a rule, but as the book is called for by the schedule, it must be sent forward. Previous to the " call " day, therefore, the necessary copies are made. The original is retained in the drafting-room; one copy goes to the purchasing department; one to the stores to check the supplies as they come in; and a third to the scheduling department. To handle the balance of the material which has not been entered in the material book, there are special " Additional Material Sheet " forms which are made out in triplicate as the further material information comes in. These are made out daily and sent to the different departments to which the material book copies have been forwarded. A clerk in each of these departments then fills in the missing information and returns the sheet to the material department. In this way, the books are finally completed, the material department keeping a check on this operation throughout.

Pattern Department. — A very complete record of patterns is kept in the drafting-room, a special form (partly shown in Fig. 10) being used to file the records away. When a pattern has been made for any particular order, such as S783 referred to in the illustration, the card shown is made out recording that fact. Patterns are numbered in a precisely similar manner to the drawings, the group, etc., being the same. When a pattern is made, a card similar to the one shown is filled out; this shows the material of which it is made and also in the three vertical and horizontal columns whether it can be lent and whether it is new, duplicated, or reconstructed. Suppose an order went through the Richmond works, R812, which used the same slide-valve cover. A clerk at Schenectady, looking up his records, would see that this pattern had been used last at Schenectady on order S783. Notification would then be sent by the pattern clerk both to the Schenectady local works and to the Richmond works, notifying the former that the pattern was required, and the latter that the pattern they needed could be obtained from Schenectady. The charge is then removed from S783 to R812 as shown. The Richmond and Schenectady works then communicate with each other and have the pattern shipped from Schenectady to Richmond. If the pattern were in use at Schenectady, word to that effect would be sent to Richmond and the latter works would then be required

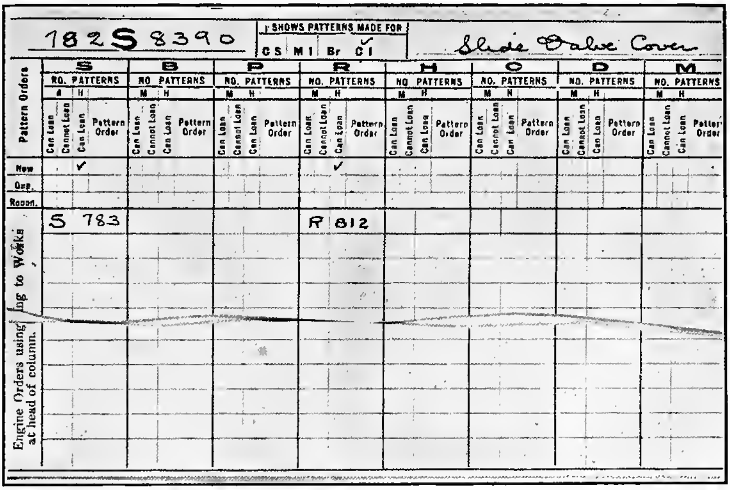
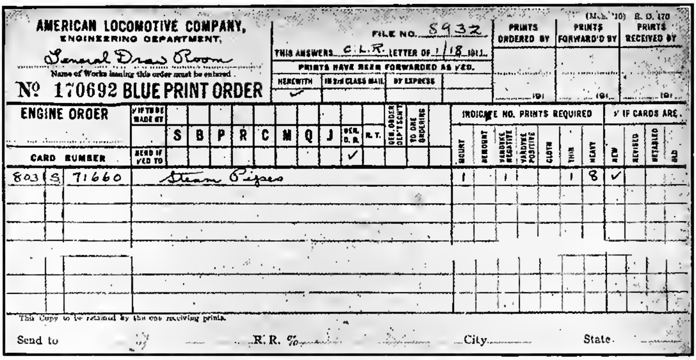


Fig. 10. Pattern Record Card

to make a new pattern. When this is done, notice to that effect is sent to the pattern clerk at the general drafting-room who records a new pattern under the same number, on the same sheet, by another check-mark in one of the nine squares. The next order coming in which requires the same part would then have two pattern selections from which to choose.

Blueprint Department. — When the elevation draftsman has finished with the newly made tracing, before it passes on to the die department, etc., a blueprint order form such as shown in Fig. 11 is attached to the tracing. This gives the tracing number, name, and the number of blueprints required. If it is not a new tracing but is already in the vault, the order form goes directly to the vault and the tracing is charged against the blueprint room. The time the order was received, the time it leaves, and the clerk filling the order are marked on the form, which then goes with the tracing to the blueprint room. Here it is again inspected for any clerical omission such as signatures, etc., when it is given to a clerk who schedules it.

The blueprinting is done by piece-work in large electric printing machines. The system is so arranged that blueprints pass in a direct line from the printing machine to the washing machines and on through the dryer over an endless chain, and are deposited at the far end where they are sorted. When the last blueprint


AMERICAN LOCOMOTIVE COMPANY,
ENGINEERING DEPARTMENT,
General Draw Room
Name of Works issuing this order must be entered.
Nº 170692 BLUE PRINT ORDER

FILE NO. 5932
THIS ANSWERS C.L.R. LETTER OF 1/18 1911.
PRINTS HAVE BEEN FORWARDED AS V'ED.
HEREWITH ✓ | IN 3rd CLASS MAIL | BY EXPRESS

(M.L. '10) B. O. 170
PRINTS ORDERED BY ...191 | PRINTS FORWARD'D BY ...191 | PRINTS RECEIVED BY ...191

ENGINE ORDER | ✓ IF TRDE MADE AT | SEND IF V'ED TO | S | B | P | R | C | M | Q | J | GEN. D. R. ✓ | R. T. | GEN. ORDER DEP'T SCH'T | TO ONE ORDERING
INDICATE NO. PRINTS REQUIRED: MOUNT | REMOUNT | VANDYKE NEGATIVE | VANDYKE POSITIVE | CLOTH | THIN | HEAVY
✓ IF CARDS ARE: NEW | REVISED | RETABLED | OLD

CARD NUMBER
803 | S | 71660 | Steam Pipes | 1 | | 1 | | | 1 | 8 | ✓

This Copy to be retained by the one receiving prints.
Send to ... R. R. % ... City ... State

Fig. 11. Blueprint Order Slip for Ordering Blueprints

has been printed, the tracing and order are taken from the printing machine to the sorting table where the order is checked with the number of blueprints made; the blueprints then pass out to the one ordering them. This order form is made out in quadruple; one copy is kept by whoever ordered the blueprint; one comes back with the prints; a third is held by the blueprint department until the fourth, which has been returned with the blueprints, has been signed by the one who ordered them. The delivery and receipt are thus automatically checked.

Standardizing. — A special department is devoted exclusively to standardizing the details of the locomotive. Formerly, there was a special series of drawings devoted to this line of work called the " A " drawings, this letter being used in place of the " S " or " B," etc., employed in ordinary drawings. This system was found to be faulty in that a drawing once made and lettered " A," must always be considered as standard. This led to a lot of " idle " drawings because, as progress was made, the standards frequently changed. For that reason, it was decided to drop the " A " standards and use the same lettering as on the ordinary drawings. The distinction made is that the drawing is marked " standard " below the title. By this system, this standard may at any time be rescinded and the standard drawing reduced to the status of the ordinary drawing by cancelling the " standard " mark. All drawings are thus kept operative.

This department, in its work, would take a series of drawings on any particular part, group them and make composites, forming a uniformly varying series of articles to replace more or less unsystematic designs of similar pieces. Ordinarily, this could not be done with all parts, but a great many improvements have been instituted in this department and considerable saving as well as improvement in work can be traced thereto.

An assistant engineer and staff devote their full time to this work, and are constantly on the lookout for new details to be standardized. When any part has been standardized to their satisfaction, before being accepted as such, it must be passed upon by the standardization board; this standardization board is composed of all the engineers whose business it is to decide upon such subjects. If it meets with their approval, the drawing passes out as standard and must in all cases be used as such, except where it conflicts with the contract specification.

Office Information Department. — This department, in charge of an assistant engineer, has to deal with general office information such as the tabulation of data for ready reference, and data of insufficient importance to bring before the standardization board. While the standard and office information departments cover much the same work, there is a distinct line of demarkation. The office information department merely works out ideas that are thought advisable to follow, whereas the standard department gets out ideas that must be followed.

The office information sheets are made on M.C.B. standard letter-size tracing linen. These sheets are formed off into oblongs, eight on a sheet, the information being printed concisely in each of these oblongs. Prints are made from these tracings and the individual parts sent to the particular department to which the information is of the most value. These tickets are mounted in a large frame placed upon the wall so that each draftsman may consult them constantly.

In general, the work of this department is to compile such existing locomotive data as can be obtained, and as the designing engineer has constant need of. The office information department takes this information and arranges it in the most convenient form so that no unnecessary time will be wasted. Briefly, it looks after such information as is considered of insufficient importance to submit to the standardization committee.

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