
OPPORTUNITY
UNITED
YMCA
SCHOOLS

Foremanship

THE STANDARD COURSE

OF THE

UNITED Y. M. C. A. SCHOOLS

BOOK I

THE FOREMAN AND HIS JOB

BOOK II

MATERIALS AND THEIR HANDLING

BOOK III

EQUIPMENT AND MACHINERY

BOOK IV

ORGANIZATION AND MANAGEMENT

Foremanship

Directing Editor
LEON PRATT ALFORD

General Editor
WILLIAM JESSUP SHOLAR

Authors of Texts

WALLACE CLARK
WALTER N. POLAKOV
JOSEPH W. ROE
HARRY TIPPER

Authors of Reading Assignments

THE STORY OF INDUSTRY ....*Leon Pratt Alford*

CREATIVE SPIRIT IN INDUSTRY....*Robert B. Wolf*

THE STORY OF RAW MATERIALS, *Frank O. Clements*

INCENTIVE AND INITIATIVE....*Chas. P. Steinmetz*

THE STORY OF LABOR SAVING MACHINERY, *George F. Barber*

COOPERATIVE DEVELOPMENT OF THE INDIVIDUAL ....*Charles R. Towson*

THE STORY OF MANAGEMENT, *Henry Wood Shelton*

INDUSTRIAL LEADERSHIP ....*Henry L. Gantt*

Materials and Their Handling

Part I

BY

JOSEPH W. ROE

Part II

BY

HARRY TIPPER

BOOK II

ASSOCIATION PRESS

New York: 347 Madison Avenue

1921

CONTENTS

CHAPTER 5

PART I: THE JOB

Gathering and Issuing Materials

PART II: THE FOREMAN

The Man and the Material

CHAPTER 6

PART I: THE JOB

Movement of Materials

PART II: THE FOREMAN

Developing Interest

CHAPTER 7

PART I: THE JOB

Care of Materials

PART II: THE FOREMAN

Workmanship and Originality

CHAPTER 8

PART I: THE JOB

Fabricating Materials

PART II: THE FOREMAN

The System and the Worker

Chapter 5

Part I

GATHERING AND ISSUING MATERIALS

Part II

THE MAN AND THE MATERIAL

Part I: The Job

GATHERING AND ISSUING MATERIALS

Section I

The Purchasing of Materials

Vital Importance of Materials in Industry.—All industry exists by doing something to materials. Hospitals, churches, and schools are concerned almost exclusively with *people;* but industry is directly concerned with *materials*. It either transports them from a place where they are *not* needed to one where they *are* needed, or transforms them from a condition of no value, or low value, to one of higher value. The lumberman cuts timber in the far Northwest and starts it toward the mill on sleds or by water. The miner brings coal from underground, where it is useless, to the surface, where it is available for distribution in making light, heat, and power. The railroad transports those products from where they are not needed or have little value to places where they are most needed. All three of these industries—lumber, coal, and railroads—exist by *moving* material from one place to another.

Manufactories, on the other hand, exist by *transforming* materials from one form to another of higher value. The furniture factory changes lumber into furniture. The textile mill changes wool and cotton into cloth. The machine shop puts pig iron, steel, and brass together and makes a steam-engine. The refinery takes crude oil and turns it into gasoline, kerosene, and lubricating oil. All these industries must have materials. If the forests are destroyed, if the mines give out, if no freight is offered, if no materials are available for the factory, the industry—whatever it is—ceases. The workers must then move to where materials can be obtained, change their occupation, or starve. Materials are as necessary to an industry as men—both are vital. Without men and the labor they put upon it, all material would remain useless and, for the most part, valueless. Without materials to work with, men would be idle and soon desperate.

Every foreman, therefore, has as definite a responsibility for the efficient and profitable handling of the *materials* under his care, as for the just control of his workmen and the effective use of his machinery.

Materials Must Be Ready When Needed.—Henry L. Gantt once told the writer that, in his opinion, "Two-thirds of all the gain possible through the most efficient management could be realized by having all the material ready *when* you want it, *where* you want it, and *in the condition* you want it." This was independent of all time-study, wage systems, or any of the frills of modern efficiency systems. But, simple as this program sounds, it represents two-thirds of the whole problem of management and comprises the larger part of production control.

The foreman is the executive in immediate control of shop conditions and he is the one who must make these conditions right. To do so will call for nothing less than the best there is in him—intelligence, foresight, close watching, and promptness in action. In large plants some of the planning may be done for the foreman, but that planning cannot be made thoroughly effective without his cooperation and support.

In a well ordered shop, the material and tools required for the job immediately in hand will be where they are needed, in proper condition, and in sufficient quantity to cover ordinary contingencies. The materials will be ready, also, for the *next* job, and succeeding jobs will be "lined out" in the order of their importance. The material required for each job will be procured sufficiently in advance to make delay of production impossible. The foreman of such a shop will sleep nights; he will run his job and not let the job run him.

Things to Remember in Purchasing.—In any industry large enough to employ foremen, the material needed will be obtained through a purchasing department. In the smaller plants this may be a single individual. In larger ones it may run into a complicated organization. No well run plant would tolerate the promiscuous purchasing of material. It would "go broke" if it did. Skillful purchasing requires that the buyer should get:

a. Lowest prices,
b. Suitable quality,

c. Adequate quantity,

d. Satisfactory deliveries.

In addition, there must be:

e. Accurate checking of the goods received,

f. Authorizing of payment therefor.

To secure these—to maintain a definite purchasing policy and to avoid duplication and confusion of orders—it is always desirable to have the responsibility rest in a single individual. This man must have business ability of a high order and only in a very small concern would he have time to care for any other duties.

The Source of Requisitions.—The purchasing agent seldom originates the demand for the material he buys. This comes to him in the form of requisitions. These originate from various sources—the storeroom, the engineering department, or the production control department; they may even come from the foremen if the nature of the business and its organization so demand. In most cases, the foreman will to some extent have to requisition materials and it is desirable that he should know something of the principles underlying requisitions. If he carries stores of materials used in his department, he may requisition the purchasing agent for these stores. If there is a general storeroom, he may requisition his material from it.

Necessity for Carrying Stock.—A storeroom is necessary as a sort of fly-wheel to take care of the fluctuations between the material coming into and going through the plant. The rate at which material is used varies, and you can't always go out and buy it over the counter when and as you may want it. Questions of deliveries, freight tie-ups, and all sorts of complications produce fluctuations in the rate at which material can be obtained. Unless a safe stock is carried right in the plant, where you are sure of it, the business may be shut down every little while. The storeroom is, therefore, necessary to ensure continuity of operation. It is a heavy expense, though, for the materials in it tie up a good deal of money which is not earning anything, and it costs a lot for care, housing, and insurance. The quantity in stores should, therefore, be kept down to the *lowest limit consistent with safety*.

Sound Practice in Making Requisitions.—If the foreman has charge of the stores and determines the amount to be carried and ordered, certain questions must be answered in connection with each item on storage. On items which are being drawn out regularly, he must order a new supply in time to have it on hand before the present stock is exhausted, otherwise there will be a shortage. There are, therefore, two questions which must be settled, namely:

1. What shall be the minimum stock allowed before requisitioning for new material?
2. How much stock shall the foreman order?

No definite answer can be made to these two questions, but there is very sound practice which can be applied in almost every case, and that practice is based on the element of *time*. It may be stated thus:

Sufficient *time* should be allowed, on the basis of past experience, to have the order put through the clerical machinery and the mails; to have the material made by the vendor, shipped, received, and inspected, with a reasonable allowance for delays all along the line.

The time which is represented in that paragraph varies from a week to many months, depending on the nature of the item. Stock articles obtainable from the wholesale houses in the town where the plant is located may require only a day or so. In the case of other supplies, such as steel, the mills may be sold out for months ahead and this must be taken into account.

Minimum Stock with Safety.—The "minimum stock," or that point at which a new order should be placed, would therefore be the quantity which will carry the shop on this article during the length of time required to get the new material, plus a certain quantity for leeway. In Book I, page 132, you were given a simple method of keeping track of minimum stock—there called "order point." While that method referred primarily to tools, it is equally good for many lines of materials. Another way of fixing the order point is the "two bin" method, for materials that can be carried in bins. A large bin holds the quantity of stock necessary for a given period. A small bin stands beside it, holding the minimum stock. Both bins are filled at the same time. When the material in the large bin is exhausted, an order should at once be put in for sufficient material to fill both bins. If material is ordered on the basis of an established minimum, the shop can be drawing from the small bin at the ordinary rate and there should still be a safe margin left by the time the new order is received and goes into stock.

Quantity of Material to Be Purchased.—The second question, namely, the quantity to be purchased, is largely a matter of policy and is to a large extent governed by the same conditions as the safe minimum to keep in stock. If the material is easily obtained from a reliable source close at hand, moderately small quantities can be ordered. Theoretically, the ideal would be for material to come into the plant, go at once into process, be finished, and shipped out; but this seldom works out in practice. The next best thing is to order the smallest quantity necessary. A month's supply might do; in other cases, six months' or more, these being based upon the normal demand. In general, large quantities can be purchased cheaper and to greater advantage. On the other hand, to do so ties up more money so that, at best, it is a compromise in which the needs of the shop and advantages in purchasing should both be considered. The advantage of purchasing large quantities without the necessity of carrying a large stock can sometimes be effected by placing an order for a large quantity, with deliveries specified on certain successive dates. This keeps the stock small, assures a continuous supply of material, and keeps down the inventory.

Anticipate Needs for Stock.—For his own peace of mind, the wisest thing a foreman can do is to form the habit of *anticipating his needs.* The time of many foremen is taken up in chasing shortages, the larger part of which might have been avoided by forethought and planning ahead. The purchasing of material to meet emergencies and shortages is a bad thing all around. It takes more time for everybody concerned than routine ordering through the regular channels, the prices are almost invariably higher, the quantities smaller and more troublesome, and the shipments frequently have to be made by express instead of freight. All this can usually be avoided by anticipating the needs.

Make Allowance for Shrinkage.—In making requisitions, proper allowances should be made for shrinkage. It is seldom that 100 per cent of the material put into a process will come out in the final product. Whether it be cloth, wood, or steel, some material is cut away, some lost, and some spoiled. Proper allowance, therefore, must be made in the requisitions for raw materials to care for this. In many cases, such as an automobile plant or a gun shop, a "bill of material" is made out covering every piece, however small, which appears in the finished product. On this bill is listed, not only each part, but also the number required, the rough size of the material from which it is to be made, the amount of stock required, and allowances for cutting-off, based on experience. Where this is the practice, the foreman is largely relieved of the responsibility of allowing for shrinkage.

Requisitions Should Be Clear, Correct, and Complete.—The foreman's own interest, as well as the firm's, requires that all his requisitions be clear, correct, and complete. This means, first, that the requisition must be *written plainly* so as to be read easily. It must specify exactly *what* is wanted and the *quantity* in terms which will be understood, not only by the storekeeper and the purchasing agent, but also by the outside man who is to supply the material. It should be worded in a way that can mean only *one* thing.

Next, state the *order* or *job* for which the material is requisitioned. In many plants, it is the practice that material for but *one* order or job shall be on a requisition. If the same kind of material is wanted for several orders, separate requistions are made for each order. From the foreman's point of view, the purpose of a requisition is to *get* material, but the requisition serves a double purpose: It is to get the material; also to provide a basis for figuring costs. Therefore, all requisitions should specify the use to which the material is to be put. When this is done they supply primary information for the cost accounting department.

State clearly *when* the material is wanted. If it is wanted in a week, say so. If it is wanted in a month, give the date. This helps those who are supplying the material to get the proper preference in deliveries. State what *department* the material is for and *where* it is to be delivered. This helps the receiving clerks when the material comes in, and saves delay and confusion.

There are two other things which the wise and experienced foreman will never omit. The first is to *date* every requisition, which will cover him in case of controversy, and the second is to *keep a copy*. Finally, every requisition, to carry any authority, should be signed by the foreman himself or someone definitely empowered to sign for him. Requisitions not so signed should have no standing whatever. Verbal requisitions and orders over the telephone should be used only in case of urgency and should be followed immediately by confirmation in writing.

Section II

Receiving, Checking, and Inspecting

The Receiving Platform.—Preferably, all raw material enters the plant at one place, which is provided with receiving platforms where railway cars can be sidetracked or trucks backed up. If the concern is large, most of the materials will be received by rail; if it is a small detached plant, they will come in by trucks. In a city plant, receipts by truck will be large even if there is a railway connection. In many plants, owing to limited track facilities, it is necessary to use the same platform for both receiving and shipping.

This means more care in order to avoid confusion between the incoming and outgoing material.

The receiving platform should be located at the level of the cars or trucks, as this very greatly facilitates handling and lessens chances of breakage. If it is at all possible, there should be ample, clear floor space adjoining the platform and under cover where the goods may be classified and checked. A crowded floor means confusion, the pawing over of boxes and packages in checking, the mislaying of articles, and the possibility of damage. Of course, the platform should be sheltered from the weather and afford protection from tampering and theft. If possible, the receiving clerk's office or desk should communicate directly with it.

Checking Bill of Lading and Shipper's Invoice. In receiving material, the first essential is to see whether it has been *damaged in transit.* No receipts for the material should be given until this is done. Claims for damage in transit are almost impossible to have recognized after receipt has been given; consequently, claims for breakage should be made at the time the goods are received.

After making sure that the packages, crates, or goods have been received in good condition, the contents of packages should be *checked with the shipping list.* It is customary to include a shipping list in each package to show what the shipper claims to have packed and what the package should contain. It is usually a copy of an original which has been forwarded by mail and which should be on hand when the goods are received. The goods should be checked with this invoice to see that all the material claimed to be in the package is there. Most concerns supply the receiving clerk with a copy of the order for the goods to enable him to identify the items and check them. Without such copies he might receive goods not ordered, or goods which had been canceled or were in excess of the quantities ordered.

It is the practice in many plants for the receiving clerk to record all receipts on a triplicate form, the original of which goes to the purchasing department and is attached to the invoice; one copy follows the goods to the inspector and thence to the storekeeper, and the third is retained on file by the receiving clerk.

What the Checker Must Look Out For.—In general, incoming material should be checked and inspected for the following:

1. Quantity and number of pieces,
2. Conformity to the terms of the order,
3. Physical and chemical properties, if necessary,
4. Accuracy as to size, and finish,
5. Fitness for its purpose.

Let us consider these points in detail.

1. The quantities received are usually checked *by counting or by weighing.* Frequently, to save time, counting may be done by weight. There are various methods of doing this, and scales have been developed especially for this work. One

method of counting by weight is to count out a definite number of pieces, say one hundred, and place these on one pan of a balance. Pieces may then be piled on the other pan, and when the two are in balance, the second pan will presumably contain the same number as the first. This lot may then be placed in the first pan with the original lot and the operation repeated, so that, by doubling up this way, large quantities may be counted in a short time. It is obvious that the count on the first lot should be accurate, as any error would be doubled with each operation. Scales which are designed especially for counting perform the operation much more effectively than the plan mentioned.

2. The goods should be checked for conformity to the terms of the orders as to *brand, style, grade, etc.*

3. It may be necessary in the case of such materials as steel to insure that they conform to physical, chemical, or other specifications. Where this is the case, samples are usually taken from the lot and sent to the laboratory, which may be in the works or outside, for a test. The material represented by the samples should be held intact until the report on the samples has been received; otherwise, although it may be found unfit, in the meantime it has gone into general stores and has been mixed up with material on hand. Thus, it would be impossible to pick out the material which should be rejected.

4. Inspection for accuracy in *size or finish* is often very important. In many machined parts received in an assembling industry—crank shafts, axles, etc.—the parts must be inspected to insure accuracy of machining, hardness, etc. If the part is an important one and its performance vital, there is usually 100 per cent inspection. If their service is not vital and the parts are used in great quantities with little likelihood of much variation, it may be sufficient to inspect a certain percentage or a certain number from each lot received. If the samples so selected are all correct, it may be safely assumed that the remainder of the shipment is satisfactory. If any of the samples are found to be below requirements, then a larger number and even the whole lot should be tested. Inspection for *finish* usually requires inspection of each article.

5. Where it is not a matter of exact size, frequently inspection may be covered by examination for the *fitness to the purpose* for which the material is intended—leather is examined for blemishes, cloth for drop-threads, etc. Rejected material should be reported at once to the purchasing department for return to the vendor or for other adjustment.

Storeroom Inspection.—The inspection of incoming material is frequently a function of the storeroom and should be done before the material goes into stores and before any work is done on it.

There should be positive assurance that it is suitable to its purpose before money is spent on it.

We have pointed out in the previous section that the foreman's first responsibility with regard to material is to requisition it correctly. His next responsibility is to be sure that the material is all right before he starts work on it. Either he should do this himself, or know that it has already been done for him.

Section III

Raw Material in Stores

Functions of the Raw Material Storeroom.—Whether or not a foreman's responsibilities include the carrying of raw material stores, he is almost certain to have some contact with the storeroom and should know something of the function, equipment, and practice of storekeeping. The functions usually performed by the raw material storeroom are:

1. Checking the quality and quantity of the material received.

2. Storing all material safely where it will be available, and as convenient as possible for use in production.

3. Issuing, on requisitions, the exact quantities needed, charged to definite order numbers.

4. Maintaining reliable records:
   a. of material received,

b. of the quantity of each item on hand at any time, and

c. of the material issued and the order number on which it is issued.

The checking and inspection of incoming material were considered in the previous section. As stated there, that should be done before the material is placed in stores. This section will take up various phases of the equipment for, and the maintenance of, raw material stores.

Location of Storeroom.—In the location, layout, and equipment of stores, the following elements should be considered:

1. The location in the plant. It must be determined whether the stores should be concentrated at one place or whether there should be branch storerooms.

2. The kinds of stock.

3. The grades of stock.

4. The varieties of stock.

5. The amount of each item to be carried.

6. The methods of storage.

7. The conditions of storage required; such as, the nature of containers needed, exposure to weather, temperature, fumes, fire protection, light, loss, theft.

8. Methods of handling the material.

These all govern the space needed and influence the location. The storeroom should be lo-

The easiest and most efficient way of storing materials in boxes or bales. Elevating trucks are used to lift and place the packages, thus saving great areas of floor space as well as labor.

Photos supplied by the Economy Engineering Company.

The upper picture shows how to store barrels of non-liquid material. The lower picture shows the modern way of storing barrels containing liquids. Tiers may be run up still higher. Bungs are turned upward, thus preventing leakage. Elevating trucks lift the barrels as high as may be necesary.

Photos supplied by the Economy Engineering Company.

cated conveniently with reference to the receiving platform on the one hand and easy distribution to the shop on the other. A good arrangement is to have the material enter it on one side, pass through, and leave on the other side. The amount of space required will depend on the kind, quantity, and volume of goods to be stored. If the materials are very heavy, the storeroom must be located on the ground floor. The overloading of floors in a storeroom must be constantly guarded against. Enormous weights can be piled up without realizing it and become a source of danger to the building. This element must be carefully considered in planning any storeroom lay-out. Enough space should be provided to afford free access to all articles and to make it possible to move any of the material without disturbing the rest.

Kinds of Storage Space.—The kind of stock carried will determine the kind of storage space to be provided. Rough material may be stored in bulk, as coal in bins. If unaffected by the weather, it may be kept outside in the yard, as in the case of pig iron. If it comes in barrels or sacks, it may be stored on an open floor space in regular tiers. Structural steel is usually kept in open air storage and bar steel in racks under a shed. In locating such racks, there should be enough clear space between the ends of the racks and the cars from which the material is unloaded to accommodate the full length of the bars. The grade of material is usually designated by painting the ends of the bars some color, according to a code established for the purpose. It is obviously desirable so to locate the stock that similar kinds will be in the same general location, subdivided if necessary into the various grades of each kind.

Arrangement of Bins.—Materials which can be carried in bins should be arranged in tiers on each side of aisles, usually with the larger and more active stocks on the floor level, and the lighter and slower moving lots in the upper tiers. The greatest accessibility should be given to those articles for which there is the most active demand. In making the lay-out, flexibility should be considered as far as possible, because it may be necessary to carry more of one item at one time than at another; consequently, adjustability in bins will often be found a great advantage.

Steel bins are by far the best. While they are expensive, they take less room and can be made much more flexible than the old type of wooden bins. Wooden bins are cheaper in first cost, but form a very real fire risk, are less easy to be kept clean, become oil-soaked, and deteriorate rapidly. Various types of sectional steel bins and shelving are on the market which can be adapted to almost every purpose. Small and valuable articles may be kept in lockers or drawers, but the general run of material is kept in bins or racks, either of the closed or open type. It is a great advantage to install bins on a unit system, which provides for flexibility in length, width, and depth, and for

The upper picture shows one end of a storeroom of the old-fashioned kind, with materials piled on the floor. The lower picture shows the same room modernized and made efficient. *Photos supplied by Walter N. Polakov.*

adjustment of the shelves to various levels. In well-kept storerooms, the bins are provided with card-holders to receive a card which both identifies the contents of the bin and affords a means of keeping a record of the stock in, and the withdrawals from, the bin. These bin tickets will be referred to in the next chapter.

Branch Storerooms.—All the stores may be carried in one place; but, if certain types of material are used solely in one department, it may be desirable to have a branch storeroom for this material located in that department. Although separated from the main storeroom, it should be administered by the storekeeper. The arrangement, whatever it is, should provide easy access to both the storeroom and the shop, so that men may come with the requisitions for material, receive it, and truck it away without confusion.

The Old-Fashioned Storeroom.—In every modern plant, the storeroom is completely enclosed. There should be no open shelves where Tom, Dick, and Harry can help themselves and mix up the material. The old-fashioned shop, where anyone could wander in and take anything he wanted, at any time and for any purpose, was hopeless so far as orderly care of the stores is concerned. Such a shop never had and never could have an accurate cost system, for it was impossible to know what orders the material was used on.

Kinds of Containers for Materials.—Different types of material present different problems which must be considered. The kind of container will be determined by the material. In general, bins or square boxes are more economical of space than barrels or drums, because the circular shape of the latter leaves much open space in between. Liquids may be contained in barrels or cans, or carried in bulk. If inflammable, as in the case of fuel oil, gasoline, etc., it may be necessary to store them outside of the buildings. These should be stored, not only outside, but in tanks so far underground that if the tanks leak or pipes burst, there can be no flow into any part of the buildings. An overhead tank with a gravity feed is a deadly fire hazard. The effect of gravity should be to drain the pipes back into the underground tank and the oil should be pumped up to the point where it is needed.

Only the rougher kinds of materials should be exposed to weather. Materials which are affected by heat must be kept in rooms where a given temperature range is maintained. Many materials are injured if subjected to acid fumes—finished machine parts, for example. These should not be stored near pickle tubs nor a plating room, as the fumes may damage them in a very short time.

Fire Protection in the Storeroom.—The element of fire protection must constantly be borne in mind, not only in the lay-out of the storeroom, but also in the daily work about the storeroom. All dangerous material should be segregated, to remove its menace from the rest of the plant. Lubricating and cutting oils should be carefully handled, and kept away from all flames and electric wiring. The floors and walls nearby should be protected by metal lining. All precautions should be taken, first, to prevent the possibility of a fire's starting; second, to provide for immediate and effective fighting of any fire which may start; third, to train the workers in the storeroom as to their duties in case of fire. If possible, the storeroom should be equipped with a sprinkler system, and the material and the bins so disposed that all parts of the stores can be reached by the sprinkler water.

Lighting the Storeroom.—It is usually impossible to have good daylight for all parts of the storeroom, but artificial lighting should be provided to enable the storekeeper and his assistants to do their work in any part of the stockroom rapidly and with certainty. If possible, the lighting should be arranged to reach into the recesses of the drawers, bins, and other containers. If this cannot be done, convenient portable lights should be provided for this purpose.

No Admission to the Storeroom Except on Business.—As mentioned before, the storeroom should be completely shut off from the rest of the plant and all loitering in it prohibited. Only those who are duly authorized should be allowed inside the enclosure. The storekeeper is properly held responsible for all the material in his care, and only with such a restriction can this responsibility be justly placed upon him.

Storeroom Practice.—How much stock to carry of each item in stores is a difficult and complicated question. So much money can be tied up in stores that this question should be determined in conference with others and not left to the storekeeper alone. The purchasing agent, the manager, and other officials may have a part in determining the general policies involved, though the working out of the details may be left to the storekeeper.

Requisitions made by foremen for materials go first to the storeroom, and, if the material is not in stores, the storekeeper will put through a purchase order for it. Having all material concentrated in the storeroom is useful in cutting out duplications arising from the ordering of material which is already in the plant but not known to the person who makes the requisition. Another effect of a storeroom is to standardize supplies. Without concentration of the material there, small stocks of similar articles are almost certain to spring up in different parts of the plant. If these are brought together into a single stock, the need of standardization becomes apparent at once. Even in the best run plants, obsolete material will accumulate due to over-ordering, changes in design, etc. If this is in a storeroom, it will make itself known and steps can be taken to clear out the stock when it is an advantage to do so.

Absolutely no material should be issued from the stores without an order signed by a foreman or other authorized person, and the material should be charged to some definite order. This will be either a stock production order or a customer's order. Most accounting systems have standing order numbers to which expense or indirect material, i.e., material which does not go directly into product, may be charged. It is quite as much a function of the storeroom to furnish the basis for the cost records as it is to keep the material; and the maintenance of a storeroom would be justified if it served the former purpose only.

Section IV

Issuing and Accounting for Stores

Withdrawing of Material from Stores.—In the foregoing sections we have considered the ordering of material, the receiving and inspecting of it, and the carrying of it in stores. Receiving and storing material involve less work and simpler operations than its delivery to the shop and the proper accounting of these deliveries. Material goes into storage in large quantities. It is usually withdrawn irregularly and in varying quantities, often very small ones. Every one of these issues should be made promptly and accurately recorded. As there are many more issues than receipts there is greater danger of mistakes.

Storeroom and Requisition Forms.—The form of requisitions for withdrawing material from stores varies greatly with different production methods and cost accounting systems. We give a few simple examples which will illustrate the

ORDER ON STOREROOM

THIS REQUISITION WILL NOT BE ACCEPTED IF CHARGED TO MORE THAN ONE ORDER OR IF ORDER NO. IS OMITTED, OR IF NOT SIGNED BY FOREMAN.

ORDER NO.

QUANTITY	MARK NO. OR SIZE	NAME OF MATERIAL	WEIGHT

FOREMAN'S SIGNATURE

DATE

Figure 1

BIN TICKET

BIN NO. ________

MARK NO. ________

NAME ________

MACHINES ON WHICH USED ________

DRAWING ________

PATTERN ________

DIMENSIONS ________

WHEN ONLY ____ LEFT WRITE OUT NEW TICKET AND SEND THIS TO STORE-KEEPER

DATE	STOCKMAN'S NAME	IN	OUT	LEFT

BALANCE ON OTHER SIDE

Figure 2

TEMPORARY BIN TICKET

STOCK LOW. When stock falls below minimum, fill out and attach this ticket. Send regular ticket to head stock clerk. When regular ticket is returned this ticket to remain attached to back of regular ticket till stock reaches required quantity.

BIN NO. ________

MARK NO. ________

NAME ________

MACHINES ON WHICH USED ________

DRAWING ________

PATTERN ________

DIMENSIONS ________

DATE	STOCKMAN'S NAME	IN	OUT	LEFT

BALANCE ON OTHER SIDE

Figure 3

points brought out. Figure 1 is an Order on Storeroom for withdrawal of supplies. Figure 2 is a Bin Ticket for recording receipts and withdrawals. Figure 3 is a Temporary Bin Ticket to be used to call attention to the fact that the quantity is below the low limit. The essential features of the forms are:

1. A clear and unmistakable description of the material.
2. The purpose for which it is withdrawn.
3. An authorized signature.
4. The date.

Upon delivery of the goods called for, the requisitions are stamped or signed to indicate that the material has been delivered; and, after proper entries have been made in the store records, they are usually forwarded to the cost accounting department as a basis for cost determinations. The requisitions are usually in duplicate, the original of which goes through the storeroom and a copy is for the department receiving the material. In the smaller plants they may be made out by a foreman or his authorized clerk; but, in highly developed shops, where there are production control departments, the requisitions are made out at the time the production order is issued, together with the receipts for the necessary material, so that the foreman does not have to make out requisitions for the material needed. In general, a well-organized planning department provides all orders covering the material, not only the requisitions from stores, but work orders and all orders to move the material between departments during the progress of manufacture and orders for assembling the material into the final product.

If the material is all on hand and can be delivered at once, its issuance is simple and easily recorded. Sometimes, however, only a part of the material called for can be delivered. There is, then, a shortage which must be promptly made good, usually by the placing of orders through the purchasing agent. These shortages are critical and must be vigorously followed up by all concerned until the material is obtained and the shortage wiped out.

Deferred Deliveries.—All the material called for on an order may not be needed at once. In such cases, a date or series of dates may be specified when the material will be required. One way to care for this situation is to set aside the material covered by the order in boxes or containers, marked for the order number on which they are to be used. Although these containers may be kept in the storeroom until the material is required, their contents are treated as if already issued, although they are physically still in the storekeeper's possession. If there are a large number of deferred deliveries, and it is inconvenient to carry the material separated, as shown above, they may be cared for on the store record sheets, where the items called for are entered for delivery, proper deductions are made, and the balance remaining is considered as being the stock on hand. Suppose there are 2,000 units in the stores and a total of 1,500 are assigned. The balance only—500 units—will, therefore, be treated as available for requisitions which may come in on future calls.

Issuing Stores in Sets or Assemblies.—Where a set of items are regularly called for in groups as, for instance, those represented on a bill of material, time can be saved by carrying these items in lots and issuing the lot on a single requisition. This is practically what is done when a subassembly is issued. In this case, the materials have been previously issued separately, assembled in the shop, and returned to the stockroom for storing in the assembled or semi-finished condition. This is, of course, the familiar practice in all well-run shops.

Three Things to Be Recorded.—It is absolutely necessary that three things should be recorded in connection with every withdrawal from the stores:

1. How much has been withdrawn.
2. What it should be charged to.
3. How much is left.

To a foreman, the actual getting of the material *when* he needs it seems to be the chief element. The absolute necessity of keeping a *record* of every small issue of material may not be so clear. Every one, whether a shop man or not, would admit instantly the necessity for guarding and accurately accounting for every cent which the cashier holds in the safe. In practically every concern, however, the amount of money tied up in the storeroom, in the shape of materials, is vastly in excess of any actual cash in the treasurer's office. Because these values are in supplies instead of in coins is no reason why they should not be guarded and accounted for with the same care.

Relation of Material to Cost of Production. No business can continue in a competitive industry without accurate and detailed knowledge of its costs on every item it makes. To know last year's profit and loss on the business as a whole is of little value in directing its policies. To guide both the sales and the manufacturing intelligently, it is necessary to know just what your output *is costing now* and exactly where and how these costs are distributed. The same profit is not made on everything manufactured. Some lines and some items may show a profit and others a loss. Therefore, the management should have accurate cost data on every item and have it promptly, so that, if losses creep in, their presence may be known at once and the situation met.

Whatever the business, there are three main elements in cost; namely, the direct material, the direct labor, and the overhead. The first two elements comprise such material and labor as can be assigned *directly* to a production or customer's order. The third includes all other items—indirect material, administration expenses, taxes, interest on loans, depreciation, fuel, light, etc. This third element is a large one and may be, even in a well managed business, the largest of the three. It is not possible to figure it specifically for any one order or item. It is, therefore, necessary to assign a proper proportion of it to each order on some reasonable and consistent basis. There are a number of bases on which this is done. Usually the overhead is applied as a certain percentage of the cost of material or cost of labor entering into the item. Generally, the direct labor cost is the best basis; but, in the case of stable and continuous industries, such as salt works or cement mills which turn out a simple and uniform product, the material will form a satisfactory basis. To determine the cost, therefore, it is necessary, whatever system is followed, to know accurately the quantity of material which has been used. This can be determined only by sending *all* material through a storeroom and issuing it from that storeroom solely on requisitions, each of which specifies definitely the order number or account to which that material is to be charged.

Orders Against Which Material Is Charged. The main classes of orders against which material is charged are three. The first consists of *customers' orders,* where the customer has ordered a definite unit, such as an engine, a printing press, etc., and all the material going into it or used for its manufacture can be charged against this order. In the second class, we find *stock orders,* which are for units of standard design, put through in lots as, for instance, 1,000 automobiles, or 100 dozen shoes. These may or may not have been sold to customers; but, as they are all alike in design and material, the cost of the lot may be handled as a unit. *Standing orders* make up the third class. There is a large amount of material used in a plant which cannot be charged to any order, whether customer or stock, such as oil, waste, fuel, office supplies, etc. It is a practice, therefore, to have a system of standing orders covering the various items for which such material is used, against which all stores so used are charged. Practically all material coming into the storeroom will be charged out against one or the other of these classes.

There is one class of material, however, which forms an exception; namely, obsolete material. This is not, or at least ought not to be, large in proportion to the others. If it is large, the causes for it should be carefully studied. The methods of doing so will be taken up in a later section.

The Requisition Is Both an Order and a Record.—It is clear from the foregoing that every foreman should remember that his requisition is not only *an order* on which he obtains material, but is also *a record* by which the firm ultimately determines how much its product costs; and that without such knowledge the firm will not be able permanently to exist in a competitive market. It is, therefore, among the many responsibilities of every foreman, not only to use his raw materials with the best economy, but also to supply, at all times, full and accurate information as to *where* and *how* this material is being used.

Part II: The Foreman

THE MAN AND THE MATERIAL

Section I

The Man and the Discovery

Discovery of Materials and Their Uses.—One of my friends is engaged in a very interesting line of work. His business is exploration—for years he has wandered through little known parts of the world, intent on discovering what these places contain and to what use their products may be put. Every few years he turns up with a series of yarns about the places and the peoples he has met, or the animals and the curious natural exhibits he has seen. The last time he came in, he said that he had been through some mountain ranges in the tropics which had not been explored before by white men. In these mountains he had found a race of people whose weapons were of stone and who had not yet learned to make any coverings. They had discovered the use of fire in the distant past but did not know how to kindle it, so they were compelled to nourish carefully, day and night, embers kept upon an altar in the home village and originally obtained from some far-away tribe. Whenever they went on any trip they were compelled to carry burning brands with them.

My friend said that he supposed these people had found out the cutting effect of the stones by walking or falling among the pieces of rock which fell from the cliffs in the mountains, and had gradually learned how to make use of them. People who have studied these matters see evidences, in the old records of different races, of the way in which materials were discovered. In every case, the intelligent observation of the effect of the material or some circumstance in connection with it was the original reason for its discovery and the attempts to make use of it.

Gold was one of the earliest materials used by the peoples in places where the gold existed, because the bright color of the gold in the sand or the rock would attract the eye and excite the curiosity. In the same way arrows and spears developed from the use of sticks in an attempt to ward off the enemy. The broken branches of trees were used at first and then some attempt was made to shape them so that they would be handier to use. In every case, however, the actual use of the material came after the men had observed the material, had some knowledge of the effect which it produced, and had applied their intelligence to the possibility of using the material.

The Beginning of Industry.—The long painful journey of the human race to a more intelligent use of all natural resources was begun when the material was discovered; but, in the early history of the matter, many hundred years passed before it was discovered how the material could be used for the greater convenience and comfort of mankind. Long after people had given up living in trees and had begun to live in caves, they had not discovered a way in which to use the wood from the trees, except by burning the ends of sticks in fire and using the pointed ends as spears. They learned that stone would cut, and they learned how to find the stone which had the right shape for cutting and, after a long time, they learned to put the stick and the stone together with some new material which would bind them and make a spear, an axe, or a knife.

This was the beginning of industry, for man has always learned, through doing the thing, how it could be improved. The man who could find the sharpest stones was soon the greatest provider of food and the greatest protector of the tribe. Then came the man who discovered how to pound these stones with another one to produce a better cutting edge. He then became a leader until he was displaced by the man who discovered that he could tie a stone to a piece of stick with a strip of skin and make a weapon that was much more useful than any of the others. All this was a part of the discovery of the usefulness of the material. The same process was also gone through with the things fit for food and the materials for clothes.

Man Advanced Because He Could Think. None of the discoveries mentioned would have been possible if man had not been endowed with thinking powers and the consequent ability to note what he saw, to remember it, and to imagine how he could make use of materials. In other words, the thinking process came first. The whole history of industry reveals an intellectual development of the man through the *doing* of things and then *imagining* how they could be done better. Thus came about continuous development of skill in doing things and improvement of the result.

Improving the Materials.—In further discussions about the tribe which my friend had visited, he mentioned how they made their stone hatchets, knives, and arrow heads. For each of these weapons different stones were chosen, and the stones were pounded with other stones until they had been put into proper shape with a cutting edge. Then the maker selected sticks to be attached to the prepared stones. He would take a short, sturdy stick for the knife handle, a thin, straight one for the arrow, and a long, substantial one for the axe. These sticks were trimmed down and shaped by other stone weapons in the hands of the workers and finally the heads and the shafts were joined together by thongs made from skins.

This work with the stones and the sticks was work in *improving the materials,* and naturally came to pass as the workmen became more skilled in their work and more apt in the manufacture of the articles upon which they were engaged. Still, the progress was unbelievably slow. With the crude methods which they had of finding the materials and of arranging them, it took a long time for a man to make a weapon, while the task of securing food and devising protection against wild animals was so urgent that very little time could be given up to these matters except as they were actually necessary. Here, as in all improvement, it was the actual *necessity* which gave an incentive to the intellect so that it got to work in devising improvements. Further, there were no other means of securing the knowledge and skill than by watching other men and gradually trying one's hand at the art. None of the knowledge was organized; moreover, it was gained by very crude experiments and the slow observations of the individual. Nevertheless, you and I today, in the materials we use and the things with which we have to work, are the inheritors of all this long struggle to conquer the difficulties of life and to establish better methods of living.

Organizing Knowledge.—Many thousands of years were necessary before man had passed from the stone age and had learned to build great houses and towns and to live with considerable comfort through the manufacture of useful products from many materials. When language and the art of writing had developed sufficiently, men began to record the things they had found out and the ways in which materials were handled to make things. In other words, we began to organize knowledge so that it was available for everybody, not merely for the apprentice who worked with the maker and could get his lessons from the skilled craftsman's lips. So, each step of the way since the art of writing entered in, the speed of discovery and improvement has been quickened by the *record* of all that has gone before and by the use of that record in saving time on keeping up the work of development. Improvement now proceeds at a much more rapid pace than in any previous era, because for years we have been able to print cheaply information about what has been accomplished in the past.

Section II

The Man and the Possibilities

Newton and the Falling Apples.—Perhaps some of you remember the old tale of the astronomer, Sir Isaac Newton, whose studies of the heavens had so important a result for the succeeding generations. It is told of him that he was out in his garden one pleasant day in the fall and, to shade himself from the sun, had sat down under an apple tree to read. There was a gentle breeze blowing and the branches of the tree swayed sufficiently to loosen some of the ripe apples. The noise of the apples striking the ground attracted his attention and he finally began to wonder *why* these apples fell. He knew that things always had fallen, but he had not thought about why they fell until the apples set him to thinking.

It was Newton who formulated for us the great laws which underlie gravitation, by which we know, not only why things fall to the earth, but why they fall with greater force if they fall from a greater height. Knowledge of that law of gravitation makes it possible for us to measure the exact speed of a pound weight at the moment when it hits the earth, no matter what the height is from which it falls. This was a wonderful discovery, for it enabled man to do many things which he did not know how to accomplish before.

For thousands of years before Newton's day men had seen things fall to the ground and they had made use of that knowledge, but the use had been very much limited by the fact that they did not know *why* things fell. It was not until Newton worked out the laws of gravitation that man was able to utilize properly the weight of things. So, finding out *why* things happen is often a much longer job than observing that they *do* happen. It is the next step, though, in the progress of getting things used to their full value.

Newcomen's Steam Engine.—After we find out why things happen, we are in a position to set our imaginations at work in order to make things happen in a better way. The first practical engine that was ever built with a steam cylinder and piston was made by a man named Newcomen in England about two hundred and fifty years ago. That engine was worked by heating water in a boiler until the steam rose and pushed a piston up. To get the piston down again, the cylinder was cooled by running cold water on the outside until the steam inside condensed and the piston fell. There was a pipe to carry the steam to the cylinder and another pipe for the water. In the first engines, which were used in the Cornish mines to pump out the water, the valves on these pipes had to be turned by hand. Boys were hired to turn on the steam valve first, then to close that and turn on the water valve.

It is said that one boy found this job a nuisance and, knowing why these valves had to be turned regularly, he tried to rig up some way of getting them turned without having to do it himself. He watched the beam of the engine go up and down and saw just when the valves had to be opened and when they had to be shut. He then attached a string to the beam at the right place, tied the ends to the two valves and got the engine to do his work. This was the first time in the use of the Newcomen engine that the valves had been turned by the engine itself. After that all the engines were equipped with valves which were opened and closed by the movement of the engine. That boy saw that the beam of the engine in going up and down could do his work, so he made the improvement. The improvement came, however, after he had seen in his imagination what could be done. His imagination then helped him as the result—or reward—of studying the machine itself and finding out exactly what it did and why. In this case, as in all other cases of mechanical development, the thinking came first and the practical result came afterwards.

Improvements in any industrial operation always come about from the careful observation of *what* happens and from the understanding of *why* it happens. But, next, there must be the ability to *imagine* a way of making it happen more quickly, or with less effort, or more regularly.

Finally, the thing which we have thought out must be constructed and we must try to make it work.

Make Accurate Records of Discoveries and Improvements.—There is one more point, the real value of which we do not appreciate, and that is the writing down of the thing which has been discovered so that other men will not have to spend time in making the same discovery but can learn about it and go forward that much more speedily. When Newton discovered the law of gravitation and wrote it down for us, it was passed on to thousands and thousands of young men who were becoming educated so that they would be able to start their experimenting at the point where Newton was obliged to leave off. That is the real reason why we have been able to develop our wonderful system of producing useful things and why the world can now support a population many times larger than that of a few centuries ago in greater comfort than the kings of those days were able to obtain.

Learning from Defects.—A friend of mine, who is the head of a rather famous school of art, says that "beauty is the strictest usefulness." What he means is, that, when something has been made so perfect that there is nothing about it that is not necessary to its usefulness, it becomes beautiful. I am inclined to agree with him, for I know that simplicity is the ideal of the thinker in industry. No machine was ever built that was not, at first, clumsy and crude and complicated in its movement and control. By constant observation, thought, and experiment, it is made more simple and more easily controlled in its movements until it loses every superfluous part and every unnecessary motion. Take a look at the little old engine which stands on the mezzanine floor of the Grand Central Station in New York City—that ancient locomotive and the three funny little stagecoach cars behind it. Then look at the engines and the cars of today. They have been improved continuously. Yet, they are more simple, more thoroughly useful, and more valuable in their capacity to do a great deal of work with a minimum of effort and attention. They are more beautiful than the first engine and coaches, I think, and their beauty arises from their more perfect adaptation to their own service.

In the century since that seemingly toy locomotive and its little train of cars ran from Albany to Schenectady, thousands of men have been studying the railroad, its equipment, and its necessities. They have seen a defect here and there and they have set their imaginations to work until they have conquered these difficulties. First one defect and then another has been seen and improved. Probably the engineers who built the first locomotive did not see any defects in it. They could not see them until they themselves had learned more by studying the thing at work and then by going back to their books and finding out how to apply this knowledge in improvements.

That is what is meant by learning from the defects of the machine. In so learning we increase our store of exact knowledge and thrust it forward with our imaginations into experiments calculated to correct errors in efficiency and so reach perfection.

Section III

The Men and the Processes

Developing New Processes Requires Patience. When you have been idling away a few minutes looking at the store windows on an off day, perhaps you have noticed some of those wonderful vases with rich deep coloring. I do not mean the flat, thin effects which are secured by ordinary painting or enamel, but the deep blue of the sea or the brilliant red of the sunset. These vases are produced by firing the porcelain after the enamel has been put on, so that the enamel is baked on with considerable heat until it becomes a part of the porcelain itself.

A French potter named Palissy is credited with having first succeeded in doing this kind of work in Europe. It is related how he got the idea that, if he could paint vases and other pottery and then bake them in an oven sufficiently hot, he could get a coloring which would last, which would be deep and rich, and which would be a part of the pottery. He started to experiment, but he had no way of telling just how hot his oven was, and no way of keeping the heat at a certain point. Year after year he tried the experiments with little success. He even went so far as to chop up his furniture to provide heat for his oven and was almost put out of the house by his family. His friends said he was crazy, but he finally succeeded in securing the right kind of paint and the right kind of baking effect.

After we have the idea of doing a thing, or after we see the possibility of accomplishing a thing, many experiments are necessary before we gain sufficient practical skill to bring the thing up to the point of usefulness and of value. That is why many industries today have experimental departments where experts are engaged all the time in trying out the different ideas and developing them to the point where they show some value and some probability of success. Very often, the discovery of a new way of making a useful product requires new machinery or new arrangements of the work in order to put the new proposition through. All this must be worked out before the product itself can be made in sufficient quantities and for a price that will make it a commercial success.

How Changes Are Suggested.—When an article is first put out to serve us in any way, it is inefficient. The first automobiles had a hard job doing more than ten miles an hour and they did not hold out for more than a few miles at a time. They broke down about every three miles, and twenty-five miles in a day was a good record. Compared with the work which can be done by an automobile today, the first experiments seem crude indeed. Think of all the changes which have been necessary to make the motor of today out of the old horseless carriage which would not go half as well as the horse it was displacing!

Everything from the frame to the top of the automobile has been entirely changed. Thousands of changes have been made year by year to secure the present results. None of these changes was made easily and none of them could have been made by experimenting in the shop or in an experimental department. They were made because the *use* of the automobile revealed the necessity for the changes and, as the necessity showed up in using the cars, the changes were made until the present cars became the result of those years of development. When those bold men who bought the first automobiles tried them out, they found they had to become expert in the repair and care of the machines they had bought. No one else knew anything about them except the man who made them and he was none too sure of what was wrong when the car went dead. So they learned to take the thing apart and put it together again, and frequently they thought of some little improvement to be made on it. The man who made the cars was hearing about them all the time or seeing his customers, who brought defects to his attention right along. The pressure was on him to do better and that pressure never ceased. So, in one way and another, changes were suggested by the use of the car and each of these ideas led to new experiments, until, finally, the new ideas were proved sound and adopted or were proved unwise and discarded. It is only necessary to talk to men who have been in touch with this business through the years of its growth to hear about the many, many changes which were made from time to time and which disappeared because they proved to be valueless.

It is well to remember that it is the user of the product who sees the defects of its service. It is he who puts pressure upon the maker in the form of a demand for improvement, and it is this demand which is constantly suggesting changes in the product or its method of manufacture.

How Development Continues. — All these changes which were effected in the automobile were important, but none of them were as important as the organization development which occurred at the same time. The most important part of this growth was the rapid exchange of knowledge between the men who were making, those who were designing and changing, and those who were using the automobile. Thirty years ago, there was no automobile. Today there is a scientific library written upon the subject which extends into hundreds of volumes and the Society of Automotive Engineers is one of the largest and most powerful of the technical societies.

It is the interchange of knowledge which is the most important part of the development and which has made the development of modern industry so continuous. No sooner is it proved that an experiment is successful than a number of men begin to find out why. They write down a statement of the *why* and that is analyzed further until the accumulated body of exact knowledge is very extensive and enables us to build rapidly from one improvement to another without going aimlessly in every direction. In the early days of the automobile, freak cars were common, and new ways of doing this and that were constantly cropping up, but as the knowledge was thoroughly exchanged between the different men who were interested, it was not long before anything radical and freakish was almost unheard of. The knowledge had become so exact that men knew the necessity for certain basic things about every car and the progress of the industry was moving more and more along lines which could be predicted with some certainty.

Section IV

The Man in Control

The Character of the Skill and the Exactitude of the Skill.—The ancient hand worker, who was a skilled craftsman, made good things and very often he made beautiful things. We admire him for the character of his work. He put himself into his product and, when he was a conscientious and skillful workman, that character showed in his work. The things he made were not alike, however, although they might be for the same purpose and made from the same general plans. The pieces varied according to the mood and the moment of their making. Fine things can be made in this way, but they are not made quickly and not enough can be made to give us the multitude of things which serve our convenience today.

It was necessary for us to learn to repeat the same work in order to get things done at a speed and for a cost which would enable us to enjoy more of them without requiring an enormous amount to be spent in getting them. So we had to add to the *skill of character*, the *skill of exactness* which would enable us to repeat the same design or the same construction any number of times. This is the development which has enabled us to use machinery to such advantage and has given us such a multitude of products and such a volume of service for our social life and our community existence. Some people think that we have lost our skill of character in work in our development of the skill of exactness, but that is not so except in a general way.

Products are made today of the utmost beauty and they are made to last. There is much work done which is work of sterling character, but, in addition, it is work of exactness, repeated thousands of times so that thousands of people can enjoy the service of the articles produced. Only a few might enjoy it, if we were not able to produce in quantity.

Organizing the Skill of Exactness.—Just as soon as we learned something of the skill of exactness and were able to repeat things, it was necessary for us to divide our work so that man's time and his tools could be used to the utmost advantage in preparing the thousands of products which it was possible to make under these new conditions. No one man alone could do all the jobs that are necessary in the making of tables or chairs or cloth or any of the other useful things now made in great quantities with the aid of modern machinery.

It is obvious that, with all this subdivided effort and these hundreds of jobs to be performed in order to finish a given product, no one man can be sufficiently familiar with all the details of the work, its value and its wastes, so that the organization can be kept going and improving. Therefore, the supervisors, from the head of the establishment down through the different departments, are divided up so that they exercise control over a part of the work only. Of all the supervisors, the foreman, being in direct contact with his portion of the work and the men who are doing it and in charge of the machines which they use and the disposition of the work, is the most important supervisor in the process of the development of the raw material into the finished product.

Knowledge Put to Work.—We hear so much about experience and so little about study that we are in danger of forgetting the dependence of modern industry upon accumulated knowledge. The reason we know how to repeat things so well and to create so much machinery and do so much work is that we have put knowledge to work and kept it on the job.

Before we could put the knowledge to work, however, we had to get it and today we are in the fortunate position of being able to take a few books and acquire all the knowledge for which hundreds of men worked all their lives. Putting knowledge to work is, in fact, the important job of every executive in industry, and for that reason it is necessary to be on the lookout for any additional information which pertains to one's particular business.

This is not only true of *your* work, but it is also true of the workers under your charge if they are to put all their capacity for proficient performance into the job. Unless they know how the most successful workmen arrange their work and unless they keep up some study of the developments of that work, they will not be able to apply their own experiences with the same capacity and the same value.

Control of Industry by Knowledge.—The essential object of industry and, in fact, the essential object of life is to provide the maximum useful service for the people who depend upon us. We can do this only so far as we can control the work by understanding the conditions, the arrangements, the tools and equipment, and the men who are engaged upon the work. Nothing can be improved until we understand it. Everything is possible when we begin to have sufficient knowledge, sufficient skill in its character and exactness, and sufficient incentive to put these to work.

Marvels which have been accomplished in the last few years in industry are sufficient evidence of the progress which can be made as our understanding grows. That is because we control where we understand and we are controlled by the things we don't understand. When we began to understand thoroughly what steam was and under what conditions it exerted its power, we began to put it to work and to provide ourselves with comforts and conveniences by reason of its work. The progress which has been made so far has not been because we have had a few great inventors or a few great discoverers or a few great master workmen, but because we have had more and more men using their intelligence, studying what has been done before, and adding their bits of improvement to the useful service.

The foreman who keeps down the idleness of the machine, who arranges his work so that it proceeds without confusion, who keeps the men occupied and comfortable in their state of mind and who puts all his knowledge to work is performing a human service of the utmost importance and one upon which the future life of the nation depends to a considerable degree.

Questions for You to Answer

1. Repeat Mr. Gantt's three requirements concerning material.
2. What are the five things to remember in purchasing?
3. What two questions must be settled before making requisitions?
4. What are the three requisites to be borne in mind in making out an order?
5. What must a checker look for in receiving incoming material?
6. Name the functions of a raw material storeroom.
7. What elements must be considered in locating the storeroom?
8. What are the essential features of requisition forms?
9. What three things must be recorded when material is withdrawn from stores?
10. What has made it possible for man to discover and utilize materials?
11. Why is accurate knowledge necessary in order to make improvements?
12. Borrow a book on physics and look up Newton's three laws concerning gravitation. What are they?
13. How are changes usually brought about in manufactured articles?
14. What is meant by "the character of skill and the exactitude of skill"?
15. Are you using your thinking powers up to capacity in your work?

Chapter 6

Part I
MOVEMENT OF MATERIALS

Part II
DEVELOPING INTEREST

Part I: The Job

MOVEMENT OF MATERIALS

Section I

Handling Materials in Bulk

The Handling Varies with the Nature of the Materials.—All kinds of materials are handled in the industries—hot and cold, light and heavy, fine and coarse, from sawdust to castings, from gasoline to sides of beef. Many types of equipment are used and it is well for the foreman to consider the various types available, and ask himself if the handling equipment he is using for his material is that best suited to his needs.

The subject of handling materials is a large one and it might be subdivided in many ways. For convenience we will consider it under three headings:

1. *Handling materials in bulk,*
2. *Handling materials in containers,*
3. *Handling individual pieces of material.*

In this section we will take up the first of these; namely, handling materials in bulk.

Make the Material Move Itself.—The first principle is to make the material move itself, if possible. Gravity is the cheapest and surest force we know. If the material is loose and slides freely, it can be dropped from one floor to another in chutes. If it is a liquid, it is run down in pipe lines or is pumped. If the liquid is inflammable, the delivery to the point needed should invariably be *against* the action of gravity from a tank below ground, and all the piping arranged so that it will drain back into the tank. There should be no check valves in the line or other valves which can be shut off. Preferably the pump used should be of the centrifugal type so that, when it is stopped, the fluid will run back through it. This is the only arrangement which obviates a heavy fire risk.

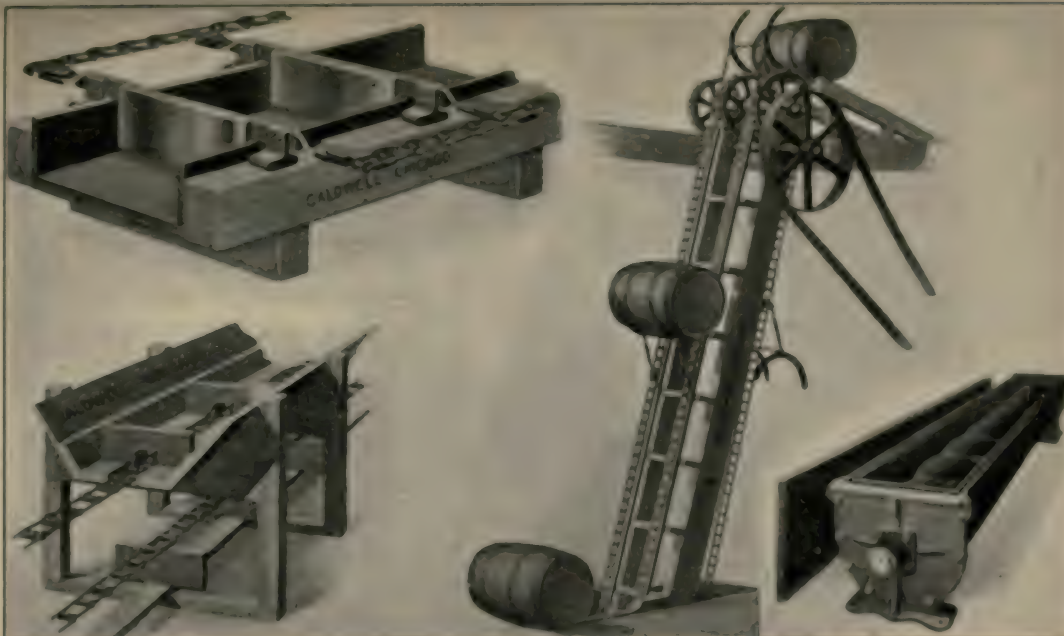
Grain, sawdust, seeds, and other light materials may be moved in pipes pneumatically. It is generally desirable to do this by suction, rather than by pressure, as the pipe lines and their connections are then dust proof. If the air is blown through the tubes, it leaks out at the joints, scattering the material being conveyed. The same principle may be used for moving solids hydraulically. A familiar example of this is the discharge of ashes from steamers, where a jet of water at high velocity carries the ashes outboard. The pneumatic or hydraulic method is convenient for handling light materials, or for handling heavy materials intermittently. It is not economical, however, for handling heavy materials continuously, as it is wasteful of power.

Spiral Flight Conveyors.—For the continuous movement of light material, spiral conveyors are well adapted. These consist of a spiral flight mounted lengthwise around a rotating shaft or drum in a trough. The material is poured into one end of the trough and moved lengthwise by the spiral motion of the flight. Conveyors of this type are well adapted for handling fine material such as seeds, grain, sand, and cement. They can handle large quantities with comparatively little power. In general, the material is dry; but one of the advantages of this type of conveyor is that it can serve as a drier as well as a transporting agent. This function is helped by breaking up the flight into a series of paddles, arranged spirally as broken sections of the flight. Their action is then a combined one of *stirring* the material while it is moved forward. This action also breaks up lumps in certain classes of material. For light materials which slide easily, such as cotton seeds, the troughs are usually U-shaped, made of sheet steel, and fit the conveyor closely so that the material slides along the smooth surface. The material fills the lower portion of the trough, part way up to the shaft. Where the material is gritty, wear on the trough is eliminated by leaving a considerable space between the conveying screw and the trough. This space fills with material which is practically at rest, and the moving material slides along on itself. Spiral conveyors are made in sections from six to twelve feet in length, which may be arranged in a series, each section discharging into the next. Each length must be straight, but they can be turned at the connections in any direction. The diameter of the screws varies from four to eighteen inches, and the total length of a conveyor may run as high as 200 feet for the lighter classes of material. See illustration facing this page.

Another type of revolving conveyor which is sometimes used is a plain cylinder revolving on an inclined axis. The material lying along the bottom is carried up the side to a point where it drops back toward the bottom. Since it drops vertically, and the axis of the cylinder is inclined, it will not drop back in the same place on the cylinder, but a trifle farther along. The repetition of this process moves the material from one end to the other. Its progress is, of course, slow, but it is an excellent device for combining drying or roasting with transportation. The most familiar cases of this type are the long revolving kilns used in the cement mill.

Chain Conveyors.—One of the principal types of conveyor is the chain type, where chains running on pulleys carry scrapers, aprons, or buckets. This type of conveyor is very flexible, has tremendous carrying capacity, can be used for almost every type of material, and will transport it either vertically or horizontally for distances up to 650 feet. There are many types of chains and attachments, designed for all sorts of purposes. Four widely used types are the drag chain, scraper, apron, and bucket conveyors.

The Drag Chain Conveyor.—The drag chain carries prongs or projections which pick up the material and push it along slides or drag it along a track. Examples of this type are drag chain hoists for moving logs along a runway and the



The illustrations at the left show two styles of scraper flight conveyors. At the right are a barrel elevator and a spiral flight conveyor.

Photos supplied by H. W. Caldwell & Son Company

chain on an inclined railway track. This type is best suited for rough work and rather limited in its application.

Scraper Conveyors.—In scraper conveyors, the chain carries at regular intervals scrapers of wood or steel which slide the material along the trough. This type can handle any non-abrasive material horizontally or up inclines not in excess of 40°. The troughs are made of wood or steel or are lined with steel plates. By opening and closing holes in the bottom, the material may be discharged at any desired point or may be carried on to the end. It may also be fed in at any place along the line. It is obvious that this type of conveyor is wasteful in power and unsuited to abrasive materials, as they are dragged along the whole length of the conveyor. See illustration facing page 58.

Apron Conveyors.—In an apron conveyor the chain carries flat plates which sometimes overlap each other like fish scales. These form a solid moving platform, onto which material may be discharged and carried to the end of the line. It will handle any material, abrasive or not, which will not stick to the apron or run through the cracks between the plates. It requires less power than the scraper conveyor, since the material lies at rest on the apron. It is an excellent conveyor for handling heavy, lumpy, gritty material, such as ore, foundry castings, etc., and is also used to convey a great variety of materials and finished products. It usually discharges only at the end, but material may be taken off at any point, especially when the apron is flush with the floor. It is used for horizontal work, but not for grades of more than 30° unless cleats are provided to hold the material so that it will not slide back along the top of the conveyor.

Bucket Conveyors.—The bucket conveyor can be used to convey material horizontally or vertically or both. The buckets are mounted between chains. They are frequently pivoted, so that they will always swing in a vertical position, whatever direction the chain may be running. Attachments are made for dumping the buckets at any point, either on a horizontal or a vertical run. Chain conveyors with pivoted buckets are used in power houses for handling coal and ashes. Coal is dumped from the cars or canal boats into the conveyor, elevated to the top of the bins, carried horizontally to a particular bin, and dumped. The empty bucket continues on over the bins, down to a tunnel underneath the boilers and back to the loading point. The same conveyor is used to clean out the ashes, which are shot from the ash pits down into the buckets under the boilers, and elevated up to a point where they are discharged into the cars or boats.

Many styles of buckets are used, depending on the service. Frequently, the buckets are perforated so as to pick up material out of the water and allow the water to drain off during transit. The buckets may be spaced some distance apart or may be arranged to overlap, in which case this

Link-Belt apron conveyor, bucket conveyor, and portable, self-propelling double-boom conveyor.

Photos supplied by the Link-Belt Company

type of conveyor approaches the apron type previously described. It is also very common to attach the buckets to a belt instead of a chain for a vertical lift. The buckets are carried on chains for heavy, slow work and on belts for lighter and faster moving work. Illustrations of both apron and bucket conveyors will be found facing page 60.

Belt Conveyors.—The belt conveyor is usually made of impregnated canvas belt, faced with rubber. They vary in width from twelve to forty inches and may be used to transport material for distances as great as 1000 feet. To increase the carrying capacity, the loaded or upper run of the belt is troughed. To one who is not familiar with these rubber belts, their wearing qualities are remarkable. Rubber will wear longer under these conditions than steel would. The power required is comparatively small; in fact, if the belt discharges down grade, it can be made to run itself by the weight of the descending material. Belt conveyors will transport any solid material, light or heavy, which will not stick to the belt, and can be used on inclines up to 20°. The material to be carried should be slid onto the belt from an incline in the direction in which the belt is running. This is important, because if this is done, the material will come to rest on the belt without wear. If it is dropped vertically or against the motion of the belt, there is heavy wear and a shortening of the life of the belt. Such belts may be driven from either end, but are usually driven from the discharge end. They may be arranged to discharge at the end or, by trippers, to discharge at any point along the run. These tripping devices may be permanently fixed at one place, may be moved from one place to another, as from the top of one bin to the next, or travel back and forth for the entire length of the belt. Two illustrations of a troughed belt conveyor face this page.

Industrial Cars.—For the intermittent handling of bulk material, industrial cars on narrow gauge tracks are most commonly used. This is usually the means of conveyance in yards where rough material is picked up in bulk and brought into the building. Cars for this purpose are preferably of the dumping type, either tilted or with dumping bottoms, and are handled singly or in trains. Where the work is continuous and the quantities handled are large, special arrangements may be made to move and to dump the material automatically. A good example of this is the skips for hoisting coal, ore, and limestone into a blast furnace. The handling of materials intermittently is so varied in its requirements that no specific description can be given.

Section II

Handling Materials in Containers

When Containers Are Necessary.—In the last chapter we considered the handling of material in bulk. Most of the methods described are used

Belt conveyors are made concave or flat and can carry 20 to 2,000 tons an hour.

Photos supplied by Robins Conveying Belt Company.

chiefly where the progress of the material is continuous. In general manufacturing plants, however, the movement of the material is usually intermittent. It is delivered to some machine for an operation and then moved on from one to another, until it is ready to go into stock or into assembly. Parts may also be grouped into subassemblies (as, for instance, a carburetor) and go into partly finished stock in that condition, to be drawn out later for assembly into the finished automobile. Generally, such material goes through in lots, which may differ but slightly in size, style, etc., and it is very essential to keep the lots intact. Here again the element of cost accounting enters in. If it is necessary to have the material charged to a definite order when it is drawn from stores, it is just as essential that it be kept intact throughout the process of manufacture until it reaches the final condition.

If the pieces are large, such as a lathe bed or an engine frame, they will be handled singly; but if the parts are small, such as screws, etc., the lots will be handled in some form of container. In a well-run shop, careful thought is given to the suitability of these containers, their convenience, and their effectiveness in protecting the material during handling. If the runs are large, the containers will be specially designed for the work they have to do. A well-designed container will be a great help in manufacture; an ill-suited one may be a cause of delay or of serious damage to the material.

Separate Container from Transporting Device.—The containers may be boxes provided with wheels to enable them to be trundled from place to place. In large plants the best practice, however, is to separate the transporting device from the container. The container usually has to remain at a machine some time while the material is going through the operation. During this time the wheels and running gear are acting merely as legs, and for the time being are not serving the purpose for which they are primarily intended. If the container and the running gear are made easily and quickly detachable, the latter can be moving other material elsewhere, while the container remains at the machine. In this way both parts can be kept working at full efficiency.

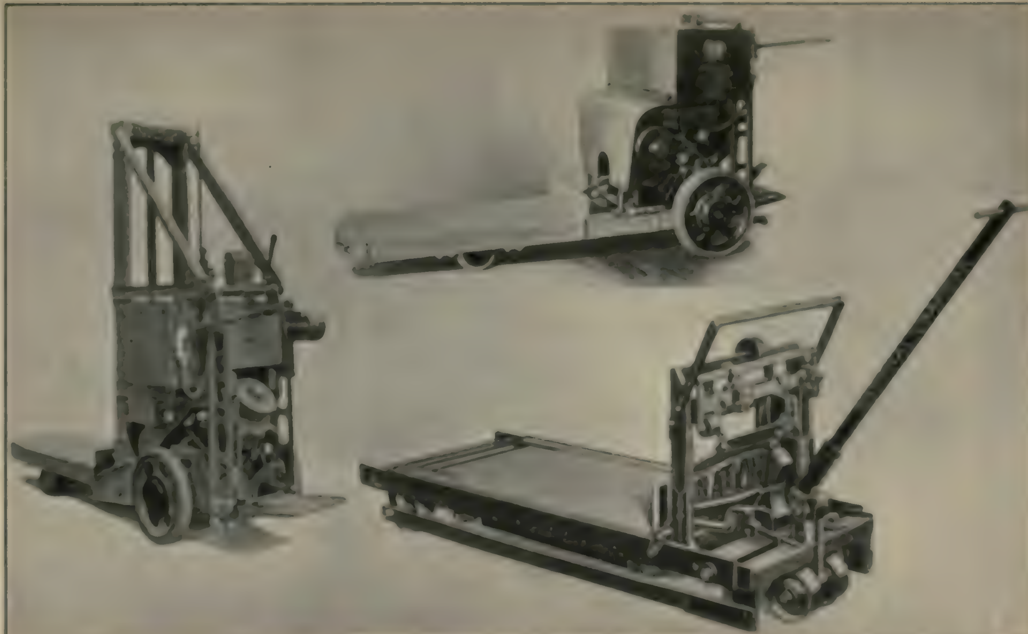
Styles of Containers.—There is an infinite variety of containers. These may be boxes, drums, tote-pans, specially designed racks, or simply platforms on which material can be piled. If the boxes or tote-pans must be lifted by hand, there is a limit to their size and weight. They should not be too large for convenient handling and, if possible, not so deep as to require leaning over to reach material at the bottom. Wood is frequently used but, where the material is covered with oil or cutting lubricants, steel boxes are the most economical in the long run, as they stand up longer under rough usage. A great many styles of tote-pans are obtainable on the market. They are usually rectangular, made of sheet steel, with a handle on each end. They may be solid, or perforated for draining. It is usually desirable to have them so shaped that they may be stacked or nested one inside of another when not in use.

There is an even wider variety in racks, and they are usually made especially for the work they have to do. They are almost always used where the material is delicate, as electric light bulbs, or where the parts are polished and have a fine finish which might be marred. These racks may serve the purposes, not only of carrying and protecting the articles, but also of positioning them conveniently, when they are to be fed into machines.

It will be remembered that Mr. Gantt stated that you should have the material not only *when* you want it and *where* you want it, but *as* you want it. The racks may be made a great aid in this last respect; and, where the quantities justify it, they should be so built that the material is presented to the operative at the *right height* and in the *right position* for convenient handling into and out of the machines. They may also be arranged to accommodate a definite number, such as 100, so that they serve the incidental purpose of assisting in counting and keeping track of the material.

Transporting Devices.—If there is variety in containers, there is also variety in the transporting devices. The simplest is the ordinary two-wheeled, two-handled truck with a projecting toe which slips under the load. This is useful for general purposes but inefficient for steady, routine use. Next, there is the four-wheeled platform truck found in a wide range of sizes. It is desirable that the platform be as low as possible to avoid unnecessary lifting of the loads, although the best height may vary for different conditions. Usually, anti-friction bearings on the wheels will pay. In the larger, modern shops, electric trucks are coming into extended use. These carry heavier loads and move faster than the ordinary hand truck. They are built of pressed steel and have solid rubber tired wheels. The motor is driven by a storage battery through a gear reduction to one of the axles, and the batteries are arranged in trays, so that they may be removed when dead and charged batteries quickly substituted, giving a continuous operation of the truck. Their capacities range from 500 lbs. up and the speed averages four to six miles an hour.

There are a number of trucks on the market which are operated either by hand or electric batteries and are designed both to lift and carry materials and finished products, usually individual pieces or goods in containers. Some of these are equipped with scales for weighing the material as it is picked up, obviating a second handling. There are also trucks with platforms which may be raised to any height necessary for the purpose of stacking and removing boxes, barrels, and bags. These trucks are efficient both in conveying materials and in utilizing storage space to the limit. Their platforms are low enough to be run under skids or containers made for the purpose. The platform is then raised up by a motion of the handle of the hand truck or a switch on the elec-



At the left—electric tiering-lifting truck. At the top—electric lifting truck. At the bottom—hand lifting truck with scales attached.

Photos supplied by The Automatic Transportation Company and The National Scale Company

Modern hand lift trucks enable a man to lift and handle two tons or more. The skid is left under the goods.

Photos supplied by The Stuebing Truck Company.

tric one and the load lifted clear of the floor. One man can lift and haul as much as two tons on a hand truck. Materials may be left on the skids until needed. Finished goods may be loaded into cars on skids and unloaded the same way at destination, thus saving boxes, for skids cost less than a packing case. Illustrations of the tiering truck are given in Chapter 5, and of other types of trucks in the pictures facing pages 66 and 67.

Gravity Conveyors for Containers.—Material in containers is frequently handled on gravity conveyors, consisting of an inclined frame with rollers mounted thereon. When the container is placed on these, it will run down on the rollers to the desired point where it slides onto a receiving platform of wood or sheet metal. Illustrations of these will be found facing page 68. Belt and apron conveyors are also used, but not so frequently.

Orderliness Shows Good Foremanship.—A foreman is often judged by the condition of the material on his floor; that is, by the condition of his containers, their orderliness, and the effectiveness with which he handles them. Many a foreman spends a good deal of thought and time in his mechanical operations and then throws away these advantages by carelessness and indifference as to the condition of the material after it leaves the machine. This latter phase seems secondary and unimportant, but it deserves careful thought and constant watching. Much fine work is marred or spoiled by carelessness in handling during transit through the shop.

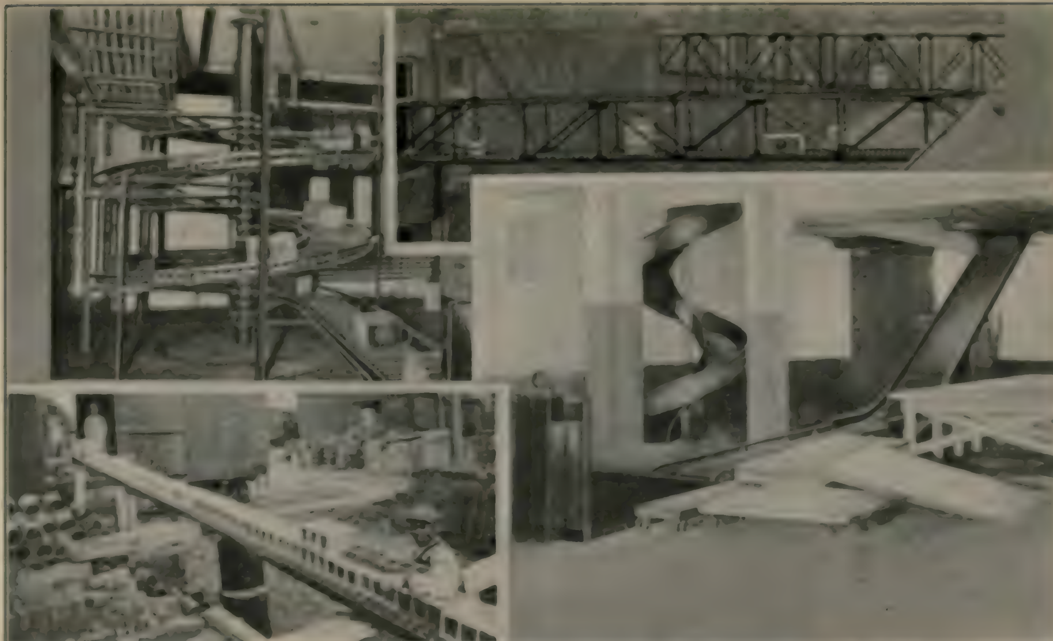
Importance of Standard Equipment.—Foremen, as a rule, are thoroughly alive to the advantages of standardization of tool and machine equipment. Frequently, however, they do not realize that the same advantages apply to the standardization of containers and methods of handling material between operations. It would be well for each student in the course to examine the containers used in his department and analyze their uses; to see how many kinds there are and whether they can be standardized and improved. Unless this has already been done, it is almost certain that there is room for improvement.

Section III

Handling Individual Pieces of Material

Hoists.—With larger work, it is necessary to handle each piece individually. For this purpose, hoists, cranes, overhead trolleys, and industrial railways are most used.

The hoist is used for lifting, usually in connection with cranes or overhead trolleys, as in handling molds in a foundry or for placing casting on machine tools. The hand operated chain hoist is best for light work and intermittent use. Where the work is constantly repeated, the pneumatic hoist is much quicker and more efficient. These are very generally used in foundries for lifting the molds from the molding machines and placing them on the pouring floor, for setting cores, etc. The electric hoist is used for heavier loads, gen-



Spiral gravity roller conveyor, straight gravity roller conveyors, and gravity chutes.
Photos supplied by Mathews Gravity Carrier Company.

erally in connection with a crane or trolley, to lift the work high enough for convenient transportation to another part of the shop.

Chains are used with hand hoists. With drum hoists the winding is usually done with steel wire rope terminating in a shackle, to which the work is slung by a chain and hook. Swiveled hooks of the standard type may be used for most work, but special tongs may be used for plates, bars, etc., when there is much work of the same kind to be handled. Lifting magnets are used for handling pig iron, scrap iron, and plates. These should not be used for carrying material over the heads of workmen, as a failure of the current will drop the load. Every foreman, using cranes or hoists, owes it to himself and to his workmen to see that all ropes, chains, hooks, etc., are inspected frequently and thoroughly.

The Jib Crane.—The principal types of cranes are the jib crane and the traveling crane. Each has a field for which it is best adapted. The jib crane, swinging in vertical bearings, is well adapted to serve in a restricted area. The trolley, running in and out on the horizontal swinging arm, enables it to serve an area limited only by the length of the arm. It is a good type of crane where the work to be done is at one point.

The Traveling Crane.—The traveling crane, with its two trucks, running on elevated tracks and connected by a bridge, is better adapted for serving large areas. Traveling cranes vary all the way from simple affairs, carrying a hand chain or air hoist, such as may be used on the side floor of a foundry, up to 200-ton cranes serving a large assembly floor and capable of lifting an entire locomotive and transporting it bodily from one end of the shop to the other.

These two types of cranes may often be worked in conjunction to good advantage: the traveling crane for general movements about the shop, for picking up a large piece at one end of the shop and carrying it to some point at the other end, and the jib crane for local use at the destination. It may be necessary to use a crane for a very considerable time at that point. To tie up a traveling crane for this purpose is not economical, as it may be wanted meantime at some other point in the shop. In serving heavy machine tools or large foundry molds, it is, therefore, often desirable to use both traveling and jib cranes, the former for the general movement to drop the piece near the machine or mold, where it is transferred to the jib crane which carries the piece while it is being set in place.

There are other types of cranes, such as gantry cranes, bridge cranes, etc., used for heavy outside work. Their use and design present engineering problems which take them out of the field of the average foreman.

The Overhead Trolley.—Another widely used type of transportation is the overhead trolley. This has many advantages. Like the traveling crane, it leaves the floor free from tracks, but it is more flexible, can be used with a low headroom, runs from one department to another, and even from one building to another. It is capable of handling moderate loads up to 4,000 lbs., and is usually used in connection with electric hoists. Some specially designed overhead trolleys are made with I-Beam tracks and carry loads as high as twenty tons. The simplest ones may be only a single straight beam carrying a chain hoist and operated by the workmen entirely from the floor. The more elaborate ones may handle the internal transportation for a whole plant, running in and out of buildings, with switches, turnouts, etc., and operated by men carried in cabs mounted on the overhead carriage. These serve the same purpose as an industrial railway, with the advantage that they leave the floor free from tracks.

Industrial Railways.—Industrial narrow gauge railways are used to carry loads of almost any weight. They are the simplest means of moving heavy material, but they are a mixed blessing. The tracks take up a great deal of room which must be given over permanently to this purpose, whether they are in use or not. They form an obstruction and the curves or turn-tables always give more or less trouble. They are generally cheaper to install than an overhead trolley. In plants handling very large and heavy work, where there is also a traveling crane, the tracks are usually of standard gauge, with direct connection to the railroad spurs outside. This arrangement permits the "spotting" of railway cars under the traveling crane, so that large pieces may be picked up from a foundry, machine, or assembly floor and deposited directly on the platform of a car for shipment.

Industrial railways are used for handling material in connection with all three of the methods we have considered, i.e., in bulk, in containers, and individual pieces. The type of cars used may be special for the first case, such as dump cars, cars lined with fire clay for molten metal, etc. For handling containers and separate pieces, plain platform cars are most common.

Find the Means Best Suited for Your Work. It is very desirable that every foreman should consider the methods of moving materials discussed in the foregoing sections and ask himself whether the means he is using are those best adapted to the work he has in hand. Often a man accepts the conditions in his plant as he finds them and, because he has grown used to them, does not realize that there may be other means available which are better suited to the needs of his work. It is a part of your job to keep abreast of modern methods of handling materials and get them installed, for in doing that you will be able to save time in getting work done and also save money for the concern.

Section IV

Scheduling the Movement of Material in Process

Keep the Material Moving.—Every foreman and executive should realize fully the advantage of rapidity in the movement of material through a factory. All material should be in *progress* during the greatest possible percentage of the time. The ideal condition would be to start work on the material when it is received, work on it continuously, and ship it out of the plant, sold, as soon as it is finished. This condition can seldom be realized.

In the first place, experience has shown that a raw material storeroom is absolutely necessary to insure continuity of operation. If a stock of material were not maintained, shut-downs would be continually occurring, and that is more costly than the loss of interest on the money tied up in a proper quantity of raw stores. The delay, therefore, due to a reasonable amount of material lying in raw stores must be accepted as an element in the cost of production. But, as every foreman knows, after the material is drawn from stores and started through the plant, it is not actually in process anywhere near 100 per cent of the time. Being in process does not necessarily mean being in motion. Hams hanging in the smokeroom, metal parts in a plating tank, or pianos drying in the varnish room are all in process, though not in motion. Even with this understanding, the time spent in actual work on the material is, in almost every business, very small compared with the loss of time which occurs between operations and is due, not to slowness in transportation, but to delays and congestion.

It will be greatly to the profit of a foreman to study carefully and thoroughly the course of the material moving through the department under his jurisdiction and make an exact analysis of what happens to it during the *entire* time it is in his department. Keep a record of the time it is being worked on, of the time it is being actually moved, and of the time it is standing about waiting for someone to act or something to happen. Such an analysis is inevitably an eye-opener to one who has never made it, and is likely to lead to suggestions and action that will result in improvements.

What Is the "Turnover"?—The reason why these delays are an evil is that they greatly increase the length of time represented by the "turnover." Shop men give the subject of turnover little or no consideration, and many good men probably have never even heard of it. By turnover is meant the length of time covered by the period in which the firm puts money into goods, receives them, fabricates them, sells them, receives pay for them, and puts the money back into a new cycle of operations; or, turnover is sometimes used in the sense of the number of times per year this cycle occurs. If a concern goes through this cycle *once* during the year, all the profits which it can earn for that year must be made out of that single turnover. For instance: If it is to declare eight per cent dividends, it must earn eight per cent clear for the business on that one turnover. If, however, it has *eight* turnovers during the year, it will earn this eight per cent dividend with a one per cent profit on each of the eight turnovers. A concern which has a rapid turnover is, therefore, able to compete more successfully against another firm with a slow turnover. It can work on a smaller margin of profit and yet show the same earnings at the end of the year as though there were twice the profits on half the number of turnovers. This principle of rapid turnover is used by the five and ten cent stores, which base their business on a great number of quick sales, each one at only a small profit; but, owing to the volume of business done, yielding large gross profits.

Anything, therefore, that the supervisors or management can do to decrease the time that the material is in process will mean an increase in the earning capacity of the business.

Delays Use Up the Time in Production.—As has been said, most of the time during which material is going through a factory is taken up, not by actual operations on it or by its movement in process, but by delays incident to its being moved from one operation to another. These form the largest element which can be worked on to reduce the time of processing.

Certain causes for delay will occur to any shop man who reviews his experiences. In the first place, there are inadequate moving facilities, not enough men to do the work, or shortage of machine equipment. Secondly, we have uncertainty as to whose business it is to move the material, failure to notify the proper person that the work is ready for movement, failure to come up to the schedule, congestion due to waiting for tools or the repair of broken down machines, and, particularly, shortage of some one necessary item.

This brings to mind again Mr. Gantt's saying, quoted in Chapter 5, relative to having "*all* the material *when* you want it."

The Production or Planning Department. Some one or some department must be responsible for the movement of the material in connection with every order that goes through the factory. That responsibility may be stated thus:

Some one must

1. Requisition the material out of the store room.
2. Schedule its movement to the first operation and to each successive one.
3. Describe the operations to be performed.
4. Fix the order in which they are to be done.
5. Determine the preference in relation to other orders.
6. Name the machines on which the work is to be done.
7. Schedule the dates through the succession of operations to the time of completion.

In a modern, highly organized plant, this layout for the movement of material is made by a production or planning department. This department takes over all the clerical work involved in the layout; designates the order of work to be done by each man or machine; supplies the necessary instruction cards, tool lists, drawings, and shop orders; and traces and follows up the performance of the work to see whether it is going through on the schedule laid down. Such a planning department is not intended in any way to minimize the importance of the shop foreman, but to relieve him of clerical work and free him for the executive work for which he is better fitted, and which he can then do to better advantage. Experience has taught us that, where such a department is well-organized and is functioning properly, a large volume of work can be handled more quickly, efficiently, and cheaply than where this function of planning has not been so centralized. It is only through such definite scheduling that intelligent promises for deliveries can be made. If unforeseen contingencies arise, the schedules are readjusted and a new date for delivery determined.

It should be borne in mind clearly that the functions outlined above are *not created by* the planning department. If this department does not exist, every one of these functions must be performed by *some* one or more of the executives throughout the plant, most of them by the foreman. If, therefore, there is no planning department, there is all the more reason why the foreman should *schedule* the movement of material, in order to avoid delays and to increase the efficiency of his department.

The Foreman Is Held Responsible for Delays. Delays clearly involve a foreman's responsibility. If the trouble is in the transportation system, it is his duty to see that the trucker, laborer, or transportation department is on the job and that the material is moved. If tools or broken down machines are causing the hold-up, he must repair them or promptly notify the persons responsible, and keep after them until the equipment is repaired. If the trouble is inadequacy of equipment, he should impress this on his immedate superior and secure definite action, if possible. If there is lack of help, he is responsible for securing it. By any and every proper means, he should work early and late to eliminate delays, most of which occur *between* operations. These delays mean either a smaller output or that larger quantities of material must be continually in process to get the output desired. These larger quantities mean a greater investment, on which interest must be paid or accounted for. Money invested in stock on hand does not meet payrolls and the history of industry contains a large percentage of failures due to too much "dead stock."

Handle the materials efficiently and you have taken a long step toward becoming a thoroughly efficient foreman.

Part II: The Foreman

DEVELOPING INTEREST

Section I

Observing Things

We See but Do Not Observe.—In New York we used to have a young reporter in our boarding house, who had just come from a small town in the South. Everything in the city interested him. When he came home at night he would keep us amused and entertained for a half or three-quarters of an hour by telling us about the things which he had seen while going around the city. All the rest of us had bumped into the selfsame things that he spoke of but none of us had paid any attention to them; so, when he reported them at night over the dinner table, they were as interesting as though none of us had ever come in contact with them. We used to wonder why it was that we did not *see* these things when we actually had them in front of our eyes during the day.

Why we see or hear some things and do not see or hear other things is somewhat of a mystery to the average man; and, unless we know something about our powers of observation and how they may be made to serve us, we cannot keep ourselves alert so as to detect everything that we might in connection with our work and our surroundings.

Observation Is Quickened by Interest.—When we are interested in a thing, we observe it consciously and keenly. Our eyes are just like the lens of a camera which we may point at a thing, but it is our interest in that thing that clicks the camera and makes the picture in our mind. Where we are interested, we see what is going on and we remember it because we make a clean-cut picture of it in our minds. Where we are not interested, we see very little or nothing of the object, although we pass it and look at it a hundred times a day.

There are a great many things about our work that are not interesting, because we do them every day—we do them as automatically as we dress, almost without thought. By and by, the habit of operation becomes so fixed that we are unable to analyze it and find out whether it is the best way of doing the thing or not. Somebody, to whom the process is not familiar, comes along. He watches us perform the work, then remarks: "Don't you think you would save yourself a little trouble if you did it this way?" That draws our attention to the matter. We become interested again in our own operations and we begin to observe them in detail. It is a fact, then, that a man does not do his best work unless he is interested; he does not *observe* the work in which he is not interested; and, therefore, he does not improve it or develop in it. For the same reason it is not much use talking to the farmer in engineering terms. He is not interested in engineering, he has not observed it, and, therefore, he does not understand it and does not want to understand it.

It is well to remember this initial step in observation—that it is governed by interest. The senses can become dead to things in which we are not interested, and one of the reasons why we lose interest is because things become so familiar that they do not force us to use our observation.

Interest Wanes Because We Let It.—Some men have gone so far as to say that it is advisable once in a while to make changes in an organization, because a new man coming in will bring fresh interest and enthusiasm and will be able to do things that the other men could not accomplish. That should not be necessary. It is not necessary for me to lose interest in part of my work simply because I do it every day. It is not necessary for me to lose interest in my town simply because I live in it all the time, and it is not necessary for me to lose my alertness in connection with any part of my life just because the surroundings do not change very much and the operations continue right along.

Ordinarily, we are interested in everything. The best example of this is the youngster. Nothing that he sees is uninteresting, and everything that comes before his eyes or affects any one of his senses immediately registers on his mind and he begins to ask questions about it. After a while, he finds that many things are not interesting to the older people. He learns that they do not answer his questions and that things must be accepted though not understood. Then his interests begin to narrow and define themselves along certain lines.

We Learn by Comparing Observations with the Things Remembered.—In our observation of things and our memory of them, we compare our observation with our memory of previous observations and we find that certain things are always associated with certain uses or with certain necessities of our lives. We discover that things occur always in the same way when the conditions are the same. If we try to imagine the man who first observed the metallic residue that was left from the brown earth that was next to his hot fire, we can see how the hardness and the brightness of that residue would attract him and how he would try to build just as hot a fire again and put some brown earth in it to see what he could get. After a while he would find that, with a certain sized fire and a given amount of the brown earth, he could always get the same quantity of this hard metallic substance, which we now call iron; and he would gradually learn by these associations how to produce the iron which he had accidentally discovered.

This process of association of ideas took not one man, but many generations of men to accomplish. The first man had to bring together in his mind, from a number of observations, the associations or surroundings. The man who learned from him made his first observation with some of the associations already determined up to that point, and from that point he was able to carry his observations and associations still further.

Putting Two and Two Together.—It is always interesting to watch a child grow, to see its scope of observation widen as the intelligence first begins to operate, to see how the observation begins to associate a few simple things together, and then to see, further, how the imagination seizes upon these associations and attempts to develop its own power of controlling them.

A lad of my acquaintance, whose family lived in the city, had been watching the traveling cranes at work on the subway excavation. That was just at the beginning of the war. Pictures of submarines were coming out in the papers from time to time and some of these had come under the boy's observation. One day, when he and I were passing by the subway cut, he turned around to me and said: "I know now how they get the submarines into the water."

I asked him, "How?"

He said: "They have a big crane at the edge of the water. They lift the submarines up, when they are finished, and drop them in."

Here was a good illustration of the method by which we arrive at our knowledge. This boy had seen the crane. It was associated in his mind with lifting heavy, cumbersome pieces and running them out to where they were needed. He had seen pictures of the submarine. These pictures had shown him that they were made of steel, were very heavy, and traveled under water. Evidently his mind had busied itself on the question of *how* the submarines, which could not be built on the water, were transferred from the land to the water. Finally, his imagination took these separate associations and linked them together on the ground of probability, because they fitted together.

In ordinary conversation, we call this association of ideas, "putting two and two together," two and two being two separate and definite associations which, however, should logically suggest that they can be combined and form a new association of four. When work becomes so familiar that we lose interest in it, the associations are not active in our minds, because they fail to record themselves afresh. There is no tendency for new associations to lodge themselves, so there is no likelihood that improvements will suggest themselves out of the associations we already possess.

Our observation is not confined, however, to the things we experience. With a little training, our observation will develop itself in our reading. The things we read about are associated with the things we have experienced. They develop the records in our minds, make it possible to widen the associations, and make them more useful. Similarly, these associations are broadened and developed by talking to people who are interested in the same things and, then, by adding their experiences to our own.

Section II

Curiosity Is the Spur to Interest

The Question, "Why?"—The whole world is a mass of movement; nothing is absolutely still. Everything changes and everything moves, or is made up of moving parts. Our observation sees the movement and we know that there must be a reason for every one of these changes and for every single movement. So when we see something for the first time we are impelled to ask, "Why, and what is it?" To notice this action in full operation, it is necessary to refer to the youngsters again. The continual emphasis on "Why?" is a natural part of the conversation of children with older people, and when the children begin to question with this eternal "Why?" of theirs, we begin to realize how little we *know* and how much we have accepted on faith.

Some of us who have grown old and somewhat cynical are inclined to say that these movements of life about us, and these developments which occur all around are dependent on chance or luck. But, because of our experiences with objects and their movements we come to know that there must be a reason for everything, so are impelled to ask *why* the thing which we observe occurs.

It is this curiosity, this desire to find out the object of or the reason for the occurrence which we have observed, that is the beginning of knowledge. It is the endeavor to answer this and the other questions which are related in our minds that enables us to secure more and more of the conveniences and comforts concealed by Nature until we find them.

We begin life by *seeing* things, and then by asking *why they are.* As we go along a great many of our questions are not answered. We, therefore, lose interest in many of the things that come before us. The scope of our interest becomes narrow and, eventually, we have a *definite* interest in our work, a *limited* interest in our social surroundings, and perhaps a *general* interest in one or two other subjects. Frequently, when we ask "Why?" the answers to the question are given hastily or because some other person has received the same answer and so passes it on to us. The same questions descend from one generation to the next, because the questions are answered in the same old way and without definiteness or satisfaction.

Information is increased when questions are answered authoritatively and convincingly, and in such a way as to induce new study on the part of the questioner. In this way we have learned what we now know about production and distribution, and we have learned something about the human beings who must control the production and distribution and for whose benefit these services are rendered.

The Question, "How?"—We are no sooner through asking *why* a thing is, than we immediately begin to ask, "How?" We instinctively know that, in connection with an object or a reason for the thing we see, there must be a process in making it come about. So we ask, "How come?"

It took a great many generations for human beings to discover how to make fire. For a good many generations previously they had known that things burned. They knew that this crawling, creeping, red hot thing, which they called a god, destroyed things. They managed to carry it about from place to place by taking a branch that was on fire and starting another piece burning before the old one was entirely destroyed. After a while, they learned that it was just as easy to carry fire smouldering in a bit of punk as it was to carry a flaming branch. Still, they did not know how to preserve it except by constantly carrying it around, and tribes must have been wiped out from time to time by the loss of their fire. Then somebody discovered that it was possible to make fire by rubbing one piece of wood against another until sufficient heat was secured to burst into flame. So they answered the question of *how* fire could be produced and that took them a long step forward in their intellectual development.

No Improvement Unless Why and How Are Answered.—These same questions of *why* and *how* have to be answered in the search for improvement in every development of industry, and unless they are answered, no improvement is made. We sometimes live so close to our work that we fail on the improvement side of it. We become so familiar with it that we cease to see it, because the work holds no interest for us and no thought is expended on it. After we have ceased to notice it, we cannot, of course, ask why it is done or determine how it should be done better. We think we know why and how, but our curiosity is not excited; our interest is dead and, consequently, our development of that particular thing has stopped.

It has been a difficult matter at all times for men to answer the questions how and why, and it has been possible to develop the answers only step by step and in one small detail at a time. That is why all improvements come so slowly. And it is also the reason why man has progressed so rapidly since he really began to use his thinking powers and to utilize the experiences of other men.

You Develop Yourself by Interest in Your Work.—It is not only that your work depends upon retaining an interest in it, so that your observation will be keen and alert and your curiosity active in regard to it, but you can develop yourself only in the same way. It is the preservation of keen interest and accurate observation, it is the constant questioning of your work and its possibilities which enlarge your mind and develop your skillfulness so that you increase your capacity for service both in quality and quantity.

A very keen business man, who has studied business and its developments very thoroughly, recently said that a man at forty either begins to develop more rapidly in his capacity, because of the experiences which he has had and the way he applies those experiences, or he begins to grow narrow and to settle down in a rut, because his curiosity is not excited and his interest is not maintained. If you look around among the people you know, you will realize that there is a sharper division among men of middle life than there is among younger men. The background of experience and habit of development which they have accumulated by the time they are forty, with the knowledge they possess, permit a more definite ripening of judgment, concentration of skill, and conservative development of influence. If the experience has been gained without enlarging the intellect or developing the habit of thought, it tends to satisfy the curiosity, to limit the interest, and to narrow the circle of observation.

Maintaining Curiosity.—Not long ago, next to me on a street car sat a little boy with his father who appeared to be a business man of good position and reasonable intelligence. It had been raining, and the contact between the trolley pole and the wire was not very good, so we were treated to flashes of electricity every few minutes. The little boy became interested and curious, and he said to his father, "Why does the trolley pole flash like that?"

I waited with interest for the father's reply, because I wondered whether his own curiosity had led him to find out the reason. He answered very easily in this way: "It always does when the wire is wet."

I do not know how many times the man had traveled in the trolley and had seen the same thing occur; but he had no curiosity about it, he had no interest in it, and consequently he had no knowledge of it. The unfortunate part of it was that instead of admitting he did not know, he was passing the results of his lack of curiosity on to the boy as an answer to his question.

Perhaps it is for this reason that we fail to understand many things about human beings. We are so familiar with their actions, and they are so much a part of our associations from the time we are born, that we lose interest and our curiosity is dull. Of course, then, we do not learn very much. In addition to that, not many of our teachers, whether they are parents or teachers in the school or friends, will admit that they do not know human nature; so they answer our questions like the father on the trolley car, with an answer that is no explanation at all.

One of the big jobs which you have is to understand your workmen. This will be accomplished if you admit the things that you do not know about men and their reactions and then go ahead to get all the knowledge you can. It will be necessary for you to question carefully and to analyze the answers, because so many of them are founded upon opinions without knowledge or upon prejudice without examination.

Section III

Linking Interest, Observation, and Action

Applying the Observation.—In industry, putting the observation to work means seeing the thing, seeing what happens to it, finding out why and how it happens, and then trying to find out where the why and the how can be changed and the result improved.

A friend of mine, who runs a little factory, had been conducting certain operations along a given line, and the results had been quite satisfactory as far as he was concerned. One day, his son happened to go into the factory and got interested in this particular part of the work. He put a little time and thought on it, and, when he got it all thoroughly in mind, suggested a change in the operation which he thought would shorten it. The experiment was tried and a definite reduction in the cost of this operation was secured. The father was much better acquainted with the operation than the son. He had a great deal more experience on the job. In fact, he had so much experience and familiarity with the job that his interest and curiosity had died out. The boy's mind, fresh on the matter, was keenly interested. His curiosity was thoroughly aroused, and no sooner had he learned the reason for the operation and the method of doing it, than his mind asked whether it could not be done better.

Naturally, we cannot put the observation to work if we have permitted it to become dulled by familiarity and we cannot effect improvement if we think the question of *how* it should be done has been answered so thoroughly that it needs no further examination.

Observe, Then Experiment.—In one of the early sections, it was pointed out that, before any progress can be made on anything, the *idea* of the possible improvement must be in the mind of the man; then this idea must be worked by experimentation until it has been changed into a practical accomplishment. The first time a man is brought into contact with a series of industrial operations, the equipment, the operation, and the men represent so much movement that the observation of the man is unable to seize upon and record them clearly. That is why the visit of an outsider to a factory leaves him confused and bewildered. Gradually, as the reasons for the operations are studied and the methods used in performing the operation are determined, they are associated one with the other in an orderly way in the mind, so that they are no longer confusing or bewildering—their relation to each other is brought out and their significance understood.

So, the man who is acquainted with the operations in the grinding room can step into another grinding room and, within a very short time, his observation has separated the familiar from the unfamiliar methods. His curiosity is aroused by the latter, because his interest has centered upon them. Immediately, he wants to know why these changes have been made and how they affect the work. He applies these changes, in his mind, to the conditions in his own grinding room and visualizes the possibility of instituting them in his own shop as well as the probable effect they would have upon his own production. Up to this point he doesn't know definitely what would be the result of making changes. When he gets back to his own shop, he thinks over the matter again and decides that certain changes can be made so that his output will be improved both in quality and quantity. This is only a conviction on his part. It has not yet become tangible and part of the operation of the shop. To find out whether his judgment of the matter is correct, he must put his ideas into practice and *experiment* to that extent. Every change, every improvement, every development is an experiment until its trial has proved that it will work in accordance with the idea which preceded it.

Developing the Observation.—Sir Arthur Pearson, who is famous for his interest in work among the blind in Great Britain and who is the practical head of the Lighthouse in London, is himself a blind man, after having retained his eyesight until about middle age. In the Lighthouse they train blind men for many occupations, and the way in which they teach a man to develop his other senses, so that he can observe almost as quickly as with his eyes, is a very interesting story.

They, first of all, take the man who has become blind and keep him in one room with the same surroundings until he has become so familiar with the furniture, with the conveniences, and with the means of getting in and out that he can steer himself around the place without any difficulty. By and by, he finds that eyes are not necessary in order to have his usual freedom. Then the teachers begin to work upon his knowledge of sounds. They train his observation through the ears, so that he becomes sensitive to sound changes which would not strike the ordinary person. By and by, those blind folk are so developed that they can do many kinds of work and go through their ordinary social affairs without indicating, except under rare conditions, that they are blind.

In somewhat the same way, observation can be developed by any individual. This development comes through the process of knowing more about the things in which we must become expert, and thereby keeping the interest thoroughly alive, so that no detail is too small to catch our observation and excite our curiosity. We cannot keep our interest in all parts of our work, unless we deliberately arrange to do so by watching and associating each detail of the work with every other detail.

It is always interesting to note how thoroughly artists, actors, and musicians study the details of their own vocation. Most of the spare time of the actor is spent in hearing other actors; musicians are always to be found in the audiences at concerts; and artists haunt the art galleries. It is not often that our interest in our own job in business is so complete that we can find recreation and relaxation in studying the details of a similar job in other plants and under other conditions.

Coordinating Thought and Action.—The accomplishment of a useful service in industry, whether the job be in a grinding-room, in a cotton mill among the spindles, in a power plant, in a railroad yard, or on the docks, requires definite mechanical skill, more or less accurate or more or less delicate according to the conditions of the work. This mechanical skill cannot be secured without thought and it cannot be retained without thought; but it requires more than the mental part of it to coordinate the brain and the hand so that the best results can be secured with the least effort. The fingers or the hands or the whole body must perform the operation over and over again and the mind must be constantly alert during the whole performance if the required skill is to be secured and then improved.

It is only as the mind concentrates upon every item in connection with the job of turning an idea into industrial production, that the man begins to approach his potential capacity. If the interest lessens to such a degree that it is almost lost, the work will actually deteriorate. Mistakes will tend to repeat themselves and to grow in number. The efficiency of a man long acquainted with a particular job may be less than the efficiency of a new man, if the older man has not retained his interest and developed it during those years of his association.

It is a part of the job of the foreman to keep himself interested in the work of each man in his group, in the personality of the men themselves, and in their relation to their work and to one another. It is part of his job to keep these men interested in their individual places in the cooperative group of which he is supervisor, because only by maintaining the interest can the work be improved and the efficiency be brought up more nearly to the potential capacity of the men.

Section IV

Multiply Results by Organizing Self

Organizing Oneself.—This is a different matter from organizing the work. The work may be organized in accordance with the general system of operation in the factory or the general system of handling in the yard, on the dock, or in any other place where your group may be engaged. These operations are organized as a part of the general system, because they must have their specific relation to all the other operations which are necessary for the same common purpose.

The man who supervises other men must, to some extent, organize their work and develop for them their attitude towards their work. He must be able to organize *himself* in his attitude towards his own work and in his concentration upon its accomplishment. It is this organization that distinguishes the leader from the follower and the executive from the subordinate.

Analyze Your Work.—One of the great masters of industry with whom I have had an opportunity to become personally acquainted, a man who is admired and respected by his associates and employes, may have been in a hurry sometime, but I have never found anyone who had caught him at it. Everyone who visited him remarked upon the fact that he seemed to have plenty of time; his desk was always clear, he had time to listen to any proposition of importance to the business or of value to its employes. He was not very active in the sense of rushing about, but he developed a great organization and, what is more, he was admired and liked by all those subordinates who came in contact with him even in the slightest degree. That man had organized himself and he was constantly engaged in analyzing his work and analyzing the men who were associated with him. Perhaps that was the reason his decisions were regarded with such respect and his judgment was sought on all important matters.

Some men seem to think that there is no golden mean between continuous activity and loafing. They have not organized themselves so that they are aware of the value of their quiet hours as well as the value of their strenuous hours. They have not learned to concentrate upon the job and, particularly, they have not learned to anlyze themselves or the work, so that they understand how their capacity can be harnessed most effectively for the accomplishment of the job.

Improvement Is the Goal.—To go on year in and year out doing the same work without improving the work and without improving oneself is about as sensible as to imitate the squirrel in the revolving cage. Every job that requires the handling of other men and the supervision of work presents possibilities of improvement in the work and the men that are sufficient to keep the man who is supervising them moving forward in his mental development and his technical skill if he retains his interest, keeps his observation alert, concentrates on the job, and analyzes everything with which he has to do.

The job of being a leader, an instructor, an interpreter of the technique of the work which is being done by the men, and, at the same time, of keeping in mind the efficiency of the work is no small one. It is big enough for any man; that is, the job is big enough for any man if all possible improvement is to be made in the development of it.

Prove That the Work Is Useful.—This whole section has to do with the development of the human qualities in their effect upon the work. There is, first, the development of oneself to be considered and, then, the responsibility of developing the other man over whom we have supervision. We have given the mental processes which govern the development to show how the interest must be secured, in order that the observation, the curiosity, and the concentration may be exercised upon the job. Unless the man develops in connection with his work, he will become dissatisfied and his work will deteriorate. His interest cannot be maintained under those conditions. You know that no man will continue upon a piece of work which seems useless.

Frank Gilbreth, one day, tried an experiment on some unskilled workers in a brickyard. He told some of them to move a pile of bricks from one corner of the yard to the other. They went ahead and did it with as much rapidity and skill as they possessed. Then he told them to move the bricks back. They started to do it but their interest slackened, they slowed up, and finally most of them quit and said they did not want to be made fools of like that.

Some of the work which you are doing in your little group looks rather useless to the man who is doing it. He does not see that it amounts to anything. He doesn't know that the little micrometer bar which he is finishing so carefully will be used to determine the accuracy of thousands of parts where inaccuracy would mean disaster. Or, the workman may not know that the rivets which he is driving in the hull of the vessel are really important in the operation of that ship and that the question of whether the vessel will come through the stormy weather at sea or not may depend upon the character of the work in his riveting.

It is pretty hard, in making a bunch of bolts on automatic screw machines or rearranging the track for the main line of a railroad, to remember that the comfort and convenience and, in many cases, the very lives of thousands depend upon the continued care, accuracy, and skill shown in the performance of that work.

In developing the man it is necessary that his interest should be retained and enlarged, and this can be done only when the usefulness of the work is thoroughly understood by him. Most men are proud of their own work, and they like to think of its usefulness. If you can develop their knowledge in this respect, you will develop their interest and they will see their work in a way that they have never seen it before.

Multiplying the Results.—The whole development of modern industry has been based upon multiplying the results. In other words, this is the arranging to secure, within a given space of time and by means of a given amount of labor, a larger number of pieces or products or a greater volume of results.

For instance, the old fashioned drill press, which they used in the factory when I was a boy, had a hand feed and one spindle and a capacity for only a limited variation in the size of the bit. It took a lot of time to drill fifteen or twenty holes in a plate. The table was not very large, the device for gripping the plate left much to the discretion of the operator, and to drill all those holes in proper alignment, with no variation, was a job which required time and patience and skill. If the plate was a long one, it had to be reset several times. Now, we have drill presses with forty-eight spindles on one press, so arranged as to drill the top and two sides of a piece at the same time. There is no difficulty in getting the proper position and alignment, once the tool has been set. By such means as these we multiply wonderfully the results within the same space and time and, consequently, we are able to turn out work with less cost, with greater accuracy, and with more rapidity. So we supply more comforts and conveniences for the people.

The automobile business would have been impossible in the volume it has today, with the old machinery of thirty years ago. The machines could not have been turned out for the price, in the time, and of the quantity required to meet the present requirement. It would be impossible, likewise, to provide furniture for half the present population of the United States if the old methods, with so much hand work, were still being used.

The biggest job you have is to develop the man, because if you can develop the man, even to a small degree, the work which he does will be more useful, more accurate, and more efficient in quality and in quantity. All this big power of accomplishment which rests in each man is drawn out by interest. Without the interest, it lies idle, and the men perform only what they can do automatically. If you can harness this power by developing the interest, you will be able to do things with your group which appear to be miraculous.

Questions for You to Answer

1. In what three ways is the handling of material considered?
2. What is the main advantage of making material move itself?
3. State the difference between spiral and scraper flight conveyors.
4. What is the difference, in efficiency and utility, between bucket and belt conveyors?
5. Describe the several types of trucks mentioned in Section II.
6. Describe the various means of moving material mentioned in Section III.
7. Give the two definitions of turnover.
8. What are the five points of responsibility in moving material through the processes of manufacture?
9. Why is it that we do not remember all of the things that we look at?
10. What is the relation of interest to observation?
11. Why should a man cultivate curiosity?
12. Is a man likely to attempt improvement in things unless the questions of "why" and "how" are answered?
13. What is the value of analyzing both yourself and your work?
14. Why is "man development" your big job?

Chapter 7

Part I
CARE OF MATERIALS

Part II
WORKMANSHIP AND ORIGINALITY

Part I: The Job

CARE OF MATERIALS

Section I

Waste and Salvage

Reduction of Waste.—Not the least of a foreman's responsibilities in connection with materials is the reduction of waste to the lowest possible point. No man or process or machine is one hundred per cent efficient, and in every business there is some inevitable waste of material which disappears during manufacture. The high prices and scarcity of materials during the Great War taught the industries of this country many lessons in thrift—not only in money, but in every kind of material. But in both the reduction and the utilization of waste we are still far behind European countries and have much to learn. There are companies in this country where the waste alone would be sufficient to provide a reasonable dividend on the invested capital. Few men in a plant are in better position than the foremen to help in reducing these losses.

Some forms of waste are unavoidable and necessary, while others are avoidable and should be eliminated. The only hope with the unavoidable wastes is to reduce them to the lowest point possible. In almost every industry there will be cuttings, chips, shavings, ends, findings, etc., produced during manufacture. It is the A. B. C. of the shop that care should be exercised in making the cuts to the greatest advantage; that they should be so laid out that the waste will be as small as possible. While this is known to every foreman, only constant vigilance will keep such waste down, and ingenuity should be set to work towards the using up of these cuttings in other ways, if there is any possibility of doing so. In machine shops, bar stock should be as close to the finished size as conditions will permit and the most efficient parting tools used. In ordering material, determination of the excess necessary to allow for this shrinkage should not be left to guessing. The lowest allowance consistent with good shop practice should be carefully studied, made a matter of record, and used in the placing of every order. With many concerns this is definitely incorporated in the bill of material.

Waste and By-Products.—Another source of legitimate waste comes from material thrown off during the chemical or other processing of material. If this is carted to the dump heap or thrown into the sewer, it is a waste product. If it is sold or utilized, it is raised to the dignity of a by-product. Every effort should be made to find a use for such discarded material. In the meat packing industries, much of the materials formerly wasted is now utilized and is a source of profit. Literally, nothing is thrown away.

The treatment of the scrap metal in a machine shop is a pretty fair index of the quality of its management. Where the scrap is allowed to accumulate and is then thrown out, or is sold unsorted to the junk man, someone is asleep on his job. The sorting of such scrap affords the junk man his livelihood and in most cases his profit can be saved for the firm if care will only be taken to separate the different kinds of scrap, such as brass, tool steel, grey iron, aluminum, etc., so that the higher priced materials may bring what they are really worth instead of being averaged down to the lowest grade in the lot. One of the writer's friends had a good lesson on this point. He had recently taken over a small foundry and machine shop and still had some of the finer points of management to learn. He gladly accepted a junk man's offer to cart away a pile of old chips and dirt which had become a nuisance outside the door. He learned, a week or so afterwards, that the junk man had netted a clear profit of two hundred dollars on the ten cart-loads which he carried away.

Reasons for Avoidable Waste.—The principal reasons for avoidable waste are:

a. Overordering,
b. Cancellation of customers' orders,
c. Lost or mislaid material,
d. Exposed or improper storage conditions,
e. Spoiling of material in process,
f. Changes in design,
g. Destruction of packing material.

Spoiling of Material in Storage.—Material may be spoiled in storage due to overordering through mistakes made by order clerks, to errors in scheduling, to cancellation of customers' orders, or it may be material which has been lost or mislaid. Such material may pile up in the storeroom until it becomes obsolete or deteriorates from age and ultimately becomes unusable. Of course, under perfect management none of these cases can arise; but, owing to the frailty of human nature, they do arise and are sources of waste. Stored material can be spoiled, also, by letting it lie in storage under exposed and improper conditions, so that it rusts, molds, decays, or otherwise deteriorates; or it may spoil by aging alone. Rubber tires, for instance, will deteriorate from aging even if kept under the best conditions. The way to decrease losses through the spoiling of material in storage is to use it for some other purpose than that for which it was purchased. If this is impossible, it should be salvaged.

Spoiling of Material in Process.—Work spoiled in process covers breakage, rough handling, etc., and all material thrown out by the inspection department on account of bad workmanship and other defects. Usually, such material cannot be salvaged unless it is possible to utilize it on smaller sizes or other orders.

Spoiling of Material by Changes in Design. Changes in design may obsolete the material which has been ordered for the old design. If the change is made because of weakness in the old design or because the old material has proved unsuitable, the material obsoleted usually cannot be saved. If, however, the change is merely an improvement on the old design and there are many machines of the old design outstanding, the obsoleted material can usually be transferred to repair-part stock and used up in that way. In a large business, changes in design form one of the most fruitful sources of waste material. Every effort should be made to keep these changes down to those which are absolutely necessary, or which constitute so distinct an improvement as to justify the expense of making the change and of possibly obsoleting considerable material.

Destruction of Packing Material.—The boxes and crates in which the raw material is received should not be ruthlessly destroyed. If they are opened carefully and the covers placed inside them when emptied, they have a good salvage value to storage warehouses, or they may possibly be used by the firm itself in shipping its finished product.

Orderliness about a plant has a marked effect on waste and would justify its cost from this saving alone. In a disorderly shop the various waste materials are all thrown together; good materials get mixed up with the bad and disappear with it. The moral effect of this method on everybody is bad. The wastes due to lost and mislaid materials are heavy in a slovenly shop, but almost negligible in a neat one.

Salvage Deserves Thoughtful Consideration. It is almost as important to provide some orderly and responsible method for the disposing of waste material as it is to hold waste down to the minimum. The best method is to have some form of salvaging committee which shall represent the purchasing department, the engineering department, the shop, and the storekeeper. This committee should go over all waste and obsolete materials at regular intervals. This should be done, first, to see if this material can be used, as it stands, for some other order; second, to see if it can be used by reworking, such as cutting down to a smaller size, sending files away for recutting, etc.; third, to find the best market for it; and, fourth, to increase its salvage value by such means as sorting, baling, and so forth. In this connection, the purchasing department can usually render effective aid. Great savings may often be realized by giving the problem of salvage the attention which it deserves.

Section II

Inventories

Inventories Are Essential to Success.—To meet competition successfully a management must have accurate knowledge at all times as to just where it stands financially, whether it is making or losing money, and how much. Otherwise it is working in the dark, and the fellow who *guesses* has no chance in the long run against the one who *knows.* To have the financial status of a company, it is necessary to know, not only the cash on hand and the accounts receivable and payable, but also the value of its physical property of every kind. This tabulation and valuation of property is called an inventory.

What the Inventory Should Cover.—An inventory must cover the following main classes of physical assets:

a. Plant—real estate, buildings, etc. If these are properly recorded they can be inventoried in a very short time.

b. Equipment—power plant, power transmission, piping, wiring, machinery, patterns, jigs, fixtures, and special tools. These items are usually carried on permanent card records, one card for each item. These cards give the name and symbol of the item, the department and location where it is used, the maker and the maker's serial number (if any), the date installed, and the depreciation rate, with any necessary remarks. On the backs of the cards may be carried the date of purchase and the purchase value; also the cost of freight and of installing the machine in place, of permanent attachments and improvements, if any have been made, and of repairs. These give the total cost to date. When the depreciation is charged off from this, the present value of the machine for inventory purposes is known. The value of *patterns* as an asset is very uncertain. It is the general practice to charge off special patterns made for particular orders. Standard patterns, on the other hand, have a very real value but are subject to heavy depreciation. In conservative practice, patterns are inventoried at a very low proportion of their original cost.

c. Supplies—all material which does not enter into the product or could not be identified with any one order, such as files, emery cloth, machine oil, belt dressing, etc.

d. Raw stores.

e. Work in progress.

f. Finished stock.

g. Obsolete, defective, and returned stock.

The inventorying of the plant and equipment is comparatively an easy matter. Inventorying of the rest of the items (d to g), which come under the general head of materials, is much more difficult, because the materials are varying continually in quantity, are moving about the plant, and are in all stages of manufacture. It is here that the main problem of making an inventory is centered.

There are two general methods in use, the *perpetual inventory* or stores ledger method, and the *physical inventory* or actual count. There is much controversy as to which of these two methods is the better.

Perpetual Inventories.—The perpetual inventory aims to give detailed information monthly, weekly, daily, or even hourly if necessary, of the state of material on hand and the rate of consumption. When a financial statement is wanted, a balance is struck on the stores inventory accounts in the same way and at the same time that the financial accounts are balanced.

Two methods of keeping perpetual inventory are in use. In one, the receipts and issues of material are *posted in a stock record* or card system by clerks whose business it is to maintain that record; in the other, the receipts and disbursements are *recorded on the bin cards* located in the storeroom. The first method is rather more accurate. Many plants operate both methods, as a check against each other. Either method should be checked by actual count in some systematic way.

The stores ledger accounts in a perpetual inventory, set up for each item, correspond to the ledger accounts maintained in the accounting department for each financial account. No accountant would think of running records indefinitely without the check of a trial balance. Similarly, no stores record should be run indefinitely without an actual check. This check may be a progressive one or may be a general periodic inventory. Some system of checking, however, should be employed, if only for the moral effect on both the storekeepers and the record clerks.

Methods of Checking.—Some firms make an actual count of each stock item whenever the "low limit" is reached before ordering. In other plants, it is the practice to check the stores and stock progressively, at stated intervals, so that all materials are covered at least once during the inventory period—say, each year. If this is done, the perpetual inventory may be considered as a device for spreading the old physical count system over the entire year in such a way as not to interfere with the operation of the plant. The general experience is that a well kept stores ledger system is reliable and it has the great advantage of giving information regarding stores balances at any time it is needed.

From the inventory point of view it is just as essential that there should be a record of every receipt of material *into* stores and stocks as that there should be a record of every *withdrawal*, otherwise an accurate balance can never be maintained. Promptness and accuracy in posting are essential, for perpetual inventories require perpetual attention, and on this hinges their success. All documents relating to the receipt and disbursements of material should be preserved for at least the period during which they may be needed as a check. This would be, ordinarily, until an actual count has been made.

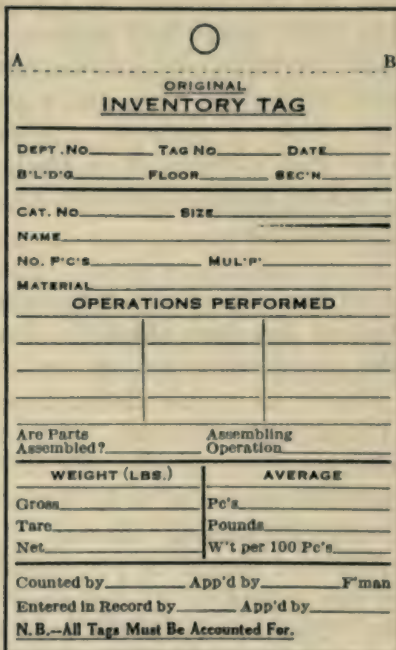
Advantages of Physical Inventories.—Advocates of the *periodic physical inventory*, as distinguished from the perpetual inventory or stores ledger accounts, claim that the former is absolutely necessary, and that the hundreds and thousands of entries in stores ledger accounts cannot be free from errors, some of which may be serious. One objection raised against the physical inventory is that it necessitates closing down the plant. It is claimed, however, that the closing down of a plant for, say, a week every year is desirable, anyway, for other reasons, such as repairs, alterations, and replacements. Some plants make a practice of shutting down for a short period in the summer when many workmen are asking for vacations.

This period can be utilized, therefore, for all three purposes—repairs, vacations, and inventory.

For a small plant, a physical inventory may be cheaper than the maintenance of a perpetual inventory. In many cases both systems are used, the perpetual inventory for information on running balances during the year, and a physical inventory for checking purpose. Whatever the claims of the two systems, it is likely that the practice of taking physical inventories will have a place for a long time.

Methods of Inventorying.—A definite date for taking a general inventory should be fixed well in advance, the organization set up, and every man instructed clearly as to his duties in connection with it. Usually, the foreman of each department has charge of the actual work of taking the inventory in his department, as he is most familiar with the material passing through it. Every foreman concerned should be responsible for the accuracy of the record of all the material in his department. It is best to take the work in process first, so that if the number of days provided does not prove sufficient the checking of the finished stock and raw material may be left to the last and handled, if necessary, after the works have resumed operation.

An ample number of consecutively numbered tags similar to Figure 4, are given out in batches of from 100 to 500 tags, as may be required, to the parties in charge of the stock-taking in each department. It is their duty to weigh and count the stock and attach these tags to *every* bin, box,


A B

ORIGINAL

INVENTORY TAG

DEPT. NO.____ TAG NO.____ DATE____

B'L'D'G____ FLOOR____ SEC'N____

CAT. NO.____ SIZE____

NAME____

NO. P'C'S____ MUL'P'____

MATERIAL____

OPERATIONS PERFORMED

Are Parts Assembled?____ Assembling Operation____

WEIGHT (LBS.)	AVERAGE
Gross____	Pc's____
Tare____	Pounds____
Net____	W't per 100 Pc's____

Counted by____ App'd by____F'man

Entered in Record by____ App'd by____

N. B.—All Tags Must Be Accounted For.

Figure 4

rack, or piece of material. The tags may be provided in different colors corresponding to the classes of materials. A record is kept of all tags given out and to whom; and all tags, whether spoiled, used, or unused, must be returned to the checkers.

The foreman of each department and a checker should supervise the weighing or counting, correct any errors, and see that the amount is entered correctly on the inventory tags. Actual weight, quantity, or the proper measure must be used wherever possible. When this is not possible and estimates only can be obtained, the foreman and the checker should agree upon the proper figure and they should both initial the tag, which should be marked "estimated." Estimating should be used only when absolutely necessary.

All material should be collected and piled in a neat manner before taking inventory, with a view to making a more correct and expeditious count. While the inventory is in progress no stock should be moved from one department to another, and there should be a very definite understanding as to the responsibility for the checking of any material in passageways, yards, and other parts of the plant where there might be duplications or omissions. Care should be taken to see that the proper unit of measure is entered on the tag, stating the quantities on hand in the unit of measure by which that article is usually priced or sold. It is important that the shop order number on work in progress, as well as the catalogue or part number, be given and the exact condition of the material stated, in order to determine the value of the labor which has been expended upon it to date.

Any material which has been missed will show up by not having a tag. Material is not likely to be counted a second time, because the fact that it has already been counted will be shown by the tag on it. When the inventory is complete all material should have a tag. After the inventory has been taken, the tags will be collected by checkers and sorted in numerical order to determine that none are missing. The last tag used in each department must be clearly marked "Last Tag, No. —."

Precautions When Taking Inventory.—In order that the inventory may be taken as quickly and accurately as possible, and the results tabulated correctly, there are a few precautions which should be observed. Not all of these fall within the province of the foreman, but he should be acquainted with them so as to give all necessary cooperation.

1. The head cost clerk should have general charge and supervision of the inventory. The receiving department should make the inventory of raw materials; the cost department should inventory the materials in process of manufacture; and the stores department should take stock of the finished products and supplies.

2. Some time prior to the day when the inventory is to be taken, every individual article, each group or class of articles, and every bin containing material in stock room, warehouse, or any other part of the plant must be labeled or tagged. The tag must contain complete information about the article; such as, name, mark, number, weight or measure or size, quantity, cost, etc.

3. The head of the cost department should issue the tags mentioned in paragraph 2, and should take a written receipt from each man to whom they are given in lots of 100 or more, consecutively numbered. These tags should have duplicate carbonized slips attached to them, which are to be torn off when the necessary data has been written on them, and kept by the person responsible for the tags. This insures having a duplicate in case a tag is lost.

4. The head stock-keeper should provide a catalog, or finding list, for the inventory takers. This catalog must list all material and finished goods in stores, giving number of the bin containing them, or their location.

5. The foremen should personally see to it that all material under benches and in out-of-the-way places is brought out, and that the shop floor is made clear of everything except material in process of manufacture.

6. In order to get the value of goods in process, the time of labor spent on the material up to the date of stock taking, as well as data about the material itself, should be entered on the tag.

7. All tags must be turned in to the head of the cost department after the inventory. This means *all* the tags that were given out by him.

Section III

Safety in Handling Materials

Importance of Accident Prevention.—Accident prevention is one of the foreman's most important responsibilities, as he is the executive in immediate charge of shop conditions. Where large forces are at work and heavy masses of material moving, it is inevitable that there should be some element of danger; but every preventable accident is a human misfortune, an economic waste, and a discredit to someone.

The subject of industrial safety includes buildings, power plants, all types of machinery and their operation, and transportation in all forms, to say nothing of the hazards of construction work and mining. In some of these activities, such as mining, accident prevention has been studied carefully for many years; in others, careless indifference has persisted almost to the present time. Among the various hazards are those relating to the storage and handling of materials. We will take up in this section the foreman's responsibilities in this regard.

Safety Rules for Foremen.—Various safety codes are published by insurance companies, and a number of books on the subject, such as "Practical Safety Methods and Devices,"* by George A. Cowee, are available. This book contains some general rules for the foreman which apply as much to the handling of materials as to other phases of his work. Some of these are as follows:

Have a thorough understanding of all the safety rules. Unless you know them and are living up to them, and enforcing them, you are not doing your full duty.

It is your duty to see that all safety rules are observed by your men.

Caution your sub-foremen regarding the prevention of accidents, as you are responsible for the men working under them.

Judgment should be used at all times in placing men on jobs. Heavy, slow men should not be placed on the jobs where light, quick men are required. Slow-thinking, untrained men should not be placed in positions of danger where presence of mind and knowledge are required.

Do not place a man at new work unless he understands his new duties. If he does not understand them, explain them thoroughly to him.

Do not put men to work on any job until you have inspected everything, and satisfied yourself that the place is safe. Warn the men of any danger that may arise in the course of their work, and see that your instructions are carried out. If you see a man taking chances and endangering himself or his fellow-workmen stop him.

Obtain a thorough understanding of each accident, and study how its repetition may be prevented.

See that your men report every injury, however slight, and that it is attended to by the doctor. Trivial wounds promptly attended to amount to little; if neglected, they may easily become infected and lead to serious consequences.

---

*The author acknowledges his obligation to Mr. Cowee for certain material used in this section.

Safeguarding Materials in the Building.—The reason why so many "fireproof" buildings burn down is simple. The brick, steel, or concrete buildings themselves may have been honestly built and may not be inflammable, but someone grew careless as to the material stored in them. Cotton waste and oils, unless properly cared for, will burn inside a building as quickly as they will elsewhere. The fire hazard in industrial plants centers almost entirely on the proper handling of the materials they contain, and all materials should be stored and handled with constant reference to this risk. Materials which are a hazardous risk should be separated, if possible, from the rest of the building by fire walls and, if necessary, located in a detached building. We have considered elsewhere the fire risk involved in the storing and use of fuel oils.

Waste, oily rags, sawdust, and other refuse should be placed in metal cans or receptacles provided with covers. Inflammable material should be stored in small piles, where possible, rather than in one large pile. No inflammable or volatile material should be allowed near any machine capable of causing a spark. Open lights should never be used in rooms where paints, varnish, turpentine, and crude oil are used or stored, nor in rooms where explosive gases and chemicals are used. These substances should be stored in separate buildings. Vats or receptacles containing inflammable or volatile substances should be provided with close fitting covers held open by fusible chain links, and these covers should be kept closed except when supplies are being withdrawn.

Empty boxes, barrels, kegs, and other rubbish should not be allowed to accumulate. Lighted cigar and cigarette stubs, pipe ashes, and matches should never be thrown on or near rubbish piles, or in other dangerous places where they might start a fire. Floors should constantly be swept clean where waste rapidly accumulates. All rubbish should be collected and disposed of each day.

Drip pans should be used to catch the oil drippings from machines and so prevent the oil from soaking into the floor. This not only decreases the fire risk, but keeps the floor from becoming slippery. Sawdust or other combustible material should not be used in the drip pans to absorb the oil; sand should be used instead.

Danger from Dust.—Under certain conditions, the dust of many organic substances, such as flour, coal, starch, sugar, rice, meal, grain, and bran, is capable of exploding with tremendous violence. Serious dust explosions have occurred in flour mills, coal mines, and other places, resulting in large loss of life and property. The dust of the above and similar substances is especially dangerous when suspended in the air in a finely divided state. It may also be ignited when deposited on floors, walls, girders, and machinery; the resulting blaze then generally causes an explosion. Under such conditions, sparks from grinding stones, belts, machinery, and electrical apparatus or open flames should not be permitted.

Floors Should Not Be Overloaded.—Another danger to buildings is the liability of overloading the floors with materials. In the best plants, the buildings have signs posted in conspicuous places giving the allowable load per foot on each floor, and it is one of the responsibilities of the foreman in charge to see to it that these maximums are not exceeded.

Safe Handling of Material in Buildings.—All hoists and cranes require constant care and frequent inspection. A definite schedule should be set up for this inspection and faithfully maintained. Limit switches should be provided on all elevating hoists to preclude the danger of overwinding. Cables are considered safer than chains for general work. The hooks should be of approved type, and so arranged that they cannot twist while hoisting. Sheaves should be provided with guards to prevent the cable from running out of the grooves.

In slinging heavy material, the load should be tried before starting away with it to see that it is securely slung and hooked. The ropes, cables, or chains should be so slung as to make an angle of not less than sixty degrees with the horizontal. This is *very important*, because a flat sling with a hook close to the work is under an enormous and unnecessary tension, greatly in excess of the weight of the load. Accidents most frequently occur from hooks catching in the work after they have been unhooked. These happen because the crane men raise the loads before they are securely hooked, or because they raise the hooks before the unhooking is finished. These are the most important things a crane man should guard against. Never drag slings, chains, hooks, or loads along the floor. Heavy side pulls should be forbidden. All hooks should be forged and of proper design. They should bend slowly and gradually if overloaded, thus giving sufficient warning.

Keep workmen from being under the load. This is not always possible, but every effort should be made to bring it to pass.

Safety in Unloading and Storing Material. Gravel, ore, and lumber should not be piled within six feet of the nearest rail, in order that there may be a safe distance between the cars and the materials in case men are standing by the track. If this is impossible, signs should be placed at each end of the pile to warn against passing between the pile and the track. Gangplanks for transferring materials to and from cars should be strong and kept in good condition.

All materials should be carefully stowed in such manner as to be secure against sliding, displacement, and breakage. Many accidents occur through piling, unpiling, and storing material. Lumber and planks should be crosstied at frequent intervals, and as much care should be taken in unpiling as in piling.

Brick should not be piled higher than seven feet, and the pile should be tied at every tier with alternate courses of headers and stretchers. When the pile is over four feet high it should begin to taper to the back from a point four feet high, not less than one inch to the foot. Brick should not be piled for storage purposes on scaffolds or runways. Tie-strips of wood should be inserted where necessary.

Cement should not be piled more than ten bags high except in storage places built for such a purpose. The corners of the pile, which are not supported by something permanent, should be cross-tied in two separate tiers up to the fifth bag, where a step back of one bag in every five bags should be made. Beginning with the fifth bag, only one cross tier is necessary. The back tier, when not resting against a wall of sufficient strength to withstand the pressure, should be stepped back, one bag in every five bags, the same as the end tiers. When piled between and against walls of sufficient strength, no cross tiers or step bags are necessary; but bags should be piled with a slight incline against the back wall, the height depending on the strength of the wall. Cement bags in outer tiers should, in all cases, be piled with the sheath facing the center of the pile. When cement is removed from a pile, the whole pile should be kept at an even height, and necessary step backs every five bags should be taken care of.

Storing of Materials in Foundry Yards. Foundry yards should be maintained in an orderly condition. Flasks, castings, and other material should be stored in a systematic manner and not too high. Sand and coke bins and other permanent bins should be substantially built and maintained in good condition—weak, dilapidated ones are unsafe. Plate moulds, when piled cribbing fashion, should be piled not over twelve feet high. When piling other moulds, the pile should not exceed five moulds high. Each tier should contain at least one less mould than the tier below, and each tier should be locked or blocked to make the pile secure. Ingots should be piled not over five feet high and, where possible, should not be stood in a vertical position unless proper barriers or supports are provided. Rolls, pinions, pipes, rods, and bars should be stored in substantial racks to preclude their rolling. Nuts, washers, bolts, and similar articles should be stored in boxes, or, when on shelves, so held by a toe-board as to prevent the pile from sliding. Patterns, pulleys, and wheels should be stored in racks or upon center poles. All storage places should be kept in an orderly condition, the aisles should be clear of loose material, and congestion avoided.

Section IV

Boxing and Shipping

The Importance of Packing.—The final phase in handling materials is the boxing and shipping. As much care should go into this as into the actual production of goods. Nothing is more discouraging, both to the manufacturer and to the consumer, than to have valuable material damaged in transit. This is particularly serious when the material goes to a far-away customer and it takes months before the matter can be adjusted or the damaged parts replaced.

The nature of the packing required naturally varies as widely as the materials to be packed. Coal or ore is simply dumped in bulk into open cars or the hold of a vessel. Cement or flour may be shipped in bags stacked in box cars; but machinery, typewriters, fabrics, etc., must be carefully boxed and adequately protected. The degree of care and the expense justifiable must be determined in each case. Certain general principles, however, run through nearly all industries where care must be used. The boxing should be substantial enough to prevent any breakage and give full protection to the contents against theft and weather conditions. From the hour that the box leaves the plant, it is liable to abuse and exposure and may be left out in the snow or rain, either on the cars or on some platform.

Preparation of Machinery for Transportation. If machinery is to be shipped overseas it is necessary to guard against rusting, due to salt air. The finished surfaces of all machinery, even when it is to be completely boxed, should be carefully wiped dry and covered with anti-rust or slushing compound. Polished parts should be perfectly clean before applying the compound, as ordinary oil or grease is apt to prevent the slushing from sticking to the metal. If the crates or boxes are not completely filled, the contents should be braced securely enough to preclude all sliding, and to make sure no pieces can come loose inside the case. With machinery, it is desirable to remove small parts and pack them, if possible, in unoccupied portions of the case rather than in separate boxes. When this is done, all the parts are received together, whereas separate boxes might become lost in transit and hold up the use of the machine until the missing parts could be located or replaced.

In the case of heavy crates or boxes which are to be handled by cranes, safety in handling is greatly helped if provision is made for slinging. This can be done by having hooks or eyes for crane slings attached to the strongest parts of the box in such a way as to make sure that it cannot slip in the sling and cause damage.

Overseas Shipment of Machinery.—Cases for overseas shipment of machinery are sometimes lined with sheet zinc and soldered to make them air tight. Small tools and other expensive articles are frequently, not only coated, as already suggested, but also wrapped in wax or waterproof paper and packed in sawdust or other soft material in small wooden boxes before going into the crate or packing case.

The Packing Room.—The packing room should afford ample space to handle the material without confusion. Preferably, a number of bins of various sizes should be provided adjacent to the packing and loading space. Items ready for shipment may be collected in these bins, for the various orders, until they are complete and ready for shipment.

Packing Cards and Packing Lists.—At the time of shipment there should be inserted in each pack-

THESE GOODS WERE

CHECKED BY PACKER

AND THEREFORE KNOWN TO CONTAIN
ALL THAT THE BILL CALLS FOR.

Please see that each bale, box or package is delivered to you in good condition by transportation company before receipting for goods. If shortage is shown, require the freight agent to note same on expense bill.

IF YOU ACCEPT SHIPMENT SHORT OF MATERIALS SHOWN ON PACKING LIST AND BILL OF LADING, YOU SHOULD NOT EXPECT US TO ASSUME THE RISK.

Attention to above will work to our mutual protection.

UNPACK WITH CARE

Many shortages arise from goods being left in packages or thrown out with packing. Your own experience will confirm this. RETURN THIS CLAIM CARD with letter advising particulars in case of disagreement with invoice, or other complaint, as packer must be held responsible.

These articles have been checked by inspector, and shipped in perfect condition. If not as ordered, return this packing card.

RETURNED GOODS

When returning goods for any reason, please be careful to mark package plainly with your name and address and consign goods to

NATIONAL MANUFACTURING CO.
DAYTON, O.

Enclose IN PACKAGE complete list of articles, and state why returned, even though this has been previously explained in correspondence.

Customer's Order No. . . . . . . Date. . . . .
Our Order No. . . . . Packed by. . . . .

Figure 5

ing case a packing card containing the manufacturer's name, the customer's order number, the shipper's order number, the date packed, and the name of the packer. There should, also, be included a full list of the contents of the crate or package as packed. Figure 5 shows a packing card, and Figure 6 a packing list. Some com-

PACKING LIST

No.________ Date________

Shipped To________

Order No.________ ________

Car No.________ ________

SHIPPING DEPARTMENT

Via________ Receipt No.________

NO.	PKG.	CONTENTS	WEIGHT

PACKED BY ________

PLEASE CHECK THIS LIST IMMEDIATELY ON RECEIPT OF SHIPMENT AND NOTIFY US PROMPTLY OF ANY ITEMS NOT RECEIVED.

Figure 6

panies include all of this information on the packing list. The packing list should be made out at least in triplicate—one copy goes into the case, one copy is sent to the consignee by mail, and the third is retained by the shipping room. Frequently, a fourth copy goes to the production department and, from there, to the office. This packing list is important because the consumer, on receiving the package, may very easily overlook some of the smaller parts, and it saves correspondence and delay over claims for alleged missing pieces, which were in fact included in the shipment.

Procedure in the Shipping Department.—In the usual procedure the shipping department receives a copy of every order, containing all the information necessary to get out and pack all the items, together with the shipping directions. It is desirable in the case of large orders that this information be furnished the department somewhat in advance of the date of shipment, in order that arrangements may be made for cars or other means of transportation. If a stock of finished material is carried, all parts should first pass into this stock and be recorded before they are shipped out. If the items are in stock and ready for shipment, the stock department sends its copy of the shipping order to the shipping department, indicating that the parts are ready for shipment or that they will be ready on a certain date. If the material to be shipped represents large machines or materials which do not go through the stockroom, the shipping department should have definite information that the material has been inspected. Ordinarily, all material which has gone through a *finished stockroom* is assumed to have been inspected before going into finished stock. Whatever the course of the material, the shipping department should know that it has been properly inspected and passed before it is sent out.

Usually, a shipping record is maintained which shows the date of shipment, the number of sheets to the order, how shipped, the car number, whether freight was prepaid, the date paid, and the name of the consignee. There will be, also, columns for partial and completed shipments, the dates on which the packing list and order copy were received by the billing department, and the name of the clerk by whom they were received. It is very necessary that this record be kept, in order to have data available for tracing lost shipments.

Car Records.—Where much material is shipped, the shipping department should receive the shipping program sufficiently in advance to put in requisitions to the railroad for the needed number and type of cars. Some time may be necessary to secure these. This requisitioning should be done intelligently and with close regard to the shipments. Delay in getting cars means delayed shipments. If the cars arrive too soon and in too great numbers the shipper will have demurrage charges to pay and will ultimately demoralize his car service. In order to handle questions of demurrage it is customary to maintain a car record, which gives the car initials, car number, date delivered on switch, date "set," date unloaded, date loaded, date taken out, party shipped to, and any other information necessary.

Constant care in the handling of shipments is necessary, as good work throughout the entire plant up to the point of shipment may be nullified by carelessness at that point.

Part II: The Foreman

WORKMANSHIP AND ORIGINALITY

Section I

Some Aspects of Labor

Value of Labor.—Everything which has ever become useful to mankind has been made useful as the result of labor. Mental labor was required in the observation of the thing, in the discovery of the reasons for it, and in working out ways of using or improving it; while physical labor was brought into play in finding it, in preparing it for use, and in improving it. From the labor of hunting or fishing, scraping and drying the hides, making stone weapons and building a fire, to the labor of manufacturing an automobile or a piece of cloth, everything has required labor before it became of any service; and always there was, first, mental labor and, second, physical labor.

The only wealth which we possess is that which results from a surplus of labor. The weapon maker of the tribe in the old days, whose weapons were worth one pig or one measure of corn and who made more weapons than the tribe needed, became wealthy in comparison with others, because each weapon was worth a certain amount of meat or corn or hides. The man who by industry was able to grow more pigs than another man, by caring for them and raising them to maturity, was wealthy, because he could exchange those pigs for more clothing and for more of other things.

Money is only the means by which we put this wealth in convenient form, so that it can be moved about in order to be easily invested in more production. A dollar is like the ticket on a railroad. If the railroad doesn't run, the ticket won't take you where you want to go.

Valueless Labor.—The dollar is worth so much meat, provided there *is* any meat. If there is no meat, the money is not worth anything. The only things which are of value to us are the things which we can use, whether they are ornaments or clothing or food or money. Everything useful is the result of labor; so, unless we *make* the things, we cannot use them. Our wealth is proportionate, not to the amount of labor, but to the amount of usefulness which comes out of the labor. That is why the Great War left us nothing but a lot of debts. It required an enormous amount of labor to prosecute the war, but it was not useful labor. That money was spent, not to produce things, but to destroy things. It did not *add* to our wealth; it destroyed wealth.

Nothing is of value without the expenditure of mental and physical labor on it, and its value is in proportion to its usefulness in supplying the needs of humanity.

Labor and Wealth.—This complex organization of industry, which we have developed through the use of machinery and specialized occupations, has become possible because the development of machinery enabled us to invest the surplus of past labor in the means for future production by putting it into the buildings, machinery, and equipment necessary for production. In the days before we had all this machinery, it was impossible to make much more than was immediately required for use. The tools with which we made things were small and clumsy and it required a great deal of time and patience and labor to convert the material into the useful product.

Just as soon as we began to get larger machinery and more of it, we were able to make things faster so that more people could use them. Only a part of our time was employed in making things for *immediate* use. Part of it was employed in making things for *future* use, and that part of it was our wealth. Without this *surplus of time* accumulated in the form of machinery and buildings and equipment, we could not continue this present civilization with all its conveniences and we could not support a population as large as the millions who are now living more or less comfortably in this country.

You all know of the old custom which young women have observed for many centuries—the custom of using their spare time to make a large amount of household stuff, which they could put by against the day when they would marry and have their own homes. Everything which they accumulated was wealth, because it was the use of a certain amount of time in making and storing up goods which would be of value later on. In other words, it was *surplus*. All the new buildings, all the machinery, all the equipment—everything which is being constructed at the present time for the purpose of enlarging useful production or distribution—is being built and being paid for out of wealth, which we call *capital*. None of this extensive consumption of time and labor in preparing for future production would be possible if it were not for the fact that part of the labor in the past had gone to make products for the future, and that surplus represented stored-up usefulness and became our capital.

Labor and Production.—The job of all labor, whether brain work or hand work, is to produce something which is useful to people. The labor of the novelist, in writing a story, provides me with useful entertainment. The labor of the musician, in becoming skillful with his instrument, provides me with useful relaxation. The labor of the architect who *plans* the house is just as valuable as that of the mason or carpenter who *builds* it, because the house must be planned properly before it can be built properly. Both these elements are useful efforts of labor.

When we began to build machinery and to use engines to drive it, we were able to make more goods and make them more cheaply, because we used less time and labor. We were able to buy more, because our own time and labor were more valuable; and we had enough surplus over our necessities to devote some of the results of our labor to buying conveniences and comforts.

You are, therefore, intimately and deeply concerned with the *speed* of production and the *value* of production in your department, for the efficiency of your group adds its part to the efficiency of the production, or its inefficiency makes things cost more.

Importance of All Labor.—A manufacturer, employing five hundred workmen, had a special scheme for showing his workers the value of their work. If he heard any worker say that this part or that part was not very important, because it was only a *small* part of the machine which they were making in the shop, he would take that man out to the place where a machine was being tested, have him remove that little part, and then try to run the machine. In this way it could be shown that each minute operation in the factory and every individual part produced was necessary to make a complete machine and, therefore, that all parts of the work were important. The supervisor of a gang of workers repairing a railroad track is doing a job which is just as necessary and useful as that done by the man who sits in the office planning improvements or dispatching trains on that part of the line, and the president of a great corporation is a workman in as real a sense as is the man who runs a lathe or sharpens a tool.

All Labor Is Really Cooperative Effort.—Upon the foreman depends, to a very considerable extent, the speed and accuracy with which all this useful work will be accomplished. After the work has been planned, after the capital has been expended in buildings, machinery, and equipment, after the material has been bought and the systems arranged, the actual labor of making raw materials into useful products depends upon the foreman and his group.

This complicated industrial organization in the United States is really a great big *cooperative* body, engaged in making life more useful and more beneficial for all the people who live here, and in thus cooperating for useful service we make our living and gain our reward.

Labor means *service,* and the more service which can be given in a definite time with the least effort, the greater will be the results of that service in the improvement of the social life of which we are a part.

Section II

The Art of Work

Following the Method.—Very frequently, a man who has charge of other men will say, concerning one of those over whom he has supervision: "If he knows *exactly* what you want, you can depend upon his doing it, but he cannot *think* anything out for himself." There are many men in industry like that. They are accurate workers after the job has been laid out for them and the method of doing it has been explained, but they have never developed their capacity to see clearly the reasons for the action and to think some of it out for themselves.

One of the heavy costs of industry is the cost of *supervision.* The people who are engaged in managing and planning—foremen, inspectors, and all others employed in supervising the work in one way and another—add to the cost of the product, although they contribute no direct labor to it. This supervision is necessary, however, in order that the work may be done regularly, accurately, and up to the standards in time and quality. It is required because there are so many workers who are skillful with their hands in carrying out what they have been told, but who have never developed the capacity to think out for themselves how things shall be done.

In order that the work may be carried out in an orderly fashion and without confusion, some instructions must be given to and heeded by all supervisors. In Book I, it was pointed out that all workers, of whatever kind, are subordinates in one part of their work and, as subordinates, are required to carry out the instructions of others. The president of a company is instructed by his board of directors and they in turn are instructed by the stockholders. So all down the line there are some instructions to be followed. You are instructed to do certain things in your work as foremen and those things are your responsibility. You are *not* instructed in all details as to how you shall do them, because you have learned to think about your job and plan how these general instructions can be carried out in detail. There is scope left for your judgment and the development of your mental capacity in your work. That is one of the things which makes your work interesting and attractive to a red-blooded man.

When a man must be *instructed,* not only on the thing to be done, but also *how* it must be done, he is not using his own judgment very much and he needs a maximum of supervision. He is, consequently, not of as great value as the man who *thinks.*

Developing Initiative in Use of the Methods. Early in the course, it was stated that the most important part of the work of a supervisor in industry is the proper judgment and capacity to handle men. The more men a supervisor can handle well, keeping them happy and alert on the job, the more valuable he becomes to industry. Men can be handled more easily and with less supervision as they are taught to *use their judgment;* for in that case they require less instruction and inspection—the two most important time-consumers in the supervision of men. The endeavor of the foreman must be to take the men who can do things, when they are told exactly what to do, and gradually educate them so that they can determine how to get the result when they are told what is wanted. This is the process of changing a man so that, instead of following slavishly the method laid down for him, he will be able to develop a new method for his own work with the help of his foreman.

Unless men are taught to use initiative and thereby gradually develop some parts of the established method, they will not grow in efficiency to the point where they require less supervision.

Improving the Methods.—It is a long step, in the development of the art of work, from the ability to plan the method to that alertness of observation and imagination which will enable you to see the possibility of improvements in your own methods of doing anything.

The painters of a stage scene, when they are at their individual pieces of work, appear to be daubing on the canvas a thick brush of one color and a light brush of another color without producing any semblance of a picture or scene. Every once in a while the designer of the scene, or the master painter, will walk back far enough from the canvas to bring into perspective the separate work of the painters; and, in so doing, he catches the strength or the weakness of each piece of work so that it can be harmoniously and accurately coordinated.

The ability to step back from our work and examine it, as though we were not engaged upon it, is a very necessary prelude to the improvement of the methods of work. There are a good many men in business whose first reaction to suggestion and criticism is one of resentment. They may not get angry about it, but they show in their first little reaction that they cannot separate their work from themselves and look at it as though it had been done by somebody else. It becomes a personal offense when their work is criticized. This attitude makes it very difficult for them to see the improvements which might be made in connection with their methods of work. It is one of the reasons for the supervision which must be given, and the instructions which must be conveyed from one supervisor to another in connection with the general program. If every man could organize his own work with due regard for the objects of that work, its relation to the rest of the work, and its agreement with orderly requirement, there would be need for a comparatively small proportion of the supervision that is necessary today in industrial establishments.

In all practical work, improvement is effected by seeing the change that can be made in *one detail at a time.* It is because of this necessity for detailed improvement that the foreman, in his capacity as supervisor of his group, can effectuate so much increased value in industry. He becomes capable of improving the methods by observing them in their relation to each other as parts of the whole. The foreman must be ready to look at his own work as though it had been done by somebody else; he must examine the details of it with the same judgment that he would use in examining the work of some other foreman, and he must determine at all times whether his methods are calculated to be of the greatest service in getting the work done on time and at minimum cost.

Knowing the Work.—Most of the workers and a good many of the supervisors in industry feel that they know the *work,* when they know only their own individual part in the work as far as their operations are concerned. But that is only a part of the knowledge of the work which is necessary for its proper government.

So, knowing your work means not only knowing *what* you have to do and doing it, but also knowing *why* it has to be done, what *purpose* it serves, and how it *fits in* with the rest of the work done in the plant. That is particularly important in your case as foreman, because you represent the whole establishment to the workers. You are supervising them, and they look to you to know why these things are to be done and what they mean. They expect you to know something about the general methods of inspection, the methods of time-keeping, the reasons for drafting, and the general arrangements of the company. That is what is meant, in the full sense, by knowing one's work, and it is this which distinguishes the leader from either the supervisor or the subordinate.

The development of a baseball team is pretty nearly equal to the character and knowledge of the coach who is engaged in training it. He knows not only what *he* has to do, but what other coaches do; he knows the history of various plays in baseball and their success or failure. He knows where baseball fits into the scheme of things in the town or organization. A leader with that capacity is equipped to make a baseball team out of ordinary, average material that will spread its achievements over the sporting page of the newspapers.

It is in this sense that you as foreman should know your work, if you are to develop yourself to the full extent of your potential capacity, and if you are to achieve the authority which should come as a part of that development.

Section III

Work and Discovery

The Teaching of Experience.—The other evening a group of men, who were pretty well versed in the history of some of the old civilizations, were discussing how long it took for the human race to change its method of transporting things from the old sled on runners to a wheel cart. They could not come to any conclusion about how long it took, but the conversation developed the fact that, after carrying the burdens himself, man discovered he could drag them and get a bigger load transported by that means. He, first of all, dragged them by means of long sticks spread out wide at the bottom and crossed near the top. The load was piled at the lower end, where the sticks were spread apart. This way became inconvenient because it would not carry a big enough load; so, after a while, the whole thing was put on the ground and dragged by means of thongs. Then, after a longer period, men discovered that they could cut a section from a tree and have round pieces, which would enable them to drag a much bigger load with much less effort; so they began to make solid wheels.

All discoveries have been made in this way, because the necessity for greater protection or for a larger supply of food or for better housing or transportation has driven men to use their powers of thinking, so that they have discovered better means of doing the thing and better ways of providing themselves with the products they needed.

Improvement Hampered by Lack of Education.—During all these centuries few people could read or write, and much of the knowledge was buried because it could not be understood except by a very few students who constantly endeavored to piece it together. So the progress in discovery was slow, because the people could not take full advantage of the experience of the past. For example: The Chinese had known the art of printing nearly two thousand years and yet Europe had not discovered it, because there was no communication between the Chinese and the Europeans. After the discovery of printing in Europe, and the discovery of how to make cheap paper, it became easy to print books showing what people had learned in the past. More people found out how to read and write and more and more people studied what had gone before, so that the past experience became available to more and more of the population.

Here again it was the necessities of work which were the great educational factors. All the discoveries in science, in the making of machinery, in the improvement of communications, and in the other physical surroundings of man, have been made possible, because we learned how to use the past experience which had been recorded for us in books, how to put our imagination to work on the job of improving that past experience. We were then enabled to do our work so much more quickly and so much more advantageously that we were in a position to make thousands of products where one or two had been made before.

The teaching of experience would have been of little moment in improving the condition of man, if it had not been coupled with the record of that experience in writing and the study of that record by thousands of other men, who were thus enabled to go further instead of having to retrace the steps which had already been taken.

Learning from Others.—When we talk about the value of *experience* as contrasted with the foolishness of *theory* and the impracticability of book-knowledge, we are simply showing our ignorance of what has gone before and why we are in the position we occupy today. As it stands now, ninety per cent of our efficiency is due to the ability which we have in using the experience of those who have gone before and of others who are practicing in the same fields today. It is very doubtful, indeed, whether we really make ten per cent progress in any decade. Whether these percentages are exactly correct or not, our work would be absolutely impossible were it not for the study which has been given to these matters by hundreds of thousands of men. Men study what those who have practiced these arts, or discovered the principles, learned previously and, in addition, they read about the methods adopted by other people in the same lines of industry today and discuss their values.

Knowing the experience of the past increases our speed of growth, just as the aeroplane would vastly increase our speed in getting to a certain place as compared with the necessity of walking.

It enables us to get all the knowledge, which men took a thousand years to acquire by experience, in the course of two or three years. The experience of others in the same line of business at the present time enables us to get the thought which thousands of men are putting upon their work, instead of being confined to the thinking we ourselves can do.

Using Experience.—Whether we realize it or not, we are using the experience of the past. The whole organization of industry is based upon past experience and the books which have been written about that past experience. The student who goes to a university to take an engineering course does not learn how to be an engineer. He learns what the engineers, who spent their lives in engineering, have said about their discoveries; so that when he is out of college he begins to get his practical experience and applies his knowledge to the engineering problems of the day. If he did not know about the things which had already been discovered, he would rediscover a great many things and spend a lot of time and energy in working them out. Now they can be studied and absorbed by him in a very much smaller space of time. When he becomes an engineer he is often in the society of engineers, he reads the technical papers and, through these means, he learns of the things which other engineers are discovering in their practice. He discusses his problems with other engineers and in that way his mind is capable of using a vast amount of material which he could not accumulate in his own experience.

That is the way in which experience is brought to its greatest usefulness by the individual. In order to do this, however, it is necessary to read regularly, so that the reasons for the things which are being done are understood. It is necessary to think when reading in order to understand what one reads, and it is necessary to enter into discussion of problems with other men engaged in the same general occupation, so that their experience may be added to our own. As an alert business man put it a long time ago: "If we exchange dollars we each have *one* dollar; if we exchange ideas we each have *two* ideas."

The processes of this use of experience follow the path suggested in the last chapter. First, we learn about our work—the operations we have to perform. That means that you must know the work which is performed by your group, for you have gained your position because you are experienced in that work. Then, it is necessary to know the *reasons* for the work. That means that you should know something about the usefulness of the things which you do, something about the organization in which you work, the other departments of the organization, how you fit into them, the methods which they use, and the way in which these methods fit everything together.

Section IV

Work and Science

Controlling the Results.—Suppose that you and I were in the business of manufacturing chemicals—dyestuffs, for example. In the course of securing the colors we had a liquid left over. This liquid had always been thrown away, because it was not of any further value in getting dyestuffs. One day, one of our workers dropped a monkey wrench into a pan of this liquid with the result that he was blown out of the window. This would indicate that we might be able to sell that liquid, properly packed, for explosive. Let us further suppose that we decided to sell the liquid and, from some experiments we made, we decided that certain sizes of cartridges should be made in order to give the proper power for certain kinds of work. We would find, after a while, that some of the cartridges were too powerful and some not powerful enough. The liquid would not be uniform, because it was only what was left over from our regular business of making dyes and we did not know how to handle it properly.

In order to be able to control the manufacture of this liquid so that it would always contain a given amount of explosive power for a certain amount of liquid, we would be obliged to put it in the laboratory and find out what it was made of, how it was produced during the process of making dyestuffs, and why it possessed the explosive power. Then we could rearrange our processes so that we could always get the same result within very narrow limits of error. But we would not have been able to make it uniform and get the same results if we had not passed the stuff into the laboratory and allowed the chemists there to experiment with it until they knew the answers to the questions that have been stated in this paragraph.

It is in just this way that experience is turned into science. Every man who seeks to find out the reasons for action, and the things which control the action, is a scientist, and science is the written record of the way in which results can be controlled by utilizing known causes.

Organizing the Information.—It is this organization of information, by research and study and practical experiment, which enables us to develop methods that are calculated to give practical control of results. How much this has developed our capacity for production in the last few years can be determined very easily by thinking back to the way things were done twenty or twenty-five years ago and comparing the methods of manufacture at that time with the methods of manufacture today.

When we know that a thing happens we can take advantage of that happening in order to make it useful to us. When we know *how* it happens we can *make* it happen and increase its usefulness. When we know *why* it happens we can control the conditions so that it will happen regularly and with the same effect each time.

While you may look upon the experimental departments of your own establishments as very far removed from your work and you may not consider them of any immediate value, yet the experimental chemist, the research engineer, and the industrial man who plans and develops will have a more intimate effect upon your work than will any other department in your factory.

Of course, the improvement which they can effect depends very largely upon the defects which you see and the possible improvements which you can suggest. There must be a constant interchange between the worker, with his daily experience at the bench or machine, and the research departments conducting their operations for the improvement of the industry of the future.

Turning the Improvement into Increase.—The object of all this improvement and development is to increase the amount of production which can be made useful to the people. We are accustomed to think that the object of all this work is to make more money for the concern in whose organization we are working. That may be the object of the concern, but it is not the reason why they make money and it is not the object of the work or of industry as a whole. The people pay because they are served by the delivery to them of these useful products and they are only discharging their obligation when they pay a proportionate price for the service. If more products can be turned out in a given time so that there are more conveniences and comforts to be secured by a larger number of people, the service is worth more to the people. Also, the company which performs this service will receive a larger total reward.

The discovery of the gasoline engine, which was made possible by the research and study and experimentation that went on for years, enabled us to provide ourselves with vehicles of transportation capable of doing what no other vehicle could do, in less time and with less man power required for its operation. This did not mean that there was less work for anybody. In fact, the use of this new means of transportation grew so rapidly that hundreds of thousands of men were segregated to provide this service for all the people. This service—because it increased the speed of getting about and the flexibility and speed of distribution of people and production—enabled us to use our time to better advantage. All through this development, organized scientific knowledge was playing its part in the working out of these new products and, consequently, in increasing the comfort and the convenience of living.

Repeating the Increase.—Just as soon as suggestion, research, and study have determined an improvement which will permit us to increase our efficiency, then it is necessary for us to devise equipment and systems by which we can repeat the increase and absorb it into our regular operations. This part of the development, which takes place in industry, concerns the planning and arranging of the new operations, or the changes in the old operations, which will allow the improvement to be absorbed in the regular work, so that the increased efficiency can be maintained, and there will be no confusion created in the organization by reason of the changes which are suggested.

From the time that an improvement suggests itself, either to the experimental department or to the man in the shop, until the time that it is absorbed into the production method as a part of the regular scheme of manufacture, a great many minds may have been engaged in making the improvement, from its original conception to the final product which the user will buy. Sometimes the improvement is one of detail in operation, which can be made immediately and absorbed into the general processes without disturbing the organization. Sometimes the improvement requires some rearrangement and some changes in connection with all departments of the factory before it can be absorbed, and there are other times when the improvement must be subjected to a large amount of experimentation before it even comes to the point of factory consideration as a matter of production.

The opportunity which you possess to observe all these details in relation to one another in connection with your own specific work is a great opportunity to improve the detailed operation—which improvement will be the backbone of manufacturing, of distribution, or, in fact, of any industrial efficiency.

Questions for You to Answer

1. Give the 7 reasons for avoidable waste.
2. Name some ways in which material may be spoiled in process of manufacture.
3. Name the 7 classes of assets which should be covered in an inventory.
4. How is a perpetual inventory kept?
5. What are the advantages of a physical inventory?
6. State the 7 precautions which should be observed in taking an inventory.
7. Give 5 of the rules laid down by Mr. Cowee, for safety in the shop.
8. What are the dangers from certain forms of dust?
9. Give the reasons for using a packing card and a packing list.
10. What is wealth?
11. What gives value to raw material?
12. How can a foreman help his men to develop initiative?
13. In what ways was improvement in production limited and hampered?
14. What is science?
15. What value is organized knowledge to the foreman and to industry?
16. How does an experimental department help the foreman and how can the foreman help that department?

Chapter 8

Part I

FABRICATING MATERIALS

Part II

THE SYSTEM AND THE WORKER

Part I: The Job

FABRICATING MATERIALS

Section I

Continuous Industries

The Nature of Materials Affects the Way They Are Handled.—We have considered materials as they directly concern the work of the foreman, from the first requisitioning, through raw stores, and the movement through the plant, to inspection and shipment. It is obvious that the detailed operations used in manufacturing materials are so diverse that it would be impossible to take them up here. It may be advantageous, however, to consider how the nature of the materials affects the way they are handled and the types of plant and buildings used. If a foreman looks beyond his own particular problems to some of the broader ones which the management must consider, he will work more intelligently and will realize better the part he plays.

Successful industrial plants and buildings must be suited to their own special needs. Their layout and design are controlled mainly by the movement of the materials. The various manufacturing operations have become pretty well defined and standardized for any one industry. For instance, competing firms manufacturing the same kind of cloth will be using practically the same processes and types of machinery. A firm may have an advantage over its competitors in the use, here and there, of a few specially designed machines; but, in the main, any advantages, as to plant, which it may have over its competitors are to be attributed to the greater convenience and economies in the movement of material during process.

Advantages to Be Sought in Laying Out a Plant. In laying out a plant, the following advantages are to be sought:

First, the movement of material should be facilitated in every way, and gravity used wherever possible.

Second, the distance traveled should be as short as possible.

Third, all congestion and crossing of two or more streams of material should be avoided.

Fourth, the material should progress in a continuous line from receipt of raw materials to the shipment of the finished product.

The line of this movement need not necessarily be straight. In a long and complicated process having many operations an actually *straight* line movement would lead to a freak layout; the line of progress may be bent back on itself one or more times. This may be done on one level or floor, as, for instance, in a U shaped building, or it may be done in a vertical plane in a number of stories. Let us consider a manufacturing plant with three stories. Here the material may be raised to one end of the top floor by means of elevators or hoists. From there, it moves the length of the building, comes back on the second floor, and leaves the building at the far end of the ground floor. In both cases, there should be a continuous movement, free from interferences or congestion.

The kind of material, its weight and bulk, and the nature of the work to be done on it have a marked effect on the layout. A type of building and location which would be absolutely impractical for one industry may be the ideal for another. An ore concentrator, where gravity is used to move great quantities of heavy material, will stretch down the side of a hill so steep you can hardly climb it, and may be located in Montana or Mexico near its source of supply. A sugar refinery may be ten or twelve stories high, with nearly blank walls and few windows, and located on the water front at a seaport. A cotton mill or a shoe shop will be in an industrial center; will be four or five stories high, long and narrow, and will have many windows to give good lighting. On the other hand, a machine shop which is handling heavy material will frequently be a one-story building, covering a wide area, with a saw-tooth roof to give light over the whole floor. Each of these types is especially suited to the particular industry and the character of the goods to be handled.

Two General Types of Industries.—There are two general types of industries: viz., continuous and assembling. A continuous industry is one in which usually only one kind of raw material is received and the operations upon it are performed in a continuous manner. Sometimes, however, more than one kind of raw material is utilized in a continuous industry. When there is only one kind of raw material received in the plant, it moves through the various processes and machines without having any other material or finished parts introduced and, when finished, it is shipped as a uniform product, often in bulk. An industry may bring together certain materials and *unite* them into one product, or it may do just the reverse, i.e., start with a *single* raw material, such as crude petroleum or coal, and *break it down* into a number of products. The first is called a *synthetical* industry and the latter an *analytical* industry. Either type may or may not produce *by-products.* A *cotton mill* is an example of a non-by-product industry and a meat-packing establishment is an example of a by-product industry.

Cloth Making—A Non-By-Product Industry. In a cotton mill, for example, *one* raw material—cotton—is worked up into certain fabrics. Only that material (minus a small percentage lost in the various steps) appears in the final cloth. The entire process, from cotton bale to finished cloth, which may or may not be carried on in one establishment, involves twelve main steps:

1. Loosening the fibers for cleaning,
2. Cleaning,
3. Paralleling the fibers,
4. Drawing the slivers or strands,

5. Spinning,
6. Doubling and winding,
7. Reeling,
8. Dyeing,
9. Pirn-winding,
10. Warping,
11. Weaving,
12. Finishing.

The plant to do this work will preferably be a multiple-story building. Textile plants are usually in cities where land values are high, so that a multiple-story building is the most economical type. This is possible because the material and the machinery required are both comparatively light. The later steps in the process require good lighting and ventilation. Much of the machinery consists of many units of standard elements such as spindles, which may be placed in long rows. Textile mills, consequently, are long, symmetrical buildings, with many windows.

Arrangement of a Steel Mill.—In a steel mill, on the other hand, the tonnage of material handled is enormous. The machines involved are very large and comparatively few in number. Most of the time the material is in either a molten or heated condition. A steel plant, therefore, covers an extensive ground area and has a large number of detached one-story buildings of fire-proof construction, equipped with hoists, cranes, and railway tracks. The ore, limestone, and coke are received at one end of the plant where they are hoisted into the blast furnaces. From there the molten pig iron is conveyed by cars to the converters or furnaces to be made into steel and cast into ingots. These are carried by cars to the blooming and rolling mills, located in another building, where the ingots will be rolled to the required shapes. From there, they go into stock or are shipped. The movement of the material in this process is from one end of the plant, through a succession of buildings, and out at the further end.

Steel Mill Develops into a By-Product Industry.—The steel mill was originally like the cotton mill—without by-products. In recent years, a large by-product industry has grown up by utilizing the slag, which was formerly discarded, for the manufacture of cement. The coke used in making steel used to be a separate, single-product industry. Now coke is often made on the grounds of the steel plant in "by-product" ovens; and the coal from which it is made produces, in addition to the coke, three valuable by-products: gas, tar, and ammonia. The gas is collected, purified, and used throughout the plant for heating and power purposes. The tar is sold to be worked up into aniline, creosote, and pitch. The ammonia is in the form of a sulphate, which after further treatment may be used as a fertilizer.

Sugar Refining—A Non-By-Product Industry. Sugar refining is an industry of the non-by-product type, handling solids and liquids. The largest refineries are located at the seaports, as the main supply of raw sugar comes from abroad. Usually, they are on the water-front so that ships may be unloaded directly into a storage warehouse, where the raw sugar is stacked in immense piles and protected from the weather. The raw sugar is first dissolved in warm water and pumped to the top of the high building to begin its process of purification. It descends from floor to floor, going through processes of filtration, boiling, crystallization, etc. *Gravity* is utilized throughout the whole process. Since not many steps in the process require much light, sugar refineries have few windows. The storage space for the raw sugar and also for the finished product is unusually large, because the goods come from overseas and heavy stocks must be carried to ensure continuous operation of the plant.

Flour Milling—A Non-By-Product Industry. Flour milling, too, is an example of a non-by-product, continuous industry, handling solids by means of gravity and bucket conveyors. Thousands of barrels a day are handled by a few dozen men. The grain is lifted by a bucket conveyor to the top of a high, almost windowless building where it is cleaned before grinding. It is then ground, screened, and purified. These processes require many steps and the flour drops in chutes from one process to another.

Meat Packing—A By-Product Industry.—Meat packing is the most conspicuous of the by-product industries of the analytical type. Cattle, sheep, and hogs—the raw material—are slaughtered and converted, not only into meats of all kinds, but also into a great number of by-products, such as hides, hair, lard, oleomargarine, beef extract, glue, and fertilizer. A stock joke is that the "squeal" is the only part of the pig which escapes. The great packing plants at Chicago are located close to the stock yards, with a general progression of the materials from the slaughtering pens to the final cold storage. The minor industries, which work up the by-products, are, as far as possible, located with reference to the point in the process at which the by-product they utilize first becomes available. The plants cover a broad area and have great diversity in styles and sizes of buildings, as there is a wide variety in the types of product and, consequently, in the necessary machinery and equipment.

Section II

Assembling Industries

The Complexity of Parts in an Assembling Industry.—In the last chapter, we saw how the handling of the material in a continuous industry governed the type of buildings used. In each case, there was only one kind of raw material or, at most, only a few kinds. These were manufactured into a single product like sugar or flour, or they were broken up into component elements, as in the packing industry. In no case were new raw materials introduced during later stages of the manufacture.

An automobile plant exactly reverses the analytical process and is an excellent example of an assembling industry. Instead of one raw material or a few materials, there is a bewildering number of different materials coming into the plant—steel in the shape of bars, sheets, and forgings; castings of gray iron, malleable iron, brass, and aluminum; wood, rubber, electrical apparatus, clocks, lamps, instruments, carpeting, paints, glass; cloth, leather, and hair for upholstery; and a multitude of other things, all of which go to make up a finished automobile. Furthermore, there are indirect activities which do not appear in the final product. This can be seen when it is understood that vast amounts of money are continually going into patterns, molds, dies, and tools.

In the continuous industries, the product is usually comparatively simple in its nature. In an assembling industry, it may be very complex. The average typewriter has over 3,000 parts. The automobile, sewing-machine, locomotive, and machine tools are also examples of complex structures, every part of which must be produced accurately and with reference to other parts with which it is to function.

Have All Parts Where They Are Wanted, When They Are Wanted.—There is the problem of assembling these parts to make the completed unit. This means they must be brought together at the proper time, ready for the final assembling. The completion of the finished product may be absolutely held up by the lack of even the smallest part necessary. The failure to have this one piece ready when needed may delay the finishing of every other piece in the machine. It is, therefore, in the assembling industries that the problem of scheduling the movement of material (having *all* of it *where* it is wanted and *when* it is wanted) becomes most vital.

Assembling industries may be *direct* and involve no steps which do not appear in the final product, as, for instance, the manufacture of shoes; or they may include *indirect* work and materials which do not appear in the final product, as, for instance, the pattern shop and molding floor in a foundry. Patterns and molds must be made before castings can be produced, but neither is shipped with the product. The principal raw material, pig iron, appears in the castings, but the pattern lumber and molding sand do not appear, although they are absolutely necessary in the production of the output.

Assembling Industries Require More Hand Work.—In an assembling industry, machinery can be used in the production of the separate pieces, but in the assembling of these pieces a large amount of the work must be done by hand. Assembling industries, as a rule, employ more operatives for a given value of output than a continuous industry. It is apparent that, in an assembling industry, it is very important that the departments manufacturing the pieces should be arranged in proper sequence, so that finished pieces may come together at the right time and place for assembling. The material, instead of moving in a continuous line from receiving to shipping platforms, will, after leaving the raw material stores, go first into independent departments or shops and will then begin to flow together like small streams uniting into larger ones, to form finally a single river which flows out over the shipping platform to the open sea of the outside market.

Assembling Industries Require Special Plant Construction.—Assembling industries also differ greatly, in their plant construction, from continuous industries. A shoe factory will occupy a building not unlike a cotton mill, while a shipbuilding plant will be broken up into separate buildings, as in the case of a steel mill. In most machine shops, the foundry is in a separate building, partly for convenience and partly to reduce fire risk. The pattern shop may be near the foundry or it may be in the main plant. Other auxiliary departments may be a carpenter shop, forge shop, drying kilns, power plant, etc.

In most assembling industries, proper lighting is of great importance, as many of the operations are delicate and require close watching. Where ground is cheap, one-story buildings with overhead lighting are widely used. In cities, where this is not possible, multiple-story buildings are used. These buildings are seldom more than sixty or seventy feet wide, in order that light may reach all portions of the floor spaces from each side.

If the product is small in size and the parts easily handled—a typewriter, for example—the multiple-story mill type of building is used. If the output is large in size and the parts heavy—locomotives and heavy electric machinery—the building is long with a high central bay served by a traveling crane, and floor spaces or possibly galleries on each side. The light machinery for making the smaller parts is located in the galleries or along the sides of the main floor, and the heavy tools, such as boring mills, planers, and large lathes, are in the main bay under the crane. Usually the floor space at one end of the central bay is used as an assembling floor. The heavy pieces are brought lengthwise by the traveling crane from the large tools to this floor, while the lighter pieces come in from the galleries on the side. Railway tracks run in onto the assembling floor, so that the crane may be used for placing the finished machinery on the cars for shipment. In this way, all the material, large and small, centers on the assembling floor and may be shipped out without confusion.

It will be seen that the aim in all these different types of buildings is to design them so that they will handle the material in the cheapest manner and move it from the beginning of its course to the end with the least expenditure of time and labor.

It will be profitable for you to notice carefully the different types of buildings in the industries about you and examine them with reference to the work they have to do, the kind of material moving through them, and the course it follows. In so doing, you will gain a better understanding of why there are so many types, and you will have a better grasp of the great problems which underlie the economic handling of materials in industry.

Section III

Inspection during Process

The Necessity for Inspection.—We have already considered the inspection of raw material. If there is any attempt at all to maintain a high standard of product, there must be, not only an inspection of the finished product, but also an inspection while the material is in process. Imperfections may develop in the material during manufacture which could not have been caught in the raw state and might be so hidden by the later process of manufacture that they would not show up even in the inspection of the finished product. Defective work might, therefore, go out of the shop. The *quality* of machine work, for instance, often can be inspected only before the part has been assembled, as it may be completely hidden in the finished product. An example of this would be the interior parts of an automobile engine, such as the crank shaft or valves.

Possible failure on the part of a workman is only one of the elements which necessitates inspection. Tools wear and machines get out of adjustment, causing variations in size of work.

Differences in the hardness of materials and many other causes influence the quality of the product.

Where there is a succession of operations, it is desirable to inspect a number of times; and important operations, the incorrectness of which would render a piece useless, should be inspected as soon as they are made and before any further work has been done. This will obviate the spending of further money on a piece which has already been spoiled.

Many foremen look on the inspector as a tribal enemy. This attitude is extremely unfortunate and unsound. Good inspection is a help in putting out good work and not a hindrance; it hinders only the putting out of poor work.

The Requisites of Good Inspection.—Good inspection is, first of all, *intelligent*. This means that there must be definite standards known to all concerned—to the foremen and workmen as well as to the inspection department. These standards should be reasonable and attainable, high enough to guarantee the adaptability of the work to the purpose for which it is intended, but not so high as to be uncommercial or unattainable. It should be possible, with the proper tools and methods of production, to maintain that standard in everyday work and earn a profit. If inspection is permitted to be too lax, the reputation of the product is lowered and an opening made for future trouble from customers and, possibly, danger to life, if the product is one which involves the safety of those who use it. To be too rigid with inspection decreases output, disorganizes and slows down production, and runs up costs to a prohibitive point.

Inspectors should be thoroughly *familiar*, not only with the product, but also with the methods of production, the tools used, and their possibilities. This knowledge will enable them to detect errors and defects intelligently and to diagnose their causes. Inspectors should be *fair and fearless*, without favoritism, and free from any self-interest in carrying on their work. For this reason, they should be independent of the foremen and the production department. This places them in a position where they are free to act without fear or favor. There is no reason why production foremen and the inspectors, although independent of each other, may not work together in full harmony. The *right* kind of foreman and the *right* kind of inspector will cooperate heartily.

Inspection should be *thorough*. Enough of the work should be inspected to *know* that *all* of it is right, that the material is suitable, that every operation has been properly performed, and that every piece will function as intended.

Inspection should be *prompt*, and should follow as soon as possible after the performance of the work. Otherwise, much material will be held up pending inspection, or much work may have been done on it before defects are caught. Sometimes both of these things happen.

The Real Aim of Inspection.—The aim of the best type of inspection is not so much to detect bad work which *has been* done as to *prevent* poor work from being done. Good inspection will aid production in every way possible to run down the causes of bad work, to remedy these causes, and to preclude the repetition of the trouble. When an occasional bad piece comes through, it may be sufficient simply to throw it out; but, if the trouble becomes chronic, a prompt effort should be made to locate the cause. If it lies with the workman, the matter should be taken up with him at once. He should be instructed in correct methods until he can do the work right; then, if he cannot learn, he should be transferred to work which he can do, or should be let go. But the blame should not be put on the workman before the cause of defective work is ascertained. It may lie with the tools and their setting, or with the machine, or with the workman's instructions. It is sometimes desirable to have a systematic record of spoiled work as a line on the capacity of the various workmen, and as a guide in the methods of manufacture.

Standards of Inspection Will Vary.—Standards of inspection involve matters of general policy, such as the demands of the market and the kind of competition to be met, as well as the methods of manufacture and the type of tools which will be used. In a machine shop, for example, the degree of refinement required will determine whether a piece is to be made on a lathe or on a precision grinder, whether a gear will be cast or generated, hardened, and ground. It is obvious that the standards will affect also the kind of gauges to be used. Where precision work is required, it should be borne in mind that the gauges themselves wear. They must be inspected regularly and kept in perfect condition, if the standards are to be maintained.

Inspection in Machine Shops.—In machine shops, where accurate work is done in great quantities, three sets of similar gauges are used:

First, *working gauges*—used by the workmen during production.

Second, *inspectors' gauges*—used by the shop inspectors.

Third, *master gauges*—used to check the other gauges.

The first and second are used continually and are, consequently, subject to wear; the master gauges are kept in the tool room and used for reference only. They, therefore, retain their size for a long time.

In such shops, inspecting may be done at various stages during the progress of the work, as follows:

a. *First-piece inspection.* Done by the tool-setter or inspector to insure the correct setting of the cutting tools and fixtures before proceeding with the work.

b. *Working inspection.* Done by the workman himself during the progress of the run, to check wear of cutting tools or changes in setting.

c. *Operation inspection.* All the pieces put through may be gauged by an inspector before proceeding with the next operation. This is done to detect the bad work, if there is any, before doing anything further on the piece.

d. *Piece inspection.* Done by inspectors of the finished part before it is sent to the assembling room.

e. *Selective inspection.* This is often used where the pieces are simple and made in great quantities under conditions where defects can creep in only slowly, as, for instance, from gradual wear of tools. To inspect every piece would add greatly to the cost of production. In such cases, one out of a certain lot or number may be inspected. If this passes, the rest are assumed to be correct. If it does not pass, others are inspected and, if a certain number are found to be incorrect, the whole lot is rejected or given a 100 per cent inspection.

f. *Unit-assembly inspection.* Done in the assembling room to make sure that the parts of a certain definite unit, as, for instance, a typewriter carriage or a lathe head, are in proper relationship to one another.

g. *Performance inspection.* Done by inspectors, on the performance of the machine as a whole.

Methods of Inspection.—Where the pieces are small and easily transported, it may be found desirable to have the inspectors in a separate room where they can do their work quietly, with every convenience for the work in hand. In other cases, it works out best to have the inspector on the floor following the work from place to place, as may be necessary, gauging the parts as they come from the machines. Whether it is better to have the inspectors go to the work or the work go to the inspectors will be governed by conditions.

It is obvious that rejected work should be promptly segregated from the good material and removed from all possibility of becoming mixed up with the rest of the product.

Too much stress can hardly be laid on the importance of a healthy relationship between the foreman and inspection. The situation is deadly where the foreman is trying to "slip it over" the inspector and the inspector is "laying for" the foreman or workman. This may be a great game, but it is played at the expense of production, and the business suffers. Where production and inspection are each doing clean, honest, effective work, they are a mutual help, and there is an output which is a credit to all concerned.

Section IV

Assembling of Materials

The Trinity of Material Requirements.—The trinity of material requirements—the *"when," "where,"* and *"in the condition,"* you want it—is particularly applicable to the assembling of a product. It is essential that *all* the parts needed in assembly arrive at the same time at the place where they are to be put together. If one part is lacking, all the other parts must be laid aside pending its arrival, or the assembly must be held up in an incomplete condition to await that part. It is, therefore, absolutely necessary to have the right balance of parts. Since this is so important it might *seem* desirable, in order to make sure of having material on hand, to get ready as many parts as possible regardless of whether there is a complete assortment available. That, however, is unsound practice, as it would mean a needlessly large stock of material in process and an expensive inventory. The danger of such large stocks has already been set forth. The ideal condition is to have just sufficient supplies of a part arrive at the assembling department to keep safely ahead of the assembling requirements.

Finished Parts Stockrooms.—A condition to be avoided is a congestion of parts on the assembly floor, as they are likely to be misplaced or damaged and, at best, become a hindrance. To obviate this, as well as for safe keeping and the avoidance of confusion, *finished parts* stockrooms are frequently maintained, from which the parts may be drawn in small lots as needed for assembly.

Responsibilities of the Foreman of the Assembling Department.—The foreman of an assembling department is responsible for watching his supply of parts, and he should keep well ahead of his actual needs to avoid getting caught short. Systematic forethought here will save a lot of delay and stock chasing. He is responsible, not only for the *quantity*, but also for the *"where."* If the assembling process is efficient, the parts must be placed, as nearly as possible, at the actual *point where* they are to be used, and in the best position to be picked up by the workmen. All carrying or lifting is a waste unless it contributes to some useful or necessary purpose.

Limit Gauges.—Filing and hand fitting in assembly are expensive, and it is one of the objects of modern interchangeable manufacture to reduce this to the lowest possible point. This is done by the use of accurate fixtures and limit gauges—the latter being designed on the "go" and "not go" principle, the limits being so set as to insure the usability of any part which fits the gauge. The inspection of the separate pieces should be made before they reach the assembly, as this is the poorest place in the whole factory to catch defective work. If it is caught there, a lot of work has been put on the piece and wasted, and it may even have gone into the assembly and have to be taken out. The detection of faults by early inspection involves only *one* piece; whereas, if the fault is allowed to run on into assembly, it may involve delays in connection with every other piece in the assembly, although the others may be all right. An assembly foreman should be able to have confidence in *all* the material which comes to him, so that he can go ahead with his work without constant dread of being held up by defective material.

Assembling on a Line.—The usual practice is to bring the work to the *assembly*. If the work is large and heavy this may be done on a cast-iron floor plate, under a crane. Small work may be done in a separate department at benches with special fixtures, if these are required.

The most efficient method of assembling is to do it on a *"line,"* or slowly moving carrier. This has been developed to a remarkable degree by some of the larger automobile manufacturers, as in the Ford plant. A chassis frame is set upon a slowly moving carrier, the assemblers working on each side as it progresses down the line. The necessary parts reach the assembling line, from the side, at the proper points. As the frame proceeds down the line, piece after piece is added until the finished chassis or automobile leaves the line under its own power. Obviously, this is possible only under rigid standardization in which the design is fixed and put through in large quantities. Each assembler, instead of putting together all of a single machine, will be trained and become highly skilled in the assembling of a single part. The principle of the *division of labor* is thus applied to assembling work, which has been slower to adopt this principle than any other phase of manufacturing.

Schedules Are Necessary on Line Assembly. Assembling on a line requires the most highly developed planning and scheduling, because a shortage of parts holds up the assembly, not of one machine only, but of the *entire product* on the line. On the other hand, if the assembly is operated smoothly and without delays, it is marvelously efficient and rapid. The work throughout the en-

tire plant which uses an assembling line must be scheduled with reference to it. This principle applies, in scarcely a less degree, to all assembling industries, because all the operations in making the separate parts lead up to the final assembly, and the starting of work on each of the various pieces must be made with reference to that assembly. This has been aptly termed "pulling" the work through the shop; that is, each piece is scheduled *back* from the time you want it, to determine the time it is to be begun.

The Control Board.—The use of diagrams or *control boards* is a great help in scheduling. In industries such as an automobile factory these may be very elaborate. A simple Control Board is shown on the insert facing this page.

This diagram shows how the person who lays out the schedule determines when the material must be requisitioned and work started on the various parts. To lay out such a schedule, he must know what machines are available, the number of operations for every piece, the time each operation takes, and the time required for each move of the material between operations.

In the case shown it is desired to have the final product ready on June 5th. It is known that assembling will require four days. It must, therefore, begin on June 1st and all parts and subassemblies must be ready by that date. Part No. 4 requires a longer time to make than any other piece; so, working backward from May 31st, it is seen that this part must start on April 10th.

Part No. 2 must start on April 24th, and so on. Part No. 3, which requires only two operations, need not be started before May 10th. Parts 5 and 6 are brought together in sub-assembly before they enter the final assembly. In the sub-assembly condition they require three operations and must, therefore, be brought together by May 2nd, and the separate parts started on April 13th and 15th respectively. The last three pieces have one operation together which requires that the second sub-assembly must be made on May 26th. Parts 7 and 8 must be brought together in a first sub-assembly May 1st, which means that Part 7 must start on April 10th, while Part 8 must be started on April 24th.

In this way, by *working backward* from June 1st, the time for each sub-assembly and the starting point for each piece is determined. Good judgment and intimate knowledge of shop conditions are required for intelligent scheduling; and constant vigilance in following up the work must be used to make sure that all the pieces "head in" on schedule time.

Part II: The Foreman

THE SYSTEM AND THE WORKER

Section I

The Individual Worker

The Individual System of Production.—When the only tools with which the work of production could be accomplished were hand tools, the apprentice learned the whole system of the work in the learning of his trade. It was an *individual* system of production. The choice of the materials, the design of the article, the making of each part of the article, the fitting and the finishing were all done by the same worker. The apprentice, who was bound for his five or seven years to any one of the trades, learned all the things which entered into the making of the finished product.

The cabinet maker, for instance, who was engaged in making furniture, chose the wood according to his ideas of how it would work up for the piece he had in mind, laid out his design upon the wood, arranged his work so that he completed each part in the sequence of its importance, brought the parts together in the final assembly, decorated and finished them. The boy, who was learning his trade at the same bench, was thus taught the entire system used by the craftsman in making the product.

No other system was necessary. People did not read or write much in those days and very few shops had more than ten or twelve workers in them. The materials were brought into the shop by hand and the number of pieces was carried in memory or chalked up in crude figures on the wall of the shop. When the material had been paid for, there was very little to be considered except the amount of money to be paid to the man who had done the job. The whole process was so simple that each man could learn all of it as he grew from apprentice to journeyman and, consequently, all the men who were working at a certain trade knew all that was required in that trade, from the securing of the raw material until the customer bought the finished product of the shop.

I remember very well the old hand weavers whom I saw, in boyhood, at work on their looms in their own cottages, making the same kind of cloth which had been made by their fathers and grandfathers before them. They would go down to the wool factor's warehouse and choose the wool, take it to the carders, and have it combed. Their women folk would spin it, then they would take it to the dyer to be colored as they required. They would make their own design and weave the cloth. Then they would sell the cloth to the merchant who came round about twice a year and bargained with them for the goods. These craftsmen knew every step of the system or method by which the wool was secured from the grower, bought from the factor, converted into cloth, and sold at last to the customer. Each journeyman thus knew his trade in actual fact, from first to last.

The Effect of Machinery on Craftsmanship. Just as soon as it was learned that a steam engine could be used to run machinery, instead of the foot or the hand, it became very important to have that machinery run all the time. It was necessary to use fuel to run the steam engine; and, when the engine was running, the machinery was costing a lot of money to operate it—in addition, it was wearing itself out. If it was running idle, it was costing just as much money to run, but was not making anything useful to pay for its cost. It was impossible, therefore, to have the worker doing a lot of jobs. He could not leave the machinery running while he went out and chose the material; and he could not go from one machine to the other, leaving a good many of them idle while he was attending to different pieces of work. Gradually it became necessary for the work to be subdivided, so that the worker on one machine could stick to that machine and keep it usefully employed all the time that it was kept running by the engine. Naturally, this also meant that the individual worker on one part of the job could know only that part of the system and method which was required in his own operations.

Eventually, it came to pass that a large part of the work necessary to the complete manufacture of the article was outside of the worker's experience and had to be planned by others for each man in the whole plant. Instead of one man doing all the manufacturing of a piece of furniture, the work became so subdivided that three or four hundred operations were necessary, and these were assigned to different men. Parts of the work were transferred to other establishments and finally segregated into special industries. The saw mill industries took over the cutting of the lumber and the making of it into boards, which would be the material for the furniture factory. The wholesale and retail merchants assumed the task of selling the furniture to the people who needed it. The railroads took over the job of transporting the raw material and the finished product.

Naturally, this evolution in the method of production compelled development in systematizing the work. Hundreds of men had to be kept at work on different jobs, all working to the same end; namely, that well constructed pieces of furniture might be available for people to use. Without a system of operation running through the whole process, these people would have been in confusion. There would have been little order, and good results could not have been obtained.

The Division of Craftsmanship.—It was necessary to take away from the individual worker the purchasing of material, and to put this in the hands of a department specially concerned with buying the enormous quantity of material required for the hundreds of workers employed in the factory. Similarly, it was necessary to put the designing of the furniture into the hands of trained people who could give their whole time and thought to it. Then, the way in which the operations should progress in the factory, so that the material would go from one to the other without confusion, meant that all the departments had to be arranged in relation to one another and to the object to be attained. This system had to be worked out with the whole plant in mind and the individual worker had to fit himself into the arrangement. Where the old hand worker had been able to chalk up his transactions on the wall of the shop, it now took a great deal of careful planning and system to keep track of all the material, the many operations, and the hundreds of transactions essential in the industrial establishment which succeeded the old shop.

Today the average article which is used by the householder passes through many industries and through hundreds of operations in coming from the raw material to the finished product, ready for use.

The Individual Worker Has Become an Operator.—All this development meant that the systems by which things were done became more and more important and more and more intertwined, so that no particular part of the work could be done unless it was properly tied up to and arranged in connection with many other pieces of work and many other departments. The individual worker no longer knew the trade as a whole. He became skilled in his own particular part of it and no more. The machinery had become so subdivided and its cost so great, that it must be kept turning out useful articles all the time it was operating if it was to earn a profit.

The individual worker has become an operator, using a machine or a group of machines as his tools and doing certain parts of the work which finally result in useful articles for business or for individual progress and comfort.

Coordinating the Operations.—In a large automobile factory, some years ago, they introduced a number of automatic screw cutting machines, to turn out the enormous number of bolts and screws required in the manufacture of the car. They bought the machines and had them installed, but the quantity of bolts was not increased as it should have been. A large proportion of the bolts were fitted with cotter pins to prevent them slackening off in the running of the car, but there was no machine capable of making the cotter pin holes as fast as the automatics could turn out the bolts. The production manager of the plant and his engineers had to find out how to build a machine which would drill the holes at the same speed which was used in the production of bolts. The two jobs had to be coordinated; otherwise, the big investment in the screw cutting machines would have been of little profit.

It is necessary, if the plant is to be efficient, that the operations be properly coordinated, so that the speed of manufacture is balanced according to the requirements of the product.

This requires accurate knowledge of the character, the time, and the arrangement of each operation and the way in which all the operations dovetail into each other. It is for these reasons that we have exact and complete plant records of material, time, cost, and machine operation. They are all devoted to the one purpose of coordinating the operations so that they will be balanced properly at all times.

The coordinating of the operations must take place first in the small group—the one which is under the care of the foreman; and it is part of his job to keep in mind the necessity for so coordinating the work that it may be completed on time and at least cost.

Section II

The Group of Workers

Two Kinds of Groups.—A number of artists may occupy the same studio, but each man may still remain engaged upon his own line of work. They are a group, but this association differs materially from that of a group of artists painting a piece of scenery for a stage setting.

For convenience, several doctors may occupy the same set of offices, while each of them has his own work and his own line of patients. They are a group, but they are not the same kind of group as that made up by a number of doctors cooperating on the same experimental work, nor do they have the same obligations to each other or the same necessities in their cooperation.

In the handworking shop, a number of cabinet makers may be gathered together, each man making his own designs and doing the job from first to last. They are a group, but they do not have the same necessity for cooperation that the group of men in a modern factory must have.

The first lot in each of these groupings is just a number of individuals, each doing his own work without relationship to or regard for the work of the others. They may cooperate to the extent of enjoying the same shelter and the same fixed equipment, but they depart from each other at that point. They must get used to working without annoying each other and they must work without stealing from each other; but beyond that it is not necessary for them to pay much attention to each other.

They do not have to give and take in their work, neither do they, as a group, have to suffer because one man does poor work. The failure of one individual does not reflect failure on the whole group. They cannot use the cooperative machinery of accomplishment, because there is no cooperation in idea or in product. They have every opportunity to express themselves individually, but they do not learn to subordinate the individual expression for the good of the whole group. They are a group of individuals engaged in individual work; they are working for no common object.

The Group as a Team of Workers.—As soon as the work is subdivided to any extent—as all industries have been subdivided since the days when hand work was replaced by machine operation—the group of *individuals* is not sufficient to meet the case. No longer is any single individual able to do the whole job of manufacturing a useful product. His work does not stand by itself and its value is dependent, not upon the result of the individual operation entirely, but upon all the other work which is done in manufacturing the product. So, the group of individuals must be developed into a *team* of workers.

Let us take, as an example, the making of tables in a shop with fifteen workers in the days of the handworkers. Each man of the fifteen was cutting his own lumber, drawing the design of the table thereon, shaping each part, fitting them together, and producing the final product. Suppose we turn that shop into a miniature modern factory where the workers are using machinery for the manufacture of those tables. One man will draw the outline of the table and lay out the work for the saw. Another man will saw the lumber, the third man will give it the rough planing, the fourth man will turn the legs, and so on through the operations. In this case, each man's job depends for its value upon all of them working together and, unless all the operations are continued, no tables can be made. Moreover, all the operations must be coordinated so that just the right amount of work is done. Then, there will be no congestion at one point or another in the processes.

In the old hand shop, if there were not so many tables to be made, they could take away four or five or all the men but one and still make tables.

In this new little factory which we are talking about, in order to make a table, there must be somebody attending to the drawing of the designs, to the laying out of the work, to the sawing of the lumber, and to each of the other operations before a table can be completed. Every man is dependent upon every other man in a way which did not exist in the old-time shop, and the jobs are not *individual* any more; they are *team jobs* and they must be continued by a number of groups working together or they cannot be operated at all.

It is this difference in the whole character of industry which calls for a very different knowledge to be possessed by all men in industry—knowledge involving a very different education from the education given to the old-time worker at the bench or the loom in the handworker's shop.

The Cooperative Job of Today.—We have subdivided industry by this time until the job of producing things is just one big cooperative job, at which many millions of men are engaged in order that we may be able to make all the things which enter into our comfort and convenience and get these to the people who need them.

That washing machine, which has just been installed in the house to lighten the work of the wash day, took some of the time of the men in the iron and copper mines getting the ore out of the ground. It took some of the time of the ore ships which take the iron ore across the Great Lakes to the furnaces. It passed through the blast furnaces and through the steel mill. It was rolled and shaped, and parts of it were machined and polished. The wood in it came from the forest, took the time of the lumber men, was transported to the saw mill, and then to the other woodworking factories. The railroads have carried parts of that washing machine many times to and fro in the course of its manufacture; engineers, salesmen, jobbers, retailers, and a whole host of other people have been occupied with getting it from the places where the materials were found to the places where they could be put into shape for use in the washing machine. They have put their services into the sale and delivery of the machine itself.

This machine could not have been made if a single one of these operations had been stopped—if cooperation had been lacking. It is pretty hard to cooperate properly unless there is a great degree of confidence between the people who must do the cooperating. We must understand each other, or believe in each other well enough to cooperate properly in the job of making things and getting them to the place where they are to be used; for no man can live apart from the endless circle of industrial cooperation.

Section III

Cooperation and Plans

Individual Play Must Be Subordinate to Team Play.—There is a good deal more to a baseball team than the necessary number of individuals who are skillful in the game. You know how much time, patience, experience, and tact are necessary to fit the players into their proper places, that they may function as *one* machine. Individual play which would be costly to the team must be eliminated. The spot light must be left out of the consideration of the individual, and his personal part must be played with the team in mind *all the time;* otherwise, there would be confusion and errors, and no victories.

Every group of men in industry, working on any part of the job of making these useful products, must be welded into a team. The job is a team job, as it cannot be done by one man. Although the skill will vary and the relative value of the individuals will vary, each is necessary to the accomplishment of the object and they must be welded together to such an extent that they will adjust the individual play, so that it agrees with the requirements of the group and the object of the group. Some of the workers in industry have seen this necessity, but they have visualized it as requiring a standardization of effort so that each man did just the same *amount* of work and without any attempt to use the *whole* of his capacity. That is not the team spirit nor the team requirement. The full development of the group means that each man will work to his *full* capacity, but that he will do this with the necessity of the team in mind and with full and free obedience to the leader whose job as leader he recognizes fully.

Not until we get the full and free obedience, which belongs to the leader of the team, shall we have a real team in the cooperative job of industry, and this team spirit will have to come *first* in the little group which is under the supervision of the foreman.

The Leader of the Team.—In the days when the Vikings were gaining power in the northern part of Europe, the men of a tribe or a family met together once a year and elected a leader and then swore to obey him till death. They knew that it was necessary to have a leader and to give him a full measure of obedience if they were to get the things done. If the leader was no good, they threw him out at the end of the year. They did not do that, however, when they had a *good* leader. He led them year after year until he died, and then they would choose his son if that son seemed fit to be the leader.

I have often wondered how many of the men who are supervising other men in industry would be *chosen* by the workers if they had to stand for election as leaders, and how many of the workers would freely swear to obey the leaders thus elected. The leader of men, who is not trusted by them to the point that they see in him their natural leader and supervisor, has wasted the opportunities of his leadership and has missed getting his men together as a team just to the extent that they lack confidence in him.

It is one thing to have the job of supervising men and to *get by* with it. It is quite another thing to be a real leader of men and excite such confidence and trust on their part that they will willingly obey, *not like animals* with a blind reaction to the instruction, but obey *freely* with the right to suggest and discuss if they think the matter might be determined in a better way.

The leader who knows his men will not miss the value of their advice and comment; and the workers who trust their leader will offer their suggestions, but without any misapprehension as to the wisdom of his final judgment or the obligation of obedience they owe to that judgment—just as you will work with and for a man you trust, at the same time anxious to do what you can by suggestion and operation to improve things, but confident that his judgment is best and that you can afford to obey it without losing any atom of your self-respect.

Plans for Systematic Action.—All the time that industry has been growing up we have kept it moving by new plans and systems, intended to take care of the troubles as they arose. We have had a lot of these systems and a good many of them were supposed to settle all the troubles of the industry. Growth, however, sooner or later, made it obvious that they were inadequate or not correct.

Our systems of banking, of subdivision of jobs, of concentration of manufacturing, of centralizing control, etc., have been secured so as to keep industry moving more freely, and they have been partly good and partly bad in their effect. They have been *good* because they answered the problem for which they were suggested, and *bad* because they were good only for the things we saw were wrong; but we did not know enough to see the whole thing.

There must be a plan for the work of the little group of which you are foreman. This plan must be part of a general plan for the factory and that must be part of a general plan for the industry if we are to keep moving properly.

There are many men who have proposed new plans for the conduct of industry. Since the War we have especially emphasized some of those already proposed. The trouble with a plan is that it must *work* or it is no good. That is why it is better to move one step at a time in getting things improved in an industrial operation. Some of these plans may be good, but most of them mean that we would have to change all of that particular phase of industry at once. If we should try one of them and it didn't work, the result would be disastrous. It is much better to move along as we are doing now, even though we are not as efficient as we should be, even though we fight each other more than is good for progress, even though we do not understand each other as we should, than it is to try some big experiment which will mean a complete change in our industrial organization and which, if it did not work, would smash the organization to pieces. That is why all theoretic plans for improvement should be experimented with in a small way until they have shown how they can be adapted to the arrangements which we have and which are necessary for our continued living.

The arrangements which are made in your factory or in your work have grown up little by little, as you find that one detail or another can be changed without destroying the chance of getting things done. Some of these arrangements are good and some of them can be bettered. No job and no arrangement in any part of the industrial world is altogether as good as it might be. There is always room for improvement, provided that the improvement does not stop the work of getting things done and provided it proves itself to be valuable, as the result of practical experiments that insure profit.

Plans from the General Standpoint.—Plans may be projected from the general standpoint. Many of them must be done that way in order that everything will fit together. The arrangements which will put those plans into effect must start at the bottom with the detail; and, consequently, they must begin at the bench, the machine, the dye vats, the road bed, or whatever it may be. That is what makes your work so important in the improvement of the factory efficiency. Both in the arrangements of the equipment and the work of the men, the improvement must start with the unit. The unit of work, the unit of equipment, and the individual man are the elements in the work of arranging the improvements so that they can be of use.

Section IV

Orderly Arrangement

What Is Order?—Twenty-five years ago, the average shop did not have a very orderly way of getting the materials to the worker and of seeing that the tools and equipment were placed so that there would be no lost motion and no crossing and recrossing of the paths.

Order is the fitting together of the parts so that they work to the same end *without confusion* and with as *little waste* as possible. This sounds much the same as efficiency, but efficiency deals with the *actual* amount of work done in proportion to the amount which *should be* done with the same equipment.

Order is concerned with the arrangements for making efficiency the regular program. If we are to fit together the parts of the factory and all the operations of the plant so that they will function without confusion, then it is necessary to know what these parts are and what the operations are. The same thing is true of all the different lines of endeavor that are a part of our industrial activity.

The Foreman Is Responsible for the Order of His Work.—The man who has the responsibility for any department of industry or any set of operations must understand the way in which each individual operation or each activity fits into the running of the department, and he is responsible for the *order* of his work just as he is responsible for the *quality* of the result. So, the foreman must understand fully the way in which the operations under his charge are fitted together, what they do in the final object of the work and why they exist as they do. For instance, the foreman in a machine shop must know the way in which the machinery fits into the particular job and the way in which the materials can be brought to the men for the best result. He must know the reason for the job, the layout, the inspection, the machine records, and all the other items which go to make up the work of his little group.

The superintendent of a plant or a railroad or any other activity must have a wider range of clear knowledge of the departments and operations because the nature of his work requires him to fit together a larger group and see that it is efficient.

The Relation between Order and System.—System is to order, what transportation is to modern industry. It ties the whole proposition together, *preserves* the order, and keeps the groups of men working to the same purposes. To serve this purpose it must take care of all the elements which enter into the production fabric, it must arrange for the work and the operations, the records and the checks all along the line from the smallest group to the largest. There would be little purpose in subdividing the work and arranging the equipment and the materials so that the job could be done, if there were not some way of tying all these many operations together so that they would move forward without any congestion or halting until the product has been finished.

The foreman can, if he is sufficiently informed, lay out the work in his own group so that it will be done in the time required; but the system with which he has to deal must be used to secure so many things outside his own work that he must accept it and work with it.

It is difficult to see the value of many of the things which we must do in the government of our little groups, because those things have been arranged to tie together a great many such groups doing different jobs, and they do not always show their value to us in our own work. So we talk frequently about *red tape* and official documents and formality, when, without something of the sort, the groups could not be kept together on the work without great confusion and a lot of waste effort and time.

System—Good and Bad—That does not mean that *all* system is good, just because it is system. Some men have become so interested in creating system and in tying things together that they have bound the whole business up so tight that it cannot move. The regiment must march with its proper scouts and its well-considered system. It must enter camp in just a certain way, in order that it may be properly protected and taken care of with the greatest ease; but it would not do to make the arrangements so rigid that the men are bound together and could not act at all except in groups, and then only when all the groups acted at the same time.

Whenever we get to the point that a method or a system or an arrangement seems to answer all the questions, we are beginning to be bound by that system and presently it will impede the movement of the whole shop or mine or railroad. The right amount of system is that amount which is necessary so that we may get the work done together, without confusion, and with the least time and effort. Anything more than that is an impediment and anything less than that is confusion and ignorance. It is through its system that we are able to get the picture of the activities of the industrial establishment and see just what is being done all along the line, how it is being done, how much it is costing in time and labor and materials, and how much waste is occuring.

Whenever it is used to tell us a lot of things we do not need to know, whenever it is used just to rearrange the information without the rearrangement being of considerable value, system is being overworked and is a nuisance. Whenever it does not tell us at once just where we stand, it is insufficient and we shall be short of materials or have the wrong work or find that it is costing too much. The system is the information avenue by which we know exactly the state of each part of the work, for each group engaged upon the work. No man who works in any industrial unit, in any group, on any job should be without a fair knowledge of the systems employed in that plant.

System and Cooperation.—If every man engaged on the work of industry, from the top to the bottom, understood all the work of industry in its relations, there would be little use for system, because that understanding would result in such a measure of cooperation that the system would become automatic. It would be created out of this understanding and the cooperative effort growing therefrom. Systems, methods, and arrangements are not cooperation. They are only the machinery by which a certain measure of cooperation is secured in modern industry.

The system of the industry, where it is a good one, will itself lead to a greater measure of understanding and a greater development of the individual, so that the operations of the system become less elaborate and less irksome. The measure of cooperation secured today in this work of supplying useful products or service is far greater than it could possibly have been in the days of craftsmanship, which required little mutual dependence.

Back of all improvement, however, is the improvement in the individual human being. It is this improvement which makes him more skillful, more alert, more able to supervise himself. It is this which makes him more responsible in his own operations and more capable of reaching greater efficiency through cooperative effort under the intelligent leadership of capable foremen.

Questions for You to Answer

1. What are the four advantages to be sought in laying out a plant?
2. What is the main difference between continuous and assembling industries?
3. How does an analytical industry get its result?
4. Name some of the by-products of the steel industry. The packing industry.
5. Why does an assembling industry require more hand work than a continuous industry?
6. Name the requisites for good inspection.
7. Name the stages at which inspection should be done in a machine assembling industry.
8. What are limit gauges?
9. What is the purpose of a control board?
10. What effect has machinery had on craftsmanship?
11. Why has the individual worker become an operator?
12. Why is team work necessary in a shop?
13. Will team work be any more efficient than the leader himself makes it?
14. What is order, in a shop?
15. What is the difference between system and order?
16. Can system be made effective without cooperation?