THE MANAGEMENT
OF
THE MAINTENANCE DEPARTMENT
IN
INDUSTRIAL PLANTS

John Joseph Wilson, Jr.
Course XV_2

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Professor A.L. Merrill
Secretary of the Faculty
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Dear Sir:

In accordance with the requirements for graduation I herewith submit a thesis entitled "The Management of the Maintenance Department in Industrial Plants".

I wish to express my sincere appreciation for the valuable aid rendered me by the various Plant Engineers with whom I came in contact while undertaking the study.

Sincerely yours,

John Joseph Wilson, Jr.

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P R E F A C E

Maintenance and plant engineering problems have increased with the increased size of the individual plant and with the rapid growth of industry as a whole. Since 1800 when industry was first born into the world on a small scale basis, problems of proper maintenance methods in regard to plant and equipment began to be felt, but it was not until about 1910 that their importance in relation to all phases of production and management was realized. With the introduction of the railway, resulting in wider markets and more rapid communication, came large scale production and its new mechanical problems. The small plant, typical of that time, had its jack-of-all trades. In him was vested the responsibility of maintaining continuous operation of the plant's machinery. He repaired belts, machines, assisted in plant layout problems, and had general supervision over the small jobs which were then and still are constantly at hand within an industrial plant. With the introduction of the telephone, which was largely responsible for making large scale management possible, came large scale management with its insistent demand that management be separated from labor.

Management recognized the necessity and importance of the maintenance phase of the industrial structure, that production men were constantly busy determining quality and the possibility of new developments in their line, and that unless maintenance was made a specialized, distinct and independent phase of the enterprise, production, the life of the business, would be struggling under a handicap if it did not fail altogether.

Thus it was that the old time handy man, whose job was to fix everything that required attention, was replaced by a well organized force of inspectors, repairmen and the like whose work is usually specialized and conducted largely in accordance with definite schedules. Modern management methods are being gradually introduced into our most up-to-date plants, but, sad to say, many plants employing the most modern methods of management in production, planning, scheduling and routing have sadly neglected this field. This neglect is largely due to the belief in these organizations that the very nature of maintenance work, in that its problems are constantly changing and that no two are ever alike, prohibits the introduction of routine methods, such as

job analysis, time study, periodic preventive inspection, etc.

Under present highly competitive conditions in almost every field of industry, with production carefully scheduled and controlled, where every operation must be performed in the most efficient manner possible, delays due to failure and inefficient operation of equipment are too costly to be tolerated. Success depends on the efficiency of each producing organization and in the Maintenance Department lies the responsibility for maintaining as high an efficiency as is humanly and mechanically possible.

The organization of the Maintenance Department, its relation to management and to the other departments of the plant, the methods and practices used in caring for the electrical and mechanical equipment, and also the fixed equipment, the type of manufacturing carried on, all vary in a marked degree with the conditions existing in a given plant. There is no one ideal plan for all plants in all industries, or even in the same industry. Industries differ far more than political units. To try to fit them all to one scheme would border on the ridiculous. Nevertheless it should be remembered that there is an ideal plan for each plant. In any organization a careful study of the service requirements

and conditions under which the equipment is operating, supplemented by some period of experience in operating under these requirements and conditions, will result in the evolution of methods by which the Maintenance Department may be most effectively organized and operated.

- O B J E C T O F I N V E S T I G A T I O N -

OBJECT OF INVESTIGATION

The object of this investigation is to compare the management methods in use in various representative manufacturing establishments having permanently organized maintenance departments, with the intention of determining the trend of maintenance methods and practices in industry.

The primary object of all industrial plants is to manufacture a product at as low a cost as possible, consistent with the accuracy and quality demanded. The general trend in industry has been toward increased quality and value in the product at no increase, and in many cases, a decrease in price. Much of this has been made possible by improved machinery, manufacturing methods, and economies due to large scale production. Another factor, often lost sight of in such an analysis, is the increased interest in, and introduction of, methods of maintaining equipment, permanent and otherwise, in its most efficient state of value.

Previous investigations by interested parties have dealt largely with the actual methods at hand to be used in correcting mechanical grievances. These persons have, in most cases, attached little importance to the management methods at hand by which those ills may be corrected. They

have described the operations but not the tools which may best be used to perform these operations.

Thus it is the purpose of this investigation to study the methods in force in practice and to determine the trend of such methods.

- METHOD OF PROCEDURE -

THE METHOD OF PROCEDURE

The first step taken in the preparation of this thesis was the examination and study of bibliography pertinent to the subject of maintenance of buildings and equipment in industrial establishments. The information gained therefrom was found to be of two distinct types, namely, general and specific. The general information served the author as a background to determine the general nature of the immediate problem. The specific information, as, for example, that derived from such an article as "Maintenance of Mechanical Equipment and Buildings" by Ira De Moss, appearing in the periodical "Industrial Engineer", volume 85, No. 2, February 1927, served as a source of general information on the subject and also as a type of method in a particular plant and as such was incorporated in the thesis. Thus, by means of such reports appearing in current periodicals, geographical distance in the scope of the investigation was readily spanned, and plants were studied which were impossible to visit.

The next step in undertaking this study was to formulate a suitable questionnaire to be sent to plants in whose methods the author was interested and also to be used

as a guide in interviewing the various department managers as to the mode and methods used in their individual plants. The questionnaire used appears in the appendix of this report.

The questionnaire having been formulated, plant visits were started. Considerable difficulty was encountered in attempting to arrange interviews with certain plant engineers who were evidently ashamed of their methods. The plants having ultra-modern and modern organizations and methods were very much interested in the investigation and from these much valuable information was received. As the investigation of each plant was completed, the questionnaire was filled out and, in most cases, where anything of an unusual or unique nature was determined, a short, detailed report was made. These questionnaires and reports were then carefully studied and compared in order to determine any similarities or dissimilarities of methods from which the trend of the methods could be determined.

- THE INVESTIGATION -

The "A" Manufacturing Company

The "A" Manufacturing Company is engaged in the manufacture of shoes and is located in Massachusetts. The total number of employees is 3000 and the annual sales $20,000,000.

The Maintenance Department was established in 1915, two years after the company was organized in its present form. Maintenance is centralized and was established as a major function, curiously enough, as a result of an explosion in the boiler room of the power plant. This accident led the management to believe that the "handy man" maintenance methods were not as efficient as they had formerly believed them to be. The enterprise at that time was experiencing a period of rapid growth and management recognized the fact that systematic methods and procedure were the only proper ways to successfully meet this rapid growth.

At the plant, the Maintenance Department operates under the name of the "Plant Engineering Department" with its head reporting directly to management. The work of the department is sub-divided into five distinct functions, namely:

(1) Research
(2) Development and Design
(3) Construction
(4) Operation
(5) Maintenance

Periodic inspection of operating and production equipment is carried on and its frequency is determined from previous experience with such machinery. Statistical methods of replacing wearing parts have not as yet been found necessary.

The men employed in the Maintenance Department number approximately fifty and were obtained from outside the plant. The plant is operating in a highly organized union district and as a result union tradesmen are employed and are paid the prevailing union wage for each trade in that locality. As a result of using union tradesmen, employees are already trained in the work when hired. The basis of overtime wage payment is "double time for overtime". The average wage of maintenance employees, in general, is higher than that of production employees. Regular working hours are the same as those of production employees although in time of need, the department operates at night and over week-ends.

The routine work, such as inspection, oiling, etc., is carried out on a definite schedule but has not been

time-scheduled. On other jobs the work is despatched and progress is checked by means of the following system. The foreman in whose department repair work is necessary fills out an"order for repairs"and calls the Plant Engineers department on the telephone, describing the work to be done in both cases. The Plant Engineers department fills out another blank with the information given over the telephone, stamps the time on it, and despatches the required number of men to the scene. These men do the work required and the foreman in charge of the department signs the slip if the work meets his approval and marks the time upon it. The men then go back to the Plant Engineers department and the time is again stamped on the ticket as well as all material used on the job. The department in which this repair was made is then charged with the material and labor as recorded on this job-ticket.

Preventive inspection is performed by oilers and when not done by the oilers is carried on by a separately organized inspecting staff.

Written reports are required of inspectors as are written recommendations for repairs.

The Maintenance Department has no means whereby it

can obtain necessary supplies by direct purchases but specifies to the Purchasing Department the material received and from then on, the purchase is carried out by the Purchasing Department.

The department is financed by annual appropriations which have a certain, but by no means definite, relation to production expected . These appropriations are granted in the fall for the coming year upon detailed written report of expected expenses during that year.

The expense of routine maintenance is charged to the Plant Engineering Department.

The expense of breakdowns is charged to the Maintenance Department, while the loss resulting therefrom is charged to Production expense of that particular department, the theory being that the Production Department should bear part of the expense as a penalty for not foreseeing the breakdown and notifying the Maintenance Department of the need of repair before the actual breakdown occurred.

The operation and policy of the Maintenance Department is governed by the expenses incurred to a small extent only. Expenses over those granted in the annual appropriation must be explained by the Plant Engineer to the management.

The "B" Manufacturing Company

The "B" Manufacturing Company is located in Massachusetts and is engaged in the manufacture of safety razors and blades. The company employs a total of 2200 people and has a maintenance department numbering approximately one hundred.

The Maintenance Department sometimes referred to as such, but more often known as the "Shop Department" is not centralized and was organized at the time of the establishment of the company. The realization that the large amount of complicated automatic machinery and very exact manufacturing specifications and tolerances necessitated careful and exact control of all production machines caused the introduction of the very modern system of maintenance now existing at this plant.

The Maintenance Department head reports to the Plant Engineer and he, in turn, directly to management. The work of the department is subdivided into the various phases of repair and maintenance, such as: painting, lubrication, machine repair and maintenance, sanitation, etc. The specific responsibilities of the department are to retain the plant and buildings in the best

possible condition and, above all, to insure the continuity of production.

The frequency of periodic inspection is determined from the experience with the various types of machinery. For example: a bank of 32 machines used in the production of blades is taken down completely on a regular schedule and sent to the repair and maintenance department. These machines are completely overhauled by highly paid mechanics, assembled once more and sent back, and another bank is then taken down. This procedure is followed in the care of all automatic production machinery. Statistical replacement of wearing parts is not used although the method described directly above borders very closely on such a method.

The Maintenance Department is made up of highly specialized non-union mechanics, some of whom were obtained from outside the shop, and the remained trained in the plant training school. This school is maintained and conducted by the company in the Maintenance and Repair Department. The course is of four years duration during which the rate of pay is increased gradually from a minimum of 26 cents per hour to a maximum of 76 cents

per hour. The students are employed on actual maintenance and repair work at all times and upon completion of the course or at any other time may leave the employ of the company if they so desire. The company confers a certificate upon the students completing the course. Sixteen students are being trained at all times.

The Bedaux system of wage payment is used in all phases of maintenance, whether routine or otherwise. A very complete and accurate time study has been made of all jobs thus far and as a result this system has been found most satisfactory to both employees and management alike. Overtime wages are also based upon the Bedaux System. The average wage of maintenance department employees is, as one would expect in view of their skill, very much higher than those in production work.

In times of depression the employees are laid off, but this has rarely been resorted to because of the fact that the plant never finds itself caught up in the routine work due to the unusually large amount of highly complicated automatic machinery. A full day's work for each maintenance employee is provided by the system of continuous overhauling of production machinery.

The work is laid out for the employee by means of carefully organized system of planning, scheduling and despatching. The progress of each specific job is checked by means of the job-order cost system.

Preventive inspection is performed in each of four different ways, namely:

(1) Inspection of product after each operation
(2) Inspection of the machine by the operator
(3) Inspection of the machine by the foreman
(4) Disassembling and overhauling of each machine at periodic intervals.

Written reports of inspectors and written recommendations for repairs are both required.

The responsibilities of the department have increased in recent years along lines of natural expansion and responsibilities for new construction.

All purchases must go through the customary Purchasing Department channel but must, first of all, be endorsed by the shop engineer in charge of maintenance.

The department is financed by annual appropriations. These appropriations do not have any direct relation to expected production inasmuch as maintenance costs do not vary directly with the volume of production.

The expense of routine maintenance is charged to the Maintenance Department while the expense of repairs is

charged to maintenance and the loss of time, etc. therefrom is charged to production. The operation and policy of the Maintenance Department is governed only to a very slight degree by the expense of operation of that department due to the fact that the management feels that the life of the business lies in the quality of the product and the quality, in turn, lies in the hands of this department.

The Bedaux System of Wage Payment has been in operation for about five years at the plant. This system was applied to maintenance and repair work two years ago. It has been very successful due partly to the fact that maintenance in this plant has been made a highly routine function, and partly due to the fact that management has provided enough productive machinery so that a large number of these machines can be disassembled at a time and thus put maintenance on a "large scale" basis, with its accompanying economies.

The "C" Manufacturing Company

The "C" Manufacturing Company is a concern engaged in the manufacture of fountain pens, ink, adhesives, carbon paper, paste and mucilages, and is located in Massachusetts.

At the present time the company is in the process of establishing what bids fair to be an efficiently organized and operated maintenance department. Formerly, three "handy men" were employed to conduct the maintenance function. These men were able to handle the work in fine shape but this was due to no exceptional ability of their own but due to a mistake on the part of management. This mistake lay in the idea that instead of trying to operate existing production machinery at a high peak of efficiency, more machinery would do "just as well". By continuing with this policy, the concern has loaded itself with machinery which, though not used except upon rush orders, would be as efficient as the machinery acquired to take its place providing a small amount of repair work and efficient maintenance practices were used. As a result of thoses methods and their high costs, management has come to realize the great value of proper

maintenance work. With the introduction of a large amount of new automatic machinery during the past few years has come also the necessity for much preventive inspection and, as a result of these factors, a maintenance department is in the process of gradual formation.

The "D" Manufacturing Company

The "D" Manufacturing Company is engaged in the manufacture of wire and cable in Massachusetts. The plant employs a total of 1000 people and retains a maintenance force of approximately 40 employees.

The Maintenance Department operates under the name of the "Rent and Power Department" and its work is subdivided into repair, inspection, manufacture and design of new production machinery, and power. The department is centrally located. The Manager reports to the Plant Superintendent.

The frequency of periodic inspection is determined for each machine or class of machines from previous experience with that or those machines; statistical replacement of wearing parts is not employed nor is it deemed necessary under the present system of maintenance.

The total number of employees in the "Rent and Power Department" under normal conditions is 120. This number may be broken down in regard to the various functions of the department in order to determine the number actually employed in maintenance. Thirty (30) are in

maintenance, ninety (90) in design and manufacture of new machinery. Under this system there is constantly at hand a potential supply of 120 maintenance employees although at no time except in emergencies does the department employ more than forty in actual maintenance work. Nevertheless, the specific responsibilities of the department, according to the organization, stress the maintenance function more than the others.

Good mechanics are sought for maintenance work and are hired from outside the plant. They are paid on a straight salary with double time for overtime. The average wage of the maintenance employees is higher than that of production employees. The employees are usually skilled along many lines of mechanical work.

In times of depression, if the depression is sufficiently serious, the excess maintenance employees would be temporarily laid off, but since there is always a demand for new ways and means of doing things and since the company enjoys a constantly increasing demand for its products, this system has not been resorted to, to any extent.

A full day's work for each maintenance employee is

planned by employing these men, when not engaged in production work, in the manufacture of new equipment. Men employed in this manner are always on call for maintenance and repair work.

Routine jobs have not been time-studied.

Preventive inspection is performed in three different manners:

(1) Oiler who reports to inspector in case he sees need for repair
(2) Operator of the machine who also reports to inspector in case he sees anything needing repair.
(3) Separately organized inspecting staff discover need for repair.

Written reports of inspectors and written recommendations for repairs are both required. The system of forms and records in use is similar to that used on production orders in the Production Department.

The responsibilities of the department have increased in recent years along lines of new design and manufacture of new equipment.

The Maintenance Department has no means whereby it can obtain necessary supplies by direct purchases; it is necessary for all purchases to go through the customary routine via the Purchasing Department.

The department is financed neither by budget nor annual appropriations. This is due to the diversity of the functions of the "Rent and Power Department". The expenses of each individual function are kept and are analyzed for each year to determine causes of any substantial increase or decrease over preceding year.

Job orders are issued for each specific task.

The expense of breakdowns is charged to the Maintenance Department while the loss resulting therefrom is figured in with the cost of production.

The "E" Manufacturing Company

This concern is located in Michigan and has a maintenance force at this plantof 2900 men, of whom less than 10 are major executives and less than 10 are general foremen. The department of maintenance was established at the time of establishment of the enterprise itself.

As to the responsibilities of the Maintenance Department, it is sufficient to say that it has under its control virtually everything that is left over after the duties of the various production departments have been assigned.

In addition to a large centrally located fabricating shop a number of small maintenance departments are located in the various buildings of the plant. About eight months ago this subdivision was made whereby the special maintenance work in any one building was placed under the superintendent of that building, the idea being that in this way the work could be done faster and at less expense. This method applies only to small maintenance jobs under $100. Those jobs over $100 are referred to the main Maintenance Department which cooperates with the

local department in performing this work.

The basis of wage payment is a day rate. The average wage of maintenance employees is approximately the same as those in production. Regular working hours are the same as those of production employees except in extreme cases.

Routine jobs have not been time studied. Preventive inspection is performed by oilers, operators and a separately organized inspecting staff. Written reports of inspectors and written recommendations for repairs are required.

Each job-order is made out in triplicate and each order blank contains the following information: serial number of the order, the account number of the department to be charged, the factory work order number, the quantity wanted, detailed pattern, and forging number. There are also spaces to be used for ordering castings, the number, kind, and pattern number, the date, by whom requested, with a space for the superintendent's approval.

The expense of routine maintenance is budgeted by departments. The expense of breakdowns and loss therefrom is charged to the manufacturing expense of that department in which the breakdown occurred.

The "F" Manufacturing Company

The "F" Manufacturing Company is engaged in the manufacture of clocks in Connecticut.

At the present time maintenance is being put upon a truly modern and elaborate basis along with the other functions of the business. The company employs 500 people including about 30 in the normal maintenance force.

Due to the highly exacting production methods required in the manufacture of high grade and even medium grade clocks, a large and exacting maintenance force is required. Preventive inspection, not only from the point of view of loss in time, etc., due to breakdown, but also from the point of view of precision of the integral parts is fundamental and assures a paramount position. That this is true was realized but a short time ago by the management and as a result, as pointed out above, maintenance is becoming a truly important function at the plant.

At the present time extensive study is being undertaken in order to determine of what the ideal organization and operation of a plant of this description

should consist.

The report on this company is included in this study not with the idea of studying the maintenance function at this plant but with the idea of showing the trend toward importance which maintenance is taking in plants of this small size.

The "G" Manufacturing Company

The "G" Manufacturing Company is located in Michigan and is engaged in the manufacture of automobiles. The annual sales amount to $150,000,000 with a total of 18,000 employees - there being 12,000 employed in production. The total number of productive machines is approximately 6,000. The company was organized in its present form in 1909. The Maintenance Department was established at that time and the circumstances under which the department was established are given as the absolute necessity of highly organized maintenance in manufacture of a product of this kind.

The Maintenance Department, employing 700 persons, operates under the name of the "Works Engineering Department"; its head reports directly to the works manager. The work of the department is subdivided into plants and is further subdivided into departments such as, carpenter, electrician, pipefitter, etc. The specific responsibilities of the department are the maintenance and construction of buildings, tracks, conveyors, machines, sanitation, etc.

Periodic inspection of the equipment is made and

its frequency is determined from experience with each piece of equipment, the period varying from daily to monthly inspections. Statistical replacement of wearing parts is used whenever feasible.

The Maintenance Department is centralized and in the opinion of the Works Manager should always be located as nearly central as possible without occupying too valuable floor area. It has been found desirable to have the Maintenance Department located nearest to those departments in a central location having the greatest machine density.

The Maintenance Department employees are taken whenever possible from depression periods of low production from the production department. Those employees in highly specialized trades such as electricians, for example, are usually hired from outside the plant. Americans are usually sought for maintenance work. Home owners, men of uniform temperament, steady, reliable, and ready and willing to stick by the job through long hours in emergencies are by far the most desired and desirable. Jobs in the maintenance department are generally not sought by factory employees in production work. The employees, in

general,which were trained for the work within the department, started in as helpers to the tradesmen.

The wage payment is on an hourly basis with "time-and-a-half" for overtime. Supervisory positions are on a straight salary basis. The average wage of maintenance employees is approximately equal, over a period of one year, to that of production employees.

The regular working hours of the department are different from those of production employees only in specific cases as,for example , power house maintenance which, when performed, might interfere with production. The employees are as a rule members of specialized trades altho' all around men are highly desirable in certain phases of the work.

In times of depression the less valuable maintenace employees are laid off. A full day's work is planned for each maintenance employee by a clerk who issues job numbers. Others have routine duties and stand by work in emergencies. The work is scheduled by superintendents through their foremen and the progress is checked by progress checking methods similar to those used in production.

Routine jobs are in the process of being time-studied

at the present time.

Preventive inspection is performed in all of the five following methods:

(1) By force when not actually making repairs.
(2) By oiler.
(3) By separately organized inspecting staff.
(4) By report of operator of the machine.
(5).By report of superintendents and foremen.

A great deal of stress is laid on the importance of the reports of defective apparatus and buildings by the production superintendents. Written reports of inspectors and written recommendations for repairs are both required. Repair work up to $25 is performed on foreman's request and work up to $100 is performed upon the written request of that production superintendent in whose department the work is to be done.

The responsibilities of the department have increased in recent years due to the tremendous expansion program and the huge increase in production.

The department is financed by appropriations granted as needed. These appropriations have a direct relation to production expected especially as applied to a change in design, as, for instance: when the production of a new model is contempleted. The expense of routine main-

tenance is budgeted for each of the two divisions of the company. The expense of breakdowns and loss therefrom is charged to manufacturing expense.

Job orders are issued for each specific task and all jobs estimated to cost over $25 must always be approved before the work is started except in cases of extreme emergency.

The Maintenance Department has a budget for normal maintenance cost per car produced. This budget is checked weekly and the reasons for any variations are studied.

The "H" Manufacturing Company

The "H" Manufacturing Company is engaged in the manufacture of metal office furniture and is located in Ohio. The company employs a total of 1150 employees of which 800 are in production work.

The Maintenance Department was organized more than ten years ago when the absolute necessity for such a department was realized. The department operates under the title of the "Maintenance Department" and its head reports directly to the Plant Engineer. The specific responsibilities of the department are to repair and maintain all defective buildings and equipment and also to install all new apparatus and improvements which fall below the $1000 cost.

Periodic inspection of equipment is made and its frequency is determined for each machine or class of machines from previous experience with that or those machines. Statistical replacement of wearing parts is not used.

The Maintenance Department is located in as near a central position as possible and it is the opinion at the plant that the maintenance department of any plant

should be located as nearly central as possible without occupying an extremely choice position. It has not been found necessary to put the maintenance function adjacent to any particular production department.

The Maintenance men most desirable in this locality seem to be Anglo-Saxons, especially for jobs requiring any degree of initiative. Jobs in the Maintenance Department are not generally sought by factory employees in production work primarily because they are considered to require too much responsibility. The Maintenance men are either trained prior to their employment or are trained at the plant in serving what might be termed an apprenticeship with experienced men. The standard job and bonus system of wage payment is in operation for maintenance employees. Overtime payment rates are one and one-half times the standard rate. The average wage of maintenance employees is generally considered to be about the same as those employed in production work.

Maintenance employees are usually not skilled in more than one line and in general are not capable of working in the production department. In times of depression the employees work on general replacement jobs, improvement and

seasonal jobs such as the following - in summer they would overhaul the heating plant, etc. A full day's work is provided for each maintenance employee by means of material and labor estimates which are made for each job. The work is then scheduled from these labor estimates. The work is laid out by the foremen and by trades from their job estimates and delivery promises. The progress of each job is checked by giving each job a starting and completing time and this is verified by the foreman in charge.

Routine jobs have not been time studied although a standard time is set to complete the task and a bonus is paid for beating this standard. It is hard to understand how standard times have been set without the jobs being time-studied but nevertheless that is the situation prevailing.

Written reports of inspectors and written recommendations for repairs are not required. The record of maintenance operations is formed by giving each job an estimate and then all actual time and materials are charged to the job.

The responsibilities of the department have in-

creased greatly in recent years especially along the lines of responsibility for new construction work.

The Maintenance Department has no means whereby it can obtain necessary supplies by direct purchases but for each purchase it is necessary to go through the customary procedure - through the Purchasing Department.

The department is financed by annual appropriation by the management. These appropriations have a direct relation to production expected in that they are usually a certain percentage of the tonnage to be handled. The operation of the department is governed by the appropriations and costs.

On jobs less than $300 it has been found that the cost of labor is usually higher than material, while on jobs above $300 the cost of material is higher than that of labor.

The expense of routine maintenance is budgeted by the departments while the expense of breakdowns and loss therefrom is charged to departmental overhead expense.

- THE TREND -

Products of Plants Studied

The manufacturing establishments whose maintenance work was studied produce a well diversified list of products. Among those enterprises studied, we find two automobile manufacturers; one clock company; a shoe company; an ink, fountain pen, and mucilage company; a safety razor manufacturer; and a metal furniture manufacturer. Such a diversity of products manufactured gives a clearer and more definite picture of what is being done along the lines of maintenance management methods in industry as a whole. This list is also well taken in that the concerns included vary from those manufacturing a single product to one manufacturing six products which are closely allied, in so far as their use is concerned but whose manufacturing methods and problems are widely varied.

Size of Plant

The size of the various plants listed is also very well diversified. When one considers size from the point of view of the number of employees, we find the classifacation varying from one plant employing 500 persons to the largest employing 25,000. When considering size as determined by

volume of sales, once again we find the diversification even more widely scattered, varying from one plant whose annual sales volume is approximately $1,000,000 to the largest having a volume of over $175,000,000. This diversification according to size as well as product is another point in favor of the plants which were selected to be studied. From this study of plants whose sizes and products are so widely varied, the trend of Maintenance Management methods should be very apparent, inasmuch as these plants were in no case chosen because they were known to have modern maintenance methods but because they were known to have modern production methods. Thus the results of this study become the more valuable when one considers that those plants having modern production methods and practices are apt to have modern maintenance methods and practices.

Is Maintenance Centralized?

It appears that the almost universal trend is toward the centralization of maintenance. By this, I do not mean that maintenance is centralized at the expense of sacrificing an ideal location of a producing department but I mean that maintenance in the majority of cases is placed as nearly central as possible without any such sacrifice.

Five of the eight plants investigated reported that maintenance was centralized. Two, whose maintenance departments have not as yet grown beyond adolescence, report that maintenance is to be centralized while the last, Plant "E" shows a decided tendency toward decentralization.

The reason for this tendency toward decentralization in Plant "E" is probably due to a number of causes which are all worthy of consideration. In the first place, we have the variety of tasks for which this particular department is responsible in Plant "E". The tasks vary from single inspection of an electric motor or shafting to the construction of a huge system of conveyors, building a balcony, manufacture of safety devices for productive machinery and, in fact, all the tributory equipment and machinery aside from that actually engaged in the production of the finished product. In the second place, we find an explanation of this tendency in the unusually large size of this particular plant. How foolish it would be, in a plant covering so large an area, to be constantly sending men out, let us say, to replace burned out fuses. It would probably require the better part of one hour in going to and coming from the scene. Thus we see the reason for the tendency toward decentralization and

the reason why all jobs under $100 are taken care of by the local maintenance department, while jobs above $100 are referred to the central maintenance department which, in turn, cooperates with the local maintenance department in the work. By "local maintenance" is meant the maintenance department in any one building which is placed directly under the superintendent of that building. In this way the work is carried on faster and at less expense.

In the average size plant where maintenance is centrally located and where under such conditions the time taken for a repair man to go from the maintenance headquarters to the farthest operating unit is not excessive, it is very good practice to have but one department. Under such conditions, the unproductive time of maintenance men is a minimum, conflict over authority on certain jobs is eliminated, and the function is apt to be carried on more efficiently than under conditions of divided authority.

Location of the Department

When new plants or buildings are being designed the tendency seems to be, and rightly should be, to locate the maintenance department centrally, as pointed out above, and still locate it near that department having the greatest ma-

chine density. The reasons for this are self-evident.

Time and Circumstances of Establishment

The age of the departments investigated vary from twenty years to one or two months. Too much weight should not be placed on the twenty year figure or, indeed, on any of the figures giving the ages of the departments as being more than six, or seven years at the very maximum. Maintenance, in Plant "G", for example, may have been organized as a function twenty years ago but certainly its policies and methods have changed many times since then. From my investigations I have concluded that the scope of maintenance work, as well as the methods and practices involved in it, have increased many times during the past five years. In fact in most cases it was found that during the past five years the department was completely remodeled.

The circumstances leading to the establishment of maintenance as an organized departmental function may be said to be practically universal. In every case it was found that the Management had come to realize that under modern competitive conditions, with straight-line production methods, and with such extensive use of automatic machinery, losses due to

breakdowns were far greater than their costs of repair. Loss of production time, broken promises, unproductive machine time, the large investment in unproductive machinery, high labor charges, are all very expensive factors and all result from each and every breakdown no matter how slight or inconsequential that breakdown may appear. Thus it was that management began to realize the presence of these losses which previously were not so apparent or important and set out to minimize them.

Name of Department and To Whom Does Its Head Report?

Under the name of the department we find a wide diversity of titles. This is due to the fact that in some plants maintenance is a subdivision of a larger department, while in other plants it is an individual, separately organized and operated department. In any case, the maintenance and repair function should be known as the "Maintenance Department" or the "M aintenance Division" (where it is conducted as a function or subdivision of another department) as any other term is apt to be very misleading.

Due to the plan of organization at some plants the Maintenance Department head reports to the head of another de-

partment. For example, he often reports to the Plant Engineer who has charge of research, development and design, construction, operation and maintenance departments. In such instances he usually will report to either the "Works Manager" or "Plant Engineer". In plants in whose plan of organization maintenance is put on a level with the production or construction department, he will usually report directly to management.

Specific Responsibilities of the Department of Maintenance

The specific responsibilities of the Department of Maintenance in various plants are so varied as to permit no way of stating in a specific manner what industry has placed upon the shoulders of this department. Yet it is possible and true to say that, in general, the maintenance department is responsible for insuring the continuity of production in the most efficient manner and for keeping buildings and equipment in the best possible repair. Thus one may infer that the work of the maintenance department should include the following:

(1) Maintenance and repair of machinery and buildings, etc.
(2) Operation, maintenance, and repair of power, heat, light and ventialtion equipment.
(3) Installation and erection of new equipment.

(4) Design of new productive machinery
(5) Fire Protection
(6) Sanitation

Thus it is true that the Maintenance department should be given full responsibility for all activities whose successful and economic performace depends largely or entirely upon the knowledge and application of mechanical engineering.

Periodic Inspection and its Frequency

Periodic inspection was carried on in all of the plants studied whose maintenance work had been put upon an orderly basis. In only one plant do we find that this function of maintenance has been carried on "to an extent only" but at this particular plant studies are now being made, at the completion of which, periodic inspection is expected to become one of the major functions of this department. When this phase of maintenance is carried on in a truly scientific style, it has been the experience of many managers that the function of repair and its resultant high costs, both in the actual repair and in losses due to the interruption of production, have decreased to a marked extent, fully enough to pay many times over for the increased cost of inspection.

The frequency of periodic inspection varies with the kind of machine, its treatment, operating conditions, make

and last but by no means least, the manner in which it is lubricated. For any given machine in any plant, the frequency of inspection is largely determined by the careful recording of all repair work done on that machine. Then, after such records have been kept for a period covering eight or ten repairs, the frequency of inspection required to discover a defective part may be readily determined. As a result any defect in the machine will be found and remedied before the machine breaks down or begins to turn out defective work and thus, savings due to continuous production of product up to standard quality will ensue.

Statistical Replacement of Wearing Parts

In only one plant of those studied was statistical replacement of wearing parts in use and in this plant it was used only to a certain extent. This method of replacement calls for replacement of certain parts which are known to cause trouble after so many machine-hours have elapsed, just before this pre-determined time is up. This method, though it is apt to be very expensive unless the time element is determined very accurately has been used with a large amount of success in many cases where interruption to the flow of production causes very serious wastes.

This plan, as previously pointed out, may prove, in itself to be very costly inasmuch as the part in question would probably operate to perfect satisfaction for a much longer period. As a result, its use is recommended only where the life of the part may be determined by the most accurate methods and where any interruption to the flow of work through the shop would cause unusual and extraordinary losses. Such cases are most apt to be found in those industries (especially food industries) where the time between the first process and the last must be a minimum in order that the product in process will not spoil or deteriorate in any manner.

Source of Supply and Type of Maintenance Employees

From the results of this study it would seem as though there must be a constant source of supply of tradesmen waiting at the factory gate. This state is known to be true generally, though not literally so, in the case of unskilled workers, of whom there is always a source of supply ,- though they may not be the desirable type in every case. Yet it is true that each plant replied that maintenance employees, who are in most cases members of a trade, were usually hired from outside the factory. Two plants reported that a part of those employed

trained as apprentices and one, Plant "B", has even gone so far as to conduct a school for the specific purpose of training young men to become mechanics and continue in the employ of that company in maintenance work, though this last clause is by no means compulsory after the training period has been completed. (For a fuller treatment see discussion of Plant "B".)

The type of man desired for maintenance work seems to vary with the labor conditions in the plant or in the surrounding community. S ome plants hire union men because they are required to, inasmuch as they may be operating under closed shop conditions. Others, where organized labor is not so strong, may be able to employ highly skilled non-union tradesmen.

In Plant "H" men of Anglo Saxon descent were found to be highly desirable especially on jobs requiring any degree of experience. Americans were found, generally speaking, to be the most desirable in Plant "G". In general, it may be said that men most desirable for this type of work are those of uniform temperament, who are steady, reliable and willing to stick by the work for long periods during extreme emergencies.

Desirability of Maintenance Work

In every case jobs in maintenance work were not sought by factory employees in production work. This is primarily due to two fairly evident reasons. In the first place those employees in production work are unfitted for maintenance work due to the nature of the production work. Shoe lasters are not mechanics, unskilled workers are not electricians, and women do not make good millwrights. In the second place, jobs in the Maintenance Department often require a certain responsibility which is often found lacking in production workers. Maintenance and repair work usually requires much overtime work especially on Saturday afternoons, Sundays and holidays. Production employees are usually the type who like to start at 9 A.M. and finish at 5 P.M. and at 1 P.M. on Saturdays. They do not relish long hours and holiday work.

Basis of Wage Payment

The basis of wage payment of maintenance workers seems to vary with the prevailing labor conditions in the community and also with the customary basis of wage payment in a particular industry. Thus in Plant "A" where organized labor is unusually strong the basis of wage payment is the pre-

vailing union wage in that district while in Plants "E" and "G", both engaged in the automobile industry where the prevalent custom is to pay workers on an hourly or day rate, we find both the hourly and day rate being used. Plant "B", in all departments of which the Bedaux system of wage payment is used, applies the Bedaux system to maintenance employees, while Plant "H" which uses the standard task and bonus system in production work, applies that system to the maintenance force.

In the majority of the plants reporting on this subject, we find that the straight pay basis was used but this by no means is typical of the tendency of wage payment in the maintenance function of industrial plants. Two of the plants studied already have placed maintenance employees on an incentive wage basis. One of these has even gone so far as to apply the Bedaux system to all maintenance workers. The other has introduced the standard job and bonus system.

Mr. R. M. Hidey and Mr. Henry Hylkema, both of the White Motor Company of Cleveland, in an article entitled "Applying a Bonus Plan to Maintenance Work" published in Industrial Engineer, Volume 84, No. 8, 1926, describe the application of a bonus plan to maintenance employees at the

White Plant. The subject matter is considered to be of great value to this problem of wage payment to indirect labor and thereforeit is in part quoted below:

> ". . . . . Under our plan, all jobs are classified so that jobs requiring equal ability and the same degree of skill will be paid equal bonus, regardless of the department in which they happen to be located. For the purpose of computing bonus pay, all jobs are divided into ten classes. Bonus Class 1 pays 25 cents for a standard 8 hour day at 100% efficiency. Continuing in jumps of 25 cents per class per standard 8 hour day, the bonus increases to $2.50 per standard 8 hour day for bonus Class 10 for 100 per cent efficiency.
>
> ". . . . . In studying the question of applying a bonus system to our indirect labor, we naturally considered the fundamental principles underlying our production bonus plan. We began consideration of its application to our Maintenance Department about three years ago, when our cost records began to show that the cost of our Maintenance Department per truck unit did not decrease with increasing truck production. Forthermore, continuous production is dependent on continuous operation of equipment and we wanted to put the maintenance of production equipment on as firm a foundation as that of production itself. These two facts, coupled with the constant requests of the maintenace men for a bonus system similar to that in the production department, provided the impetus for our study of the situation.
>
> "Our maintenance group is organized under the general supervision of the Plant Engineer, and under the immediate charge of the Master Mechanic.

The group includes Maintenance proper, steam, air and power equipment, janitors and watchmen, yards and ways, garages, locomotives and cranes, refrigeration, and general.

"These plant services are usually the ones included in Plant Engineering and are classified as indirect labor; they are seldom considered as coming within that group of activities which can be estimated or predetermined closely enough to place on a time schedule or under a bonus system.

"However, we thought that our basic fundamentals were sound, and determined to try to develop a bonus plan for the Maintenance Department. We decided that any plan adopted must consider those elements of maintenance work which could be individually time-studied and placed on individual bonus as were all of our production jobs.

"This was the first step, and after an analysis had been made of all of the jobs in the Maintenance Department, they were classified into two groups: first, those which could be individually time-studied, and second, those which seemed to be applicable to some sort of a group plan.

"We then started out to get as close an estimate of the general efficiency of that part of the Maintenance Division as we could under the group plan and then devise a means of measuring this efficiency. We proceeded in about this manner: We assigned, for example, three trained time-study observers to study three plumbers. On alternate days each observer recorded everything which his man did during the date. In this way we obtained three independent observations of each plumber.

"In general investigations in a large number of plants by various authorities who have made a study of wage incentive plans, show that men working without extra wage incentives will have an efficiency of about 50 per cent. The loss of 50% in efficiency is due to unnecessary or un-

planned time, or to a poor method of doing the work. For the first two the men themselves are responsible, and for the last case the management is responsible. When we first adopted the bonus system in 1921 , we made it a part of our job to see that adequate provision was made to provide the proper equipment to perform the work by the very best methods. We have tried to adhere strictly to this policy.

"The procedure for plumbers was followed through for carpenters, electricians and others to whom this method could be reasonably applied. Having determined the relative efficiency of the men in the maintenance group, our next step was to ascertain the maintenance force required for any given volume of production.

"The first step was to determine what were the minimum requirements. For this purpose we assumed the plant to be shut down to zero production and boarded up for at least a year. Then by employing our judgment as to the reasonable precautions for adequately protecting our property under these conditions, we figured out the number of men necessary to keep on our maintenance payroll.

"By making use of our records of different maintenance forces employed at various production schedules, we then worked out a curve which gave us the man-hours required for almost any rate of production. This, of course, was with our maintenance men working at 100 per cent efficiency. Correlating all of our information, we obtained the maintenance man-hours applicable to a single truck unit. Adjusting this figure again for gross plant operation, fi-

gured at 80 per cent efficiencywe now had a figure which represented the maintenance man-hours required to produce a truck unit.

"With the information now available, it was a simple matter to incorporate our findings in a table which represents man-hours at various efficiencies required to maintain various production schedules. This table is the basis for figuring all bonus pay.

"It was evident that to obtain the largest saving possible, it would be necessary to secure coordination and cooperation between all of the men in the maintenance group. The functions and activities of this group are so overlapping that it was not feasible to attempt to make any fine distinctions as to proper division of work. For this reason it was decided to make the group large and include all of the divisions of the Plant Engineers' group in our bonus calculations. This gave not only each group but also each member of each group a definite incentive to cooperate and coordinate his work with that of the others. Therefore on Jan.1, 1924, we put our maintenance department as a whole on the bonus plan.

. . . . . .

"It is of interest to know, however, that new construction work which does not exceed ten per cent of the allowance in standard hours for all maintenance work, must be included with this department's regular activities. New construction work exceeding the 10% allowance is handled through contracts with outside concerns.

"Bonus for janitors, scrub women, and others whose work can be timestudied by ordinary time study methods is figured daily.

"A question which we are frequently asked is, 'If the men receive a bonus on the saving of time on a job, what is there to prevent them from rushing it through as quickly as possible, even though they might know that a few minutes saved now will mean more minutes in repairs later?' It has been our policy to retain men in our employ regularly. We take considerable pride in the service records of our employees. The men know or soon find out that it is not the single job which gives them their bonus, but the accumulated savings on many jobs through a long period of time. They expect to be on the job a month or a year from today and so they do not want to risk the chance of losing their bonus at that period through false economy now. Maintenance and service must come first and the bonus will follow naturally.

"When a bonus plan of this sort is in effect, the men object strenuously to hiring extra help unless they see that it is absolutely necessary. This is because the extra man-hours will go into the total hours worked, to compare against the standard hours. This, of course, decreases the departmental efficiency and so decreases their individual bonus. Thus each man has a definite incentive to do as much work as possible himself, and to keep the number of men in the department down to a minimum. The men soon notice if one of their members does not put in his best efforts. In such a case they do not hesitate to let him know about it, thus taking care of the situation themselves.

. . . . . .

"In substantiation of the statement that it appeals to employees, little more need be said than that it provides them increased wages, good working conditions, steady employment, and a chance for individual recognition.

"Unusually low labor turnover testifies to the steady employment which the system assures.

"We regard the successful operation of the plan as being due to the following characteristics:

First, the plan itself is fundamentally sound. It is reasonable in every respect and is based on logical study of all the elements involved in the situation.

Second, it satisfies both workmen and employer. The extension of parallel studies, modified according to the demands of the situation, to our tool room and our material handling division, which is really another story, at least gives an indication of the manner in which the operation of the plan has been received by all concerned.

The third, and by far the most important, reason why our plan has been successful, is one for the lack of which most unscientific plans have been unsuccessful. Every bonus chart which we issue carries this guarantee: 'These bonus prices will not be lowered no matter how long the job may run with this equipment and by the method and design specified in the instruction referred to in the foregoing.'

"This guarantee never has been and never will be violated. It is the basis for the success of the whole system. Our men believe in it and in us. And when there is that relationship between employer and employee, success should come to both."

Basis of Overtime Payment

Overtime wages of maintenance employees, from the results of this study, show a tendency toward either "time-and-a-half" or "double time". At Plant "G", where the Standard Job and Bonus System is in force, overtime is paid at 1.5 times the standard rate. In Plant "B", which, it will be remembered, used the Bedaux System in maintenance work also uses this system as applied to overtime work. It may definitely be said, therefore, that where straight pay is employed in maintenance work, the overtime basis is either time-and-a-half or double time. In cases where a special wage system is employed, overtime payment is usually based upon that system.

Comparison of Production and Maintenance Wages

One half of the plants reporting on this subject report that maintenance employees' average wages were higher than the average wage for production employees while the other half report that their average wages were approximately equal. It is significant to note that those plants reporting maintenance wages to be the

highest are, in every case, engaged in the manufacture of a product whose process of manufacture entails little or no actual trade skill. One of these plants employs women in production work. (Plant "B") It is natural, therefore, that maintenance employees whose work requires skill in handling of machinery and knowledge of machinery receive a higher rate of pay. Those plants reporting the average wages of these departments to be about equal are all engaged in the manufacture of a product whose process of manufacture requires, at least, a certain amount of mechanical skill and therefore the reason for the approximate equality is evident.

Thus it may be definitely said that in those plants manufacturing a product whose process of manufacture requires no trade skill (usually those using a large number of highly automatic machinery), the average wage of maintenance employees will be higher than that of production employees, while in the plants manufacturing a product whose process of manufacture requires a certain amount of trade skill on the part of production employees, the average wages of production and maintenance employees will tend to be approximately equal.

Working Hours of Maintenance Employees

The working hours of maintenance employees are, in general, the same as those of production employees. Plant "D" has inaugurated a system of periodic inspection of its heavy machinery which necessitates that a certain number of these machines be taken down and overhauled weekly. As a result of this inspection system a certain portion of the maintenance employees is employed on Saturday afternoon and all day Sunday in doing this work. These employees are then allowed one and a half days off during the week, not at the same time, however, in order that the maintenance department will not become embarrassed with an insufficient force in the event of an emergency.

In cases of repairs or inspection of heating, ventilating and power equipment, the hours will be different from those of production employees in order that the continuity of production will not be interfered with. In all other cases, except in cases such as those mentioned above, the regular working hours of employees are found to be the same as those of production employees.

Skill of Employees
(Are they skilled in more than one line?)

From the results of this study it seems to be very definitely true that maintenance employees are not skilled in more than one line. A man may appear to be an "all around mechanic" and yet could not be called a skilled millwright, electrician or carpenter. Maintenance employees are usually members of a specialized trade and experience with such men appears to show that they are not skilled in any other trade than that of which they are members.

Depression Periods and Maintenance Work

What to do with maintenance employees in times of depression has long been a problem in industrial plants. In the majority of cases the less valuable employees are laid off, while in the remainder they are put to work repairing in a most minute manner those production machines, which, due to the depression, are not in operation. This latter method provides a means whereby all productive machinery and all other machinery may be in the best repair to meet the rush season. Often

the maintenance force is put to work on an elaborate program of building repair, such as painting, roofing, etc., for which they find only a limited amount of time during rush seasons. As a result of this method the plant never becomes run down in any respect and, perhaps more important, the employees have a steady job and as a result are fully satisfied,- which goes a long way toward creating employee good-will, itself a vital factor in the existence of any industrial organization.

Planning a Full Day for Each Maintenance Employee

A full day's work for each maintenance employee should be planned on the basis of labor time required for all jobs to be done. Enough routine or stand-by work in the nature of periodic overhauling should be constantly at hand to provide work for employees when emergency repair work is not being called for. This practice is now in use in the majority of plants whose maintenance function has been properly organized and properly managed.

Time Study of Routine Maintenance Work

Although routine maintenance work was time studied

in only one plant of those visited it may be said without hesitation that the trend in maintenance methods is toward such practice. One establishment, The "G" Manufacturing Company, is now engaged in the making of time studies on such work. The "B" Manufacturing Company has made very elaborate time-studies in connection with the Bedaux system of wage payment for maintenance employees. The other plants have not found it necessary nor feasible as yet to time-study this phase of the work, but, without doubt, these plants were also the very ones who were loathe to adopt time-study to their production work when such methods were first introduced into the production phase of industry many years ago.

Preventive Inspection; By Whom?

Preventive inspection was found to be a highly organized and efficiently managed function of maintenance in all maintenance departments studied. It was found to be carried on by different individuals and, as a result of this check-up system, it has been carried on with a marked degree of success.

The most common and without doubt the most effec-

tive means of performing this work are as follows:

(1) Inspection of product after each machine operation.
(2) Inspection of machine periodically by its operator.
(3) Inspection of machine periodically by the foreman in charge of the department.
(4) Inspection of the machine by the oiler
(5) Inspection of the machine periodically by a separately organized inspecting staff under the guidance and direction of the maintenance department.

When inspection is carried on in this manner any defective part is almost bound to be discovered before it causes trouble. Of course breakdowns will always occur when machines are overloaded even though the parts are not visibly, at any rate, defective.

Written Reports of Inspection

Written reports of inspectors were, with one exception, found to be required. Evidently it has been found necessary to have a check on inspectors. These written reports serve primarily to check up on the inspector's ability to analyze machinery accurately. If an inspector after reporting a machine to be in good operating order, is faced with repeated breakdowns, his

ability may readily be determined. Much of the proper function of maintenance work depends on the ability of the inspector to inspect properly. Maintenance may soon become a joke in the minds of production men if inspections are not made accurately. Thus, when the inspector realizes that he is actually signing his name to a slip and that his analysis may make or break the reputation of the department in whose employ he is, he will be more careful and as a result the maintenance function will be, to that extent, protected.

In addition, these written reports usually affect the individual machine operator inasmuch as when he realizes that the condition of his machine will be inspected and a written report will be made, he is apt to give it more careful attention and use it more carefully.

System of Forms and Records

The system of forms and records in use in connection with the inspection and repair of each piece of equipment has, to a certain extent, been standardized. In some plants where maintenance is carried on to an elaborate extent, these forms and records form the basis

upon which maintenance is operated. Inasmuch as the extent of elaboration of such systems will vary with the needs and desires of each individual plant, it would be useless to study the system used in each plant. Nevertheless, it would be exceedingly helpful to outline the methods and to exhibit some forms found in a plant located in Pennsylvania where maintenance forms and records do form the basis for the operation of the department.

The forms under discussion will be found in Appendix "B" of this thesis.

The foreman of the department in which the repair work is to be done, makes out form E3353A in quadruplicate. These forms are supplied to the foreman in small booklets and are carbon-backed so that with one writing on the first copy, four copies are made. This foreman retains the fourth copy in his book and sends the other three to the Maintenance Engineer who makes an estimate of the cost of the proposed work. This estimate is, in most cases, based on past experience. If the cost is under $25, he proceeds; if not, he must have authority of the Plant Superintendent be-

fore he may proceed. The white copy (number 1) is now forwarded to the cost department which fills out the back of this copy after the proper cost requisitions etc. come through.

The yellow copy (number 2) is sent to the repair department foreman. He keeps this copy, and the red copy (number 3), which was also sent to him, gives to the worker who is to do the actual repair work. A written copy of the original foreman' s order for repair work is now in the hands of the repair worker, the repair foreman, the cost department, and the original foreman who issued the order.

The worker's copy may be used as a requisition for tools or materials from the stockroom. When such is the case, the stockroom clerk records the number of the order and the amount of materials, tools, etc. taken by the worker in his stock records. After the work has been completed the worker must get the approval of the Safety engineer and the department foreman in which the work was done. Spaces are provided in his copy for these approvals. The worker then returns his copy to his own foreman who sends it, along with

his yellow copy to the plant engineer who follows both of these to the cost department with a notice that the job is done. The cost department then is able, with this information, to figure the cost.

After the cost department has figured the cost of labor and material for the job, the maintenance department copy (number 2) is returned to the maintenance department with the costs of the job in the space provided on it. The large red card called "Equipment Record", one of which is kept for each machine, is then called into play and this repair job is entered into the "Maintenance and Repairs to Equipment" portion of it - back side.

The "Summary of Maintenance and Repair charges" which represents all the equipment of a given department is next filled out with the information of that repair.

As a result the maintenance and repair costs for each machine are kept in monthly and yearly totals as well as for individual jobs (see back of "Equipment Record")and also the total maintenance and repair charges for each department are kept on the "Summary of Mainten-

'ance and Repair Charges" card.

Thus the maintenance costs for each machine or department may be determined at any time. Another card carrying monthly department totals may also be used and thus the total plant maintenance costs can be determined at a "moment's notice".

An additional slip is provided and is the one which is sent to the Maintenance Department by the department foreman, in whose department the repair was made, upon completion of the repair work. It affords a means whereby the Maintenance Department may classify repair jobs, determine the cause of the breakdowns, and attempt to effect a remedy.

Maintenance Department Purchases

In no case was it found that the Maintenance Department had a means whereby it could obtain supplies by direct purchases. In every case it was found that it was necessary to go through the company's Purchasing Department. The reasons for such strict rules in this report are very obvious and should always be carried out in each organization.

Financing the Maintenance Department

In every case, with but one exception, it was found that the Department of Maintenance was financed by appropriation. In this one case, Plant "D" where maintenance was but one function of a large department, the expenses of the department were carefully kept and scrutinized in order that such expenses would not grow beyond control. This plant, evidently was the exception rather than the rule.

These appropriations in general are based upon an annual report to Management by the Maintenance Manager. This report shows all anticipated necessary repairs during the coming year, all routine expenses in budget form, and all anticipated purchases of new equipment. Usually any expenses above those covered by the annual appropriation based upon this report must be explained to Management. Thus the expense of indirect material and labor is to a large extent carefully watched by Management and rightly so, inasmuch as the lower its amount, other things being equal, the greater the profits, and indirect expense, in most cases, has a very definite effect upon profits.

These appropriations in the majority of cases were found to have a direct relation to production expected. This relation is usually not specific but simply varies with the expected production. Plant "H" reports that these appropriations are usually a percentage of the tonnage to be handled by the plant during the coming year. This seems to be an exceptionally good method for determining the outlay to be made on maintenance and repair work. Any plant would do well to examine its total production and total maintenance charges for a number of years back. Thus, if there was found to be any direct relation between the two, the appropriation for maintenance work would be a simple matter.

Budgeting the Expense of Routine Maintenance

The expense of routine maintenance is generally budgeted to the Maintenance Department itself. This seems to be the most logical method and has to its advantage a smaller amount of clerical work and results in less routine accounting work, although in two of the Plants("E" and "H") it was found that the expense of routine maintenance was budgeted by departments.

Job-Orders for Each Task

In every case it was found that Job-orders were issued for each specific repair or inspection task. This method results in less confusion, enables costs to be figured more accurately, allows the Maintenance Manager to know where every one of his men is at any time, and keeps a check on the repair men themselves in that by means of this method each minute of their time must be accounted for. The Job-ticket is usually stamped with the time when the repair man is sent out on a job, and upon completion the time is again recorded by the foreman in whose department he did the work. As a result the worker cannot afford to lose any time on his way to and from the job inasmuch as the time he left for the job and the time of its completion are both recorded.

Charging the Expense and Resultant Loss of Breakdowns

The prevalent practice in industry, from the results of this study seems to be that expenses of repairs (labor, materials, etc.) are borne by the Maintenance Department, while the losses due to such breakdowns are figured in to manufacturing expense.

The theory behind this practice is that the Maintenance Department should bear the loss of the breakdown because, theoretically at least, the breakdown was due to improper inspection on its part, while manufacturing expense should bear all losses resulting from such breakdowns (such as loss of production time, overhead on unproductive machinery, idle labor costs, etc.) inasmuch as either the inspection routine, as carried on by the Production Department, was deficient in not detecting the defective equipment or the Production Department was responsible for the breakdown due to overloading or other improper use of the machine.

Is the Operation of the Maintenance Function Governed by the Appropriation?

The operation of the Maintenance Department is usually governed to an extent only by the appropriations granted to it. Any expenses over those for which the appropriation was made may usually be gotten around by proper explanation to Management of the reason for these unexpected increases in costs.

- A P P E N D I X A -

CHARGE

№ 155227 (1)

TO MAINTENANCE DEPT.	BLDG.	EQUIP'T
PLEASE PERFORM THE FOLLOWING WORK	FLOOR	NO.

(1)

Cost Department's Copy.

REASON NECESSARY

DATE WANTED	EST. COST	MAT'L	ACT. COST	MAT'L	
		LABOR		LABOR	
PROMISED		TOTAL		TOTAL	

SUPT.'S APPROVAL IF OVER $25	WORKS ENGINEER	DEP'T FOREMAN	DATE

F 3353A

ORDER ON AN DEPT.

PRINTED IN U. S. A.

CHARGE________ EQUIP'T NO.________ ORDER NO.________

MATERIAL				LABOR					
DATE	ACCT.	DESCRIPTION	AMOUNT	DATE	HOURS	AMOUNT	DATE	HOURS	AMOUNT

Back of Cost Department's Copy.

TOTAL LAB.	
TOTAL MAT.	
GRAND TOTAL	

DATE COMPLETED________

DATE FOREMANS COPY RETURNED________

(2)

CHARGE No. 155227

TO MAINTENANCE DEPT. PLEASE PERFORM THE FOLLOWING WORK	BLDG. FLOOR	EQUIP'T NO.

(2)

Repair Foreman's copy

REASON NECESSARY

DATE WANTED	EST. COST	MAT'L	ACT. COST	MAT'L
PROMISED		LABOR		LABOR
		TOTAL		TOTAL

COMPLETED BY	DATE	O. K. BY DEPT. FOREMAN	DEP'T FOREMAN	DATE

F 3353A

MAINTENANCE DEPT. COPY

PRINTED IN U. S. A.

CHARGE

No 155227

TO MAINTENANCE DEPT. BLDG. EQUIP'T

PLEASE PERFORM THE FOLLOWING WORK FLOOR NO.

(3)

Workman's Copy or Job ticket.

REASON NECESSARY

DATE WANTED

PROMISED

EST. COST { MAT'L / LABOR / TOTAL

ACT. COST { MAT'L / LABOR / TOTAL

AN DEPT. O. K.	DATE	SAFETY O. K.	DATE	DEP'T FOREMAN	DATE

F 3253A

THIS COPY TO AM. DEPT. TO DEPT. FOREMAN WHEN WORK IS COMPLETED

PRINTED IN U. S. A.

CHARGE No. 155227

TO MAINTENANCE DEPT. | BLDG. | EQUIP'T NO.

PLEASE PERFORM THE FOLLOWING WORK | FLOOR

(4)

Department Foreman's Copy.

REASON NECESSARY

DATE WANTED

PROMISED

EST. COST { MAT'L / LABOR / TOTAL

ACT. COST { MAT'L / LABOR / TOTAL

SUPT.'S APPROVAL IF OVER $25	WORKS ENGINEER	DEP'T FOREMAN	DATE

F 3353A

FOREMAN'S COPY

PRINTED IN U. S. A.

REPORT ON COMPLETED MAINTENANCE ORDERS (5)

DATE	MACHINE No.	SERIAL No.	MECHANIC'S No.	FINISHED

NEGLECTED OILING

FAULT OF OPERATOR

INCOMPETENT WORKMANSHIP

GENERAL REMARKS

(5)

Filled out by Foreman in that Dept. in which thebreakdown occured.

Sent to Maintenance Dept.

FOREMAN

F 3492

DESCRIPTION

EQUIPMENT RECORD

REPAIR NO. (7)

PROPERTY, CLASS & NO.

TO BE USED FOR

PURCHASED FROM

P. O. NO. DATE

MAKER'S SIZE

PURCHASED OR BUILT ON W

INSTALLED ON W

DRAWING REFERENCES

	MAT	LABOR	EXPENSE	TOTAL
INVOICE PRICE				
TRANSPORTATION COST				
CONSTRUCTION COST				
INSTALLATION COST				
TOTAL COST				

H. P. TO OPERATE WEIGHT

DATE CLEARED FROM W

ESTIMATED LIFE

IS THIS AN ORIGINAL INSTALLATION

__ IF __ WHAT DOES
NOT IT REPLACE

REPAIR NO.

PROP. CLASS AND NO.

DEPRECIATION

YEAR	DEPR'N RATE	VALUE END OF YEAR
19	%	
19	%	
19	%	
19	%	
19	%	
19	%	
19	%	

DISPOSITION

MAINTENANCE RECORD

MONTH	19				19				19				19				19			
	MAT.	LAB.	PROD	HR. OPR.	MAT	LAB.	PROD	HR. OPR.	MAT.	LAB.	PROD	HR. OPR.	MAT.	LAB.	PROD	HR. OPR.	MAT.	LAB.	PROD	HR. OPR.
JAN.																				
FEB.																				
MAR																				
APR.																				
MAY																				
JUNE																				
JULY																				
AUG.																				
SEP.																				
OCT																				
NOV																				
DEC.																				
YR.																				

F-87-C Printed in U.S.A.

MAINTENANCE AND REPAIRS TO EQUIPMENT

EQUIPMENT NO.

DATE	DATE	DATE

EQUIPMENT NO.

DATE	DATE	DATE

DATE	ORDER NO.	MATERIAL	LABOR	DATE	ORDER NO.	MATERIAL	LABOR	DATE	ORDER NO.	MATERIAL	LABOR	DATE	ORDER NO.	MATERIAL	LABOR

F 2370 PRINTED IN U. S. A.

Card No. Of (8)

SUMMARY OF MAINTENANCE AND REPAIR CHARGES

.................................DEPT.

EQUIP'T.	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER		TOTAL	
NUMBER	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	LABOR	MATERIAL	LABOR
TOTAL FORW'D.														
TOTAL THIS SIDE														
FORWARDED														
GRAND TOT														

- A P P E N D I X B -

Questionnaire for Thesis on

"MAINTENANCE DEPARTMENT"

John J. Wilson, Jr.

1. Name of Company -

2. Products Manufactured -

3. Total Number of Employees - Total in Production -

4. Annual Sales -

5. Approximate Number of Machines -

6. When was company organized in its present form?

7. Is Maintenance centralized?

8. When was the department established?

9. What were the circumstances leading to its establishment?

10. To whom does your Maintenance Department head report?

11. What name does the department operate under?

12. How is the work of the department sub-divided?
(Organization chart)

13. What are its specific responsibilities?

14. If periodic inspection of equipment is made, how is the frequency determined?

15. Do you use statistical replacement of wearing parts?

16. Where, in your experience, should the Maintenance Department be located?

Where is it located?

17. What departments has it been found desirable to be adjacent to?

18. Total Number of men in department?

19. Where did you obtain your Maintence men?
Transferred from shop?
From outside?

20. What type of employee do you seek for Maintenance work?
Nationality?
Personality, etc.?

21. Are jobs in the Maintenance Department sought by factory employees in production work?

22. How are employees trained for this work?

23. What is the basis of wage payment?

24. What is the basis of overtime payment?

25. How does the average wage compare with that in the production department?

26. Are regular working hours different from those of production employees?

27. Are your employees skilled in more than one line?
(i.e. Are they capable of working in production dept.?)

28. What do you do with your employees in times of depression?

When they are caught up in the routine work?

29. How do you plan a full day's work for each maintenance employee?

30. What are the main activities carried on by the department?

31. How is the work laid out for the employees?

32. How is the work scheduled and progress checked?

33. Have the routine jobs been time-studied?

34. How is Preventative Inspection performed?
By force when not actually making repairs?
By oiler?
By separately organized Inspecting staff?

35. Do you require written reports of inspectors?

36. Do you require written recommendations for repairs?

37. What system of forms and records do you use?

38. Have the responsibilities or importance of the department increased in recent years and, if so, in what manner?

39. Does the maintenance department have a means whereby it can obtain necessary suplies by direct purchases or is it necessary to go through the customary procedure of obtaining supplies thru the company's purchasing department?

40. How is the department financed?
By annual appropriations?
By appropriations granted as needed?

41. Do these appropriations have any relation to production expected?

42. Do you find that the cost of labor is higher than material on most repair jobs?

43. How is the expense of routine maintenance budgeted?
By departments?
For whole plant?

44. Are Job-Orders issued for each specific task?

45. Where do you charge the expense of breakdowns and loss therefrom?

46. Do you compare your monthly maintenance expense figures with your budget?

47. Do you analyze such expense figures periodically to determine reason for increases or decreases?

48. Is the operation or policy of the department governed by these figures?

- B I B L I O G R A P H Y -

B I B L I O G R A P H Y

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