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INSTALLING EFFICIENCY METHODS

BY

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INTRODUCTION

IN this book Mr. Knoeppel undertakes not the mere declaration of principles, but the exact definition of practice. He does not explain why greater efficiency should be sought in industrial plants; that has been ably argued already. He describes what the actual methods are that increase the efficiency of a manufacturing establishment, and how they are put into practical effect.

The whole exposition undertakes to answer completely the questions many a manufacturer has put to himself or others, hitherto without satisfying answer. These questions are: what is the first thing an efficiency engineer does when he comes into a plant on the first morning of his engagement—and what is the next thing, and the next, and the next? How does he find out where to begin the work of betterment, and what does he do when he has found it?

This is what Mr. Knoeppel explains step-by-step, and chapter-by-chapter.

As originally prepared the material appeared in a series of articles published in *The Engineering Magazine* during the year 1914. In this volume the matter is much expanded, and to a considerable extent recast. The first five chapters, which give vividness and a sense of concrete application to the whole thing, are new, except the list of questions for self-examination in Chapter V. The chapter on Auxiliary Devices for the Planning Department (XIV) and the supplementary chapter on Costs (XIX) are here published for the first time, while the chapter on the Efficiency Clearing House (XVIII) is considerably enlarged, and minor interpolations amplifying or clarifying the sense have been introduced at many points. Furthermore, new charts, diagrams, and illustrations to the number of thirty or more have been added, thus making the book presentation of much increased value even to those who have followed the series in the magazine.

The earnest purpose always and everywhere has been to give wholly frank and thoroughly practical working instructions and explanations, covering the entirety of efficiency practice, as tested and proven in many important and successful undertakings carried out by the author. This purpose both Mr. Knoeppel and his editors sincerely hope has been attained.

Charles Buxton Going.

November, 1914.

PREFACE

According to a Latin custom, the author of a book is supposed to establish his status, in other words his right to presume upon the reading public, to the extent of acquainting it with his ideas and convictions.

It was my good fortune as a boy to be brought up in the atmosphere of the shops. From a serious minded sire, himself a shop man, who talked with me as he would have talked with one of his own years, I gained some idea of shop problems, successes, and shortcomings. My ambition was to go through college and fit myself for mechanical pursuits. Through circumstances of no consequence to the reader, this was unfortunately denied me. The best substitute at hand was to take up work in the shop, which I did, starting in the foundry, first as a laborer and then as moulder.

It soon became apparent that lack of education would prove a decided handicap. Study out of work hours seemed the only solution. As a result I was able in time to take up work on the drafting board, which I found a most valuable training.

It was at this point that I began to be interested in discussions of cost and production matters, and the further I read and studied, the more determined I became to devote my life to management problems. During the fifteen years that have passed since I took up industrial work I have had an excellent opportunity to study industrial deficiencies at close range, in a large number of plants, manufacturing widely varying lines.

It seemed strange to me that almost invariably a manufacturer had to be coaxed into accepting better methods. Instead of deciding a case on its merits, instead of doing a thing because it was good business to do it, the campaign was one of doing what was expedient, often unnecessary, and many times wrong. It was necessary to worship the god "diplomacy," and if a man possessed tact, ability became a secondary consideration. What was done was with the consent of the organization. Opposition, sometimes passive, sometimes active, was often encountered. Heart failure would have resulted if a manager had said: "Here is the factory; you have been found competent to introduce efficient methods; go ahead."

The word "efficiency" has been juggled until it has lost its real meaning simply because it stands for anything that a person wants it to mean. Because of the mystery with which the methods have been enveloped it is viewed with suspicion and distrust. Failures have been many. In some cases the engineers have been responsible, but case after case could be cited that would convict the client of "contributory negligence."

Getting into a plant on any pretext and on wild promises and guess work, securing a trial contract for one week or longer, in the hope that by "hitting the high spots," enough would be uncovered to warrant a continuation, never has secured and never will secure results. If a manufacturer feels that the work is impractical—a dream—a game to fill the pockets of certain men with large fees—no mere argument will convince him that he needs it. If he is induced to go ahead because of excellent salesmanship or in a momentary burst of enthusiasm, he becomes discouraged at the first sign of complication.

The profession, for such it is, has not been altogether professional. Ethics in many cases have been flagrantly violated. Contracts have been stolen—men won over to the client through promise of greater earnings; business thunder has been appropriated. Men with a copy of Emerson's "Twelve Principles of Efficiency" and Taylor's "Shop Management," *plus* a prayer, have been able to convince unsuspecting clients that they knew exactly what these clients wanted and were prepared to give it to them.

Why this condition? My whole experience has taught me that one thing stands out above all else as the real reason:

Lack of a thorough understanding of the proposition both as regards the work itself and the methods followed by the men identified with the movement.

It therefore seemed to me that what the industrial world needed most was a work of such a practical nature as not only to induce managers to investigate it and try it out in small ways in their own business, but to serve in an indirect way to furnish the measure of the men competent to handle the details. Knowing more about the proposition themselves they would be in a better position to gauge the ability and success of the engineer. I have tried to keep to the tried and proven, rather than to resort to logic and argument, and it is hoped that in some measure this book will open the eyes of executives to the value of the work—so necessary to our industrial progress.

It seems only fitting in connection that I should give credit where credit is due. To Harrington Emerson I owe much. In a sense the book is the result of an association from which considerable was gained in the way of inspiration and higher ideals. To the editor of *The Engineering Magazine*, Mr. Charles B. Going, I am indebted for counsel and kindly advice. To my many friends in the profession I owe much for helpful suggestions and encouragement.

August, 1914. C. E. Knoeppel.

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Chapter I

THE CONDITIONS

"I FOR one am convinced that the only course open is to sell the business on the best terms possible." Such was the determined statement of John Barlow, president and one of the directors of the Enterprise Manufacturing Company, at a meeting of the directors called for the purpose of considering ways and means for bettering the business.

"An action of this kind would of course be regrettable, but if there is nothing left for us to do, I am disposed, reluctantly, to agree with Barlow," was the remark made by another director, Elwood Wilson.

"Consider the facts for a moment," said Barlow. "We have been losing ground steadily for years. Our profits have been on the decrease. We have been forced to raise the wages of our workmen from time to time, and I cannot see that they are doing much more than they used to. Material is much more costly. Competition is more intense. It is much more difficult to sell our product than it was ten years ago. Business conditions have been anything but encouraging. In desperation I have thoroughly canvassed the situation. The possibilities in buying out our competitors, cultivating foreign markets, adding new lines to those we are now handling, extensive selling campaigns, have all been discussed. It means spending considerably more than we can afford, no matter what plan we adopt. We can of course cut expenses with a meat axe, but this would prove harmful to the business. A reduction of wages, to my mind, is the wrong way to save money. My candid opinion is therefore that we must sell out or face the alternative of voluntarily going out of business."

At this point the general manager, William Lewis, who had been carefully considering the remarks made by Barlow, suggested that a consulting engineer on management and organization be called in to study the leaks and weak places and outline such constructive measures as would put the business on a firm basis.

"Never while I have a share of stock in this company will I agree to a step of this kind," was the heated retort of Barlow. "If we are incapable of managing our own business, then we deserve to lose out, for a stranger who knows less than we do about it would only manage things in a way that would invite even greater disaster."

"I am of the same opinion," said Wilson, "for to my knowledge three firms who have had work of this nature done were so dissatisfied with results that after repeated efforts to keep things going, they were forced to discontinue the improved devices."

"That constitutes no argument against the plan," remarked Lewis. "Successes can be pointed to, and there may be excellent reasons why the installations referred to have failed. The work to date has been largely along pioneering lines. Considerable in the way of obstacles has been encountered as a result. Progress has been slow. The ounce of gold has had its ounce of dross, but as in mining 'pay dirt' has finally been reached."

"But," said Barlow, "how can a man, no matter how brainy he may be, without any knowledge whatever of our business, show us where we, who are constantly at work, have failed to manage properly? It sounds mighty inconsistent to me. Here we have a management that costs us thousands of dollars yearly and yet we are sliding backward. You suggest an untrained outsider who may never have heard of us. You'll have to show me."

"I know that it sounds inconsistent," said Lewis; "the industrial world is not as yet as educated to the extent of calling in a business doctor as readily as a business man would a medical doctor or lawyer. But isn't it reasonable to suppose that a man who is constantly solving industrial problems in a variety of lines will accumulate a vast amount of practical information, some of which might prove of value to us in the business here?"

"Undoubtedly, if he understood our business with its peculiar and complex conditions," replied Barlow.

"Does the physician you call in know your peculiar and complex bodily conditions when he diagnoses your case? Isn't he banking on his knowledge of medicine, his experience with many other cases, and his ability to find out what ails you before prescribing a course of treatment?" asked Lewis.

"Your argument sounds logical, Lewis," said Wilson, who had been an attentive listener to the discussion. "While I must confess that I am somewhat skeptical I am willing to say that if such a man as you mention can assist us, I am in favor of retaining him, for the business must certainly get assistance from some source or we stand to lose a good part of our investment."

"Who is your man, Lewis?" said Barlow. "I am a skeptic, like Wilson, but to the drowning man the straw looks pretty good."

"His name is George F. Brown and he has an excellent reputation in the industrial field," said Lewis. "My suggestion would be that we get him to come here and give us a talk if nothing more. Then if he impressed us, he could be delegated to make an investigation, which would determine for itself whether we should or should not go ahead."

Without much further debate, it was agreed to ask Mr. Brown to meet the directors and discuss with them the possibilities in the plan suggested by Mr. Lewis. The day was selected and an invitation to meet the directors the following Wednesday was sent to Brown, who replied that he would be glad of the opportunity to discuss his work with the company.

Chapter II

THE PRELIMINARY INVESTIGATION

AT the time appointed, Mr. Brown arrived at the company's office and was ushered into the directors' room, where he was presented to the several men gathered to hear him describe the much talked of subject—management. The directors looked at a normal, keen-eyed, serious looking individual and wondered to themselves what there was about him that enabled him to reorganize industrial concerns.

"Mr. Brown," said Barlow, "we are confronting a problem more or less serious to us, and while we are skeptical with reference to outside assistance, we finally agreed to ask you to meet us, in order to ascertain whether you could assist us in solving it for us."

"What is the problem?" asked Brown.

"We are steadily losing ground with our trade," replied Barlow. "Unless we find some means that will enable us to do a larger or more profitable business, we will be forced to discontinue. As we are operating at present, this is only a question of time—a matter of financial ability to withstand losses that are bound to come."

"Do you know what the trouble is?" asked Brown.

"No; if we did we would not have asked you to meet us," rather testily retorted Barlow.

"Perhaps I can find out by asking you a few questions," said Brown. "They will serve at any rate to give me an idea regarding the problem with which you are confronted. In asking them I may appear blunt and personal, but I shall ask you to excuse it all as I am desirous of getting at the real situation."

After thinking for a few moments, Brown began his questions, addressing them to Barlow.

"In the first place, how many men do you employ?"

"About 1,000."

"What do you manufacture?"

"Gas and steam engines and a general line of steel-plate construction."

"Do you make your own castings?"

"Yes."

"Your plant therefore consists of foundry, machine shop, smith shop, wood-working shop, and structural shop?"

"Yes."

"When was the business established?"

"In 1855."

"How is the business managed?"

"Our general manager, Mr. Lewis, is in active charge, under the direction of the board of directors."

"Does he have a free hand?"

"Well, in a way—yes."

"And in a way, no, I suppose?"

"He is supposed of course to take up important matters with me or the board."

"Can he engage or discharge a foreman or purchase a machine on his own initiative?"

"Oh, no! such matters he must take up with me."

"In other words he carries out your wishes and those of the board of directors?"

"Yes, that expresses it."

"What does the balance of your organization consist of?"

"We have a superintendent, a foreman in charge of each one of the shops, with assistants under them."

"Who hires the men?"

"The superintendent."

"What else does he do?"

"Looks after the foremen and is responsible for the purchase of equipment."

"What are your cost-finding methods?"

"We have a cost system that gives us the cost of what we manufacture in our plant."

"How do you ascertain your costs?"

"The workmen turn in time cards showing time worked and pieces produced."

"Do you use a time clock, or do the men make out their own time reports?"

"The men make out their own time cards."

"What prevents them from putting down inaccurate time?"

"We try to get them to be as accurate as possible. I do not believe you would find their time statements very far off."

"This doesn't answer the question. They could, if they so desired, set down figures that would not be accurate, and this would not mean that they purposely intended to send in misleading figures. Men will leave the matter of time keeping until just before quitting time, and it takes more than a man's memory to set down accurate starting and quitting times. This is true isn't it?"

"Yes, I presume so; but we have never felt that we wanted costs that would balance to the third place."

"Do you analyze the times the men report?"

"No, we have never done that."

"Just how do you compile the costs from these cards?"

"We file them all away, and when we want the cost of an article, we take the cards, add all the cost items, and divide by the pieces produced."

"Is material issued on requisition?"

"No."

"How do you compile material costs, then?"

"We know what material goes to make up a unit. We use current market prices and calculate the costs on this basis."

"You do not balance material issued with material purchased?"

"No."

"Does the total amount, as shown by the time reports of the men for a period of a week or month, balance with the amount you spend as shown by your payroll?"

"We could not say as to that, for it has never been done. We have felt that we could sacrifice extreme accuracy for the sake of simplicity."

"Do you figure your burden or overhead expenses?"

"No, we estimate them."

"Is your costing a part of your general accounting?"

"No."

"Do you maintain a continuous inventory of your materials?"

"No."

"Do you know the total of your work in process from time to time?"

"We have no figures to show this."

"You are in no position to tell monthly what you have made or lost?"

"No, we have no monthly income statement."

"Do you know what you make or lose on the various classes of goods you manufacture?"

"We know in a general way, for we take our costs from the time reports, add the material cost, and estimate the burden. The total is deducted from the price."

"Do you ever have to deduct the price from the cost?"

"Yes, we often lose money on articles we make."

"Who looks after the speeds and feeds of your machines?"

"The foremen."

"Who takes care of the belts around the plant?"

"Sometimes the workmen fix their own belts, or the foreman sends for a millwright to take care of the trouble."

"How is material supplied to the men?"

"We aim to keep the men furnished with what they need in the way of material, otherwise the men go after it themselves."

"Do you know what the men are producing?"

"Yes, we get these figures from the time cards."

"You do not make a comparison of daily productions per man, do you?"

"No, we do not go after things that close, but we do look the time reports over from time to time."

"How often?"

"Well, I couldn't say exactly, but our cost man is supposed to look after this feature."

"Suppose the men are not producing up to their maximum?"

"The foremen figure that if a machine is running and the man working steadily, the production is forthcoming."

"If the tool is cutting wind and the foreman is not around, you lose production don't you?"

"Yes, in this case we would lose."

"How do you know that this is not often the case?"

"The foremen are expected to look after this feature."

"Are the workmen given definite tasks with instructions regarding the way to make the work?"

"Yes, the foremen tell them what to do."

"Verbally?"

"Yes."

"I assume that you do not employ time-study methods?"

"No, we figure that our foremen know more about what should be done than would a clerk with a stop watch in hand."

"Who plans the work to be made?"

"The foremen."

"When do they plan it?"

"They are supposed to know what the men are doing, when they will be through, and what they will do next."

"Is there anything on record to show this?"

"Yes, the file of orders and the follow-up from the office."

"In other words, you have no regular advance planning?"

"No, we have no system that automatically plans. Such methods may work in other establishments, perhaps, but they would not work in our business."

"Why?"

"Because we have too many rush orders and changes made by the customers."

"In other words you plan as you go along?"

"Yes, that is about it."

"How are the men paid?"

"We use both the day rate and the piece plan."

"Which plan covers the largest number of men?"

"The piece-work plan."

"Do you ever cut piece rates?"

"Yes, when we find men earning too much money."

"In other words you limit their earnings?"

"No, I would not say that we limit them, but we don't want them to earn too much."

"What do you consider too much?"

"Oh, $3.50 to $4.00 per day."

"What do you do when men produce enough to make close to the $4.00 mark and then stop?"

"We would cut the rate to get them to produce more. We do not expect to let our men hold back production."

"What figures do you compile of your idle equipment?"

"We have never compiled any."

"In other words, machines could be idle part of the time and you wouldn't know it?"

"The foremen are expected to keep the machines busy."

"Suppose they are engaged in looking after other things?"

"In that event the machines would be idle. Our machines, however, have been bought and are paid for. I cannot see that we are losing anything if there happens to be no work for them. They certainly make money for us when they are busy, for many of them were designed to produce the parts rapidly."

"Evidently you have never figured a rate for your machines that would cover repairs, depreciation, power, supplies and the like, in addition to that paid per hour for the operator?"

"No, we never have."

"What net profit do you estimate you are making?"

"About 3 per cent."

"What did you make ten years ago?"

"As near as I can recollect it was 15 per cent."

"As you are operating now you are losing from 2 per cent to 3 per cent."

"How do you figure that out?"

"If you had the money represented by the proposition here, invested in good securities, you would expect to receive at least 5 per cent in profit?"

"Yes."

"You are making 3 per cent, therefore losing 2 per cent?"

"I see your point. It is well taken."

"In other words if you were making 5 per cent you would be making nothing?"

"That is true."

"Do your workmen grind their own tools?"

"Yes."

"Are tool shapes and angles predetermined?"

"No."

"Who orders the castings and forgings from your foundry and smith shop?"

"Our foremen."

"Do you have any shop chasing methods?"

"Our foremen look after this too."

"In other words, it is up to your foremen not only to order what they are to work upon but to see to it that they get it and follow it through the departments?"

"Yes, that is the situation."

"Are your shipments made promptly?"

"Fairly so, although we are often forced to ship our product after promise date."

"How often does this occur?"

"Well, I cannot say exactly, but we have our shipping troubles;

in fact, we lost a good customer only last week because we have been unable in the past to make prompt shipment."

"Who makes your piece rates?"

"The foremen look after this part of the work."

"What is your power cost?"

"We never compiled it. We figure that power is the cheapest thing about the place. I cannot see that we would gain anything in knowing the cost. We use all the power we generate."

Chapter III

THE CONCLUSIONS

AFTER asking a number of other questions along the same lines as those listed in the previous chapter, Brown said: "I think that I have asked enough questions to get the desired information of a preliminary nature. If you will overlook what may seem to be a too candid presentation of my opinion, I will indicate what my impressions are with reference to the information you have given me.

"In the first place," said he, "I am not at all surprised that you find yourself on the down grade and that you are only making 3 per cent net. I am frank to say that the business is not being managed efficiently. By this I do not mean that it is being mismanaged. There is a distinction between the two. The evidence simply indicates a failure to consider certain essential fundamentals in successful manufacturing, a fault that I found, in some degree, in almost every plant that I have been in. Naturally you are anxious to know my reasons for this conclusion.

"Your costing is extremely loose. Without a knowledge of what your work is really costing you, you are in no position to say to what extent your real costs vary from what your work should cost you. You have no gauge on performance. Further, because you do not employ time-study methods and have no definite tasks, you have no means of knowing what performance should be. Consequently, lacking standards and with no provision for measuring attainment, you can readily see that it is a case of operating blindly."

"Hold on," said Barlow; "our foremen know what should be done and they know what the men are doing."

"You told me, Mr. Barlow," replied Brown, "that it was possible for the machines to be cutting wind and the foreman not know it. As the foremen cannot be everywhere, it follows that this can often happen. You do not analyze time reports, and we have found that when this is not done workmen often take more time to do work than is necessary. Suppose the foremen do not know what the men should do—and without any reflection whatever on the ability or worth of your foremen, we have found many who do not know what constitutes a fair day's work under conditions that we know should exist. The whole piece-work controversy proves this."

"Even admitting the above for the sake of argument, I fail to see how it affects the compiling of our costs," said Barlow.

"Your men keep their own time reports," answered Brown. "This puts a premium on inaccuracy. You neither analyze time reports nor maintain daily production records. You make no attempt to balance your costs with the payroll, and as a result you can easily neglect to consider all the costs. You estimate the burden, and I judge you use an average ratio. Not making the costing a part of the general accounting, it is safe to assume that expense items are overlooked in estimating. Material is not issued on requisition—a practice that can only stand for waste. Under such circumstances, the costs that you compile are misleading because they are based on inaccurate returns as to labor, no returns at all as to materials, an average burden rate (which being estimated is subject to error), failure to balance what is used in labor and material and what is expended for them."

"To do all that would require too much red-tape," said Barlow.

"That is an excuse, not a reason," retorted Brown. "You are really losing 2 per cent by doing business, as was pointed out. I am trying to show you what is responsible for failure to make more than you are making. You reject it because it savors of the complicated. Wouldn't a bit of 'red-tape,' as you call it, be justified, if you could get down to 'brass tacks' and make 10 per cent, and in time get back to where you were ten years ago when you were making 15 per cent?"

"Yes, if we could accomplish this desire."

"Have you any reason to feel that it is impossible, that better and more up-to-date methods would fail to accomplish much more in the way of results than you are now securing?"

"No, I have not, but I cannot see just how it can be done."

"I have just outlined some of the causes, the elimination of which would assist materially. There is another point, if you will pardon me. Your foremen, under the conditions you describe, are so busy that they are in no position to run their departments efficiently."

"It never occurred to us that we were overworking our foremen," said Barlow.

"Perhaps they are not overworked," stated Brown, "but if they did as efficiently as possible all the things you indicated as their duties, they would have to work 24 hours a day without being able to cover the ground properly. They may not appear overworked simply because they are unable to take care of all the functions mentioned, and as a result do the best they can on what is most important."

"I do not see what possible grounds you have for such a statement," said Barlow. "Our foremen have never kicked about doing so much work as to make it impossible for them to attend to their jobs."

"Take your speeds and feeds as an example," said Brown. "It requires considerable analysis and experimenting to determine proper combinations of speed, feed, and cut; the best angles and shapes of tools; the best cooling agents; the kind of steels to use. Yet you expect your foremen to do this efficiently. Piece rates cannot be set without careful study. It needs infinitely more than a look and a guess. You look to your foremen to set fair rates. Unless there is a careful advance planning, machines are bound to be either idle or congested. You expect your foremen to keep work running through the plant in a proper manner with reference to relative importance. You keep no data on idle-equipment time because this, you say, is up to the foremen. They must also break in new men, adjust differences as to wages with them, look after quality of production, keep up discipline, keep down rejections. On top of all this you expect your foremen to exercise the functions of an order department in ordering their material, and then act as chasers in keeping the work flowing through the plant. The only conclusion possible is that you saddle about all the responsibility on the foremen. What can they do under the circumstances? Delegate it to the men under them, the ones least fitted through training, ability, and from the standpoint of earnings, to assume it."

"That is all bosh," said Barlow, rather heatedly. "Mr. Lewis and the superintendent help the foremen out."

"How?" asked Brown.

"They are in the shops often and take up matters with the foremen, calling their attention to things needing consideration, giving them the benefit of their advice and in a general way supervising the whole proposition."

"Let me try and prove to you that I am right," said Brown. "Mr. Lewis and your superintendent are further removed from the actual work than are the foremen. They have their own work to attend to. You admitted that Mr. Lewis did not have a free hand, and that your superintendent hired the workmen, in itself no small task and one which should be performed by an employment department. They look to the foremen for results, and naturally they have heart-to-heart conferences with them when results are not up to expectations, perhaps behind closed doors. What is this but 'putting it up to the foremen'? I have given very good reasons why the foremen are forced to 'put it up to the men.' Now let me go a step further. The men grind their own tools. Without standards as to shape and angles you naturally have a large variety, some good and others bad. In all likelihood the men set their own pace because you have no definite tasks, your time records are in their hands and you make no effort systematically to analyze time data. You say they sometimes take care of their belts as well as go for material, when it is not supplied to them. Because there is no proper planning, they may have to go to their foremen for jobs or wait until one is given to them. Consequently they perform other functions than that for which they were expressly hired, assuming responsibilities that rightly belong to the management. What other conclusion is possible under the circumstances?"

"I must confess," said Barlow, with considerable feeling, "that I cannot see your argument. We expect our men to help themselves, and when they do this they assist us."

"Yes, but in the wrong way," replied Brown.

"In other words," said Barlow, "your feeling is that we are to blame for the condition we find ourselves in."

"That is my candid opinion," answered Brown.

"I fail to see it," was the curt rejoinder of Barlow.

"Let me outline my reasons more fully," said Brown. "In the first place you will admit that you hire men to produce certain articles?"

"Yes."

"If they produce a maximum quantity, your costs are less than if they produced a smaller quantity?"

"Yes."

"If they are interrupted, interferred with or delayed, they cannot operate at maximum efficiency?"

"No, that is true."

"Therefore, if they are at work on tasks that can be performed by others, the time they spend in this way means that much less in production, does it not?"

"Yes, I see that."

"What happens when a man grinds a tool?"

"His machine is idle."

"You are also willing to admit that the tool may be ground in the wrong manner, perhaps burned?"

"Yes."

"You lose the equivalent of this time in production?"

"Yes."

"Who runs the machine when a man goes for material, fixes his belt, or waits for a job?"

"Why, no one."

"This would also mean a loss in production?"

"It certainly would."

"I think," said Brown, "that I have made good my assertion that you put so much up to your workmen that they are forced to let their equipment remain idle while they do the work mentioned. You lose as a result. How serious the exact situation is can only be determined by a study of the actual shop conditions. It is serious enough, however, to warrant your giving the matter your most careful attention. I feel that your basis of manufacturing is unsound."

"I see your argument," said Barlow, "but wouldn't it cost just as much to have these things done by others?"

"Admitting for the sake of argument that it would, you would be producing more, wouldn't you?"

"Yes."

"Your expenses would be less per unit manufactured so that your total cost would be less?"

"Yes, I think so. It would seem so, at any rate."

"The time spent by men in grinding tools to all kinds of shapes, and often burning them, would be greater than required by experts who would grind them properly and uniformly and in quantities?"

"Undoubtedly."

"This applies to belts also, doesn't it?"

"Yes."

"Ordinary labor at a saving of from 10 cents to 20 cents per hour could furnish the workmen with material just as efficiently as the men procure it themselves?"

"Yes."

"With a proper system, clerks at $65 to $100 per month could do considerable that is now being done by foremen to whom you no doubt pay from $100 to $300 per month?"

"Yes, this might be done."

"If orders were properly issued to shops, planned in advance, and automatically followed up, this would ease up on your foremen, enabling them to do more important things, as well as save time that is often wasted by workmen waiting for jobs?"

"Undoubtedly, if it could be done."

"The best answer to that is that it is being done in a variety of lines."

"It looks to me," said Wilson, who had been paying close attention to all Brown had said, "that we have overlooked a number of essentials."

"I am frank to admit," said Barlow, "that I am beginning to see his point of view myself. Perhaps we have been lax."

"I regret to say," replied Brown, "that what you have told me indicates that you have not taken advantage of up-to-date methods. Take your material, for instance. You have no control over it at all. You may be carrying too much of one kind and not enough of another. It could be lost, spoiled or stolen and you wouldn't be the wiser."

"I think," said Lewis, "that you have opened our eyes to a number of things. I am sure we would all be glad to have you outline for us what your ideas would be along lines of betterment."

"This would of course have to be determined by a close study of your activities. In a general way, however, I would advise a number of changes. First, your organization is not the type to secure best results. It means delegated responsibility from the president through to the men. The men should be able to turn out a maximum production of high quality. Beyond this their responsibility should cease. You should therefore create a staff of men who could supplement the efforts of the line, your regular organization—who, through study, analysis and constructive work, could outline betterments. Both line and staff should be properly organized along legislative lines. Then effort should be made to harmonize any warring factions in your organization, secure co-operation of the workmen and pave the way for the introduction of betterments. The mere fact that you cut your piece rates when men earn too much money, shows me conclusively that there is room for work of this kind.

"You should then take steps to co-ordinate the production details—to plan, in other words—so that machines would be kept busy, congestion avoided, jobs, material and tools supplied in advance of requirements, and proper consideration given the most important orders. The conditions under which you operate should then be given consideration and standardized wherever possible, as for instance shapes, angles and grinding of tools, belts, etc. You would then be in a position to determine, and to set before the men, fair tasks which would consider fatigue and unavoidable delays. The men should be offered an incentive, in the way of greater earnings, to warrant them making every effort to attain the standards set, their earnings to depend upon their efficiency."

"Wouldn't this program take considerable time and cost quite a little money?" asked Barlow.

"No doubt it would," replied Brown, "but it is my firm opinion that the expenditure would give you what you need most and the gains that could be made would many times offset the cost of the service, so that, in the long run, the installation would cost you absolutely nothing.

"I would say further," continued Brown, "that the task is not an easy one. The first requirement is a change in the attitude and opinions of many who may have strong views. Progress must be made slowly and surely. I would certainly not advise you even to think of starting the work unless you are prepared to see it through to a successful conclusion, instead of simply 'trying it out.' A trial indicates doubt and disbelief which could easily make for failure. We have found that nothing so hampers our work as the necessity of curbing the impatience of a client at one time and sustaining his faith at another."

"What would you advise?" asked Barlow.

"I would urge an investigation of conditions to determine what the real troubles are, what should be done, what time the work should take, and the cost, along with an outline of possible results."

"What do you think we would gain by starting a campaign such as you outline?" asked Lewis.

"That would be guessing," said Brown, "and guessing is not scientific. I would not venture an opinion until I had had an opportunity to study the facts."

Chapter IV

RESULTS AND OBJECTIONS

BARLOW, in common with the other directors, was plainly impressed with Brown's presentation of the case, but still gravely doubtful of the expediency of approving changes which seemed to involve so much immediate work and, possibly, expense. Still, as a business man, he saw clearly that it was a question of the ratio between expenditure and income. He spoke after a moment's careful consideration of the problem in his mind. "Could you give us a general outline, Mr. Brown," he asked, "showing what has been accomplished by the methods you stand for?"

"I know from my own experience," said Brown, "that if all of the successes could be written up in one book and placed before industrial managers and workers, there wouldn't be enough capable engineers to go around. For your benefit I will outline a few cases where this work meant excellent gains." He spoke deliberately, turning the pages of a small note book containing his points.

"In one foundry averaging 1,125 pounds per man per day, when efficiency methods were started, the production was increased to 1,634 pounds per man per day in eight months from the start, an increase of 45.2 per cent through the introduction of planning and bonus with better conditions.

"It was found in one department of a plant that 8.8 motions were required per piece. Study and analysis revealed that the motions could be standardized at 6 per piece.

"General Crozier, Chief of Department of Ordnance, in reporting on the work done at the Watertown arsenal, stated that on 6-inch disappearing gun carriages the direct cost was reduced from $10,229 to $6,590 and the indirect cost from $10,263 to $8,956.

"In a structural plant a gang had been driving by hand 432 ¾-countersunk rivets per day of 9 hours. The operation was covered by planning and bonus and the production rose to 731 per day—an increase of 69 per cent in production with a corresponding decrease in cost of 13 per cent.

"Frank Barkly Copley, in *The American Magazine*, stated that in one case previous moulding time was 53 minutes. Moulding was standardized at 24 minutes. Moulds were turned out in average of 20 minutes and one man for an entire day averaged 16 minutes per mould, making one in 10 minutes. Cost was cut from $1.17 to $.54. Earnings of men increased from $3.28 to $5.74.

"On candy machines it was found that the pieces were coming out of the machines with spaces between them ranging from 1 inch to 6 inches. By standardizing both the conditions and the operations, the loss in space was reduced to ¼ inch to ½ inch.

"In hand-filing metal, the operation was studied, planning and bonus arranged for, with the result that 2½ men are now doing what previously required 6 to 7 men.

"The time on steel furnace bells was found to be 147 hours each. Work was standardized at 85 hours each. The actual time following planning and bonus was 92 hours each with the following results:

Decrease in time	32.5 per cent
Decrease in cost	30 per cent
Increase in production	60.1 per cent
Increase in earnings	12 per cent

"In one plant a large multiple radial drill was studied with the results shown in the table below:

EFFICIENCY IN DRILLING

	Actual	Standard	Efficiency
Speed	210	325	65 per cent
Feed	.006	.012	50 per cent
Drills	2	4	50 per cent
Average efficiency			16.25 per cent

"Low efficiency due to law of dependent sequence.

"In making tobacco pouches, it was found that girls were averaging 275 per day. After planning and bonus was introduced, they were able to make 550 per day, an increase of 100 per cent.

"In one case three men made, poured and shook out 143 flasks per day. Better methods enabled them to make 219 per day—a gain of 53.1 per cent.

"Rejections in a foundry were analyzed with following results:

Fault of men	51 per cent
Fault of iron	33 per cent
Fault of cores	8 per cent
Miscellaneous	8 per cent
Total	100 per cent

"It seems to me," he concluded, putting his note book into his pocket, "these instances are enough to show the possibilities—I might well say, the probabilities."

"I have heard it said," stated Lewis, "that the methods speed the men beyond their safe working limit. Is there any foundation for this statement?"

"There is no foundation for it," said Brown. "The engineer takes into consideration the effect of increasing exertion and he recommends the provision for rest periods. In one case a man turned out 16 pieces per hour working as he usually did. When allowed 10 minutes rest per hour, he produced 23 pieces."

"If methods are so efficient, why are not more concerns installing them?" asked Wilson.

"The movement is a new one," replied Brown, "and because of this fact the men competent to install the service are few in number. Further, it takes time to study conditions, outline betterments, and pave the way for the attainment of greater efficiency, and as a result executives have held off on account of the cost. Then there is the natural skepticism to overcome that always attends any innovation. In many cases concerns have refused to consider the matter because they felt it would be equivalent to acknowledging their inability to secure maximum results."

"But how about labor," said Barlow, "why is it opposed to the work?"

"In the first place, labor does not fully understand the principles. The men also feel that they have no interest in the matter because they have nothing to say about what shall be done. They also fear what they feel will be the wholesale dropping of men. The fallacy of overproduction also worries them. Another factor is suspicion of anything new, due to considerable in the way of harsh treatment in the past."

"Is the expenditure of considerable money necessary in the way of equipment?" asked Wilson.

"The aim is not to recommend extensive changes and new and high-priced equipment," said Brown, "for standards are determined under conditions as they exist and the way paved for their attainment."

"Does it cause friction?" asked Barlow.

"Never, if the way is properly prepared for starting the work and the importance of tact, diplomacy, and co-operation are fully appreciated."

"Are the methods dogmatic and inflexible?" asked Lewis.

"There is no part of the service," said Brown, "that cannot be readily adjusted when analysis shows the necessity for change. Procedure there is, to be sure, but it is not of the iron-clad variety. Common sense and the facts in the case are the governing considerations."

"Does the work disrupt the organization?"

"The principle is to work with the organization as it is found. A difference of opinion is due to faulty assumptions, and the plan is to ascertain and correct these assumptions."

"Why," asked Lewis, "do so many feel that the service can help others, but is not applicable in their own plant?"

"This is a natural attitude," replied Brown, "and one most universally met with. It is due largely to the familiarity with local conditions. The result is that the executive is so close to the details as to miss many points that would impress the outsider. Another reason is the lack of a full and complete understanding of the methods proposed and how and why they secure results."

"Do men slight their work under bonus payment?"

"Efficiency is as much concerned with turning out *good* work as it is in saving time. Spoiled work lowers a man's bonus, and it is therefore to his interest to keep rejections to a minimum. Further, one workman will refuse to take bad work from another, which in many cases makes inspection automatic."

"Is the human factor ignored?"

"*It is not.* It is recognized that everything depends upon the human element. If results were not accomplished through securing the co-operation of the men they would not be secured at all."

"Is there danger of labor troubles when starting the work?"

"Not if the campaign is properly started. Tact, diplomacy, fair dealing and announcing in the right way what is to be done and why, will anticipate any difficulty likely to arise. Object lessons will assist materially in allaying fears."

"I would think," said Wilson, "that intensive methods would rack equipment. Isn't this the tendency?"

"They should not," replied Brown. "In one plant tools are ground two or three times a week. In another the practice is to grind every hour. The increase in production in the latter plant pays many times over for 'burning' up the steel. Speeding-up machines is preceded by strengthening the parts, by preparation, by careful attention, etc."

"Isn't there a danger," asked Barlow, "of the concern losing the benefit of the work done after the engineer leaves?"

"Not if the client from the start works with the end in view of arranging for a permanent means to carry on the service. In one case the client unassisted brought the efficiency from 90 per cent to 115 per cent after professional service had been discontinued."

"I fail to see just why we should organize a planning department," said Barlow, "when our foremen are supposed to look after this work. Why is it, Mr. Brown?"

"For the same reason that a railroad would not allow a conductor to schedule his own train. Accomplishment is both planning and performance, and a foreman can secure better results when he can do his planning, through the right kind of assistance, well in advance. This furnishes the opportunity for getting everything in readiness and leaves nothing to chance or memory."

"Have you had any failures in your efforts to increase the efficiency of plants?" asked Barlow.

"Yes," said Brown, "along with my successes I have had my failures and I would be glad to give you some of the facts in connection."

"I did not suppose," said Barlow, "that an efficiency engineer would admit that he had ever encountered failure."

"Why not?" said Brown, "failures are stepping stones to successes and are extremely valuable for the lessons they point out. If clients would profit by the failures in the past, most of the obstacles to success in this work would be removed."

"Your frankness is something decidedly new to us," said Lewis; "I am sure we would like to hear some of the facts."

"Gladly," said Brown, "but in doing so it must not be looked upon as an apology. In one case where a bonus plan was at work in which 20 per cent bonus was paid for 100 per cent efficiency, the client complained that the money did not interest the help as it had formerly. When I installed the plan I recommended a 5 per cent premium in addition to the 20 per cent bonus, for all who over a period could qualify as 100 per cent men. This was to be an added incentive. I figured that men who might otherwise be satisfied with 10 per cent to 15 per cent bonus, for showing 90 per cent to 95 per cent efficiency, would be willing to make the little additional effort, to attain 100 per cent efficiency, for this extra 5 per cent. This the client could not see and what I was afraid of actually happened.

"In one plant I got the work fairly started. I had the confidence of the management and everything was progressing nicely. I turned part of the work over to an assistant, a very capable fellow, who had previously done some very good work for me. The organization simply would not work with him, and this was not due to his being tactless or undiplomatic, for he was careful of what he did and said. The organization had confidence in me and no matter what the assistant proposed, it wondered what I would have done. As a result progress was slow, opposition developed, and nothing like the expected results were accomplished, all because of a lack of confidence that was not justified, and because there was not a strong determination on the part of the client to see the thing through.

"I know of another case. The combined efforts of two men, working at different times, failed to get the client to see the necessity of some action, of some move, that would get the work started. Report after report was made, valuable suggestions were outlined, but the work never got very far because the client took too much time considering pros and cons, and being too busy on other matters, the efficiency work did not get the attention it deserved, and as a result the gains possible were not forthcoming.

"In one department of a business fair times were determined. When the engineer left the efficiency was about 90 per cent. It kept climbing until it was about 120 per cent. As the times were carefully set, it could only mean that the men were exceptionally quick and sure or that quality was being sacrificed. Poor workmanship was found, and the client blamed the system when as a matter of fact the fault was entirely his own. He should have seen that the men who showed high efficiencies were producing work of the right quality. If he had the efficiency would have stayed around 100 per cent, the schedules calling for a fair and reasonable effort at standard.

"Another illustration will serve to show the pitfalls to avoid. The things that the engineer wanted and considered vital to the success of the work, he could not get. Even though a plan had been carefully worked up and approved, he was forced by dominating factors in the management to put in what he did not want. For instance, the client wanted schedules made and the men put on bonus without first planning the work and bettering the working conditions—a policy absolutely suicidal to the best success.

"Failure to get clients to consider properly and decide deliberately on betterments has been a factor, with the result that time passes, money goes, and nothing is accomplished. Then there is the task of sometimes trying to please too many in the organization. This makes the work extremely difficult. In one case the client refused to allow the engineer to announce to the shop management and workmen what the plan contemplated was and what it would mean to them. Knowing that something was going to be put in, the men grew suspicious when they were not advised—a perfectly natural feeling. Even religious differences have interfered with well-formed plans of the engineer, something you would not dream would be a factor in this age, but which did considerable damage nevertheless. In another case I was told that if I would join the Elks the methods would go in.

"When you meet clients who do not care to know what their costs are; who see no possibilities in knowing the idle time of their machines; who fail to consider savings in burden and in equipment charges, as a gauge of results; who are mortally afraid of system and a few forms; who cannot see anything in studying power costs; who consider the tool room as a non-productive proposition, and as a result have a most inefficient tool practice; who get the opinion about parts of the work from foremen who, knowing little about the work at first, are naturally opposed to it—the wonder is not that more concerns have failed to try it, but that there have been so many unquestionable successes that can be pointed out.

"My whole experience leads me to but one conclusion. If the client makes up his mind that he wants the work, he should get the best man that he can find. Having found him, and having decided to go ahead, he should be very careful not to interfere and place obstacles in the way of what virtually is his own success, for after all the engineer is doing for him what he lacks the time to do for himself. I do not mean that the engineer is to be the final authority as to everything, but if he knows his business (and he should not be there unless he does) then he should have both authority and status, and be allowed to say what should be done, how it should be done, with the right to go ahead, without interference, in the quickest possible time and at the least cost."

"That has all been most interesting," said Barlow, "and it is the first time that I have heard anything at all about the wrong end of this proposition. I agree with you that when we know more about the failures, the work will be better understood and more easily installed. The great trouble has been that we have been led to feel that there was something mysterious about it all; that it could not fail and was a cure-for-all.

"You have gone over the ground in a thorough manner," added Barlow, "and I am sure we are all very grateful and very much impressed. I think we can call this meeting to a close and later the directors can get together and decide upon some form of action."

"Before I go," said Brown, "I want to leave with each one a list of questions for self-examination. You will find them of particular value to you at this time and will assist materially in enabling you to come to the right decision."

Chapter V

THE SELF-EXAMINATION AND THE DECISION

AFTER Mr. Brown had left the meeting, each director read the following list of questions. There was a noticeable seriousness in the air. Each face was thoughtful as the questions were considered and gave eloquent evidence of the impression Brown had made.

List Your Answers for Reference Purposes

Questions	Answers	Remarks
1. Is your condition one of *low* costs and *high* wages?		This can be attained.
2. Do your employees co-operate to the extent you desire?		They will if the way is properly paved.
3. How many valuable suggestions have you received from your men during the past year?		Suggestions can be made an important factor.
4. What proportion of your force has been with you one year, five years, ten years?		Something is wrong if workers are constantly shifting.
5. Are your men satisfied and contented?		The majority can be made so.
6. Is rest and fatigue of the worker studied?		It was found that rest of 16 per cent resulted in 100 per cent efficiency whereas no rest meant 70 per cent efficiency.
7. Take an hour or two and study an operation as to——		Proper study and analysis of operations will mean a standardization which will eliminate wastes in time and in motions.

Questions	Answers	Remarks
A. Material to be handled.		
B. Method of bringing the material to machine and taking away.		
C. Method of piling material.		
D. The machine itself—its speed, arrangement, etc.		
E. Putting work in and taking out of machine.		
F. The facilities furnished.		
G. Strength and skill of man.		
H. Size of unit handled.		
I. Length of travel.		
J. Position of worker—and—		
What delays did you observe?		
Were there any unnecessary motions?		
What was efficiency of man?		
Did you see any possible improvement in methods?		
Were there any inefficient conditions?		
8. Are you satisfied with the percentage of orders shipped on or before date promised?		Proper planning will anticipate delays and result in prompt shipment.
9. Is strenuousness fostered or is the attitude one of preparedness, care and system?		Strenuousness is not efficiency.

Questions	Answers	Remarks
10. Is the margin between the planning of the work and the performance such as to enable you to get everything in readiness?		Time losses between jobs can be almost entirely eliminated by advance planning and efficient scheduling.
11. Do your workers hold back to influence rates?		This can be overcome.
12. Do your men have anything to do with getting tools, drawings, materials, and whatever they use?		This should all be done for them.
13. Do you employ time-study methods in your plant?		Time study is one of the basic factors in management.
14. Take the time to study your planning:— A. Are there delays between operations? B. Are materials, tools, etc., furnished in advance of requirements? C. Does each man or machine work with reference to other men and machines?		Wise planning eliminates delays, anticipates requirements and arranges for best co-ordination.
15. Is the work of your men *enervating* which saps energy, or *energizing* which stimulates energy?		It makes a decided difference which from the standpoint of both men and results.
16. Do you arrange to plan work each day for the next 24 hours and is there a "next" job ready for each man or gang?		This is being done in a variety of lines.
17. Is the type of your management line, staff, functional or legislative?		This is an important factor.
18. Is inefficiency as between the men and the management known in the form of a mathematical factor?		This can be ascertained and the information is extremely valuable.

Questions	Answers	Remarks
19. Do you know whether the efficiency of your men, machines or departments is 90 per cent, 60 per cent or 110 per cent?		Definite ratios can be determined.
20. What would this knowledge mean to you?		Elimination of waste follows a knowledge of efficiency.
21. What is done with reference to training your men so as to make them efficient and desirous of remaining with you?		This is one of the possibilities under right methods.
22. How do you overcome the inertia of your men due to habit?		This can be accomplished through wise leadership and patience.
23. Is the Sales Department able to sell more than the plant can make?		Planning methods and furnishing incentives to men will assist in matching the plant against sales requirements.
24. Are piece rates cut without changing the methods of working?		This is not the way to secure the full co-operation of the men.
25. Are facts as to manufacturing details in the heads of your men or a matter of record like your drawings?		Study of your details and standardization will give you these facts in proper shape.
26. Do you study economy in time with the same care as you study the design of your product?		Such study means more efficient use of time.
27. Are your men paid by—		
A. Day work?		A. No incentive is furnished in this plan.
B. Piece work?		B. Leads to strenuousness and does not foster efficiency.
C. Bonus plan?		C. Furnishes incentive and insures day wages. Real effort is rewarded.

Questions	Answers	Remarks
28. Are conditions such as worry or harass the workers?		Men cannot do their best work and worry at the same time.
29. Are efforts made to overcome the men's attitude of "mental impossibility?"		Men do not attempt more simply because they do not *think* they can do more.
30. Do you anticipate breakdown of machines belts, etc.?		This can be done with less cost of maintenance and with less in the way of lost time due to stops.
31. Is there team play and the athletic spirit among your men?		This attitude can be fostered with profitable results.
32. Are ideals placed before your men that they can readily comprehend?		Many men become discouraged when large tasks are given them. Advance them by easy stages.
33. Are you losing power anywhere due to inefficient transmission lines?		Study usually proves that gains can be made here.
34. Do you encourage your men to complain about what seems unreasonable?		This makes for a healthy spirit and leads to betterment.
35. Do you get all of the available energy out of the fuel or power you buy?		Many firms do not.
36. Do you provide for investigation and betterment of unfair conditions?		It pays in better relations with men and in improved conditions.
37. In reviewing would you classify your results as fair, good or excellent?		Nothing short of maximum results should satisfy.

What Are Your Conclusions?

"Well," said Barlow, "I move we adjourn to the Phoenix Hotel, have dinner, and spend the evening in discussing what has interested me to a greater extent than I would want to acknowledge generally. I am simply astounded at the food for thought this man has given us."

"Your suggestion is a good one," said Lewis. "It will give each one of us an opportunity to think it all over before resuming the discussion."

Two hours later, in one of the hotel rooms, the meeting was again called to order, at which time Barlow said:

"You who know me best realize that I am not inclined to exercise snap judgment with reference to important matters. Nevertheless I must say that I am profoundly impressed with what took place this afternoon. I know that I vigorously opposed the idea at the start. The arraignment by Brown was a most bitter one, and I must confess that several of his statements angered me; but as I cooled off, I was forced to acknowledge the soundness of his conclusions."

"There is no getting away from the fact," said Wilson, "that Mr. Brown had us on the defensive. Every question he asked seemed to make it worse for us, and I for one am willing to admit that he has shown us what we ourselves have overlooked—that there are certain fundamentals which must be considered if our success industrially is to be all that we desire."

"What is your feeling, Lewis?" asked Barlow. "You were the one that started all this."

"After considering his talk," said Lewis, "and reading the questions he left with us, my conviction is that we should go ahead along the lines he mentioned. He convinced me that we need just the kind of medicine he prescribed. He discovered our shortcomings, outlined what would better things, and gave us a frank, straight-from-the-shoulder outline of results, objections and failures. Everything considered, we would be making a serious mistake in refusing to heed his advice."

"While the admission is a most disappointing one to me," said Barlow, "I am frank to state that we have undoubtedly been lax. I can see that our past achievements are not the kind to warrant us in patting ourselves on the back. We can bury the past, however, and determine to run things in a more efficient manner in the future. What are your suggestions?"

"I believe, under the circumstances," said Wilson, "that we should engage Brown to undertake the task of introducing a campaign of betterment. I feel we have a good future before us if we can get on the right basis. We have a reputation for quality; our credit is good; we are an old and established concern, all of which are distinct assets. New tactics would undoubtedly assist us. Further, my money is tied up here and I want it to earn something. The statement that we are losing 2 per cent hit me with unusual force. We certainly cannot get our money out of the business by selling at this time. Spending enough to put the business on its feet, in every sense of the word, would undoubtedly mean dividends for us. We have all done the best we could and, without any reflection on the ability of Barlow or Lewis, a fresh, unbiased, competent anaylsis of our troubles would mean a most valuable assistance. I am for going ahead on some such plan as Brown suggested."

"I feel the same way," said Barlow. "We have all done the best we could but our best has not been quite good enough. While we have been using the same methods for years, new and better methods have been developed and we have simply closed our eyes to the possibilities for us. We have been too busy with our own affairs to realize that those on the outside were devising just what we need. I know my views are different than when I advised selling, but this man Brown has impressed me by his arguments. I am the last man to continue a senseless argument when I am once convinced. How can we go about it all?"

"I would recommend engaging Brown," said Wilson, addressing Barlow. "In addition, I would suggest that you assume more of the duties now being looked after by Lewis. This would leave him free to devote considerable time to the new work. The superintendent should be given such assistance as would enable him to spend some of his time with Lewis. Then let Brown, Lewis and the superintendent act as a 'steering committee.' We no doubt have a man who can act with Brown under Lewis, who would be trained to handle things when Brown left. This to my mind would mean a strong, healthy and conservative growth from the start in addition to assuring us a prominent part in what will be done."

"Your suggestions are excellent," said Lewis. "The trouble has been in a number of cases that the engineer has come in, after which everyone lies back on the assumption that so long as he is there to show them how to run things, let him go ahead and do it. Naturally when he leaves, there is no one in a position to carry the work on simply because no one has been trained to do so. It is like putting a lot of lawyers in a submarine after the boat has been designed, built and launched. No matter how good the boat is, someone because of inexperience is going to sink it."

"I agree with you both," said Barlow. "We must organize the work from the start and the best brains we have should be a factor in it. I will immediately take steps to relieve Lewis and our superintendent of enough to enable them to take hold with Brown. If we are all agreed I will make the necessary arrangements with Brown."

This was agreed to by all and the meeting adjourned, each feeling that the decision was the beginning of a new era for the Enterprise Manufacturing Company.

Chapter VI

THE BUSINESS ANALYSIS

WHEN an engineer enters a plant to commence the inauguration of an efficiency campaign, whether in a professional capacity or in the direct employ and on the payroll of the company, he is immediately confronted with a problem more or less complicated. On the one hand are all the workers, with their many variables. On the other hand is the management, with its peculiarities. To both he has two definite relations:

1—The personal or psychological relation.

2—The business or practical relation.

His ultimate success depends largely upon the care with which he studies these relations and the extent to which he can get the forces on either hand to work to best advantage.

The engineer will undoubtedly find himself without status or authority. To be sure, he is in the plant for a definite and clearly defined purpose, but nevertheless he is not in a position to dictate, hire nor discharge, order changes, buy the things needed, nor to do as he pleases in his efforts to accomplish the results the management wants. *In other words, he cannot increase the efficiency himself.* This must be done by and through those in the employ of the company. Consequently it may be said that everything depends upon how he utilizes and manipulates the forces at his command. Therefore, the first thing the engineer must do is to "get acquainted" with the members of the organization, and to this end he should have the executive properly prepare the way. It would be folly, for instance, to call all the heads of departments and officials together, and then have the president or general manager address them in this strain:

"I want you to meet Mr. Blank. He is here to show you all up. You are not producing all that you can. The results for some time have not been all they should be, and it is about time that we cut out the wastes and got down to business. Mr. Blank will show you the way."

The only advice possible under such circumstances would be kindly and charitably to advise the well-meaning engineer to pack up his belongings and go home. He would have as much chance to secure results, in the face of such a blundering start, as I have of designing a 100 per cent efficient flying-machine to-morrow.

A meeting should be held, by all means. It is a most excellent way of starting the work, and if the men are approached in the right way, it will mean much to the success of the undertaking. The men should have pointed out to them a brief outline of the principles; what has been accomplished elsewhere; what the work means to them, and to the company. Concrete examples should be cited. A brief description of the possible local application should be given. The keynote of the whole meeting should be the value of co-operation. The men should be made to feel that the service contemplated is in no sense a reflection on individual worth or ability.

The engineer should then arrange to talk to the men individually at their work, ascertaining their ambitions, desires, complaints, troubles, criticisms and suggestions. Cold-blooded and austere men are often met with, and it seems difficult to get "under the skin" but some plan will usually be found to get a man to "warm up" and discuss things in a detailed way. I do not mean by this that the engineer is to grow so familiar as to arouse the contempt of the department heads. *I do mean, however, that the engineer must be kindly, sympathetic, desirous of showing that he wants to assist—to build up and not tear down—and must be able to hold his own viewpoints in abeyance until such time as he can discuss them with some hope of having them accepted or at least looked upon with favor.*

You cannot expect to go out to a man, hit him over the head with an argument, and expect him to swallow your bait, hook, line and sinker. He won't do it. He thinks he knows more about his business than the engineer does, and in this he is undoubtedly right. The engineer cannot make him see that he knows more about the application of the principles of management, until the engineer has convinced him that there are elements about his work that make him doubtful about his own ability. Diplomacy and tact, the quality of inspiring leadership rather than forcing co-operation, are most essential elements.

To test for co-operation and to secure much in the way of excellent leads from the organization, the form shown in Fig. 1 can be used to advantage. If few are turned in it means that the co-operation is not all it should be.

EFFICIENCY RECOMMENDATIONS

SUBJECT DATE
DEPT.

The efficiency of the above department could be increased if the following could be eliminated bettered or installed

DESCRIBE CONDITION BELOW

REASON FOR ABOVE

RECOMMENDATIONS COVERING ABOVE, FROM DATA AT HAND

TO EFFICIENCY DEPARTMENT:
Kindly investigate above, advising as to outcome.
SIGNED________________

The Engineering Magazine

Fig. 1. Form for Securing Efficiency "Leads" from the Organization

So much for the personal relation. The engineer must also devote his attention to getting acquainted, in another way—with such factors concerning the practical features of the business as will put him in touch with the necessary information on which to outline a plan of action.

The following plan of investigation will, in this connection, be found of value to the engineer:

1. Make a list of the *members of the organization*, and ascertain as to each:

A—What does he cover?
B—Whom does his work influence?
C—How is he influenced by others, and to what extent?

2. As to each *person*—study him at his work, in conversation, in disputes and quarrels, by interviewing his superiors, and by eliminating all personal bias and giving each person the benefit of the doubt, answer the following:

A—What other work is the man qualified to cover?
B—Who else in the organization can assume his duties?
C—Is he responsive to suggestions?
D—How does he take criticism?
E—Is he spasmodic or consistent?
F—Does he think for himself, or depend upon others?
G—Is he a keen, deliberate thinker, or quick to jump at conclusions?
H—Is he overworked?
I—Considering ability, as poor, fair, good or excellent, how do the following check up?
1—Judgment.
2—Accuracy.
3—Executive ability.
4—Initiative.
5—Co-operation.
6—Energy.
7—Aggressiveness.
J—Is he capable of self-direction?

3. As to *methods*, secure a copy of each form used and discover as to each:

A—Who uses it?
B—Who supplies the information from which the form is made out?
C—In what manner is the information furnished?
D—Who gets the forms?
E—What other forms are affected?
F—What use is made of the information?
G—What is the relation between the forms?

4. Get from the company, or make, a complete set of floor plans, showing location of machines, benches, vises and floors.

5. What is the class of product?

6. Is it made in

A—Stock quantities?
B—To specification only?
C—Combination of two?
D—If "C," which is greater, "A" or "B"?

7. Is the type of *organization*

A—The usual, leading from manager to superintendent, to foremen, to men?
B—Functional or Taylor?
C—Staff or Emerson?
D—Legislative?
E—Combination, and if so of what nature?

8. As to *departments:*
   A—How are the departments divided as regards sequence of operations?
   B—What is the nature of the work done in each?
   C—What is the number of men employed in each?
9. As to *costs:*
   A—What is the method of costing?
   B—Is costing part of the general accounting?
   C—Is costing on a 30-day basis?
   D—What basis is used for apportioning burden to production?
   E—Are cost reports prompt, reliable, and comprehensive?
   F—What real use is made of cost statistics, and by whom?
10. As to *workmen:*
   A—Is the plant union or non-union?
   B—If union, in what departments?
   C—What have been past labor troubles?
   D—Causes, and how settled?
   E—Any agitation at present or in prospect?
11. Are *employees* paid by
   A—Day rate?
   B—Piece rate?
   C—Premium plan?
   D—Bonus plan?
   E—In what departments do they apply?
12. As to *efficiency of men:* Are they working
   A—In a leisurely way?
   B—At very low efficiency?
   C—At fair efficiency?
   D—At high efficiency?
   E—Holding back?
   (Note—List according to departments.)
13. As to *planning:*
   A—Is material furnished in advance of requirements?
   B—Is supply adequate?
   C—How about the handling?
   D—What delays were noticed?
   E—Cause of delays?
   F—Who does the planning?
   G—How is it done?
   H—How far in advance?
   I—What records are used?
   J—What is nature of the preparation covering "next job"?
   K—Is material handled back and forth unnecessarily?
14. As to *materials* on each floor:
   A—Did you see plenty of material ahead?
   B—Where were the places where material was running low?
   C—What steps were taken to replenish a low stock?

D—What time elapsed between running out of material and replenishment?
E—Was material piled in an orderly manner?
F—Is material easy or difficult to get at by workmen?
G—Who is responsible for moving material and how does he get move orders?

15. As to *inefficiencies* noted:
A—What were the conditions found?
B—What are the principal defects?
C—What would you outline as constructive measures?
D—What was the efficiency?
(Make a number of time studies if possible. If this cannot be done, make notes and estimate the inefficiency.)

16. As to *belting:*
A—Are belts tight or loose?
B—Are they laced properly?
C—Are they clean, or in dirty, greasy condition?
D—What is the alignment of shafting and pulleys?
E—Do belts ride true or against cone steps?
F—Are belt records maintained?
G—Who looks after work, and when?
H—How many belts in use?

17. As to *inspection:*
A—Do prints show plus or minus allowances?
B—Who is responsible for inspection?
C—Is there inspection of raw material?
D—What disposition is made of raw material not up to specification?
E—What is done with incorrect drawings?
F—Are first pieces of any operation inspected as completed?
G—Is there inspection upon completion of a lot of pieces before movement to the next operation?
H—Do men use rules and micrometers, or are there gauges for the work?
I—Is there inspection previous to final receipt by stores or shipping departments?

18. As to *power:*
A—Number of tons burned per day?
B—Horse power developed?
C—Kind of coal used, and the cost?
D—Method of firing?
E—Is feed-water heater used?
F—Is economizer used?
G—What is evaporation of water per pound of coal?
H—What is temperature of feed water?
I—What is the stack temperature?
J—What is proportion of CO_2?

19. As to *conditions:* Outline your impression as to
A—Lighting.
B—Heating.

C—Ventilation.
D—Generation and transmission of pneumatic power.
E—Power transmission.
F—Trucking and conveying.
G—Hoisting.
H—Storage, handling and piling of materials.
I—Sanitation.

20. As to *operation:*
A—To what extent are labor-saving devices studied and installed?
B—How is the jigging of the work handled?
C—Describe fully the tool room arrangement and the system used.
D—To what extent is multiple machine-work done?
E—What are the methods of inspection?
F—Do men work to drawings or to gauges?
G—Does work necessitate much filing and fitting?
H—Who looks after the speeds and feeds?
I—Do men grind their own tools?

21. As to *employment:*
A—What is the nominal force employed?
B—How many men were hired per month?
C—How many men quit?
D—How many men were discharged?
E—What is the cause of dissatisfaction among men, if any?
F—What is the relation between A and B?

22. As to *buildings:*
A—Is plant well laid out?
B—Nature of building construction.
C—Are buildings old or new?

23. As to *sales:*
A—What is method of distribution?
B—How are selling prices made, and by whom?
C—How are selling policies determined, and by whom?
D—How are salesmen selected and trained?
E—How is unexpected competition anticipated?
F—Is the selling organization able to sell more than the plant can make?
G—What is done to add new lines of work?
H—How is sales efficiency determined?

24. As to factors influencing *co-operation:*
A—Are men satisfied and contented?
B—Is rest and fatigue of worker studied?
C—Is the work enervating or energizing?
D—Do workers hold back to influence rates?
E—What is policy regarding cutting rates?
F—Do conditions worry and harass the workers?
G—Are men allowed to complain about what seems unreasonable, and what attention is paid to such complaints?

H—Is strenuousness fostered?

I—What is done with the inefficient men?

General Questions.

25. Are breakdowns of machinery anticipated?
26. If so, in what manner?
27. What is your impression of the foremanship?
28. What are the average earnings of men by departments?
29. Is the control of material as to purchasing and stock-keeping such as to insure the maintenance of the proper amount of stock at all times?
30. Does the company arrange for securing suggestions from men and rewarding them for those accepted?
31. What proportion of orders are shipped on or before date wanted? Reason for delays?

The above is sufficient, with the many other questions which will naturally suggest themselves to the engineer, to cover the various details in connection with the operation of an establishment. The engineer will have as a result of an investigation as outlined a fund of very valuable information. He will have to analyze and study it all—in other words, make a diagnosis to determine what is wrong, where it is wrong, and what will cure. He is then in a position to prescribe a course of treatment.

Chapter VII

THE DIAGNOSIS

NO physician blindly prescribes a course of treatment. He first examines to get at the facts, then gives serious consideration to what he has collected through questioning, tests, etc., and from his conclusions he is able to state what the matter is and what will eliminate or cure the trouble. This "synthetic analysis" is what is popularly termed the "diagnosis." The engineer bears exactly the same relation to the client as the physician to the patient. The client is in no better position to tell the engineer what is the matter with him and what he needs than the patient is in to tell the physician what ails him. It is therefore obvious that the engineer must diagnose exactly as the physician does. He must analyze symptoms, local complaints, functional disorders, and then outline the course of treatment. In other words, it is not so much a question of what to do as of *how to determine* what to do.

The engineer should therefore take his forms, his time studies, his impressions, his floor plans, his facts as to planning conditions, and other information gathered as the result of the examination outlined, and after retiring to a quiet corner, commence the task of matching facts and considering evidence. He is a judge, in other words, considering arguments for and against the application of certain definite laws and principles. It is true that no definite rule can be laid down for diagnosing a case. This is largely a mental process, but it is a process nevertheless based upon and determined by the many facts gathered.

The engineer is on speaking and perhaps friendly terms with the various members of the organization. He knows who are for him, who are against him, and who are neutral. He has a fair conception how to approach each member. He knows what each covers or is supposed to cover. He has in addition an excellent idea as to the real worth to the company of each member of the organization.

A chart should be drawn up in graphic form, showing the organization as it exists, as indicated by the answers to the questions covering

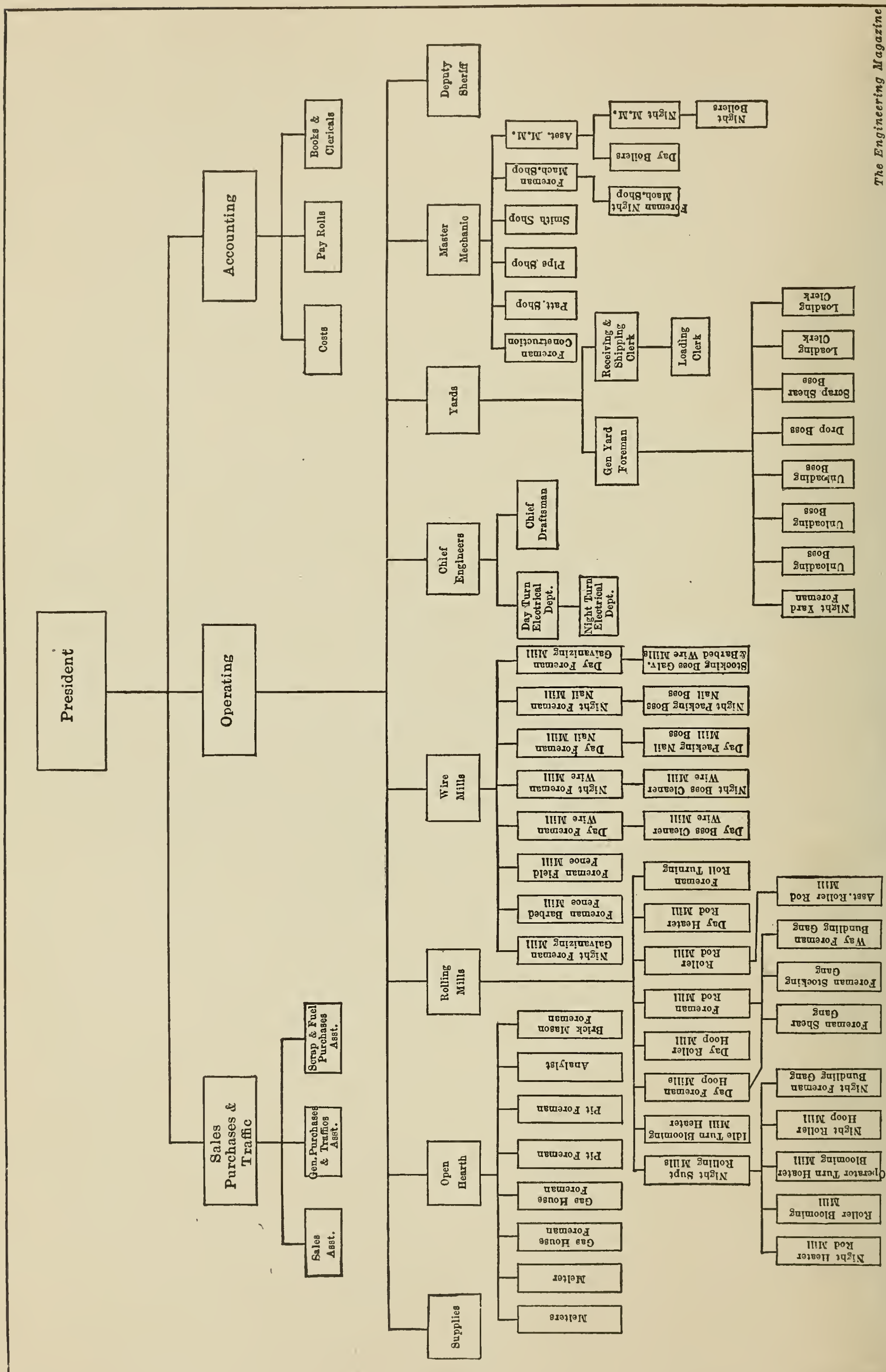

Fig. 2. An Outline of a Graphic Organization Chart

this point. This will show the relation of each person to every other person, a study of which will be productive of much good. It will make it possible to tell whether the organization is good or bad; where functional lines cross; where factors are inefficiently covered, or where too much attention is given to other factors. See Fig. 2 for an outline of organization.

The engineer, if the business is of a complicated nature, should make a process chart showing the travel of the operation through the plant. Fig. 3 is a sample chart of the processes in one plant, from which it can be seen how difficult it would be to write a description of the details in a comprehensive and intelligent manner.

The answers to questions covering the methods in use should also be charted, as indicated in Fig. 4. A picture covering methods and forms will enable the engineer to tell exactly what the real situation is, where too much or too little in the way of system is employed, where several methods are in use to accomplish the same results, where certain individuals are overburdened with detail work, what points are not covered properly, etc. Finally this chart will be a decided convenience when the engineer plans out new methods to graft to the old.

A chart outlining the manufacturing practice can be made to assist in diagnosing, as shown in Fig. 5.

In going further into the matter of diagnosing, we can use a number of assumptions to illustrate as clearly as possible the method to follow. The imagination will not be drawn upon in this. *The assumptions are based upon absolute facts and not theory.* The conditions will be arranged on one side, opposite which will be set the conclusions.

Conditions	Conclusions
1. During his investigations the engineer observes that a workman completed on an operation, 30 pieces of a certain article, which at the piece rate of 18 cents would equal $5.40 for the day. The man in reporting, however, only claimed 18 pieces as the day's work, which would mean earnings amounting to $3.24.	Here we have a case in which fear is aroused in the man. The man was afraid of a cut in the rate. Further, deceit is fostered. This condition is the result of a false managerial policy and can mean only that industrial conditions are not what they should be.
2. The engineer has been advised by the shop foreman that a certain job takes 27 hours for 2 men. Study develops, however, that 9 hours for the 2 men are sufficient.	In this case we have every evidence that the shop management does not know what constitutes a fair day's work. The fault is *lack of standards.*

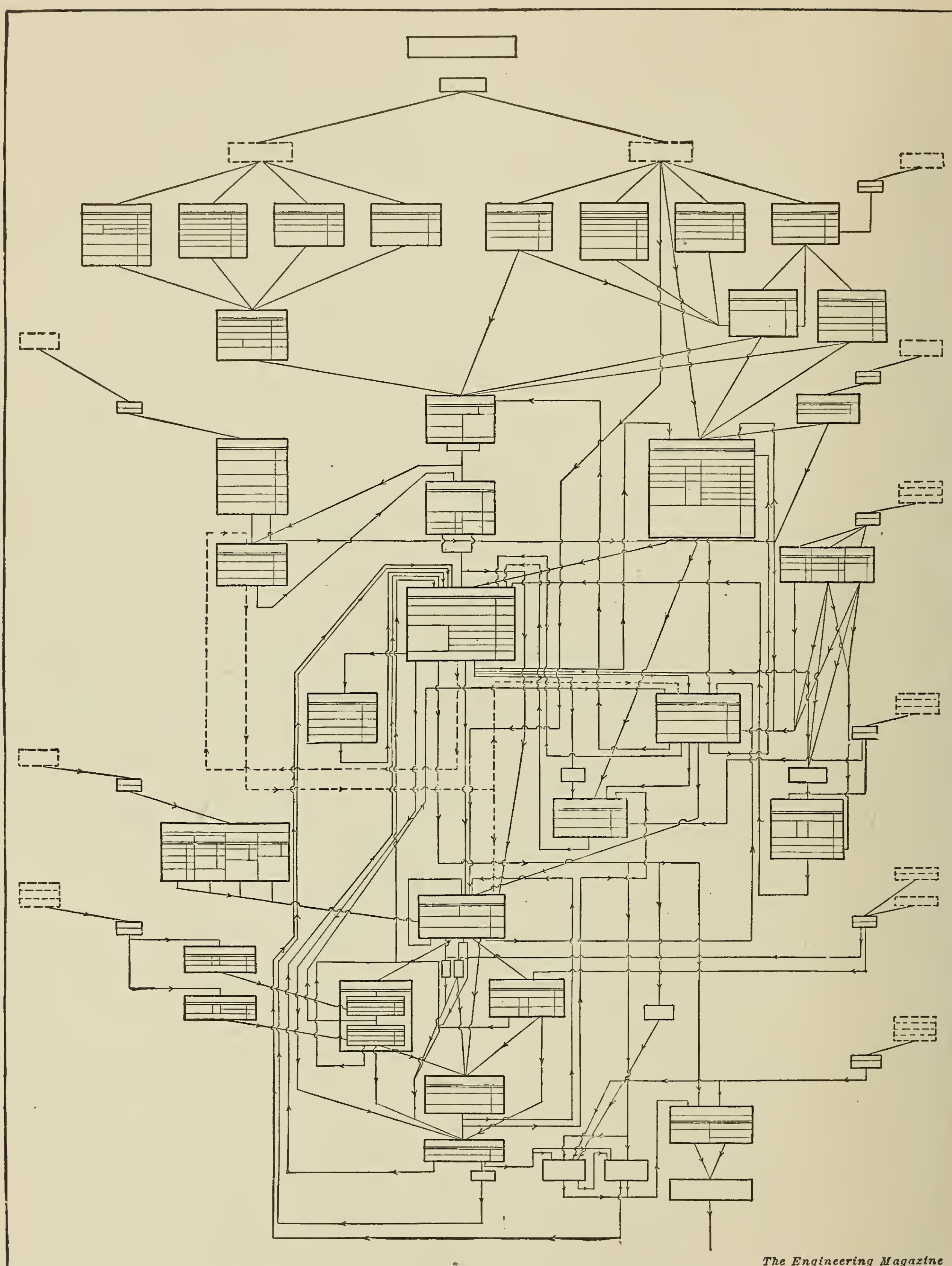

Fig. 3. Graphic Representation of Processes and Routing in a Representative Plant

Names of departments and operations are omitted by the request of the proprietors of the establishment in which this chart was made.

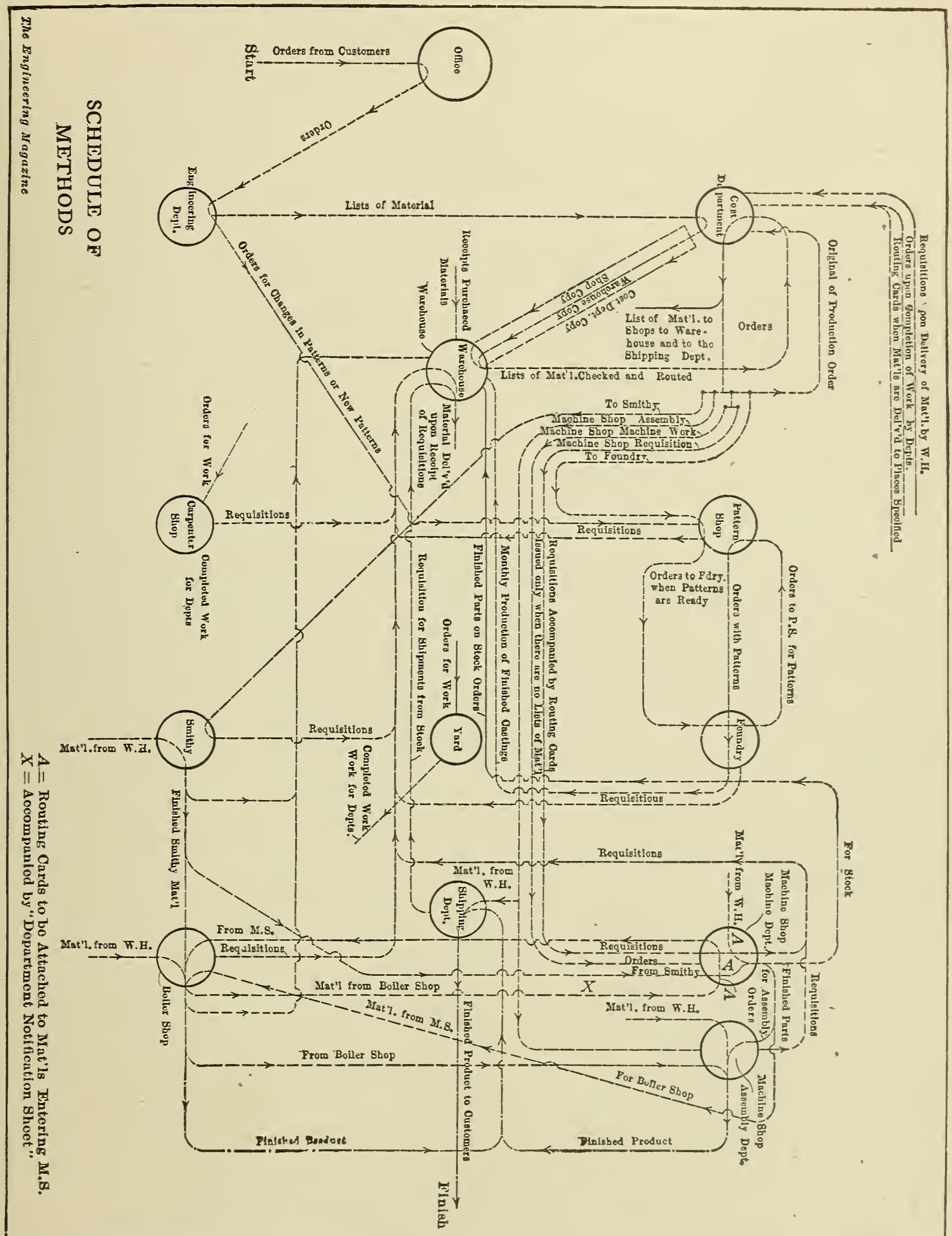

Fig. 4. Graphic Representation of the Nature and Use of Methods and Forms in a Manufacturing Plant

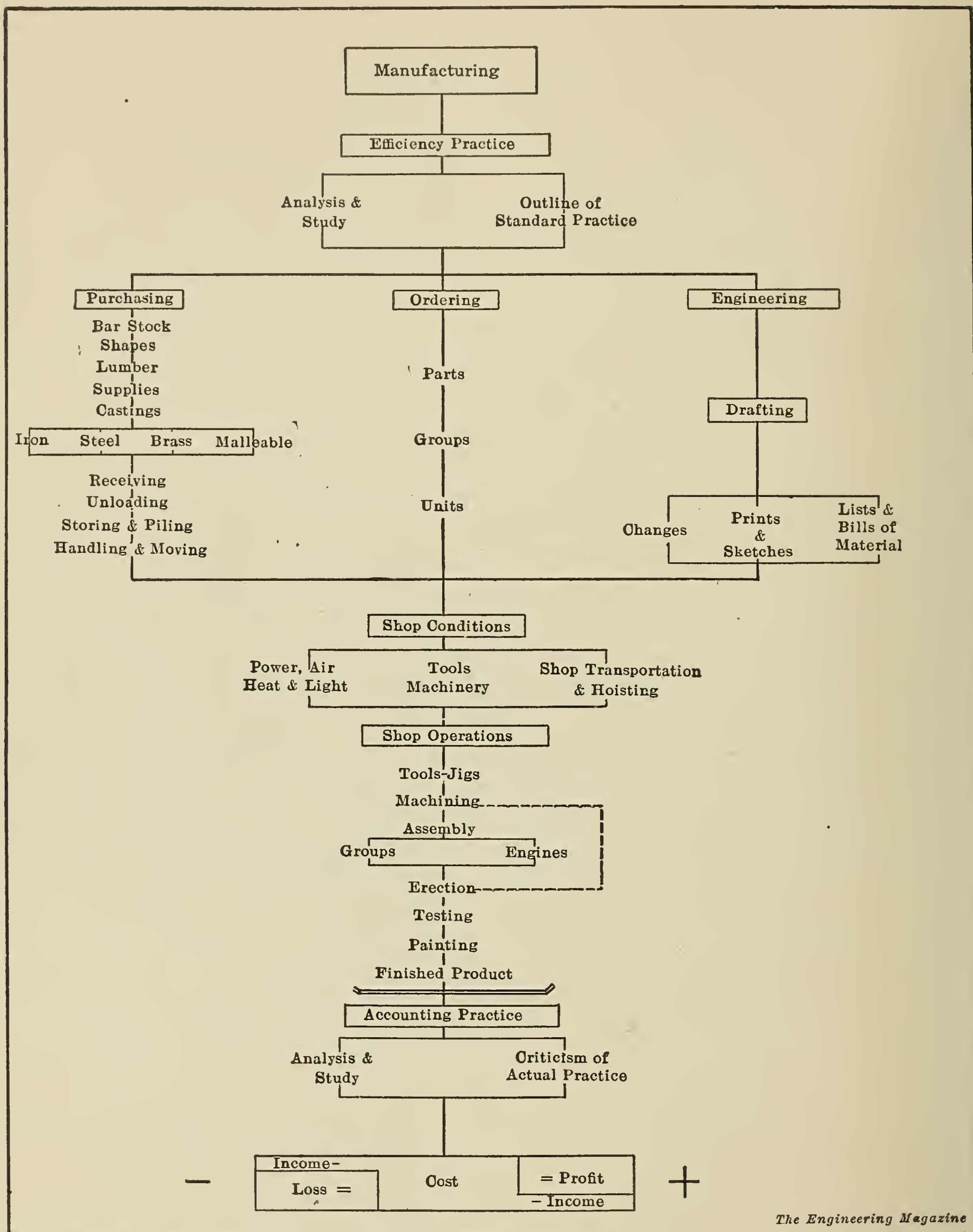

Fig. 5. Graphic Outline of Manufacturing Practice

CONDITIONS

3. He further noticed that on repetitive work only one jig was supplied on certain operations, with the result that the machine was idle while the workman was taking piece out of jig and putting in another.

CONCLUSIONS

As a second set of jigs could have been made and supplied the workman, it is plain that the working *conditions* as well as *operations* for this particular work are unstandardized.

Conditions	Conclusions
4. In making brief studies of the machines it is found that on a number of them the proportion of actual working time to the running time is as follows:	As regards this condition, every evidence points to *lack of planning and failure to standardize operations and conditions.*

Per Cent		Per Cent	
A.	32.6	J.	62.3
B.	31.9	K.	59.0
C.	40.0	L.	40.4
D.	51.0	M.	29.5
E.	36.0	N.	24.3
F.	59.0	O.	33.9
G.	63.0	P.	44.0
H.	45.0	Q.	50.9
I.	37.3		
	Average		44.1

The balance, 55.9 per cent, was made up of delays, machine changes, lack of work, etc.

Conditions	Conclusions
5. The superintendent states that when men hold back production, he promptly cuts the rates to force them to speed up, and when he finds that men earn too much, the rates are also cut.	This the engineer feels to be a case of the man "getting his" going and coming and explains the condition described at 39. No co-operation could be expected under such a suicidal plan. It can mean only the existence of the *worst kind of industrial relations.*
6. It was also noticed that drills and sockets were supplied the men in an unsystematic manner, making it necessary for the men to sort and fit whenever they change drills.	This means *poor working conditions* as well as *failure to plan.*
7. The engineer is advised by a workman that he had been turning out 4 pieces per day paying 65 cents each or $2.60. He found a way, without any help from the company, to produce 6 pieces, with the result that the rate was cut to 45 cents. The man stated that he offered to do the 2 pieces for 45 cents if he could get 65 cents for the other 4. *The offer was refused* and another man assigned to the job who could only turn out 4 pieces per day, so the rate was placed back to 65 cents.	Another example of the policy which tends to kill co-operation. *Poor industrial relations.*

Conditions	Conclusions
8. In the foundry he notices that moulders have to wait for jobs, patterns, flasks, cores, rigging, etc.; that the sand is not in the proper condition in the morning to enable the men to start right to work; that the men have to hunt for rods, nails, gaggers and other things they need and that the men themselves spend more time than is necessary in ramming, setting the gaggers, finishing, etc.	Here we have *lack of planning, unstandardized conditions and failure to supply incentives.*
9. The attempt of the engineer to get suggestions from the heads of departments through the use of the "efficiency recommendations" results in practically nothing, only a few being received.	An indication that there is *lack of cooperation.*
10. The engineer in going into the structural shop observes a gang riveting at the rate of 570 rivets per day and his brief time study indicates that 750 per day would be a fair standard—an efficiency of 70.6 per cent.	Another case of *lack of standards.*
11. The engineer finds in testing the attitude of the shop management through questions designed to bring out their feeling towards better methods, that the basic consideration seems to be that so long as production is not interfered with he can "try" anything he wants to.	This spirit indicates that the shop management considers the proposition as "on trial."—*It means possible opposition.*
12. In studying the foremanship the engineer is struck with the conditions which make job- and material-chasers out of the foremen. This he finds is due to lack of advance knowledge; assembly work is undertaken before it is known whether material is on hand or will be ready; when parts are needed, it is the task of the foremen to get behind and push and crowd them through.	This can be summed up as the brute-force type of well-intentioned but inefficient shop management, due to *lack of planning.*
13. In analyzing the work of a large multiple radial drill, which had been pointed out to him as working at high efficiency, he gets at the following facts:	Another case of *lack of standards and failure to functionalize the work.*

Conditions	Actual	Standard	Effy. per cent.	Conclusions
Speed	210	325	65	
Feed	.006	.012	50	
Drills	2	4	50	
Efficiency 65x50x50=			16.25	

14. In studying the machining of parts he notices that in a certain lot of an order of 50 parts, 5 are at the assembly bench, 10 at the milling machines, 15 at the drill presses and 20 at the lathes. Further, the assemblers are grabbing the pieces from the machines while still hot.

This is strenuousness due to *lack of planning.*

15. The moving of material, the engineer finds to be a "one-man" proposition. He finds there is no regular plan of moving as regards the relative importance of the work. There is no selection—any job finished is movable. The urgency for parts is such that in many cases part shipments are rushed—a truck containing only a few small pieces. Instead of a regular schedule of travel, truckers go here, there, and elsewhere, unable to keep up with the work at one time and not having enough to do at another.

Another case of *failure to plan and lack of proper working conditions.*

16. In studying the machine operations themselves, he is impressed with the fact that while there is little evidence of delays and stops, the men seem to be holding back. He observes further that each machine seems to have plenty of material ahead although it is piled in a "fall anywhere" fashion.

This simply means a quiet or passive sort of conflict between men and management for which *faulty industrial relations* are responsible.

17. It is found that the theory of manufacturing is to get out a definite number of units each week; that there is a variation in manufacturing operation times of 180 to 1; that all the pieces requiring little work are usually ready while the parts taking longer time are hard to get. It also means few units at the beginning of the week and a peak load at end of week.

The theory is wrong to start with. It should be *at the rate of a definite number per week.* There is a decided difference between the theories.

Conditions	Conclusions
18. The engineer notices several cases where the moulder is nailing up a loose bar in his cope or cutting out part of a bar so his pattern will fit.	This is due to *lack of planning.*
19. It was also noticed that the workmen on assembling are subjected to numerous delays. It was found that men could not get the material they needed and in several instances were forced to work on what they could get rather than on what they should have received. A lack of an even balance also appears. In the beginning of the week material is not in sufficient quantity to keep the men busy. Towards the end of the week, as the material arrives in larger quantities, the gangs are rushed, making overtime, night work, and Sunday work a necessity. It is also noticeable that material is delivered in an unsystematic manner, making it necessary for the men to paw over and find the parts needed. A large amount of filing and fitting also attracts attention. Workmen are also noticed going to machines and waiting for certain parts to be completed so they can proceed with their work.	In this condition we have inefficiency due to a *wrong theory of manufacturing, lack of planning, and poor working conditions.*
20. It is further found that although the shops are not operating under any of the newer types of management, with studies showing that the men are working at a low efficiency, the average day rate is 23 cents per hour and the piece rate earnings 34 cents per hour—a bonus of 47.8 per cent.	This means that piece rates were set too high to begin with and explains why cutting is resorted to. Another case of not knowing what constitutes a fair day's work, because of *lack of standards.*
21. The engineer is informed that workmen often turn in times on piece-work jobs that would not be sufficient to do a good job, turning in the balance of their times on day-work cards.	This means *lack of supervision, inefficient records, and failure to provide standards.*
22. In the drill-press department, he finds that against an average day rate of 20 cents per hour, 34 out of 40 drill-press hands average 31 cents per hour, for 71 per cent of their time, while lathe and planer hands earn 37 cents per hour.	Not only is this another example of high piece rates, but the situation can mean only dissatisfaction on the part of the more skilled workmen in the shop. *Lack of standards* is again responsible.

Conditions	Conclusions
23. In making a power chart the engineer notices that the maximum required is not reached until 7.45 in the morning, where it remains until 11.50. In the afternoon it is not reached until 2.05, dropping off about an hour before quitting time.	This means that there are delays in the morning due to setting up for new work. As regards the afternoon it may mean either a natural inclination to take things easy after dinner, or that piece work earnings in the morning, when men were fresh, might easily have run over the normal half-day's wage, and under fear of rate cutting the men might deem it advisable to slow up in the afternoon. Another case of *lack of standards and failure to supply incentives.*
24. In studying the generation and transmission of air, the engineer finds that the average pressure at the power house is 93 lb. In one department readings as low as 55 lb. were found, and at no place did pressure exceed 75 lb. In 202 leads 75 leaks were noticed. It was found that men used air from openings as large as 7/8 inch for blowing purposes; that tools were thrown on floor with air turned on; that the men were forced to use wrenches in operating valves because of broken valve levers, and that hose was in wretched shape in many places.	*Conditions decidedly unstandardized.*
25. In the boiler shop it is observed that the margin of time between getting drawings and prints and starting the work in the shops is too short to admit of any advance planning; that it is a case of working as best they can on whatever they can get. The immediate present is all that is concerning the shop.	Another case of *lack of planning.*
26. It is found that boiler test readings show 7 lb. of water evaporated per pound of coal with a feed water temperature of 190 degrees.	*Unstandardized conditions.*
27. As to planning, the engineer finds that there is little or no attempt to plan and schedule the work in advance. He finds it a case of assembly foremen crowding the machines and the machine foremen crowding the foundry. He further	*Lack of planning.*

Conditions	Conclusions
notices that the preparations covering "next jobs" is a matter of verbal notifications by foremen to men. He also finds that it is up to the men to go for drawings, tools, materials and that they have to grind their own tools.	
28. In charting the travel of many of the standard parts made in large quantities, the engineer notices that there is considerable unnecessary handling between machines, due to poor location of machines.	Due to failure to *standardize operations.*
29. Upon examining the employment records, it is found that to maintain a nominal force of 600 people, 2,100 are hired in a year or 3.5 changes per year. It further develops that 250 of the 600 men were in the employ of the company for the year, raising the ratio to 6 men hired to maintain one position.	This is conclusive evidence of the worst kind of *industrial relations.* No efficiency is at all possible under such conditions.
30. In studying the stoppages and breakdowns of certain machines, the engineer finds upon careful investigation that 75 per cent of them are due to preventable causes.	This is due to lack of anticipative inspection and failure to *standardize working conditions.*
31. As to wage plans it is found that as far as possible piece rates have been introduced, all other work being covered by the day-work plan. The policy is to cut rates when the earnings of the men get too high, a matter left entirely to the judgment of the superintendent.	This simply means that maximum efficiency cannot be expected from those paid by the day, and from the evidence gathered the piece plan also fails to accomplish what is desired. A case of failure to *supply incentives.*
32. The engineer finds that the costing is a matter of compiling data from inaccurate shop records as to labor and material; that no attempt is made to figure burden accurately; that the costing is not on a 30-day basis nor a part of the general accounting plan; that such reports as are made are neither prompt, reliable nor comprehensive, and that no systematic attempt is made to analyze cost records, the information being used chiefly for estimating and sales purposes.	This means that there is absolutely no way of gauging the efficiency of operations, and even if standards were set up it would be difficult if not impossible to compare actual results against them.

Conditions	Conclusions
33. The engineer finds that the type of organization is the one most common to industrial plants, in which president forces manager, manager forces superintendent, superintendent forces foremen, and foremen force men.	A force-and-drive type, wrong in theory and in practice and incapable of securing maximum results.
34. As to belting, the engineer finds things in wretched shape—belts greasy and dirty, running on pulleys any old way, against the cone steps and splitting along the edges, with faulty lacing and pulleys and shafting improperly aligned.	Another example of failure to *standardize conditions.*
35. He notes further that machines are repaired when they break down, *not before;* that there is no anticipation of trouble that is likely to develop in factors which should have periodic attention, and that repairing is done in working hours.	Means *unstandardized conditions.*
36. In analyzing the shipments he finds that less that 1/3 of the orders were shipped on or before date wanted; that cancellations were high, due to failure to ship as promised, and that the shop is constantly forced to rearrange its plans to meet demands of customer. Rush orders act as a "flying wedge."	Due to *lack of planning.*
37. The engineer notices that the foremen are so busy chasing jobs and materials, assigning work, and answering questions about drawings, that little or no time is left for studying the best combination of speed, feed, and cut, the limitations on the machines, the most efficient jigging, and other matters vitally affecting the matter of cost and production.	Failure to functionize the work due to *unstandardized conditions.*
38. In watching the work in machines, the engineer notices case after case where a machine is broken down to set up for one or two pieces of a rush or forgotten order and then set up for regular job again.	Due to *lack of planning.*
39. As to the men themselves, the engineer senses a feeling of distrust, of sullenness, of hostility. They do not offer sug-	*Faulty industrial relations* due to lack of proper ideals on part of management.

Conditions	Conclusions
gestions, they are crowded hard, until the result is a strenuous drive for production. Rest and fatigue are not studied, the men resent the cutting of rates, there is every evidence of holding back—some men openly stating that they could and would do 50 per cent more work if rates were guaranteed.	
40. The engineer finds that in certain operations 8.8 motions are made per piece, when 6 would do the work just as efficiently.	Due to failure to study and *standardize operations.*
41. In studying the work coming from machines he notices that the space between the pieces is from 1 inch to 6 inches when ample allowance would be 1/2 inch.	*Unstandardized operations and conditions.*
42. In a foundry it is claimed that 90 per cent of the rejections are due to the materials used. Analysis shows that the men themselves are responsible for 51 per cent of the rejections.	*Unstandardized conditions.*

The engineer is confronted with no easy task in attacking this mass of evidence preparatory to blocking out his plan of action. It is like valuing intangible assets—little to go by with plenty of evidence to work on.

The questions are—what are the problems ahead of the engineer? How is he to reduce these forty-two cases to a concrete basis? How is he to determine the relative values of the points brought out? It is obvious that a general reading would be confusing and that some form of summarizing is therefore necessary.

THE SUMMARY

A.—Faulty industrial relations
1-5-7-16-29-39

B.—Lack of standards
2-10-13-20-21-22-23

C.—Unstandardized operations
3-4-21-28-40-41

D.—Unstandardized conditions
3-4-6-8-15-19-24-26-30-34-37-41-42

E.—Lack of planning
4-6-8-12-14-15-18-19-25-27-36-38

F.—Failure to supply incentives
8-23-31

G.—Lack of Co-operation
9-11

H.—Incorrect theory of manufacture
17

I.—Inefficient records
2-32

J.—Wrong type of management
33

THE PRINCIPLES

The engineer is getting closer to "brass tacks." Before he can write the planks in the platform on which he will carry the fight against inefficiency to the limit, he must analyze to determine logical arrangement. He does this and here is his outline:

1. *He must from the start arrange for the substitution of a better type of management.* Why? Because what is accomplished will be done through the organization, and it needs a type of the highest order. It is the machine, in other words, that will turn out efficiency as a product, and it must therefore be properly designed to start with.

2. *He must then arrange to anticipate opposition and turn it into co-operation.* Why? No results of value can be secured without co-operation. A good type of organization with opposition encountered is about as efficient as a gear stripped of its teeth.

3. *He must correct the theory of manufacture and arrange for the most improved methods of planning.* Why? Given 1-2 how could results be secured, if the co-ordination of the thousands of details in connection with production is left to chance, to guess work, to memory?

4. *He is then in a position to arrange for standardized conditions and operations.* Why? Because the planning in itself will have a direct influence on conditions and operations. Because standardizing operations and conditions would accomplish much less without planning.

5. *He is now in position to place definite standards before the men and management and make the records more efficient.* Why? Could a man make a piece of work in 10 hours which previously took 15 hours without planning and with conditions and operations unstandardized?

6. *He must then plan out ways and means for bettering the industrial relations—supplying incentives to those employed.* The best organization in the world with the best of co-operation is powerless to accomplish anything worth while if industrial relations are faulty.

In other words the principles about which he will carry on his entire work are—*Organization, Co-operation, Planning, Standardization, Incentives.*

Chapter VIII

PRESCRIBING THE TREATMENT

IT is one thing to diagnose a case and find the troubles, and quite another to prescribe the treatment necessary to eliminate them.

The engineer in whom we have personified our efficiency work through the preceding chapters was able to satisfy himself, after the investigation made, that every evidence pointed to the worst kind of relations between men and management; that planning was conspicuous by its almost entire absence; that conditions were not as efficient as they should be; that operations were unstandardized, and that the proper incentives were not furnished the workers. He further determined that the principles about which he would have to build his plan of campaign were:

1. Organization.
2. Co-operation.
3. Planning.
4. Standardization.
5. Incentives.

THE OUTLINE OF PROCEDURE

The problem confronting the engineer, then, is to determine what to do, why, where, the order in which it should be done, when and how. He can do one of two things—select the most obvious course and "feel" his way along as he goes on with the work, or he can plan the entire procedure in advance, varying it later as may be determined by subsequent study. The first course is a vague, unbusinesslike, unintelligent, leave-it-to-the-Almighty method, as against a comprehensive, definite and prearranged plan.

He adopts the following as ideals:

1. For everything that is done, there is, under existing conditions, a best way of doing.

2. No man should be allowed to do any work that can be done by another with less skill and at less expense.

3. Men should be given every opportunity to measure up to the limit of their possibilities.

4. What is done should be in the *right* way, on the *right* thing, at the *right* time.

To make these ideals practical he arranges for the following steps:

1. Search out the inefficiencies at all points in the business, at such time and in such a manner as to secure all the facts needed.
2. Make careful time and motion studies covering planning, conditions and operations.
3. Arrange for co-ordinated planning.
4. Determine standards as to conditions and operations.
5. Devise methods for carrying on the work as outlined.
6. Prepare instructions covering the procedure determined upon.
7. Ascertain accomplishment so as to measure same with standards.
8. Investigate reasons for failure to attain standards.
9. Analyze delays, complaints, allowances, rejections and inefficiencies.

Consideration shows the engineer that the existing organization which he calls the "Line" is too busily engaged in performing the various duties in connection with its regular work to devote painstaking and comprehensive attention to the factors mentioned. It must be properly assisted and, to this end, he decides to create an organization to be known as the "Staff"—advisory in nature and without jurisdiction over any of the line officials. Its chief function is to analyze and point out the road to business efficiency. *The task of attaining the ideals pointed out is the function of the Line.*

Before taking up the matter of welding staff and line to make an efficient machine which will produce the results possible, the work of the staff should be fully outlined under the following headings:

1. Study division.
2. Planning division.
3. Standards division.
4. Bonus division.
5. Analysis division.

He now proceeds to a detailed analysis of the factors in each of these divisions of staff work.

1. Study Division

The work of this division will include the making of all time and motion studies, investigations, preliminary surveys, or general studies covering the various features of the business, as well as the classification and proper arrangement of the facts secured for use by either the Planning or Standards Divisions. The responsibility of this division ceases, however, when studies have been made and arranged in permanent form. The work of this division will be divided into:

A.—Organization.
B.—Engineering and Drafting.
C.—Inspection.
D.—Planning.
E.—Conditions.
F.—Operations.
G.—Materials.
H.—Relations and Incentives.

The details of these classes may be further defined thus:

1A. Organization

Compiling lists of departments, product manufactured in each, approximate quantities, capacity, force employed, department heads and assistants, and their relation to the management.

Securing facts that will determine strength or weakness of the various members of the organization.

Determining to what extent there is concerted action in all important matters.

Studying for evidence of "individualistic" management.

Ascertaining wishes of company officials as to where constructive measures shall be started.

Observing where surface indications point to the possibility of making gains quickly.

Making list of starting departments for considering the advisability of beginning in these departments.

Drafting the measures necessary to unite line and staff.

After due consideration of these points, drawing up a tentative program covering the introduction of the work in the various departments.

1B. Engineering and Drafting

Co-operation between engineering and operating departments.

Limits and tolerance.

Clearness and accuracy of drawings.

Foundry and pattern work in relation to designing.

Scaling for measurements in shop.

Designing with reference to using most efficient machine tools in shop.
Designing without reference to jigging when jigging is necessary.
Studying proper use of chucking and finishing bosses.
Studying designs making necessary the cutting of excess metal.

1C. Inspection

Purchasing and stores control.
Ordering methods.
Shop routing.
Drawings and sketches.
Gauges and precision instruments.
Methods used in inspecting.

1D. Planning

Collection of such data for purposes of planning as may be necessary to establish relations between parts, groups, and assemblies, and between shops and foundry.

1E. Conditions

Plant	Buildings and fixtures.
	Drains and sewers.
	Tracks and switches.
Tool Equipment	Machines.
	Jigs and fixtures.
	Cutting tools.
Power Generation	Steam.
	Electricity.
	Compressed air.
	Hydraulic power.
Power Transmission	Shafting and pulleys.
	Boxes and hangers.
	Belting.
Air Transmission	Pneumatic tools.
	Pneumatic lines.
	Hose and connections.
Yard	Loading.
	Unloading.
	Handling.
Facilities	Transportation.
	Hoisting.
	Storage.
General	Ventilation.
	Heating.

Lighting.
Sanitation.
Lockers and baths.
Medical attention.

1F. Operations

Setting work in and taking out of machines
- Kind and weight of material to be handled.
- Size of unit handled.
- Method of bringing material to machines and taking away.
- The facilities furnished.
- Strength and skill of the man.
- Position of worker.
- Length of travel.

Speeds and Feeds
- Kind of work to be done.
- Pulling power of machine.
- Shape of tool.
- Kind of steel.
- Limits reached and why.

Small Tools
- Control as to types, sizes, and shapes.
- Number to carry.
- Kind of material.
- Clearances and angles.
- Forging, tempering and grinding.
- Arrangement as to:—
  - Uniformity.
  - Accessibility.
  - Distribution.
  - Inspection.
  - Maintenance.
- Machines on which they are used.
- Position in tool holders.
- Faulty and inefficient practice.
- Relation to work to be done.

Machine Tools
- Arrangement.
- Limitations in cones, bearings, heads, rests, beds, tool holders, stocks and clamps.
- Chatter.
- Power.
- Inspection.
- Maintenance.
- Adaptability to work.
- Too much or too little equipment.
- Modern or out of date.

Jigging of work
- Setting jigs and fixtures.
- Putting work in jigs and removing same.
- Removing jigs.
- Faulty practice.

Assembly and Erection
- Supply of parts and groups.
- Best combination of groups and parts.
- Best method of assembling.
- Limitations and faulty conditions.
- Methods of piling and handling.
- Filing and fitting.
- Floor space used and required.

Fitting, Riveting, Welding, Caulking, etc.
- Study of current practice.
- Limiting conditions.
- Supplying material.
- Facilities furnished men.
- Wastes in time.

Moulding and Coremaking

Study of men as to physical characteristics, earning power, training, experience, skill, health, habits, tendency to fatigue, etc.

Study of work as to moulds, cores, flasks, patterns, irons, sands, facilities, surrounding, etc.

Study of motions as to ramming, setting gaggers, nailing, slicking, finishing, shoveling, setting cores, closing, pouring.

1G. Materials

- Price.
- Uniformity.
- Quality.
- Unit quantity.
- Adaptability.
- Equivalency.
- Margin to carry.

1H. Relations and Incentives

Getting men to discuss problems and troubles.

Consideration of force, worry, strenuousness, mental attitude, habit, faith and exertion.

Study of concentration, interest, imagination, initiative, memory, imitation, attention.

Disputes and complaints.

2. Planning Division

It will be the function of this division to investigate at all points in the plant with reference to the planning and dispatching of production details, and to devise the standard practice necessary for putting this feature of the work on the best possible basis. The work of planning will be considered under three heads:

A.—Basis for Planning.
B.—Making Plans.
C.—Execution of Plans.

The details of these headings will be as follows:

2A. Basis for Planning

Knowledge of what to make, quantities, and the time allowed.

Analysis of orders as to operations, units of work, the assignment to gangs and machines and operation times.

Complete knowledge as to receipts and disbursememts of material, showing balances at all times.

Determination and maintenance of stock limits.

Prompt checking of requirements against stock.

Scheduling orders received.

Control of movement of material.

Control of shop timekeeping.

Securing facts as to work finished by men and machines.

2B. Making Plans

Routing orders that have been analyzed to machines and gangs.

Selecting and scheduling each day sufficient work for the next day.

Furnishing shop with information regarding plans made.

Study of previous planning to avoid congestion at machines.

Rearrangement of schedules to meet unforeseen contingencies.

2C. Execution of Plans

Having one job ahead at all times.

Having materials, tools and drawings ready for next job.

Delivering work to machines and gangs.

Checking orders as to progress.

Studying conditions which interfere with prompt execution of plans, or with keeping machines and gangs fully supplied with work.

Advising management as to items needing attention.

Following up shortages.

Ordering parts to replace spoiled or defective work.

3. Standards Division

This division will have charge of the work of determining the best practice under existing conditions, from studies turned over to it by the Study Division. The complete procedure is then to be outlined and standards determined in terms of time, cost or production.

This division will also have charge of making and issuing all schedules, operation instructions and standard practice instructions covering the details in connection with Standardization. In scope this division will cover:

A.—Conditions (See 1E).
B.—Operations (See 1F).
C.—Materials (See 1G).

4. Bonus Division

This division will have charge of the work of introducing and handling the details in connection with the bonus system, as well as with the matter of allowance made to men for conditions not under their control. In a general way its duties will be

Properly placing schedules before men.

Responsibility for issuing correct information as to standards on service cards for men.

Figuring standard time on service cards.

Calculating efficiencies.

Figuring bonus earnings.

Keeping bonus record.

Issuing bonus checks.

Forwarding record of bonus earnings to payroll department.

Keeping part efficiency record.

Placing efficiency showings before men and departments.

Investigating and recording complaints from men.

Adjusting disputes with men.

Adjusting efficiency records on account of rejection and allowances.

Recording allowances.

Ascertaining inefficiency of men and management.

Determining causes of delays and complaints.

Placing responsibility for inefficiency of management.

Investigating allowances made but not approved by foremen.

Making reports showing efficiencies of men, machines, departments and operations.

Making record of and investigating low efficiencies.

Investigating conditions which interfere with attainment of standards.

Making charts covering average bonus earnings per man. Proportioning bonus time to total time. Inefficiency of men and management. Men at classified efficiencies.

5. Analysis

The Analysis Division is to be the "efficiency clearing house" in that everything in the way of data and information of value is to be taken by this division, carefully analyzed, and compiled for quick reference for use by those whose work it is to increase the plant efficiency.

Its work will consist of the compilation and analysis of the following:

Delays.
Allowances made to cover inefficiency and management.
Rejections according to departments, men, operations and causes.

ACCOMPLISHMENT REPORT	
SUBJECT	DATE
DEPARTMENT	OPERATION
DESCRIBE CONDITION PREVIOUS TO BETTERMENT	
OUTLINE NATURE OF BETTERMENT ARRANGED FOR	
APPROXIMATE COST OF BETTERMENT $________	TIME TAKEN TO EFFECT
RESULT OF BETTERMENT	
APPROXIMATE YEARLY SAVING $________	INCREASE IN PRODUCTION ________%
DECREASE IN COST________%	DECREASE IN FORCE ________%
SIGNED BY	

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Fig. 6. Accomplishment Report

Changes in working and manufacturing schedules.
Complaints from men and foremen as to working times and working conditions.
Efficiencies.
Low efficiencies.
Inefficiency of management.
Bonus earnings.
Materials and supplies used.
Time and production reports.
Operation time for purposes of estimation.
Results attained, whether in planning, conditions, or operations.
All time-study data.

Inspection reports covering conditions.
Relative importance of parts and groups.
Manufacturing and efficiency progress reports.

In organizing this staff there should be a chief-of-staff, who will have full charge of the work as outlined, as well as the charge of and direction over the men under him.

To cover the work of the various divisions the chief-of-staff will have as assistants a study supervisor, a planning supervisor, standards supervisor, a bonus supervisor, and an analysis supervisor.

It is obvious that the work to be done must proceed along logical lines. Consideration will show that in anything, study precedes action. This study may be general in character or the minutest detail can be investigated. Consequently the starting point is *study* and as a result, *planning* and *standards* are influenced. No *bonus* would be arranged for until planning was under way and conditions and operations standardized to the extent necessary.

Analysis would then take the facts secured, and through compilation and analysis use them in an effort to indicate new fields for study.

Therefore whether the consideration is an operation or machine, a single department or the entire plant, the procedure is exactly the same —there is no end anywhere. Analysis precedes study the same as study precedes planning or standards.

To gauge the success of the work done by the staff, use should be made of the form shown in Fig. 6, which is a report on accomplishment. It is most important that the staff hold at least one meeting per week, to talk over the work done and to outline tentatively future efforts.

Chapter IX

THE ORGANIZATION

"WILL the tail wag the dog or the dog wag the tail?" This question may not be clothed in the most dignified English, but it sums up the situation now confronting the engineer. In other words, after making the examination, diagnosing the case, and prescribing the treatment, he must next induce the patient to take the medicine. The doctor would not say—"here is some medicine, take it"—leaving it entirely to the whims and inclinations of the patient. He would say—"take two of these before each meal and one of these before going to bed and upon arising in the morning." His directions would be explicit, rather than general.

The client may balk. So does the child when the taste of medicine is disagreeable. The client will want to take something else than the dose prescribed. We have all done the same thing many times. The client may want to change doctors. We have felt the same about this also. We have, however, taken disagreeable medicine, followed exactly the doctor's orders, with no thought of a change in pilots, only when we first realized the seriousness of our case and fully appreciated that the doctor seemed to know exactly what he was doing.

The relation of the staff to the line must therefore be considered. As can be appreciated, the staff, being analytic and advisory in character, with no supervision over department heads, can do little in itself in the way of actually producing results, because it is not a performing function. *It cannot force acceptance of its orders.* It is therefore imperative that some plan be devised for so organizing the relations between staff and line as to enable both to work to best advantage.

To accomplish this the following is necessary:

1. Organize the staff as outlined.
2. Maintain the line organization intact.
3. Functionalize the plant activities in a concise yet comprehensive manner.

4. Arrange for the consideration of all important matters, by both staff and line, along such legislative lines as to render it difficult, if not impossible, to determine where staff advice ends and line acceptance begins.

In order to organize for "Legislative Management," the line activities should be thus functionalized:

Engineering and drafting.

Planning.

Conditions.

Operations.

Materials.

Relations and incentives.

The factors making up each function are as follows:

Engineering and Drafting

Estimates.

New designs and changes in design.

Experiments, tests, analysis of data pertaining to the product manufactured.

Repair work on product.

Supervision of new work being made.

Installation of product.

Sketches, drawings, tracings.

Disposition of incorrect drawings.

Issuing drawing with important dimensions properly marked and in addition showing plus and minus allowances.

Changing and proper issuing of changed drawings to the shops.

Arranging for return of superseded drawings.

Blueprints and bills of material.

Photographs and catalogues.

Preparing drawings for tools and jigs.

Passing upon points of inspection when inspectors are unable to reach a decision, in cases where there is a possible departure from the design called for.

Consideration of complaints from the trade.

The handling of cancellations.

Making changes called for by customers.

Conditions

Delivery of material to men and machines.

Standardizing conditions from outlines received from staff.

Maintenance of plant and equipment.

Responsibility for requisitioning equipment for shops.

Responsibility for keeping departments clean and orderly and free from congested material.

Responsibility for maintaining methods designed to cover conditions.

Inspection of equipment at regular intervals to anticipate delays and breakdowns.

Use of floor space.

Maintaining records covering tools, jigs, and dies.

Moving tools and jigs from storage to machines and returning them when work is finished.

Keeping tool storage clean and orderly with tools properly arranged.

Keeping tools in readiness for instant use.

Maintaining proper supply of tools, drills, cutters, to enable the plant to operate to best advantage.

Forging, grinding and tempering tools for most efficient service.

Responsibility of efficiency of tool room.

Charge of and authority over material chasers.

Periodic inspection of tools at machines to insure their being kept in best condition.

Control of small tools as to size, shape, and kind of steel.

Accident and surgical service.

Maintenance of most efficient belting conditions.

Study of high speed steels, their proper use and treatment.

Cleaning up and disposing of refuse in shops.

Responsibility for reports on conditions.

Provision for necessary watchmen.

Responsibility for keeping track of changes or additions to equipment.

Responsibility for delays in shop when due to conditions within the control of the management.

Operations

Responsibility for best combination of speed, feed, and cut.

Directing men as to proper use of speeds, feeds, and cuts.

Responsibility for gauges, tools, etc., necessary to properly inspect the product manufactured.

Responsibility for most efficient jigging of work.

Standardizing operations from outlines received from staff.

Execution of orders as to quality.

Employment of workmen.

Responsibility for operation delays in the shop when due to causes within the control of the management.

Appointing and discharging foremen.

Laying off, disciplining, or discharging workmen.

Responsibility for efficiency of labor.

Supervision of foremen and men.

Responsibility for maintaining methods designed to cover operations.

Tools and jigs:—

- Designing.
- Approving drawings.
- Requisitioning.

Character, capacity, and limitations in machines.

Listing antiquated machinery, if any, and machines that have little to do.

Keeping men and machines producing up to maximum.

Placing spoiled work for inspection.

Setting work in and taking out of machines.

Study of parts in their relation to groups and units to facilitate proper inspection.

Inspection of raw materials as to rough dimensions, and to drawing in case of intricate work.

Responsibility for efficiency of inspection.

Responsibility for stating whether rejected material is due to faulty workmanship or defective material, and if to faulty workmanship, who is to blame and why; and if to defective material, what is the cause.

Analysis of rejections to determine to what extent errors and defects can be eliminated.

Handling rejections:

A. Deciding whether rejection is total loss or not.

B. Disposition if not total loss.

C. Breaking down rejected assemblies and movement of parts to proper place.

Charge of inspection department.

Inspecting parts after each operation before movement of material to next operation.

Improvement or changes in manufacturing processes that do not interfere with design of product.

Directing men to work to drawings and specifications.

Approving the standard times determined for various manufacturing departments.

Execution of orders for delivery specified or promised.

Planning

Responsibility for carrying out in the various departments the methods devised for efficient shop planning.

Getting jigs and drawings in readiness for work.

Analysis of groups and parts as to relative importance to the whole or to each other.

Giving each department sufficient time in which to turn out product desired.

Keeping after repair parts in shop.

Starting job with drawing, tools, jigs, etc., in readiness.

Supplying proper information to shop truckers and material chasers.

Responsibility for seeing that no material is moved from machine to machine until approved by Inspection Department.

Following up shortages of material.

Following up orders.

Rearrangement of manufacturing schedules to meet delivery dates.

Arranging for such meetings as may be necessary to properly plan work ahead.

Keeping track of material due on orders.

Responsibility for having at least one job ahead of each machine or gang in addition to the one being worked upon.

Reporting departmental delays that will interfere with schedules.

Analyzing and routing parts from detailed drawings.

Planning all orders that have been previously analyzed and routed.

Responsibility for replenishment of rough and finished parts.

Scheduling deliveries.
Securing necessary manufacturing information from engineering department.
Knowing whether material is on hand before starting.
Study of previous planning to avoid congestion at machines.
Replacing defective material.
Reports showing work in process and work not started.
Progress of orders through the factory.
Creation of orders to build and assemble parts and groups.
Maintaining daily schedule showing planning for next and succeeding days.
Delivery of material to proper departments and machines.
Reporting on material unobtainable from shops.

Materials

Checking material received against schedule, determining what is due or behind schedule.
Maintenance of reports showing materials on hand.
Allowing sufficient time in which to secure material.
Supplying shortages of material.
Responsibility for material lost or stolen.
Knowledge of rough and finished stock with high and low limits.
Reporting on material unobtainable from outside.
Disposition of raw material not up to specification.
Proper care and piling of rough and finished material.
Maintenance of records as to receipts and withdrawals of material.
Taking and figuring of inventories.
Responsibility for requisitions for materials from which the products are made.
Requisitioning and purchasing to replace defective materials not made by us.
Receiving materials and checking them as to quality, specifications and quantity.
Returning defective materials to vendors.
Responsibility for requisitioning and purchasing factory supplies.
Notifying departments as to arrival and purpose of materials received.
Determining amount of material to carry.
Maintenance of limits arranged for.
Unpacking and placing material away.

Relations and Incentives

Study of relations between men and management.
Wages and hours of labor.
Incentives furnished the men.
Light, heat, and sanitation.
Co-operation of workers.
Unfairness and favoritism.
Discipline maintained.
Rules governing conduct of the men.
Enforcement of rules adopted.
Investigation of complaints from men.
Outlining constructive measures aimed to better relations.

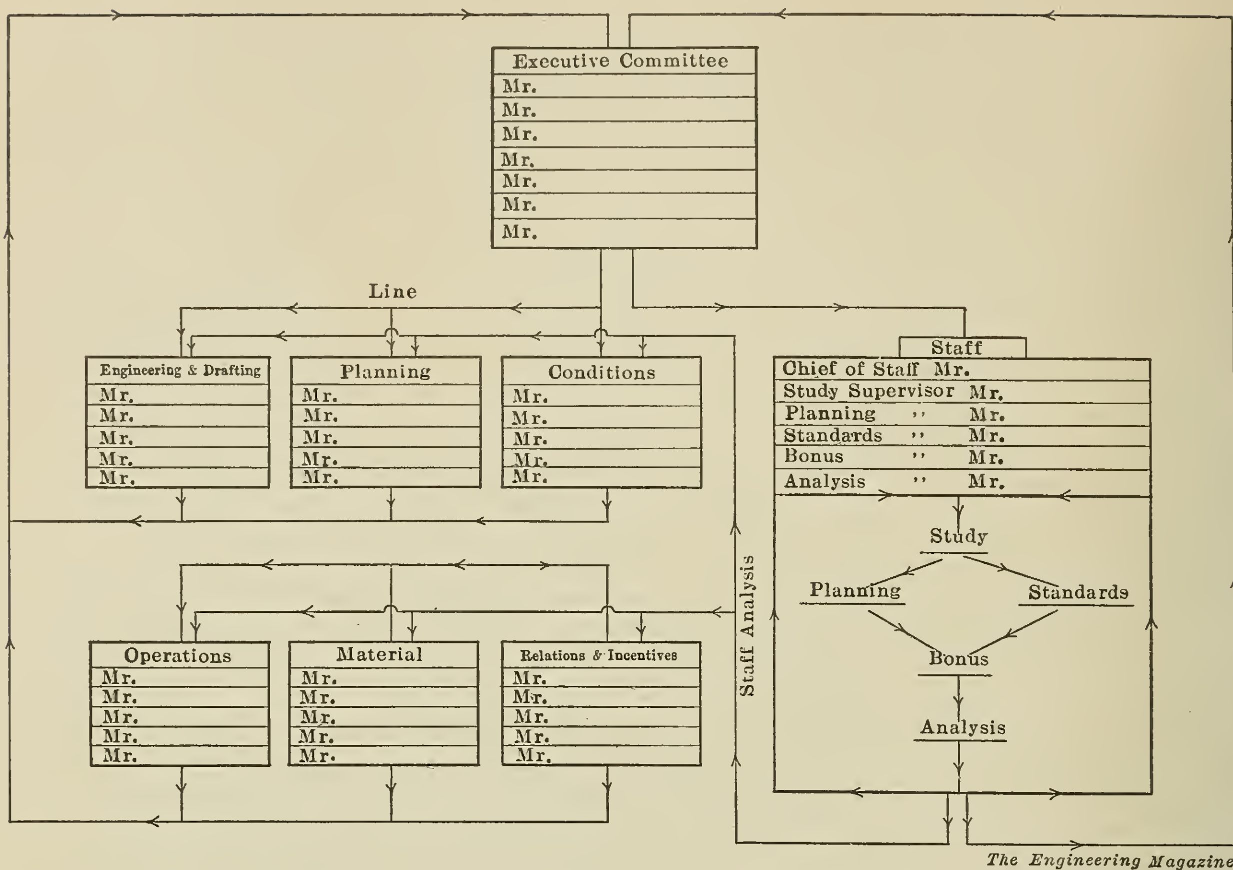

Fig. 7. Chart of Organization of Staff and Line, Showing Relations of Committees and Course Taken by Business

Executive Committee

In addition to controlling the work of the various committees, the executive committee would also have charge of the following:

Responsibility for the quantity of product manufactured.

Creation of orders to build units.

The selection and training of capable understudies for the various positions.

Responsibility for advising shops sufficiently in advance of work to be made, to allow shop time in which to schedule and get out the same.

A committee composed of the best material available should be organized to cover each one of the functions. These would be functional committees. The organization of the staff has already been outlined. Therefore, to weld the two forces, an "executive committee" controlling both should be organized. This will mean one staff committee, six functional committees, and the executive committee, or eight in all. Reference to the chart on organization of staff and line (Fig. 7), will show the relation between committees.

It is, of course, as important to make a correct choice of personnel of the committees as it is to define their functions and responsibilities. They may be made up as follows. The explanatory words in parentheses indicate the interest represented by each member of each committee:

Executive Committee

General manager (administrative); chief designer (product); office manager (records and data); treasurer or accountant (finance); superintendent and assistant superintendent (shop); and efficiency engineer (betterment work).

Engineering and Drafting Committee

Sales manager (customers); chief designer (product); superintendent (shop); and efficiency engineer (betterment work).

Planning Committee

Superintendent (shop); purchasing agent (materials); foreman of department affected (individual department); and efficiency engineer (betterment work).

Conditions Committee

Superintendent (shop); master mechanic (mechanical work); labor boss (labor work); foreman of department affected (individual department); and efficiency engineer (betterment work).

Operations Committee

Superintendent (shop); chief inspector (quality of product); functional supervisor (speeds and feeds, or jigs and fixtures, or foundry work, or belting, etc.); foreman of department affected (individual department); and efficiency engineer (betterment work).

Materials Committee

Purchasing agent (supply of materials); stores keeper (custody of materials); foreman of department affected (individual department); and efficiency engineer (betterment work).

Relations and Incentives Committee

Superintendent (shop); foreman of department affected (individual department); representative of workmen (labor); and efficiency engineer (betterment work).

An outline of the procedure necessary to secure the desired results under this type of management is next in order. In the first place the relation of line with staff and staff with line is through the executive committee and therefore indirect in nature, making it necessary to arrange for some means of communication. A folder about 9 by 12, with suitably ruled and printed spaces on the outside and inside front cover for entering the subject, conditions found, betterment plan proposed, action taken by special committee, final action of executive committee, can be used as record and container of all papers relating to the subject.

As to meetings, the staff committee made up of chief-of-staff and his assistants may hold meetings at its own discretion, the functional committees at the call of the executive committee, and the executive committee when the press of work to be considered justifies it. Regular meetings are advisable if they can be held to advantage. Requests for investigations can originate in any committee.

Functional committees at their meetings are to consider carefully the matters referred to them, to give them thorough discussion, to arrive at some decision for or against, to give reasons, and then to submit their findings to the executive committee. Upon receipt thereof the executive committee is to consider the matter carefully, and if the measures recommended are satisfactory they are adopted and *then become binding on all line officials.* If not satisfactory, the reasons are to be entered in the report and either returned to the functional committee for further deliberation and action, or to the staff committee for further investigation.

To show more clearly the procedure outlined, assume that the staff, through its Study and Standards divisions, finds inefficiencies in belting conditions all through the plant. It would make out a report showing the result of the investigation, along with a set of recommendations covering betterment, which would be supplemented by a report on standard belting practice. This would be sent to the committee on Conditions. Here the matter would receive careful consideration, and after stating its views for and against, with reasons for a dissenting opinion, if any, the committee would submit its findings to the executive committee. The executive committee now having complete information from both staff and line, is in a position to pass intelligently on the procedure recommended. If its decision is favorable, the procedure then becomes binding.

Assume further that the committee on Planning is not satisfied with the dispatching of work in certain departments. It can request an investigation from the staff committee. The procedure from this point would be the same as in the belting illustration.

The chief-of-staff should be a member of each functional committee, to present the facts intelligently from his point of view. He should also be a member of the executive committee. The superintendent should be a member of the executive committee to present his side of the case.

Committees should consist of three to five or seven members. Voting can be by majority rule, or the management can decide that all decisions must be made unanimous or they fail to carry. If a committee consist of four members, the general manager can be appealed to in case of a tie vote.

The executive committee should employ a stenographer to attend all meetings, note the procedure, and issue in typewritten form the minutes of all meetings, these to be filed in the folders.

All reports (which are to be numbered) covering work to be taken up should be sent to this stenographer, to whom is to be given the task of properly arranging them by subjects according to functions. With the chairman of the executive committee, he is to arrange for functional and executive committee meetings, with everything in readiness so as not to waste time or discuss side issues. As all reports and minutes covering the same subject are to be bound together, an excellent set of standard practice instructions will be accumulated covering every conceivable subject in connection with plant activities.

A study of the possibilities in the type of organization above outlined will show that it combines into one the Line, Committee, Functional, and Staff types. This is considered an important principle. Two men on opposite sides of the fence may disagree until they grow old, but if they can get together with a third party, there is every likelihood that compromise and action will result. Another principle has also been considered—*every difference of opinion is due to faulty assumption somewhere,* and in these conferences the searchlight is put on three times—once by the staff committee, once by a functional committee, and once by the executive committee.

Finally, the advantage is that relations in and between all functions are so systematized that, regardless of the questions that may come up, a way is provided for considering them, in a comprehensive, prompt, and intelligent manner, with the least likelihood of ill feeling or antagonism being created.

Chapter X

THE ENGINEER, THE MANAGEMENT AND THE MEN

THE engineer is now at the parting of the ways. He is ready to start the practical work in connection with his betterment campaign. He has analyzed, diagnosed, prescribed, and arranged the way for administering the treatment. Before he proceeds further he must do more than merely *throw the machinery he has designed at the management and the men*, trusting in their sincere belief in the whole proposition and their entire willingness to do all that is wanted. He must be sure that the digestive apparatus of the organization is in good working order or he will find an excellent case of faulty assimilation. He knows that the application of the laws and principles of efficiency is largely a matter of "applied psychology" and it would be folly for him to ignore this fact.

Relations are somewhat involved and look something like this—

Company { Works Management ↑ ↓ Efficiency Engineer } Men

In other words the engineer must not only deal with the shop management and it with him, but *he must stand between the company on the one hand and the men on the other*. He has no authority, cannot give orders, and what he does is, as one man termed it, "an appeal to reason." He realizes fully that the shop management is there to get results and that it wants nothing to interfere with this duty. Further he knows that the shop heads can get results in their way better than he can get them in their way, and he must therefore substitute something that will enable them to get results in his way—a way which they know less about than he.

Whether he wants to or not, the engineer must assume that everyone is "from Missouri"—that some will be open in their opposition—and with this as a basis he must arrange to lay before the company, the shop management, and the men such facts and data as will bring about a belief in the work, a desire to assist, or at least an attitude of patient waiting before criticizing, until time has been allowed for the methods advocated to prove their worth.

This is sometimes a very difficult task. Human nature is complex. The management may be and often is unreasonable as regards a number of things, and because of this attitude the engineer is many times forced to change his plans, not because the change is a good one—it may in fact be suicidal—but because the management exerts a dominating influence and insists on varying the procedure to suit its own ideas.

The Engineer

The engineer must keep in mind certain fundamentals or he is likely to court trouble and perhaps failure. They are:

1. He Must Find and Follow the Lines of Least Resistance.

Nothing will convert the whole attitude of management and men from passiveness to full co-operation sooner than object lessons, and the engineer should study the places where gains can be made, within a reasonable time and at small cost. He should concentrate on these points without losing sight of his regular program. By this is not meant "hitting the high spots" as some have termed it. In every case where this has been done *it has been the management and not the engineer who, through impatience for results, has forced it.* This is always to be deplored and is altogether unnecessary. *I do claim, however, that because so much of this work is psychological in nature, it is legitimate to concentrate on places which will yield quickest returns, for the sake of the favorable impressions that will follow.*

2. He Must Work on the "Exception" Principle.

The engineer must be a master in the art of detecting where to throw his energies. He should study to determine what work he can put on the shoulders of his assistants and on the management, keeping in his own hands the difficult and the complicated. He should keep in close touch with the situation to enable him to tell what foreman or man, because of opposition or failure to co-operate, needs the most attention and it should be his duty to try and convert them—to make them see the merits in the methods advocated.

3. He Must Arrange to Get the Best Results from the Men Under His Supervision.

He must, in other words, create a standard and get his assistants to measure up to it. Consequently he draws up the following instructions:

Instructions for Staff Members

In attaining the results that all have a right to expect from the work that has been undertaken by us, considerable depends upon the relation between staff members, our relations to others about us, and the manner in which the various duties are performed by us. This feature of our work is so important as to warrant an outline of standard practice.

We have neither status nor authority. We have no right to give any orders. We cannot force an acceptance of our views. We stand between the management on the one hand and the men on the other. Some with whom we will deal will be for us. Many may be open in their opposition to our plans. What we accomplish will be through and with the consent of the existing organizations.

Our problem is therefore complex, *although not at all discouraging.* Our approach must at all times be indirect in nature. A consideration of a few essentials is therefore necessary:

1. We must be extremely tactful in all our dealings with those about us. A genius lacking diplomacy in this work will accomplish less than the man of ordinary ability with an abundance of tact.

2. *We must play a waiting game.* We must recognize first, last, and all the time that a workman or foreman may consider his opinion equal or superior to ours. If, after submitting what we consider proof, we find opposition to our plans, we must take a new tack, secure additional proof, present it in a different way, and work the thing around indirectly. *If we are right time will prove it. If wrong the less said the better.*

3. *Personal bias must be eliminated.* Ill temper must *never* be shown, no matter how great the provocation. Nothing will tip over the structure we hope to build more quickly than losing one's head.

4. Never indulge in destructive criticism. If we cannot recommend something constructive, *say nothing at all.*

5. Apply the *WHY* to everything. The field here is a good one. Surface indications may not point to much, but by digging hard and applying the *WHY*, something substantial will result.

6. We must not appear too serious, as this is a negative attitude. A *smile* and a *cheery word* will assist where a frown would prove harmful.

7. Do not go to a foreman and say—"*This* is the way to do it." Approach him in this manner—"Don't *you* think this would be a good way to do it?" It makes a difference which method is used.

8. We must often let others have the credit for what we may evolve. We must keep out of the limelight. Others want the "Spot" turned on them occasionally. Imagine the feeling of a foreman who after getting the germ of an idea from one of us, and after developing it with us, is allowed to present it to the management as his. *Let us place our thunder where it will occasionally be stolen.*

9. We must never so conduct ourselves as to convey the impression that we are walking libraries of valuable knowledge.

10. *Never become discouraged.* If an obstacle cannot be pushed over, try and walk around it. If this is impossible, *dig under it.* It will give in time, as all obstacles do.

MATTERS TO BE CONSIDERED			
SUBJECT			
JOB	BLDG.	FOREMAN	
BRIEF OUTLINE OF EXISTING CONDITIONS		SUGGESTED METHOD OF BETTERMENT	
DATE MADE OUT	MADE OUT BY	SCHEDULED FOR	DATE

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Fig. 8. Memorandum of Matters to be Considered

11. Do not discuss plans for betterment with shop men until these plans have been talked over with the chief-of-staff and his approval secured.

12. We must commit ourselves to nothing that we are not absolutely sure about. We must know what we want and why we want it. *Mere opinions don't count.*

13. Getting results cannot be secured in an office. *The leads are in the shop.* We are not gifted with second-sight, so our place is *where the leads are.*

14. Ignore what may seem to be watching on the part of others as regards how much work we do, when making investigations. *If we are doing our duty, we can well afford to disregard what others think.*

15. Never rely on memory. *Make notes.* Don't be afraid of using a pencil and note book in the shop.

16. As we think of new avenues of study, make out a card "matters to be considered." (See Fig. 8.)

17. Verbal reports will receive no consideration. Each staff man is to put his findings in writing, submitting same to chief-of-staff.

18. *Never indulge in personalities.* Everyone is right as he sees things. If we lack the ability to change a man's point of view, don't let us attempt to cover up by pointing out the failings of another in none too careful language.

19. Be square with everyone. Taking an idea from someone else and using it as our own *will not be tolerated.*

20. If things go wrong, first analyze to find out where *we* were at fault before criticizing everyone and everything around us.

21. The influence of object lessons on those about us should always be kept in mind, as they will do more towards changing the attitude of those who may oppose us than anything else. *Don't use a trumpet, however.*

22. By all means be friendly with everyone, whether foreman or workman. *It*

costs nothing and will mean much to us in the way of results. *If we cannot rub people the right way we should give way to those who can.*

23. Never go to a workman and flash a stop watch without first acquainting him with our purpose. This the man is entitled to.

24. The hours to be observed are 8 until 12, and 1 until 6. Taking time off must be with consent of chief-of-staff. Jokes and stories are to be reserved until the noon hour or after 6 p.m. *We have a large task ahead of us, requiring our undivided attention.*

25. Staff members must be willing to subordinate their particular desires or pet theories to the good of the work as a whole. *We cannot all have our own way.*

26. Never criticize others to shop men or management. It may be passed along the line, with embellishments at each repeating.

27. A *snap* to the eye and a *barb* on the tongue are things to avoid as they can cause considerable harm.

28. Mingle with the men and foremen as much as possible. This makes for a healthy spirit and will lead to much in the way of new avenues of investigation.

29. Study each move made as a chemist would the completed experiment. Make each move the basis for the next one. Mistakes will happen, *but there is no excuse for two of the same kind.*

30. *Don't call a man down.* It is not our function.

31. Remember that we are here to *lead*, not *drive* or *force*.

32. *Never jump at conclusions.* They may be wrong.

33. If *criticized*, present your argument in a courteous manner, *then stop. Do not fight back.*

34. Never air your personal opinions about the ability or worth of those about you. It will only mean trouble.

35. Review the above *carefully.* Make the various points brought out a part of your everyday work. *The results will surprise you.*

The chief-of-staff is here to *help each staff member secure the greatest results from the efforts exerted.* Give him the opportunity.

The Engineer and the Management

So much for the engineer himself. How is he going to handle the Management? The factors are:

I. The procedure outlined.
II. The order in which the work should be undertaken.
III. The time element.
IV. Co-operation of executive management.
V. Co-operation of shop management.

I. The Procedure Outlined. The engineer should take up with the management the general procedure as he has outlined it. The time to thrash out the details is *before the real work is started* and not after the start is made, for nothing so hampers the securing of results as repeated changes of front. The management will most likely have many preconceived notions which may be good, bad, or indifferent.

The engineer must test to find out just what these notions are so he can combat them if necessary, or vary his procedure to suit when the management "hits a bull's eye." Many times the management wins out over the engineer because the engineer presents a weak case, or a half-baked scheme with which he is not entirely familiar himself and which he cannot explain to the entire satisfaction of the management. If, however, his outline of procedure has been based on a careful analysis and diagnosis, he need worry but little about the attitude of the management, who by comparison is possessed of incidental information, which will not materially influence the case that the engineer can so admirably present.

II. The Order in which the Steps Should be Undertaken. In any plant there are a number of departments to which the methods can be applied. To each the work to be undertaken will bear a definite relation. Such difference as may exist in the influence exerted by the methods installed will be of degree only.

A plan of procedure should therefore be drawn up which will consider all factors, in such a manner as to result in logically selecting the points where a start should be made and deciding what the selections to follow should be. A proper sequence should be kept in mind at all times.

There are several ways of beginning activities:

1. Starting with the plant as a whole, beginning with study, then introducing planning, standardizing conditions and operations, and finally rewarding the workers in proportion to the individual efficiency.

2. Selecting such departments as indicate opportunities for effecting the greatest savings.

3. Beginning the work in starting departments, as for example, in machine works, the foundry, and smith shop.

4. Selecting places where the influence on other departments will be most beneficial.

5. Beginning where the work done bears a definite relation to the measures contemplated.

6. Starting where indicated by a consideration of company policy, or by the effect on men or foremen.

Plan No. 1 can be eliminated, for while it would be productive of results in the end, the progress would be slow at first, without noticeable results, and would tend to prove discouraging to men and foremen. The other plans mentioned are important, and no start should be made in any department until the effects of the various methods of beginning have been fully considered. It is obvious that the ideal start would be in a starting department, showing the greatest opportunities for gains in the quickest time, exerting a decided influence for betterment on the other departments, and having a definite relation between the work done there and the installation as a whole.

Therefore to block out the procedure in an intelligent and comprehensive manner, a list of departments should be made out, showing the product made in each, approximate quantities and capacities, force employed, and source and destination of product. Each department should be studied separately and the following points given careful consideration:

1. Sequence of work, by which is meant travel through plant.
2. Co-operation of department head.
3. Nature of betterment work which should be done.
4. Results possible—whether fair, medium, good, or excellent.
5. Influence of work to be done on other departments.
6. Men employed.

1. As to Sequence, the departments should be classified as:

a. Originating departments, such as foundry and smith shop.

b. Preparatory departments, such as planer, lathe, and drill departments.

c. Assembly departments, where sub-assemblies are built and finishing work done previous to erection.

d. Erection departments, where units are put together.

2. As to Co-operation of Department Heads, each one should be classified under one of the following heads:

a. Active in co-operation and easy to handle.

b. Active in co-operation and hard to handle.

c. Passive in co-operation and easy to handle.

d. Passive in co-operation and hard to handle.

e. Likely to oppose.

3. Under Nature of Work to be done, state whether planning, conditions, operations, bonus, or special features.

4. As to Results Possible, classify departments under fair, medium, good, or excellent.

5. Regarding Influence, the following will illustrate the manner of arrangement:

Influenced by	Dept. being considered	Influences
E and F	A	G
H	B	E
K	C	D

6. Finally, make a list of men in each department.

The essentials are now a matter of record. To reach definite conclusions, set down according to sequence of work, by classes of departments (see No. 1), the points regarding each department as follows:

Dept.	Co-operation of Dept. Head	Handling Dept. Head	Plan of Procedure	Prospects	Influences	Men
A	Active	Hard	Operations Planning Bonus	Medium	K-L-M	55
B	Opposed	Hard	Conditions	Excellent	F	30
C	Passive	Easy	Conditions Operations Planning Bonus	Good	M-N-O-P	100
D	Passive	Hard	Conditions	Excellent	E-F-G	40
E	Active	Easy	Planning	Fair	A-B	60
F	Passive	Hard	Operations Planning Bonus	Good	M-K-L	50

Recapitulation—Departments...... 6
Men.............335
Co-operation...... 2 active, 3 passive, 1 opposed
Handling......... 4 hard, 2 easy
Prospects......... 2 excellent, 2 good, 1 medium and 1 fair

It is obvious as one reviews the above that department C is the place to begin work. The largest number of men are involved, four departments are influenced, the prospects are good, the plans contemplate working along the largest number of lines, and while the foreman is passive, he is nevertheless easy to handle. Department B would come last, for here we have a foreman opposed to the work who would be hard to handle, a small number of men to consider, influencing but one department, with one element of betterment to take care of. Department D is in about the same class, so we can put this as fifth in order.

We have therefore eliminated three departments. Of the others, A, E, and F, analysis will show that Department A should come second. The foreman, although hard to handle, will be active in his co-operation; and while the prospects are medium, the number of men and the plan of procedure are worth considering as well as the departments influenced. Study of E and F will show that F should be third and E fourth. Consequently as to these six departments, the program is as follows:

First..................	Department C
Second................	" A
Third..................	" F
Fourth................	" E
Fifth..................	" D
Sixth..................	" B

After planning the campaign, study is of course the first step. It would be general in character at first, to serve as a basis for planning and for standardizing conditions and operations. Men could be put on bonus to begin with, but the outcome would be dissatisfaction, no results worth mentioning, and a discrediting of the whole proposition simply because the way has not been properly paved for the attainment of the standards.

The first consideration after pointing out higher ideals and arranging for a campaign of study, is to begin the installation of planning and dispatching methods. It will take time to get these methods in proper working order, for the change from planning on short notice, to planning days and weeks ahead—*not in a general way, but as to the details*—is a process evolutionary in nature, starting in a crude way and developing into an efficient and orderly control of manufacturing.

The idea of subordinating the individuality of each department head to a central function is at first distasteful. The planning is for a time open to criticism, for in getting all to look ahead, items are often forgotten or improperly planned. The eventual outcome however will appeal to all, who will say as did one shop Superintendent—"it has simply revolutionized our shop."

The aim at the beginning is to furnish the shops with:

1. Better dispatching of materials and jobs.
2. A good start towards better conditions.
3. A start towards standardization of all operations.

These are the best means for getting the management and men to take every advantage of betterments resulting from the program decided upon. When planning is on a firm basis, with conditions bettered, more careful studies can be started for standardizing operations as to procedure and time, putting the men on schedules, paying bonus, etc.

III. The Time Element. The engineer should make every effort on the start to anticipate the criticism that may come later on, as to the time needed to install the methods. *Few executives have any conception of the time necessary to install the various steps of the program,* and while it may not be considered good policy to "scare" the client before work is even started, it is not good business to make him feel or take for granted that results will be quickly secured when the engineer *knows* that this is quite impossible. This is simple deceit.

Few appreciate, for instance, the work involved in making time and motion studies, nor the immense amount of valuable information they contain. Mystery and secrecy must be avoided. The work requires good judgment and an unbiased mind. It must be started slowly and every step must tell.

The right men must be selected when starting these studies. The work must be carefully analyzed, the best method of procedure under existing conditions determined upon, the tools listed, delays noted, and a number of studies made to arrive at a fair average.

As the work progresses one of the most important features is the investigation of complaints from the men and foremen concerning times and conditions. They are close to the details, and their interest when fully aroused will result in their unwillingness to stand for obstacles in the way—an excellent lead for future betterment. Then there is the matter of securing and analyzing data as to delays which the management can control—a very productive source of information. This must all be investigated, responsibility placed where it properly belongs, and allowances made to men and foremen for what they cannot control.

After records are made showing the efficiency of men, machines, and operations, they must be carefully analyzed to ascertain where standards have not been realized. Failure to attain standards means that inefficiency is still at work, and steps must be taken to find out why, as well as to consider and provide the means necessary to eliminate the causes.

Another field lies in the analysis of material rejections about the plant, for when considered according to causes, men, product, etc., excellent chances to increase efficiency will be discovered.

To get the results possible the management must furnish moral support and active co-operation. The work is not easy, for after standardizing there comes the task of convincing the shops that the standards can be realized, furnishing them object lessons, and pointing out the way to greater things.

The men will feel that they are not getting enough out of it, and the task is to point out to them that the management assumes all the responsibility at first, the men none; that putting in a staff of men, improving conditions, bettering the planning, and taking the time to study carefully all operations, is very costly; and that as soon as the work is well under way the men can earn a great deal more than they can secure elsewhere.

This all takes time, the gathering of considerable information, and careful study and analysis. The results, however, are so great as to make the cost a comparatively insignificant item.

IV. Co-operation of the Executive Management. The introduction of scientific management in a plant is not the work of a day. It is a work requiring the consideration of countless details, unimportant in themselves perhaps, but having a decided influence on the proposition as a whole. It requires tact, patience, and a strong determination to see the thing through to the success possible, regardless of where it hits. It requires the expenditure of money—more than many manufacturers are willing to spend, because of their failure to see the insignificance of the cost compared to the savings possible.

Progress will be slow at first. Men will not have the confidence in the management that is necessary, and steps will have to be taken to show them that the management means business and intends to play fair. During the early stages there will be many things which will not seem to have any bearing on the problems, although a part of the foundation. There will be criticisms of many things undertaken—well meant and logical from the particular viewpoint. There will be suggestions aimed to vary the procedure, although the plans decided upon should be strictly adhered to. The tendency will be to take "short cuts" instead of following the seemingly longer plan outlined.

The management must stand back of the work in its various details. *The methods are not experiments, and should be installed in the way that past experience dictates as the most efficient.* There must be no wavering, for nothing communicates itself so quickly to the working forces as doubt and indifference. Failures are due not so much to the obstacles in the way as to the lack of determination to overcome them. It is difficult and trying to the men responsible for the introduction of efficient methods at one time to sustain the faith and courage of the management and at another to curb its impatience for results.

V. Co-operation of the Shop Management. The engineer must get in touch with the members of the line organization, often doing trivial things which have no real bearing on the object in view, in an effort to fix their attention on higher and better things. The next step is to arouse interest by raising a doubt as regards the success of the existing methods.

This will get them to thinking—noticing the places where improvements can be made, thus paving the way for the next step—desire. This can be accomplished by pointing out what has been done for others in varied lines; what such gains would mean to them and to the company; what stands in the way, etc. Then with the plan of campaign as mapped out in the eighth and ninth chapters fully explained, the details so arranged that everyone's work can be outlined in a specific way, efforts can be concentrated on the task of pointing out the advantages of the methods designed to enable the line officials to apply the principles of efficiency; the importance of the line officials in the scheme of things, and how with much less expenditure of time and energy they can accomplish infinitely more than they are doing.

In the early stages of the work, the tendency will be to become discouraged, to criticize, to want to go back to the old ways, and object lessons must be pointed out. The time element must be considered and discussed. The basis for their fears must be studied, pessimism must give way to optimism, the meaning of each step must be pointed out, and above all they must be assured that the work is in every sense a man's task and worthy their best efforts.

The Engineer and the Workmen

It is most essential that the engineer give serious consideration to the task of securing the support of the men in the plant. This may not be an easy task, but it is not impossible by any means. The workers are going to have an enormous amount to do with the new methods, and their actions and attitude can materially influence success or failure.

In the first place a plant "Efficiency Club" should be organized by the engineer, to hold at least two meetings each month, and it should be made known that the workmen are most welcome as members and that *it is going to be their club.* Various topics can be discussed at the meetings, lectures can be arranged for, all of which will do considerable towards creating a favorable impression.

Another good plan is to give noon-hour talks, one day per week, to such workmen as desire to attend, explaining the practical features of the work, discussing local applications, etc.

Still another excellent means of creating sentiment in favor of the methods is to insert in the pay envelopes of the men brief discussions of the various features of the methods. The stop watch—the relation of conditions and operations to standards—planning and its importance—how standards are made—relations between men and management—the bonus plan—the principles of efficiency, are topics which can be considered. The following is a sample of one presentation which was a printed 3 inch by 4 inch booklet, showing the workman's name on the cover:—

The success of this Company depends upon the success of *each one* employed by it. The success of each one depends upon *the success of the Company.* Our interests are therefore *mutual* and can receive proper attention only through *co-operation.*

We are undertaking the task of increasing the efficiency of our plant. *By this we do not mean speeding up and driving our workers.* We mean that we want to eliminate waste, whether in the form of time, energy, or materials. Our *aim* is *not* to stimulate strenuousness, *for this is not efficiency.*

Strenuousness means *work harder and produce more. Efficiency,* on the contrary, means *work less hard and produce more.* As an example: If you have to walk six feet to the supply of material, you can walk twice as fast and produce more through *strenuousness.* If, however, conditions are improved and the supply placed three feet away, you can accomplish more through *efficiency,* without the expenditure of additional energy.

You want *steady employment* at as *high wages* as you can get. We want as high a production at as low a cost as is possible. This condition *can be brought about* if we will work together in the manner that will be indicated to us by a careful and constructive investigation of the details of the business.

What we want to do is to eliminate:

1. Waste due to faulty planning of work.
2. Waste due to inefficient shop conditions.
3. Lost motion in the operations themselves.

Perhaps you do not get material as you should; you are delayed through no fault of your own; machines may not be working as they should; tools supplied you may mean unnecessary work, *with the result that you cannot do yourself justice.*

Our efforts will first be directed towards improving the planning of the details in connection with production. In theory, we will follow the same method as is used by a railroad company in scheduling and dispatching its freight and passenger trains. In practice, it will mean *working on the right thing, in the right way, at the right time.* This you can see will mean better deliveries, satisfied customers, less rush and hustle in the factory, better working conditions, plenty of work, and, as a result, *you* will share in the success that will naturally follow.

You can assist us to a greater degree than you imagine. Look about you. Study what you are doing. *Do you see a better way to do things? Can you suggest an improvement anywhere?* Remember it is the *little things which count*, so do not hold back because the matter seems too small to talk about.

Remember this also. We want a force of *well-paid, satisfied, willing and progressive workers.* All we ask is that you give those assigned the task of studying our business your support and co-operation. They will help us find waste and inefficiency and assist you in eliminating it.

There should of course be the personal touch between the workmen and the engineer. Getting the men to talk of their ambitions and desires, the rough places in their lives, their criticisms, suggestions, and complaints, will do much to enable the engineer and his assistants to do considerable towards securing the good will and co-operation of the workers.

A reference library should be made a part of the arrangement. All the best books and magazines on efficiency and management should be kept on file and loaned to the men. The literature on the subject is becoming extensive both as to principles and applications. Intelligent workmen and foremen will not only be glad to read the books, but the educational process will be a mighty factor in the attainment of maximum efficiency.

Chapter XI

THE TIME STUDY

IN diagnosing the results of his examination as outlined in the seventh chapter, the engineer found plenty of evidence of inefficient operations and conditions. To secure greater efficiency he first designed the machine necessary to produce results, then he considered the factor of co-operation. What is his next step?

In a casual, accidental sort of fashion he can study by general observations, where surface indications indicate inefficiency. *But supposing there are no surface indications?* He knows from his past experience that two facts stand out so prominently as to admit of no argument:

1. Men can accomplish considerably more than they do.

2. As business is usually conducted, managements do not know what constitutes the best a man can do.

Planning will be outlined to enable the plant to work on the right thing at the right time. *Not necessarily in the right way, however.* Planning answers the *what* and *when.* The engineer must consider the *how* as well.

This can be done only by stop-watch analysis of time and motion. As a preliminary outline of factors, and to show the comprehensiveness of the method, the following steps in making studies may be defined:

1. Resolve the work being studied into its various elements and movements.
2. Determine by the stop-watch the elapsed time spent in each element.
3. List the particulars concerning each element, with the time spent thereon, on sheets prepared for the purpose.
4. Note on this study all delays, useless motions, faulty conditions, and whatever may be found in the way of inefficiency.
5. Note such delays and interruptions as are unavoidable.
6. Study the rest and fatigue of the worker.
7. Analyze the facts secured, determining the amount of preventable waste in time, and ascertain the efficiency.
8. Note the best elements or sets of motions on any kind of work for duplication in other lines.

9. From the data compiled, standardize the operations as to sequence of elements, and prescribe as far as possible the procedure as to the motions.

10. Set opposite each element or set of motions an allowed time which will consider rest, fatigue, and unavoidable delays.

11. Analyze the facts concerning waste and inefficiency, and outline constructive measures to correct the faults found.

12. Index the facts secured so as to file them, for study and reference purposes with like information.

We are now in possession of facts covering the elements to be considered, the functions of time studies, and the general plan of making them. A further refinement is next in order. A machine is in itself a lifeless thing, capable of doing only what man makes it do. The human, however, is altogether different, and no consideration of study methods can be complete without an analysis of the variables in both the worker and the work done.

As regards the work there are:

Size of unit to be handled.
Weight of unit to be handled.
Position of unit to be handled.
Method of handling.
Length of travel.
Position of worker.
Rapidity of motion.
Exertion called for.
Automaticity of motion.
Facilities furnished.

I have repeatedly called attention to the variables of the worker which have as yet received little or no consideration from the industrial world. They are as follows:

CONCENTRATION.—Focusing the mind on one thing.
REASON.—Ability to draw conclusions.
INTEREST.—Exciting attention in a particular thing.
JUDGMENT.—The faculty of reasoning logically.
ENERGY.—Strength and power exerted.
IMITATION.—The inclination to follow the lead of another.
IMAGINATION.—The faculty of forming images in the mind.
ATTENTION.—Application of the mind to a particular thing.
LOYALTY.—Faithful acceptance of a trust.
MEMORY.—Power of retaining and reproducing mental impressions.
INITIATIVE.—The power of commencing something without guidance.

Pleasure in Work.—The faculty of being satisfied with one's work.

In connection with the practical work of making time studies we can divide the work into three classes and then consider each one separately.

First Class, or General Studies

The first class would be used in cases where it is wished to determine the exact time spent on a job. The watch is started when the work is started, it is stopped for delays and irregularities, using the accumulating stem at the left of the winding stem, so as not to set the hand back to zero, and started again when work is resumed. Upon completion of the study the watch will show the net time spent in actually making the work. It will not, however, give any data as to the time taken by each step, nor the wastes in any of the steps. The readings would look about as follows:

Pieces	Minutes
First	85.5
Second	70.8
Third	62.6
Fourth	90.7
Fifth	50.9
Average	72.1
Low	50.9
High	90.7

Second Class, or Operation Studies

The second class of studies are much more valuable than the first class. In this class the work is to be divided into its logical steps and each step listed on sheets along with the elapsed time for each.

These studies can be made in two ways:

1. By listing delays and faults as they are noticed.

2. By throwing out all such information and simply recording net working time.

I prefer the first method, for it is the analysis of such data that indicates the measures necessary to eliminate inefficiency.

There are also three ways of using the watch:

1. Snapping the hand back to zero after each reading.

2. Upon completion of each step, stopping the watch with the accumulating stem, reading the time, and then starting again.

3. Reading the time after each step without stopping the hand.

Personally I prefer the third method, for in this way no time is lost in stopping and starting the watch. An operator soon learns to read the watch accurately without stopping it.

The following studies will illustrate the method of arranging operation studies in permanent form:

Study No. 1—Machining Operations

		Minutes
A	Waiting for piece	6.2
X	Pick up and place in machine	1.4
X	Center	2.5
X	Rough turn	7.1
X	Finish turn	6.5
B	Getting cutting tool to replace wrong one supplied	3.2
X	Face one side	5.1
X	Face other side	4.9
C	Grind cutting tool	5.7
X	Rough turn taper	6.5
X	Finish turn taper	7.2
X	Form radius	5.5
D	Having belt repaired	12.5
X	Forming edge	3.1
E	Waiting for foreman for instructions	5.7
F	Getting cutting tool	3.6
X	Cutting first groove	9.2
G	Grinding cutting tool	5.1
X	Cutting second groove	9.7
X	Cutting thread	10.2
H	Getting chains	6.1
I	Getting leathers to place between chains and work	4.2
J	Delay due to poor working of pneumatic hoist	5.1
X	Piece out	3.2
	Total ... Minutes	139.5

Total of necessary operations (marked X) equals 82.1 minutes.
Efficiency therefore is

$$\frac{82.1}{139.5} = 58.8 \text{ per cent.}$$

The waste or inefficiency of 57.4 minutes or 41.2 per cent is divided as follows:

Due to planning		Minutes	Per Cent
A	Waiting for piece	6.2	
B	Getting cutting tool to replace wrong one	3.2	
E	Waiting for instructions	5.7	
F	Getting cutting tool	3.6	
		18.7	32.6

Due to conditions		Minutes	Per Cent
C	Grind cutting tool	5.7	
D	Having belt repaired	12.5	
G	Grinding tool	5.1	
J	Poor working hoist	5.1	
		28.4	49.5
Due to man			
H	Getting chains	6.1	
I	Getting leathers	4.2	
		10.3	17.9

Comments by Person Making Study

Under planning: the man should not have to wait for material; the right cutting tool should have been supplied him, and the planning should contemplate making the instructions and prints so clear that the foreman would not have to be called upon.

Under conditions: tools should be kept properly ground and ready for use. Delay due to the belt failure should have been anticipated. This also applies to the delay due to poor working of pneumatic hoist.

As regards man: he should have seen to it that he had chains and leather when cutting his second groove or thread. If he tried to get them and failed the delays would be chargeable to faulty conditions.

P. L. Jones.

Time Study No. 2—Moulding Operation

		Minutes
X	Laying board and pattern	3.4
X	Placing drag	2.0
A	Getting riddle from another workman	3.0
X	Riddling sand	2.5
X	Shoveling heap sand	5.2
X	Ramming drag	20.6
X	Placing bottom board	2.1
B	Looking for clamps	6.2
X	Clamping and rolling	5.1
C	Waiting for cope side of pattern to be brought in	9.4
X	Placing cope side of pattern	1.4
D	Waiting for cope	6.7
E	Waiting for carpenter to cut bar	8.3
X	Placing cope	2.1
F	Looking for gaggers	6.3
X	Placing gaggers	4.2
X	Ramming cope	12.4
X	Lifting cope and placing	4.1
X	Finishing mould	27.3
G	Waiting for cores	7.3

	Brought forward (minutes)	139.6
H	Filing cores	4.7
X	Setting and securing cores	12.7
X	Closing	7.1
X	Clamping and weighing	8.3
	Total	172.4

Total of necessary operations (marked X) equal 120.5 minutes.
Efficiency therefore is—

$$\frac{120.5}{172.4} = 69.8 \text{ per cent.}$$

The waste or inefficiency of 51.9 minutes or 30.2 per cent is divided as follows:—

		Minutes	Per Cent
Due to planning			
C	Waiting for cope side of pattern	9.4	
D	Waiting for cope	6.7	
E	Waiting for carpenter	8.3	
G	Waiting for cores	7.3	
		31.7	61.0
Due to conditions			
B	Looking for clamps	6.2	
F	Looking for gaggers	6.3	
H	Filing cores	4.7	
		17.2	33.1
Due to man			
A	Getting riddle	3.0	5.9

Comments by Person Making Study

Regarding planning: pattern and cope with bar properly cut should have been on the moulder's floor when he was ready for them. This also applies to the cores.

Under conditions: the moulder should be kept supplied with clamps and gaggers. Cores should be so made as to require little or no filing.

The man should be responsible for such tools as are given to him and not allowed for time spent in getting same from other workmen.

P. L. Jones.

Time Study No. 3—Structural Shop Operations

Riveting ¾-Inch Countersunk Rivets by Hand

		Minutes
X	5 rivets	7.0
X	10 rivets	12.0
A	Rivets not hot enough	2.0
X	10 rivets	6.0
X	5 rivets	4.0
X	5 rivets	3.5

	Brought forward (minutes)	34.5
B	Waiting for rivets	2.4
C	Reaming 5 holes	3.0
X	10 rivets	11.0
X	10 rivets	7.0
D	Reaming 3 holes	2.5
X	10 rivets	7.2
X	5 rivets	3.5
E	Rivets not hot enough	2.2
X	10 rivets	8.0
X	10 rivets	6.5
F	Waiting for rivets to heat	7.4
X	10 rivets	6.7
X	10 rivets	7.1
G	Reaming 5 holes	3.5
X	5 rivets	4.0
X	10 rivets	6.1
H	Reaming 6 holes	3.5
X	10 rivets	6.7
	Total	132.8

Total of necessary operations (marked X) equals 106.3 minutes.

Efficiency therefore is

$$\frac{106.3}{132.8} = 80 \text{ per cent.}$$

The waste or inefficiency of 26.5 minutes or 20 per cent is divided as follows:—

		Minutes	Per Cent
Due to planning			
F	Waiting for rivets to heat	7.4	28
Due to conditions			
A	Rivets not hot enough	2.0	
B	Waiting for rivets	2.4	
C	Reaming	3.0	
D	Reaming	2.5	
E	Rivets not hot enough	2.2	
G	Reaming	3.5	
H	Reaming	3.5	
		19.1	72.0

Comments by Person Making Study

Under planning: rivets should be supplied in advance so that there will always be rivets in the furnace.

Regarding conditions: rivet boy at furnace should be instructed to not throw rivets to gang that have not been properly heated. The reaming should be done by a separate gang, which should follow up the riveting gang.

P. L. Jones.

TIME STUDY No. 4—WOODWORKING SHOP OPERATION—TENONING

		Minutes	
X	Running	33.03	
X	Changing head	33.72	(1 change)
A	Getting work	.19	
B	Getting material to replace spoiled	9.80	
C	Taking work away	3.12	
X	Oiling	1.08	
D	Looking over next load	3.12	
E	Changing trucks	2.44	
F	Asking for next job	9.82	
X	Changing for length	5.90	(5 changes)
G	Waiting for job ticket	12.52	
H	Interrupted by rail sticker man	1.08	
X	Measuring rail	2.23	
X	Marking rail	1.26	
I	Getting drink	.84	
J	Getting chalk	3.68	
K	Removing sliver from hand	.98	
L	Talking to Superintendent	6.91	
X	Changing for thickness	1.98	(1 change)
X	Changing belt for speed	1.30	
	Total time	135.00	

Production, 725 rails running two at a time.

Total of necessary operations (marked X) 80.50 minutes.

Efficiency is

$$\frac{80.50}{135} = 59.6 \text{ per cent.}$$

The waste or inefficiency of 54.50 minutes or 40.4 per cent is divided as follows:—

		Minutes	Per Cent
Due to planning			
F	Asking for next job	9.82	
G	Waiting for job ticket	12.52	
		22.34	41
Due to conditions			
E	Changing trucks	2.44	
J	Getting chalk	3.68	
A & C	Getting and taking work away	3.31	
B	Replacing spoilage	9.80	
		19.23	35
Due to man			
D	Looking over next load	3.12	
H	Interrupted by rail sticker man	1.08	
I	Getting drink	.84	
K	Taking sliver from hand	.98	
		6.02	11

Due to management	Minutes	Per Cent
L Talking with Superintendent	6.91	13

ANALYSIS OF NECESSARY OPERATIONS

		Minutes	Per Cent
Running time		33.03	41
Changing time			
Head	33.72		
Length	5.90		
Thickness	1.98		
Speed	1.30	42.90	53
Other operations			
Oiling	1.08		
Measuring rail	2.23		
Marking	1.26	4.57	6
Total		80.50	100

COMMENTS BY PERSON MAKING STUDY

Delays F & G under planning can be avoided by not only scheduling a "Next Job" but having material ready at machine.

Under conditions: delay H could be avoided by arranging so that machines will be properly supplied with trucks. Chalk properly sharpened should be supplied men. Material supervisor should also arrange to get work to machine and from machines when finished. Workmen should not have to replace spoilage. This should be done under direction of planning department and material supervisor.

As to the workman: a study of the delays will show that he should not be allowed for the delays listed.

P. L. Jones.

TIME STUDY NO. 5—WOODWORKING OPERATIONS—BORING

		Minutes
X	Running	59.12
X	Changing for style	15.13
X	Changing for length	4.44
A	Getting work	10.19
B	Taking work away	3.67
C	Consulting about time study	2.89
D	Scraping away sawdust	21.88
E	Consulting about shortage	4.19
F	Getting shortage	16.39
G	Recording production	2.09
X	Getting rod	2.79
H	Drink	2.31
I	Stile stuck in machine (too long)	2.14
J	Interrupted for layout	.69

	Brought forward (minutes)	147.92
X	Testing point of bit	.62
X	Taking off 4 bits	2.68
X	Putting in 4 bits	2.26
K	Waiting for clerk	1.11
X	Consulting about layout	1.61
L	Waiting for layout of stiles	13.51
M	Looking for truck	9.02
X	Comparing stile with rod	.52
	Total time	179.25

Production, 305 pieces.

Total of necessary operations (marked X) 89.17 minutes. Efficiency is

$$\frac{89.17}{179.25} = 49.7 \text{ per cent.}$$

ANALYSIS OF NECESSARY OPERATIONS

		Minutes	Per Cent
Running		59 12	66.3
Changing			
Style	15.13		
Length	4.44		
Bits	4.94	24.51	27.3
Other operations			
Getting rod	2.79		
Testing point of bits	.62		
Comparing stile and rod	.52		
Consulting about layout	1.61	5.54	6.4
Total		89.17	100.0

The waste or inefficiency of 90.08 minutes or 50.3 per cent is:

Due to planning			
G	Recording product	2.09	
K	Waiting for clerk	1.11	
		3.20	3.5
Due to conditions			
A&B	Getting work and taking away	13.86	
D	Scraping away sawdust	21.88	
E&F	Consulting about and getting shortage	20.58	
I	Stile stuck in machine	2.14	
J	Interrupted	.69	
L	Waiting for layout	13.51	
M	Looking for truck	9.02	
		81.68	90.7
Due to man			
C	Consulting about time study	2.89	
H	Getting drink	2.31	
	Total	5.20	5.8

Comments by Person Making Study

Under planning: man should not have to record production, and the planning should be so arranged that a man should not wait for a clerk.

Under conditions: material supervisor, in conjunction with dispatcher, should arrange for supplying work scheduled and taking same away. The necessity for scraping away sawdust should be eliminated by bettering the suction apparatus. Man should not have to replace spoiled work. This should be done under the direction of the dispatcher and material supervisor. Steps should be taken to see why pieces are too long so that material won't stick in machines. Properly arranging for laying out work in advance would do away with delays like J & L. Trucks should be provided so men won't have to look for them.

Man should not be allowed for delays C & H. *P. L. Jones.*

Riveting; ¾-Inch, Countersunk by Hand (See Page 103)

	Riveting		Reaming		Delays	
Time	Number	Time	Number	Time	Time	Reason
0–7.0	5	7.0				
19	10	12.0				
21					2.0	Rivet not hot enough
27	10	6.0				
31	5	4.0				
34.5	5	3.5				
36.9					2.4	Waiting for rivet
39.9			5	3.0		
50.9	10	11.0				
57.9	10	7.0				
60.4			3	2.5		
67.6	10	7.2				
71.1	5	3.5				
73.3					2.2	Rivet not hot enough
81.3	10	8.0				
87.8	10	6.5				
95.2					7.4	Waiting for rivets to heat
101.9	10	6.7				
109.0	10	7.1				
112.5			5	3.5		
116.5	5	4.0				
122.6	10	6.1				
126.1			6	3.5		
132.8	10	6.7				
Total....	135	106.3	19	12.5	14.0	
Reaming.....		12.5				
Delays.......		14.0				
Total time...		132.8				
A	B	C	D	E	F	G

10/26/13

P. L. Jones.

Name of Part		
Symbol	Group	Mat'l
Operation		
		No. of Tools in use
Type of Machine		No. Pcs. Machined
Machine No	Gang No	Dept.
Belt Motor	Kind of Steel	Tools

NO.	OPERATIONS	SPEED	FEED	CUT	MEN	Minutes Actual	Minutes Allowed
TOTAL TIME IN MINUTES							
TOTAL GANG HOURS MEN							

Remarks		
NAME OF OPERATOR OR LEADER	RATE	EFFY
Time Study No.	Made by	Date
Approved by	Schedule No.	Date

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Fig. 9. Form for Recording a Time Study

In listing the information when the study is made, the best plan is to use plain quadrille ruled paper in a loose-leaf binder, making the entries in pencil. The study should then be written up in ink or by a typewriter on some standard form designed for the particular work. Fig. 9 will illustrate the method to follow in the machine shop. To show clearly how to make the study previous to transcribing, we can use the riveting study, shown in the lower half of the opposite page, as an illustration.

The entries in columns C, E and F would be made in the office upon completion of the study. The cumulative time at A along with the number of rivets driven and holes reamed, as shown by B and D and the reasons as given at G, would be entered when making the study. From the information as shown Study No. 3 is written up in permanent shape.

The following assembly study will outline the method of making such studies prior to transcribing and putting data in permanent shape:

	Btm Stile	Top Stile	Btm Rail	Top Rail	Panel	Take Away	Delays Time	Delays Key	Production √ = 1 door	Delays
	.18	.25	.05	.13	.05	.13	.41	D	√ √ √	A Waiting for
	.18	.24	.05	.16	.06	.13	.95	E	√ √ √	work
	.20	.23	.05	.13	.07	.12	.61	B	√ √ √	
	.18	.27	.07	.17	.06	.12	.62	B	√ √ √	B Waiting for
	.19	.31	.07	.13	.06	.13	.43	B	√ √ √	press
	.21	.29	.08	.14	.08	.12	1.50	B	√ √ √	
	.22	.23	.08	.11	.07	.13	2.31	C	√ √ √	C Taking doors
	.21	.28	.09	.17	.06	.11	.51	B	√ √ √	apart
	.22	.30	.06	.13	.08	.13	1.05	B	√ √ √	
	.20	.31	.07	.12	.06	.14	.61	B	√ √	
	.22	.30	.06	.12	.07	.13	1.31	A	√ √	D Piling mate-
	.24	.28	.08	.12	.09	.14	5.12	C	√ √	rial
	.23	.30	.08	.15	.07	.13	.89	A	√ √	
	.23	.31	.08	.15	.07	.12	1.41	C	√ √	
	.23	.30	.08	.12	.08	.14	.45	B	√ √	
	.22	.28	.09	.17	.08	.13	.42	A	√ √	E Changing
1.	.21	.28	.07	.14	.08	.13	1.22	A	√ √	
2.	.18	.23	.06	.11	.05	.11	.55	A	√ √	Gluing machine
							.58	B		
							.62	B		
							.17	B		
							.80	B		
							11.80	A	49	
							.51	B		
							.31	B		
							.11	B		
							.08	B		
							.50	B		
							.10	B		
							.28	B		
							.38	B		
							36.61			10/21/13

1 Average time
2 Best time

P. L. Jones.

In putting this information into permanent shape the facts would be copied as in studies 1 to 5 in addition to which there would be the following data to make the study complete:

TOTAL OF NECESSARY OPERATIONS

(.21 + .28 + .07 + .14 + .08 + .13) ÷ 49 doors = 44.6 minutes average time

Necessary operations	44.6	minutes
Delays	36.6	"
Total	81.2	"

Efficiency therefore is 44.6 ÷ 81.2 = 54.9 per cent

The waste or inefficiency of 36.6 minutes or 45.1 per cent is divided as follows—

Due to planning			
Waiting for material	16.19	16.19	44.2 per cent
Due to conditions			
Waiting for clamp	10.22		
Taking doors apart	8.84		
Piling material	.41		
Changing machine	.95	20.42	55.8 per cent

COMMENTS BY PERSON MAKING STUDY.—Sufficient material should be furnished in advance so men will not have to wait for it. A helper should be placed with clamp man to eliminate waiting for clamp. Faulty panels should not be used. This would do away with taking doors apart. Material should be properly piled for assemblers by men taking the material to benches. *P. L. Jones.*

The following study will show the method of noting when the times are large enough to enable the operator to record the time for all factors. In the door study the times were so small that the study man could not get readings on each of the operations for all doors. This also illustrates the method of making assembly studies.

ASSEMBLING A & C FRAMES X 220

Operation	C	N	C	N	C	N	C	N	C	N	Avg	Best
Placing Shaft on Skids	0.7	0.7	15.3	1.0	31.2	0.6	49.2	0.8	75.5	0.7	0.76	0.6
Attaching L. H. Collar	2.1	1.4	17.3	2.0	32.4	1.2	51.0	1.8	77.1	1.6	1.60	1.2
Attaching R. H. Collar	3.6	1.5	18.6	1.3	34.5	2.1	54.0	3.0	79.1	2.0	1.98	1.3
Fastening bolts	5.1	1.5	20.3	1.7	35.7	1.2	55.8	1.8	81.2	2.1	1.66	1.2
Putting on clutch	8.5	3.4	24.5	4.2	38.5	2.8	60.9	5.1	84.9	3.7	3.84	2.8
Attaching Spring	11.3	2.8	27.6	3.1	43.9	5.4	68.5	7.6	89.4	4.5	4.68	2.8
Bolting on lever	13.3	2.0	29.4	1.8	46.3	2.4	73.0	4.5	93.6	4.2	2.98	1.8
Removing	14.3	1.0	30.6	1.2	48.4	2.1	74.8	1.8	95.5	1.9	1.60	1.0
Total		14.3		16.3		17.8		26.4		20.7	19.1	12.7

C Cumulative Time. N Net Working Time.

To illustrate further the method of making studies when times are so small as to render it next to impossible to take consecutive readings, the following turret-lathe study is offered. This would be written up in permanent form exactly as taken, plus such comments as the time-study man would be able to make.

	Putting Piece in	1st Roughing Cut	Changing Tool	2d Roughing Cut	Changing Tool	Square End	Removing Piece
	.20	.35	.06	.18	.06	.26	.14
	.18	.37	.07	.21	.04	.23	.13
	.14	.33	.05	.19	.07	.23	.14
	.13	.29	.04	.19	.06	.25	.12
	.15	.34	.07	.19	.05	.22	.11
	.16	.30	.06	.19	.05	.25	.12
	.14	.33	.05	.16	.04	.26	.11
	.13	.28	.05	.20	.07	.24	.12
	.18	.31	.06	.19	.06	.25	.12
	.13	.29	.05	.18	.06	.19	.09
	.15	.30	.07	.22	.04	.23	.16
	.14	.30	.04	.21	.05	.27	.14
	.15	.32	.04	.23		.32	.14
		.32		.22		.29	.12
		.34		.21		.26	
Avg.	.152	.318	.054	.198	.054	.25	.125
Best	.130	.280	.040	.160	.040	.19	.090

The chart reproduced in Fig. 10 will show the possibilities in presenting time-study data in graphical form. It will further illustrate the making of two studies at the same time by two different men. Being a rolling operation, one man covered the production of the roughing rolls while the other covered the delays of the finishing rolls.

Third Class, or Detailed Studies

Some time ago I studied the making of candy. In watching the girls hand-dipping the centers I was surprised at the rapidity and co-ordinations of the motions, which were made with such swiftness and dexterity that the eye could scarcely follow them, and I thought it was going to be by far the most difficult task of time-study work I had encountered.

Close study soon revealed the fact that the motions were divisible into certain classes, each class having its own peculiarities. By starting the watch when the girl began the motion and stopping it by using the accumulating stem when she finished the motion, then waiting

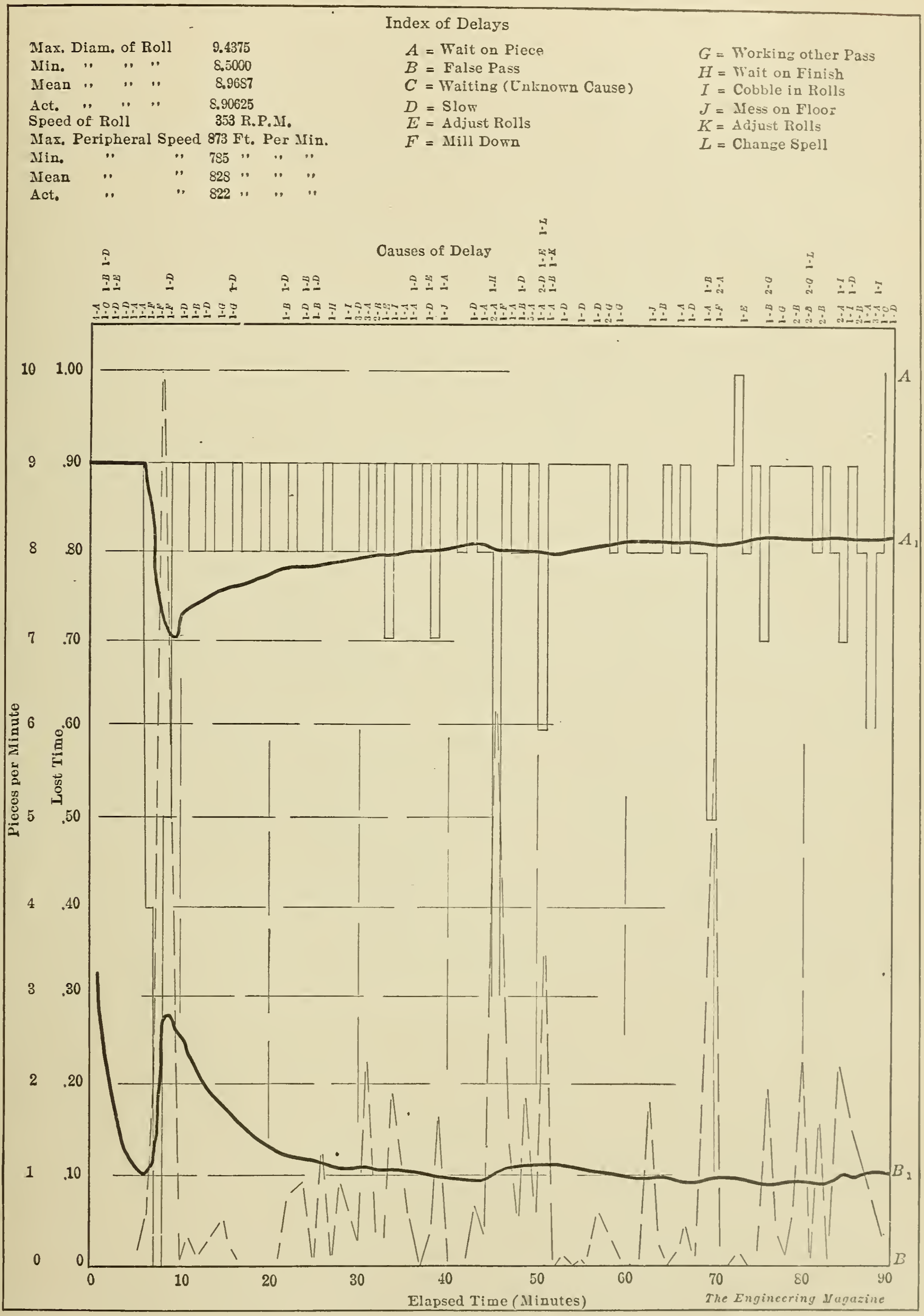

Fig. 10. Chart of Dual Time Study of a Rolling Operation

A = Pieces per minute passing through the rolls. A1 = Accumulative average pieces per minute.
B = Lost time per minute on the rolls. B1 = Accumulative average lost time per minute.

until she started the same motion again, then starting the watch, I was able to get some valuable information. I saw, too, that there was a definite relation between one motion and another, and by studying the performance of a number of girls separately, to determine the peculiar motions followed by each, it became possible to reach some important conclusions. Some girls made ten motions per piece, others 5. The average was 8.8 motions. Standardizing showed that 7 motions were sufficient, and that through proper directions and training 6 motions would do the work as efficiently as 8.8 motions. When it is considered that the girls averaged 83,000 motions per day of 9 hours, it can be seen how impossible it would have been to study the work in any other way.

To explain the method of following this class of studies let us assume the motions and times for six operators as shown in the table following:

A.		B.		C.	
Motions	Time	Motions	Time	Motions	Time
1	2.0	M 1	2.2	M 1	2.4
M 2	2.1	N 2	2.2	N 2	3.1
3	3.0	O 3	1.9	3	1.6
N 4	1.5	P 4	2.1	O 4	2.1
O 5	3.4	Q 5	1.6	P 5	3.4
6	1.2			Q 6	1.6
P 7	2.4				
Q 8	1.3				
	16.9		10.0		14.2

D.		E.		F.	
Motions	Time	Motions	Time	Motions	Time
1	2.4	1	2.6	M 1	1.8
M 2	1.6	M 2	1.4	2	2.4
3	2.1	N 3	1.6	N 3	1.2
N 4	1.9	4	2.1	O 4	3.0
5	3.4	O 5	1.4	5	2.0
O 6	2.0	P 6	2.2	P 6	1.6
7	1.3	Q 7	1.6	Q 7	1.8
P 8	1.5				
Q 9	3.0				
10	2.0				
	21.2		12.9		13.8

Operator B had the fewest motions, 5 in number, designated by letters M, N, O, P, and Q. The motions of the other operators corresponding to these 5 motions have been marked with these letters, which means that those not marked are the unnecessary ones, capable of elimination through training and study. The average number of motions is 7.16, the lowest number is 5. Consequently efficiency as to motion is

$$\frac{5}{7.16} = 69.83 \text{ per cent}$$

Let us now analyze the times, covering the same motion, as follows:

M	N	O	P	Q	Total
A 2.1	1.5	3.4	2.4	1.3	M 1.91
B 2.2	2.2	1.9	2.1	1.6	N 1.91
C 2.4	3.1	2.1	3.4	2.0	O 2.30
D 1.6	1.9	2.0	1.5	1.6	P 2.20
E 1.4	1.6	1.4	2.2	1.8	Q 1.65
F 1.8	1.2	3.0	1.6		
Avg. 1.91	1.91	2.3	2.2	1.65	9.97

The average time of the motions per operator is as follows:

A	16.9
B	10.0
C	14.2
D	21.2
E	12.9
F	13.8
Avg.	14.8

The efficiency as to speed of motions is therefore:

$$\frac{9.97}{14.8} = 67.36 \text{ per cent}$$

The average of the efficiencies 69.83 per cent and 67.36 per cent is 68.59 per cent. Is this the real efficiency? First consider the following ratio:

$$\frac{\text{Standard } 9.97 \times 5 \text{ motions}}{\text{Actual } 14.8 \times 7.33 \text{ motions}} = 47.04 \text{ per cent}$$

The product of the motion and speed efficiencies of 69.83 per cent and 67.36 per cent is 47.037 per cent. Consequently this is the real efficiency *due to the law of dependent sequence.*

Law of Dependent Sequence

In order to understand this law of dependent sequence more clearly, and it is a most important factor, let us show an actual performance against a standardized multiple radial-drill operation.

Item	Standard	Actual	Efficiency per cent
A Speed	325	210	64.61
B Feed	.012	.006	50.00
C Number of drills	4	2	50.00
D Drilling Time	2 minutes	12.4	16.15
E Handling Time	6 "	20.7	28.98
F Production	75	18	24.00

It will be observed that in the efficiency column there are five ratios. What is the real efficiency and why? Let us try a few calculations.

		per cent
The average of A B C D and E	=	41.94
" " " A B C and E	=	48.39
" product " A B C D and E	=	.75
" " " A B C and E	=	4.68

The discrepancies are such as to show that final efficiency is *neither the average nor the product of the elements.*

Considering the machine, and there are three factors—speed, feed and number of drills. The drilling time is 12.4 minutes. From the rule "Actual time × Efficiency = Standard" we find the following:

12.4 min.	× 64.61 per cent	speed	efficiency	= 8 min.
8 "	× 50 "	feed	"	= 4 "
4 "	× 50 "	drill	"	= 2 "

Now from the rule "Standard Time ÷ Actual Time = Efficiency" we have:

$$\frac{\text{Standard time 2 min.}}{\text{Actual time 12.4 min.}} = 16.15 \text{ per cent efficiency}$$

The product of the three factors A, B, and C (64.61 × 50 × 50) yields 16.15 per cent efficiency.

Considering man and machine together, we have:

	Standard	Actual	Efficiency per cent
Drilling time......	2 minutes	12.4	16.15
Handling time....	6 "	20.7	28.98
Total............	8 "	33.1	24.0

Applying the efficiency rule to production, the result is:

$$\frac{\text{18 pieces actual}}{\text{75 pieces standard}} = 24 \text{ per cent efficiency}$$

These calculations show that the *law of dependent sequence* applies to the product of A, B, and C, and that the *law of average* applies to the product of A, B, C, and the element E.

Many wonder how long a study should take. This is a difficult question to answer. When starting a study it is next to impossible to determine just what will be unearthed in the way of data and facts. A study may take an hour or it may take a week. It all depends upon the work studied, the degree of complication and where the strings lead to. A safe rule to follow is—"*Take as much time as will result in sufficient facts on which to base conclusions which will withstand any attacks.*"

Rest and Fatigue

No standard should be determined from a time study without considering the fatigue of the worker and the amount of rest required. If an ultimate attainment is 10 units in a day, it requires greater exertion per unit to go from 9 to 10 units than from 7 to 8 units. Counting normal effort 1, exertion for greater accomplishment is not 1, 2, 3, 4, 5, but rather 1, 2, 4, 8, 16. Yet men are often criticized for not attaining the 20 per cent from 80 to 100 per cent efficiency as readily as the 20 per cent from 60 to 80 per cent efficiency. The rule to follow is:

"Any standard determined should be one that a man can attain day in and day out without injury to his health of body and mind."

To give a practical example: An operation was recently scheduled at 23 pieces per hour, and the workman over a reasonable period was unable to attain the standard. It was decided to make a careful analysis to ascertain why he was unable to do so. The man, working as he usually did, produced 15.8 pieces per hour during the morning of the day he was turned over to the writer. The following time study will show how rest was considered, and the influence it exerted.

Hour	Rest Minutes	Work Minutes	Pieces Produced	Total Pieces
1st	noon	25	9	18
	5	25	9	
2d	5	27	10	20
	3	27	10	
3d	3	17	7	22
	3	17	7	
	3	17	8	
4th	3	10	5	23
	2	10	4	
	2	10	5	
	2	10	4	
	2	10	5	

Highest time recorded per piece—3.0 minutes. Lowest time recorded per piece—1.55 minutes. Best time for short run—5 pieces in 10 minutes.

The operation was intensely fatiguing, yet you will notice that in the fourth hour after starting the study, or the ninth from starting time in the morning, *the worker did his best work.* The average pieces per hour for the four hours run was 20.7 as against 15.8 in the morning—an increase of 32.6 per cent. It may be well to say in connection that the man subsequently attained an efficiency between 95 per cent and 100 per cent on this work.

To illustrate more clearly how the stop watch can be used to advantage in determining the part fatigue plays in work, the following figures will be found interesting to the student of the human. A man grinding castings on a 6-foot grindstone was studied for 1.8 hours. At the beginning of the work 21 pieces were studied, showing an average time of .739 minutes per piece. When about one-half of the work had been completed, 16 pieces were carefully timed, which showed an average time of .907 minutes per piece. As the man was about to finish, 8 pieces were studied with an average time of 1.07 minutes per piece. The showing is as follows:

At beginning	21 pieces	.739 minutes	Base
One-half way	16 "	.907 "	22.7 per cent above base
At finish	8 "	1.070 "	44.8 " " " "

The chart (Fig. 11) shows the effect of fatigue on this operator.

The man worked consistently and there was no sign or evidence of loafing. During the first part of the work, he turned out several pieces in times ranging from .59 to .75 minutes each. The work to be done was fairly constant, and consisted of grinding the same surface each time, instead of removing fins, so that the variations due to the material and kind of work played a small part. It was simply a case of the man going at it too hard at first and becoming exhausted before finishing. This can better be appreciated by explaining that, in working, the man did not work by standing over the wheel and bearing down with his entire weight, nor was he standing in front of it bearing against the wheel with all his power. He was in front and a little above the center so that he had to bear down at an angle of about 35 degrees. Further, in picking up the pieces, at the beginning he took an average of .025 minutes per piece, while at the finish *he was taking .052 minutes per piece, an increase of 108 per cent.*

Speeding the Workers

I am sometimes asked if the stop-watch time study is aimed to speed up and drive the men. If I felt for a moment that this was

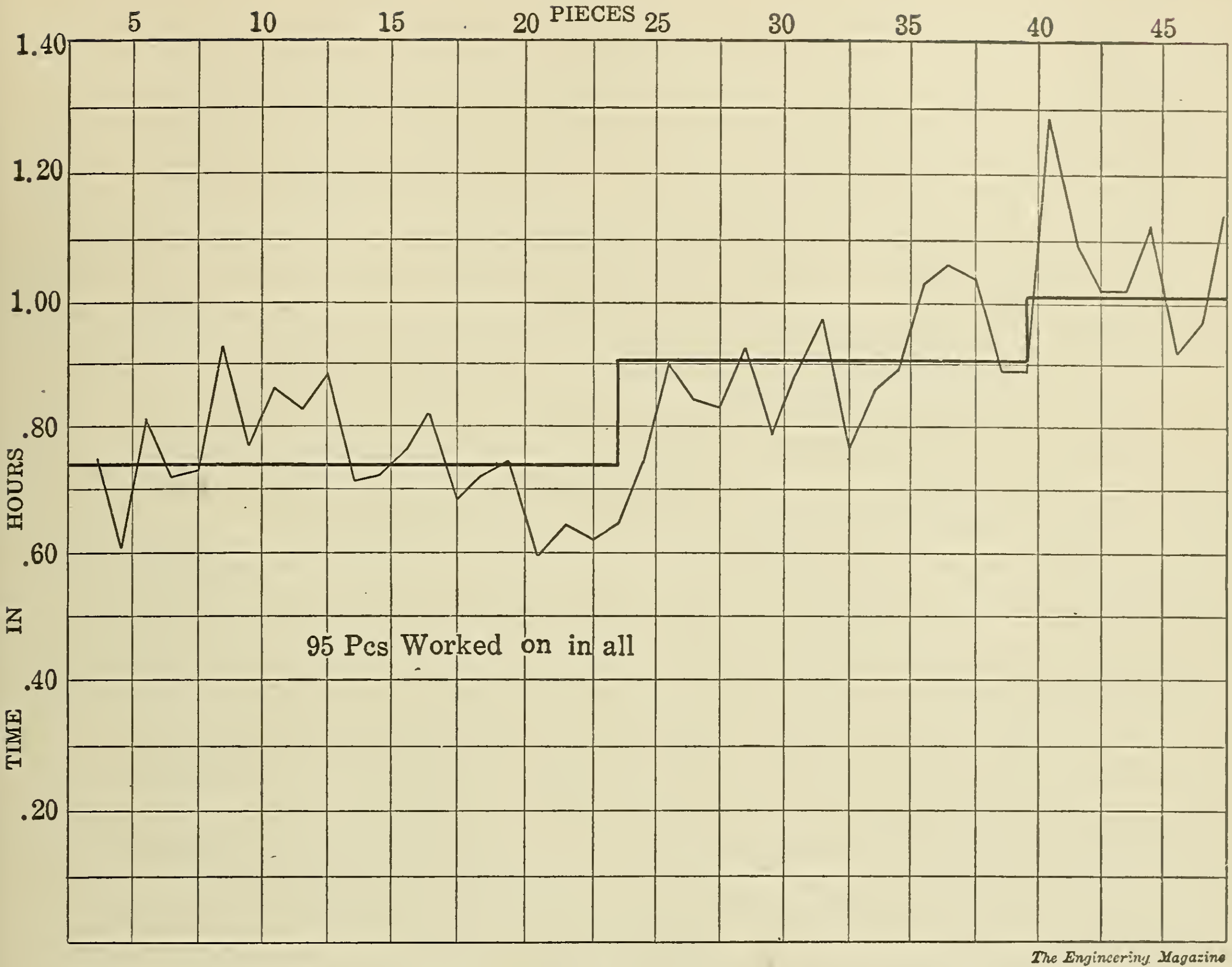

Fig. 11. Chart Showing Influence of Fatigue on a Grindstone Operator

so I would in the future refuse to use one or have one used for me. In the hands of men *with their hearts in the right place* the time study is one of the most powerful agencies there is in bringing about greater efficiency.

There are three ways to make a time study:

1. Keeping the watch in the pocket so as to fool (?) the workman.
2. Going up to a man and, without saying a word, flashing a watch and beginning to make notes.
3. Explaining to the men the purpose of the study; why the watch is necessary; what it all means; winning their consent and even their interest and approval, and then making the study.

The first plan is the rankest kind of deceit, and the man who uses this method should not be surprised if the men in turn try to "go him one better." He deserves it.

The second plan is disconcerting to the men; it arouses their antagonism and makes them feel that they are mere puppets—to be observed without any right to protest or to ascertain the purpose of the study. Only a man lacking tact and with no knowledge of human nature would attempt this sort of a study.

With the stop watch I have studied coal miners, moulders, smiths, laborers, machinists, structural workers, and men and girls in other lines. I have yet to have my first difficulty because my plan has been:

1. Getting acquainted with the men.
2. Explaining the use of the time study and the stop watch.
3. Securing the confidence of the worker.
4. Explaining and discussing with the men the details of the work as the study progressed.

Starting the Time-Study Campaign

In order to begin the work of time and motion study, the first consideration is the selection of men possessing the following qualifications:

Tact
Patience
Accuracy
An analytical mind
A good imagination
Constructive reasoning ability
Experience in the line of work being studied.

In case you cannot find such men (and they are scarce indeed), the men to make the studies should possess the first five. Their studies should then be turned over to men possessing the last two. Chemists make first-class time-study men because of their thorough training along lines of analysis and precision.

After the men have been found, they must learn how to use the stop watch and make the studies. Having them read all about it, telling them what to do, and even elaborate instructions, will accomplish less than their actual contact with the work. The best advice is therefore to turn the men loose, *after the way has first been properly paved*, and have them start in, no matter how crude their findings may be at first. They will learn more about how to make studies in their efforts *actually to make them*, than in any other way. Their reports should be taken and carefully reviewed by the person in charge of the work, and advice should be given upon the points they fail to grasp. Send them back and repeat the process and they will in a short time have a thorough conception of the work, in addition to considerable experience of a decidedly practical value.

As soon as they can be trusted to make the studies and record their data properly, have them start the work of commenting so as to test for imagination and constructive ability. If their comments are good and they show promise of constructive ability, they can then be trained along lines of outlining betterments. Otherwise this part of the work should be turned over to a second set of men who should be trained to take time-study data, briefly study the work studied so as to be familiar with the details in a general way, and standardize the findings as to conditions, operations, and planning.

Chapter XII

THE PLANNING DEPARTMENT—ANALYSIS AND MATERIAL CONTROL

MANUFACTURING should be regarded as an attempt to realize an ideal, concretely expressed in business as the production of a definite number of units of design, in a definite time, within a definite cost limit. Success in realization depends upon:

1. The ideal itself—whether high or low; whether clearly defined or imperfectly stated or understood; whether effectively kept before the organization by constant measurement of performance, or lost to sight by neglect to compare performance constantly with standards.

2. The means provided the organization for working out the ideals.

3. The use of the means provided.

With this as a basis, how are we to proceed to the development of the machinery which will create the ideals, provide the means, and arrange for their proper use? The basic thought can be expressed in the form of a theorem:

> Given a plant and equipment with an organization to handle the work, the manufacture of all that is designed by the engineering department and sold by the sales department can be handled to best advantage only when the details, instead of being considered independently by each department, *are controlled by one function* which can consider each detail in connection with all the others and act as a "clearing house" for all information in any way affecting the manufacturing.

It is obvious that no man should do any work that can be performed as well by another with less skill and at less expense, nor should work be assigned to men because they have nothing else to do, instead of to those best fitted to do it. Further, efficient manufacturing requires the assignment of sufficient work in advance and properly coordinated to keep the men fully employed during the day. It is also conceded that the relative importance and availability of all work should be known and considered—that lost motion and waste time should be eliminated, and that changes and rush orders should be reduced to a minimum.

This can all be done in the most efficient manner from one place instead of many. Our theorem is therefore true, and means *planning*—the purpose of which is to provide a means whereby all details in connection with production can be intelligently planned in advance and efficiently dispatched—each machine or gang enabled to work with reference to all other machines and gangs—the shop management enabled through advance knowledge to provide the necessary elements —materials, machines, tools, drawings, etc.

The fundamental considerations in any scheme of efficient planning must be known and built into the planning structure. They are:

1. A knowledge of what to make, the quantities, and the time in which to make them.
2. Complete up-to-the-minute knowledge of stock receipts and disbursements.
3. Prompt checking of requirements against stock records.
4. Maintenance of stock margins that will insure material being on hand when wanted.
5. Analysis of the parts entering into the manufacture of the product, their operations and the estimated time per operation.
6. Routing of orders analyzed to machines and gangs.
7. Study of planning to avoid congestion.
8. Rearrangement of schedule to meet unforeseen contingencies.
9. Replacing spoiled or defective material.
10. Charting progress of orders.
11. Study of conditions interfering with prompt execution of plans.
12. Delivery of material to machine and gangs.

With these agreed to, it is necessary to consider a few rules so important that the *success or failure of the planning is entirely dependent upon their observance.* These are:

1. No work should be undertaken in any department of the plant without an order in writing.
2. No orders are to be started until they have first passed through the planning department for attention and scheduling.
3. No job will be considered available until everything *is* or *will be* ready for the work.
4. No job is to be changed after starting until the planning department has been notified and arranged for the changes.
5. No part of an operation is to be started by a succeeding operation until the planning department has arranged for it.
6. Sufficient work must at all times be scheduled ahead so that there will be no likelihood of a machine or gang running out of work. Better to schedule too much work than not enough.
7. No material is to be moved to a starting operation without the knowledge of the planning department.

8. There must be a "next job" for every machine and gang with everything in readiness for the work.

The engineer should first of all arrange for the immediate selection and training of the staff that will look after the work of planning. This staff should consist of the following:

A *planning supervisor*, who is to have charge of the work of planning and dispatching under the direction of the engineer. Under the planning supervisor are to be:

A. A *chief dispatcher*, who is to have charge of the details in connection with scheduling the work.

B. A *material supervisor*, who is to have control of all details in connection with the movement, handling, and recording of all material.

Under the chief dispatcher are to be:

a. Department dispatchers.
b. Schedule clerk.
c. Record clerk.
d. Messengers.

Under the material supervisor:

a. Stock keeper.
b. Receiving clerk.
c. Material clerk.
d. Men in charge of moving material.

Now what? It is obvious that no planning of any kind can be done until it is known what is going to be made. Further, no work can be undertaken until it is known what is in stock, what must be made, and what must be purchased. It is also necessary to know what is done and when it is done in order to keep track of progress. This therefore means:

Analysis of work to be done
Material control
Time keeping

and the engineer can do no real work towards the realization of his ideals as to planning until he has provided for these essentials.

Analysis of Work

This matter of analysis is important, so much so as to form the real basis of the work whether the thing to be made is an engine, a stand pipe, a door, or a lot of castings. There must be a comprehensive knowledge regarding what is to be done.

ANALYSIS OF PART No.__________

TYPE GROUP PART

NO.	NAME OF OPERATION	ASSIGNMENT		SPEED	FEED	CUT	TOOLS-JIGS	PRICE PER____		SCHEDULE NO.	TIME PER____	
		STD	CHANGE									

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Fig. 12. Form for Recording Time Analysis of a Part

The starting point is therefore some kind of a bill of material covering machine-shop, structural-shop, or other departmental work, on which are to be listed the parts that enter into the manufacture of the particular design met with. This can be in the form of a stock list for standard units or a special write-up each time, for irregular work.

It must further be known what work is to be performed on each part and how the various parts are to be assembled. Then comes the task of assigning the work to be done to the machines and gangs best equipped or qualified to do it. It is also necessary to know the time the various operations should take. This answers

What is to be made?

How it is to be made?

Where it is to be made?

How long the work takes?

The analysis which is to consider these questions must be made from the standpoint of the *importance of the work to the shop or department.*

For part analysis the form given in Fig. 12 can be used. On this are to be entered the operations in the order in which they are to be performed. The machine or gang that should do the work is also to be entered, as well as the speed, feed, and cut to be used. The jigs and tool used should be listed, also the piece-work price, the schedule number, and the standard time allowed. This information is to be worked up from actual studies, from analysis of drawings, or from estimates and outlines prepared by the foremen.

In order to secure estimates systematically, Fig. 13 can be used to advantage.

ESTIMATE CARD

TO ______________________ DEP'T DATE __________

KINDLY FURNISH US AT ONCE WITH TIME ESTIMATE ON-

ORDER NO. ______________ QUANTITY ______________

FOR ______________________________

OPERATION ______________________________

____

UNIT OF WORK ________ TOTAL UNITS ______________

TIME PER UNIT ________ TOTAL TIME IN GANG HRS ______________

NO. MEN IN GANG ________ GANG / MACHINE } CONSIDERED ________

ESTIMATE WANTED BY ______________ SIGNED ______________

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Fig. 13. Estimate Card

So much for the detailed operation of parts. We must now consider their tie-up into groups, assemblies, and erection. How can this be shown? Let us take up the order of importance first. If the assembly and erection floors could have their own way, study and experience would conclusively show that groups and parts are wanted in a regular and logical order. *Why not give them their way?*

Assume for instance that it takes 250 hours to erect a certain unit; that the erection floor wants parts 1, 2, 3 and 4 to start with; that parts 5, 6, 7, 8 and 9 properly assembled are wanted in 25 hours after starting erection; that parts 10, 11, 12, 13, 14, 15, 16 are wanted 150 hours after starting, and parts 17, 18, 19, 20, 21, 22, 23, 24 are wanted 225 hours from the starting time. This means that certain definite requirements can be given the machine shop and sub-assembly floors. Graphically we can show the general outline in Fig. 14.

In arranging to get these parts and assemblies to the erecting floor *exactly as wanted,* let us further picture the details showing the part and sub-assembly times, so as to make the planning as simple and easy as possible. Fig. 15 shows these details.

As a further and most important aid, each line should show the times on the various operations. Fig. 16 is an example.

This all means that with finishing date known as B, Fig. 15, the starting time of the various parts can be definitely determined, and that the time of turning over parts to sub-assembly and from sub-assembly to erection can also be determined. *Further it is known what part should be started first.*

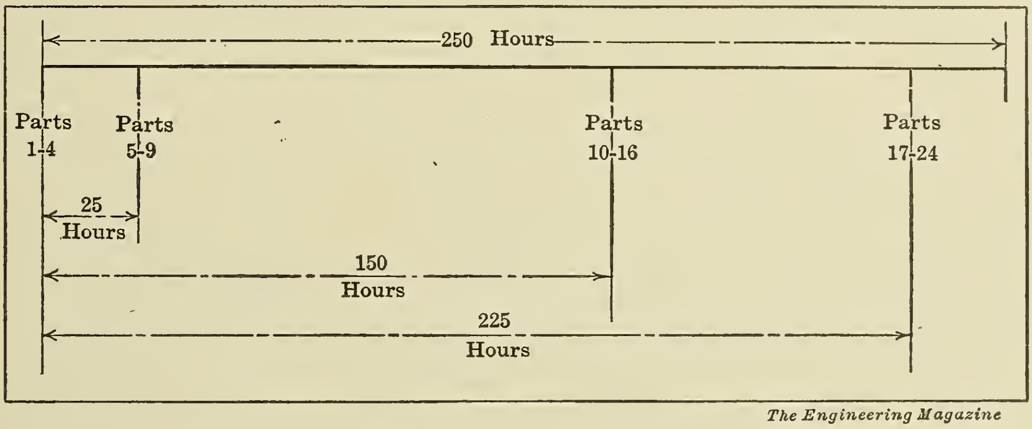

Fig. 14. Graphic Analysis of an Assembling Job

Reference to Fig. 15 will show that part A, Group XX1, should be the first thing started, with parts D, C and B following in order. Then comes XX2, part G first, followed by I, E, H and F in order. On XX3, part J with 80 hours should be started first, followed by N, P, L, M, O and K in order. Following soon after the start of N, Group XX3, however, part X, Group XX4, should be started. There is only 10 hours difference (see C) between parts N and X. It can be seen that if all parts of XX4 were begun *after* parts on XX3 were finished, it would set the work back 36 hours (see C1) unless night or overtime work were resorted to. Part X must therefore be started a long time before beginning the other parts of the same group.

This establishes an important law:

The selection of a starting operation is governed entirely by the line whose starting point is furthest from the finishing line.

Let us study Fig. 16 for a moment. Assume that the time of 46 hours covers the machinery of 50 pieces. The first operation takes 6 hours, the second 10 hours. If in 3 hours the man on operation No. 1 turns over 25 pieces to operation No. 2, *it means that 5 hours work has* *been released from No. 1 to No. 2.* It would therefore be safe to turn parts over to No. 2 as fast as they are finished at No. 1. But, if man on No. 2 finishes and turns over the 25 pieces taking 5 hours to No. 3, which requires 4 hours, it means that only 2 hours work has been released. *In other words if man on No. 3 takes pieces from No. 2 as fast as completed, the man on No. 3 will have to waste 7.2 minutes per piece,*

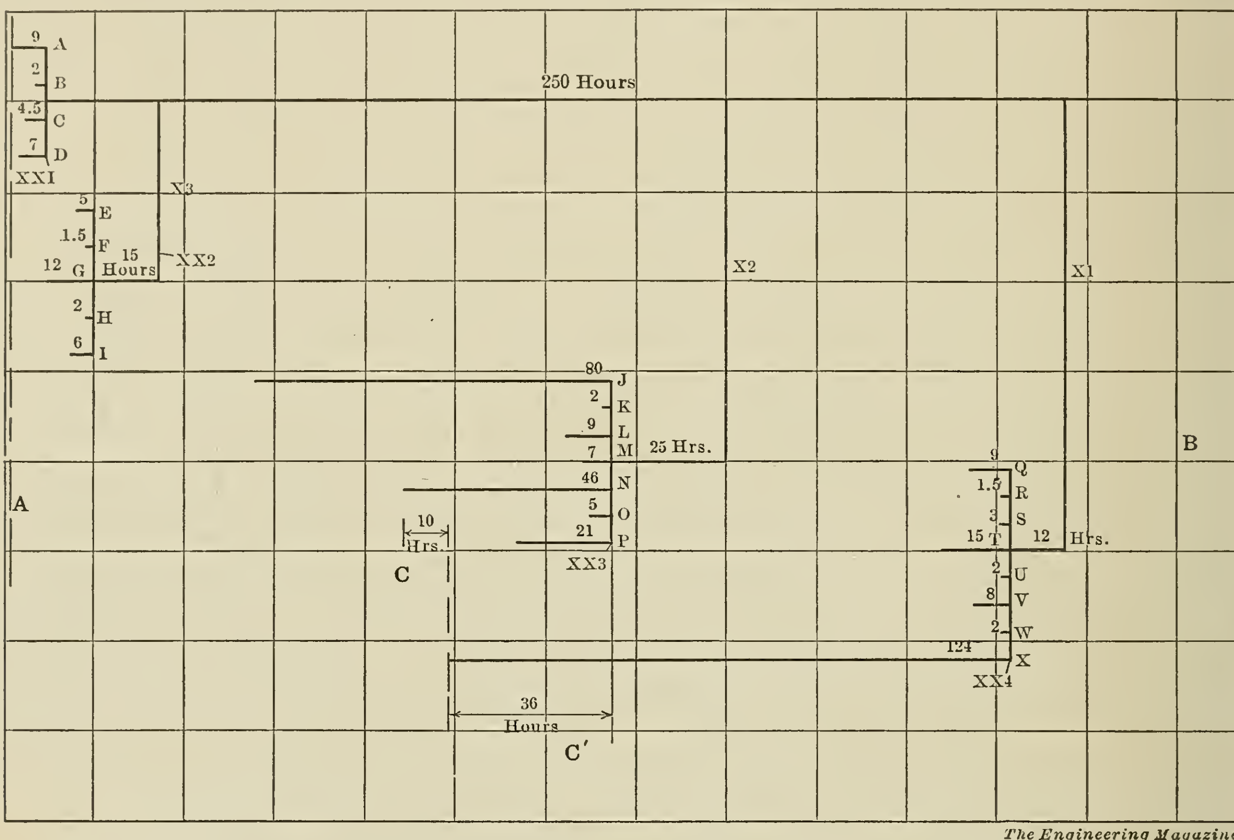

Fig. 15. Graphic Analysis of Assembly and Operation Details

for while man on No. 2 is taking 12 minutes per piece, man on No. 3 requires only 4.8 minutes per piece—a difference of 7.2 minutes.

This establishes the second law of planning, of such far-reaching importance as to be almost revolutionary:

No succeeding operation should be scheduled when its ratio to that of the preceding operation is less than one to one.

In the illustration on Fig. 16 we have:

Operation	Time	Ratio	Safe Yes	Safe No
1.......	6	1.66 to 1	√	
2.......	10	1.66 to 1	√	
3.......	4	.4 to 1		√
4.......	10	2.5 to 1	√	
5.......	4	.4 to 1		√
6.......	6	1.5 to 1	√	
7.......	6	1 to 1	√	

We can go a step further, and on Fig. 16 show actual progress of work by dotted lines. In the illustration, work on operations 1, 2 and 3 has been completed and 4 hours on operation 4. Further by using the letter "Y" for yes and "N" for no, the information whether or not succeeding operations are safe to start before completion of preceding operations, can be entered under line.

It can thus be seen how valuable this would all be when used in connection with Fig. 15. Progress would be shown at all stages of the work. If it was necessary to get after an order, the chart would present a clear and comprehensive picture of the exact situation showing *where to apply pressure.*

A further point of advantage is that in case certain classes of work are wanted to keep machines and men busy, these charts can be looked

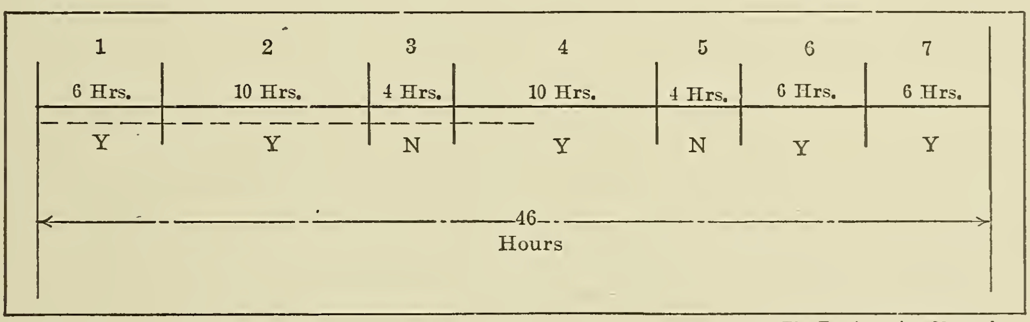

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Fig. 16. Graphic Record of Operation Times and Progress of Work

up and studied, by concentrating attention on the full lines covering the class of work desired showing no dotted lines under them.

The method outlined also leads to an important principle which all should work to, and which will do much to correct the usual policy found in shops. It can be stated as follows:

The method to follow in getting the work through a shop is not to apply pressure at A towards B, but to draw at B from A.

This means a "pull" type instead of a "push" type, as one man expressed it.

Assembly and erection foremen have told me time and time again that they could not schedule ahead because they did not know what was coming to them from the machines. Subsequent investigations have always borne out these statements. How could they be expected to do so when in a guess-it-will-get-there-all-right manner, an attempt is made to start work in and through without definite reference to where it will be from time to time and where it will end up? Further, I have often seen plenty of work at machines with men working at a very fair rate of efficiency, while the assembly and erection men were either hungry for parts or working on whatever they could get so as to keep busy. Instead of planning to keep the machines busy with only a general idea as regards the erection, *the task should be to keep the assemblers and erection men busy on what they should have, and then to fit the work in and through the machines to suit this line-up.* Five minutes spent on a study of Fig. 15, tracing from B to X1, X2, and X3, and from XX1, to XX4, through to the end of each line will show

ANALYSIS SHEET

WANTED

UNDER PROGRESS ——— WORK TO DO ——— WORK DONE

ORDER N. CUSTOMER QUANTITY ARTICLE

LIST WORK AS IT SHOULD BE TAKEN THROUGH SHOP

ITEM NO.	AVAILABLE YES	AVAILABLE NO	RELEASE	PCS	DESCRIPTION	OPERATIONS IN SEQUENCE	ASSIGNMENT STD	ASSIGNMENT CHANGE	UNITS NO	UNITS KIND	TIME PER UNIT	TIME TOTAL	PROGRESS EACH SPACE =ONE HR.
				10	Plates 96 X 96 X 3/16	Lay out							
				5	" 108 X 48 X 1/4	Punch							
						Shear							
						Roll							
				10	Plates 120 X 96 X 5/8	Lay out							
				5	" 96 X 96 X 3/16	Punch							
						Shear							

The Engineering Magazine

Fig. 17. Analysis Sheet for Structural Shop

that planning in the manner advocated can easily be done. In addition to this, by putting in the finishing time at B and the starting time at A, *the time to complete becomes the difference between A and B.*

Further, the value of using lines in graphic form is so apparent from a study of the facts just outlined that we can consider this a basic principle without further argument.

In this connection let us combat a pernicious theory which prevails in many plants. It is to the effect that a definite number of units are to be built each day or each week. From Fig. 15 it will be seen that X2 is 100 hours from B, with 25 hours of sub-assembly time and 80 hours as the greatest amount of work on the parts making up the group, or 205 hours in all. This means, if the erection and assembly are double-gang operations, that 50 hours and $12\frac{1}{2}$ hours and 80 hours, or $142\frac{1}{2}$ hours, is the time necessary to get part J, with the other parts, to X2 at the right time. If the week consists of 60 hours, it is obvious that it would be the height of folly to start part J at the beginning of the week. If we divide $142\frac{1}{2}$ by 60 we have 2.37 weeks as the work factor. In other words, if the start is made in the same week the work is wanted, it will mean overtime, night work, and perhaps Sunday work. The theory should therefore be:

Requirements should be expected "at the rate" of a certain quantity each day or each week, and the planning arranged accordingly.

The value of the plan outlined is not confined to the machine or structural shops alone. The foundry can be scheduled from Fig. 15 as a basis, and the purchasing department can be notified well in advance of the order in which certain material is wanted. It all means that the end is at all times plainly in sight, instead of starting somewhere with the end "up in the air."

The form shown in Fig. 12 does not as a rule apply to the structural shop owing to the special nature of a large part of the work. Charting as outlined in Fig. 15 can be used to advantage, and to cover the analysis Fig. 17 is shown. Time-study work rather than planning makes foundry analysis necessary, so this feature of analysis will not be considered at this time.

Control of Material

It stands to reason that even though a job may be analyzed ever so carefully, work cannot be scheduled properly until the planning department knows the exact situation with reference to material. Some will be in stock. Some will have to be made. Some will have to be purchased.

The control of material as to routing, movement, and knowledge is to be vested in the planning department. It is to maintain a "material record" showing each item carried as stock. Further, no material, whether in warehouse, yards or shops, is to be moved to starting operations until authority has first been secured in writing from the planning department.

All requisitions for purchases are to be sent to the planning department before being sent to the purchasing department. As material is ordered, the purchasing department is to send to the planning department requisition showing the fact. The planning department is

ARTICLE — BIN NO.______ — ORDER IN LOTS OF ______

WOOD — SIZE: THICKNESS X WIDTH X LENGTH — WHEN AVAILABLE REACHES ______

TIME TO REPLENISH STOCK ______ DAYS

1-ORDERED (Not yet delivered from Shop)			2-RECEIVED (In Warehouse)				3-RESERVED (For orders but not issued from Warehouse)				4-AVAILABLE (Received but not reserved)			5-DELIVERED- (Material shipped or issued to shop on shipping orders)			
Upon issue of order ADD amount to this column.			When material is received- ADD amount to column 2; SUBTRACT amount from column 1; ADD amount to column 4				When material is reserved- ADD amount to column 3; SUBTRACT amount from column 4				ADD to this for column material received; SUBTRACT from this column for material reserved. SUBTRACT from this column for material delivered but not reserved.			For issues of material SUBTRACT amount from columns 2 and 3 if amounts have been reserved; SUBTRACT amount from columns 2 and 4 if amounts have NOT been reserved.			
DATE ORDERED	ORDER NO.	QUANTITY	DATE REC'D	ORDER NO.	QUANTITY	DATE ISSUED	DATE	FOR ORDER NO.	QUANTITY	DATE ISSUED	DATE	QUANTITY	REMARKS	DATE DEL'D	QUANTITY	TO ORDER NO.	REMARKS
	(a)	400		(B)	100			(C)	20		(B)	100		(D)	10		
	(B)	100		(D)	10			(D)	10		(C)	20					
		300			90				10			80					
					10	at	3 +	80 at	4 =		90	at	2				
					90	at	2	+	10	at	5 =	100	Received				
					100		+	300 =		amount		ordered					

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Fig. 18. Form for Material Record Sheet

BILL OF MAT'L	B	WANTED	W	SHIPPED	S	ANS. TO TRACER	A
REQUISITION	Q	MAY EXPECT	E	RECEIVED	R	PURCHASE SCHEDULE	
ORDERED	O	PROMISED	P	TRACER SENT	T		

ORDER NO.	QUANTITY	ITEM	KIND OF MATERIAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
					B			*Q*			*O*												*W* *T*				*A*		*P*				*R*	

The Engineering Magazine

Fig. 19. Form for Graphic Record of Purchases

to be furnished with a list of all the receipts of material from outside and from the foundry. Further, all requisitions for material delivered to the shops are to be sent to the planning department for entry in the stock record. If these rules are lived up to there will be no excuse for failure to have at all times a complete and accurate knowledge of material due, on hand, and in process.

Fig. 18 shows a "material record" sheet, which with the entries and explanation under each heading will make the record self-explanatory.

The planning department must also keep itself fully informed as to material purchased. Because it takes nothing for granted, it should maintain a careful watch over material ordered so as to know what to depend upon. This can be done only by scheduling and tracing the purchases.

A "purchase schedule" is to be maintained, and as requisitions are received covering the purchase of material, the planning department is to list this information in the record mentioned. As material is ordered, the purchasing department is to give the planning department a copy of every order for entry. All letters, confirmation of telephone conversations, telegrams, etc., between the purchasing department and vendors, which give information as to promises of shipment, etc., are to be sent to the planning department. Notices of shipment are also to be received by the planning department.

Lines and letters are to be used instead of writing for recording the history of a purchase. The rule to follow is: the letter corresponding to the condition of the order is to be entered under the proper date. If requisition is reached on the 5th, material ordered on the 8th, wanted for the 20th, promised for the 26th, and received on the 30th, the showing would be as pictured in Fig. 19. If it is necessary to carry the record beyond the month in which the entry is made, a cut sheet can be inserted.

When it is desired to trace an order, a formal purchase schedule tracer is to be made out in duplicate by the planning department. The duplicate is sent to the purchasing department and the original placed in file in the planning department. The purchasing department is to secure such information as it can, on receipt of which it is to enter in a purchase tracer the facts as secured and return the tracer to the planning department.

Each day the planning department is to take the purchase schedule and the clerk in charge of the work should observe under the proper dates the items that are due as indicated.

He should also observe what will be due five or six days from the date. Tracers are to be made out from this analysis. To keep in close touch with overdue items, the line covering such items should be entered in red. When new promises are received, the items are to be re-scheduled as outlined.

Chapter XIII

THE PLANNING DEPARTMENT — THE NECESSARY MACHINERY

NOW that methods have been provided for properly analyzing the work to be done, and the material has been brought under intelligent control, we can take up the practical steps leading to actual scheduling of the various operations.

The first factor to consider is the matter of time keeping. It is most essential to know when a man starts work on an operation, when he finishes, and what he does. Otherwise it would be impossible to schedule the work to be done. There are four ways to secure this information:

1. To let the workmen make out their own time reports.
2. To have a clerk make regular trips among the men getting time and production.
3. To have the workmen report to offices when starting and finishing work.
4. To use an annunciator system enabling the workmen to notify the planning department of changes. (See Fig. 20.)

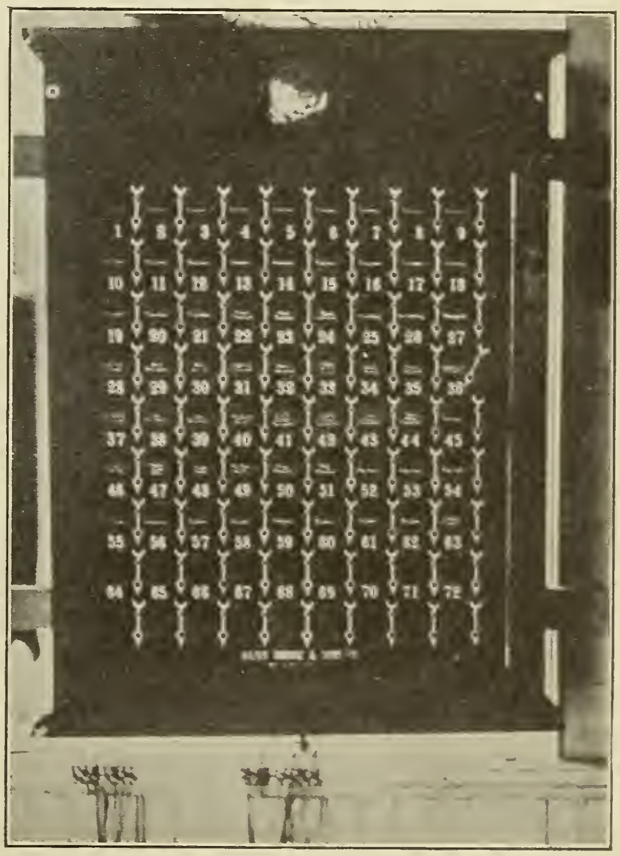

Fig. 20. Annunciator Board

The fourth plan is the most efficient, and if the plant is not too large, it should be adopted. In this the machines and floors have push buttons connected to an annunciator board in the planning office. A ring brings a clerk to the particular floor or machine. Further, by using signals the clerk knows what is wanted. The signals used are:

One ring; change in job, taking up next one scheduled.

Two rings; rejected work.

Three rings; delays.

If the plant is large, the cost of installing the annunciator system may be prohibitive, in which case the third plan should be followed. Sub-stations should be placed in different parts of the shop to which the men are to report when starting, finishing or changing work, for delays, rejections, etc. A station should be provided for every 100 men.

Form 148-5-26-13-2000-N

MACHINE SHOP SERVICE CARD

ORD. NO. 5310	FOR "A" Engine	DATE 3/10	
DWG. NO. 604	PART Piston Head	UNITS OF WORK	
JOB NO.	GROUP NO. 41 SHEET 3 ITEM 2	PIECE WK.	
		DAY WK.	✓

PRODUCTION			TIME AND COST					
ITEM	PCS.	UNITS	MEN EMPLOYED	TIME			RATE	COST
QUANTITY	100		LEADER 142	QUIT	9	3	72	1 56
FINISHED 3/20	10		HELPERS	STARTED	2	1		
				ELAPSED	7	2		
				ALLOW		1		
BALANCE	90			ACTUAL	7	1		

	THIS OPERATION	NEXT OPERATION	MOVED
ESTIMATED TIME PER UNIT	NAME Plane	NAME Drill	DATE 3/20
	MACHINE 412	MACHINE 304	
ESTIMATED TIME WORK FINISHED	GANG	GANG	BY H

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Fig. 21. Form for Service Card

In both plans Fig. 21 known as the "Service Card" (3 by 5 inches in size) should be used. This is made in triplicate, one copy for filing by order in the cost department for costing purposes, one in the planning department for planning and efficiency records, and one to be used by the man. Dispatching boards are to be used in connection. Fig. 22 shows the method as used in one installation. At the machine and floors are to be placed small two-clip boards for holding service cards. The top clip on all boards is to hold *jobs being worked on.* The lower clip is to hold *next job* tickets. It is a good plan, to have on the boards in the planning department a third or bottom clip to hold tickets covering jobs *to follow* the "next job" tickets, these to be arranged in the order that work should be undertaken. In this way the process is continuous. As soon as a man completes the job he is on, the card in the

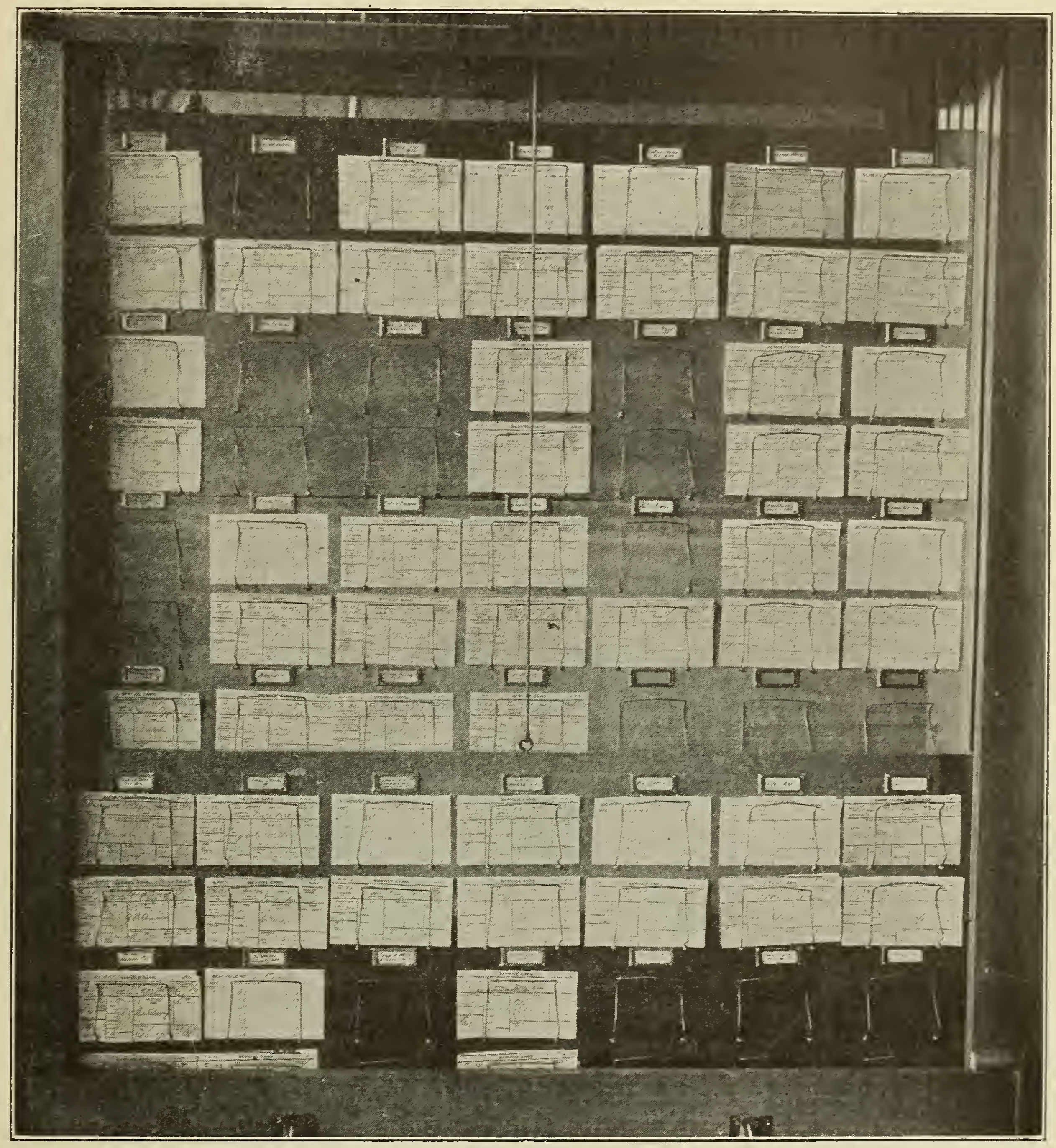

Fig. 22. Dispatching Boards for Holding Service Cards

second clip goes to the top clip, while the top card in the third clip is moved up to the second clip. *An important rule to observe in this connection is that men are to turn in their tickets at night, stating what they have finished, and continuation service cards are to be made out and posted on the boards for the men when they report in the morning.* Decimal time should be used in calculating time, which is to be expressed in hours and tenths. See Fig. 24 for illustration of a decimal clock, made from an ordinary dollar clock.

Form 155-2-26-13-1000N

DAILY PLANNING SHEET

Dept. Operation A- Machine 604

Unit of Work ________ Kind of Work ________

Week Ending ________ Machine or Gang ________

ORDER NO.	Sheet and Item	DRAWING NO.	PCS.	ITEM	THIS OPERATION Total Units	THIS OPERATION Total Time (Each Space = One Hour)	NEXT OPERATION Total Time (Each Space = One Hour)	NEXT OPERATION Total Units	NEXT OPERATION Name	NEXT OPERATION To Be Done At	RATIO B/A	SAFE TO START No.	SAFE TO START YES Date	SAFE TO START YES Hour	AVAILABLE WORK-IN TIME (Each Space = One Hour)	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	Carried To
						A	B															
5212			20	Cyl. Heads					B	520	1.66			✓								
5214			100	Pistons					C	410	.55			✓								
5221			50	Valves					C	410	.77			✓								
5218			25	Flywheels					B	520	.45			✓								
5341			100	Beds					B	520	.3			✓								724
5421			25	Pistons					C	410	1.77			✓								
5340			250	Valve Cages					C	410	1.75			✓								
5495			100	Cylinders					B	520	.45			✓								
5622			50	Brackets					B	520	1.66			✓								
5428			20	Valves					C	410	2.85			✓								
						113 / 30 / 83									83							
							Operation B-Machine 520															
5212			20	Cyl. Head					D	516	2.0			✓								
5218			25	Flywheels					E	612	.55	✓										
5341			100	Beds					E	612	.4	✓										
5495			100	Cylinders					E	612	.22	✓										
5622			50	Brackets					D	516	1.0			✓								
						48 / 10 / 38									9.5							
							Operation C-Machine 410															
5214			100	Pistons					E	612	.4	✓										
5421			25	Pistons					F	710	.3	✓										
5418			20	Valves					F	710	.45	✓										
						45									6.8							
							Operation D-Machine 516															
5212			20	Cylinder Hds					F	710	.35	✓										
5622			50	Brackets					G	820	.40	✓										
						30									17							

Note – All operations under "A" safe to start as they are starting operations.

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Fig. 23. Form for the Daily Planning Sheet

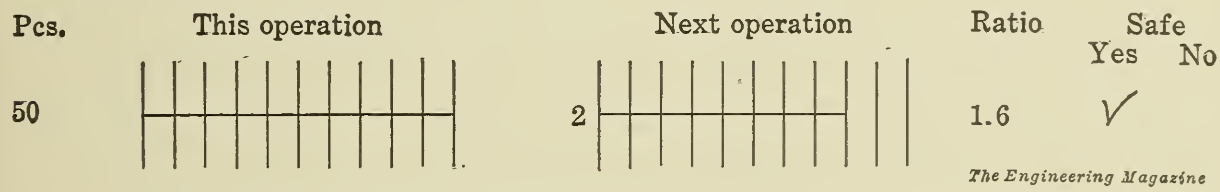
With this all too brief description of the time-keeping methods, we can proceed to the plan used in assembling the facts. The form shown in Fig. 23, the "planning sheet," can well be considered *the key to the whole work of planning* and is the result of several years of study, experiment, and actual practice. It is easier to use the sheet than to describe it intelligently, but a careful study of the procedure will be well rewarded.

On these sheets "available work" only is entered, and as the term has two meanings, we must make the distinction clear:

1. A job having six operations is available if the material is on hand *but only as far as the starting operation.*

2. All operations following the first are available *only when they receive from the preceding operations all or part of the work called for.*

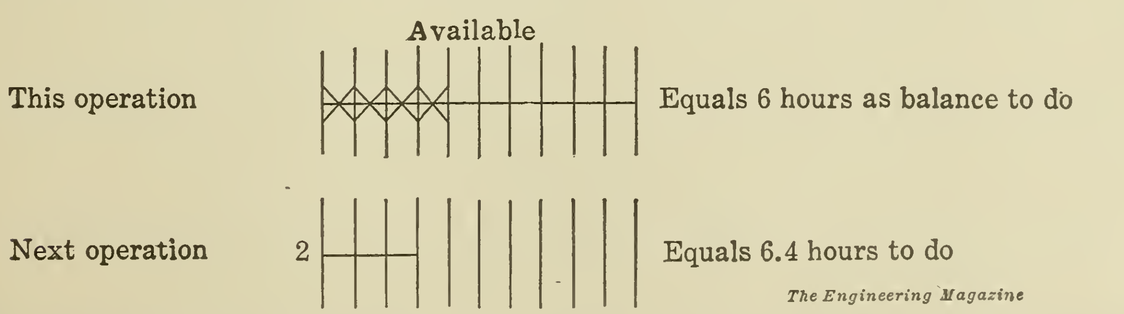
Let us briefly consider the basic principle of the planning sheet before we attempt to explain the entries on the form illustrated. Assume that operation times are 10 hours and 16 hours, as shown in the graph below:



(Note: Figure 2 means that the value of each space is 2 hours instead of 1 hour.)

which means from the rule governing the selection of succeeding operations as laid down in the preceding paper, that the ratio is 16:10 equals 1.6, or for every hour worked at "this" operation 1.6 hours of work are released to the "next" operation. *Why not enter work to succeeding operations as released?*

Assume that the workman on "this" operation does 4 hours of work. Multiplying 4 hours by 1.6 equals 6.4 hours for the "next" operation. In other words, we credit for 4 hours and charge for 6.4 hours which we can show graphically as follows:



(Note: The Figure 2 is used as prefix because 16 hours will be entered when work is completed.)

A brief description of the procedure is now in order. Each machine gang or man is to have a planning sheet, which is to cover the work of a week at a time. No work is to be entered on the sheets that is not available as defined in the first definition given above.

When available work is selected for starting, the information covering the *first operation only* is to be entered on the planning sheets. Succeeding operations will be entered as work is released from preceding operations. In making an entry, the order number, sheet and item numbers, drawing number, piece, and description of items are to be entered. Under "this operation" is to be entered the number of units* and the total time. Under "next operation" is to be entered total time, units, name of operation and where work is to be done.

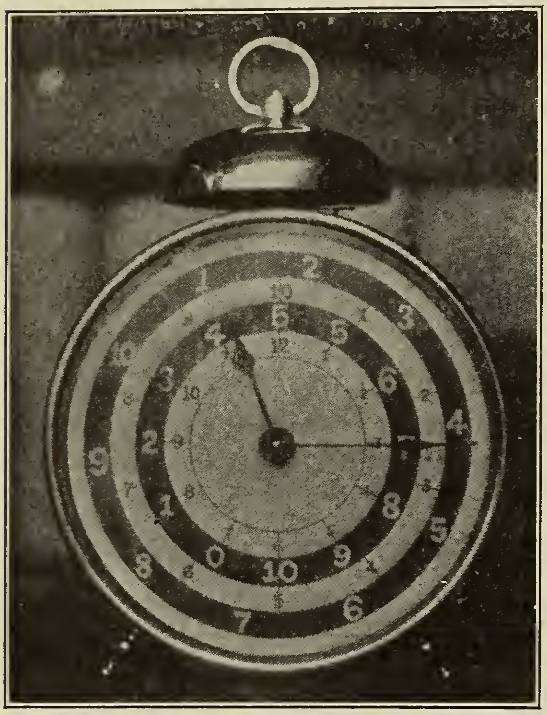


Fig. 24. Decimal Clock

Times for both this and next operations are to be expressed by lines each space equaling one hour. In cases where the time is greater than 10 an index figure is to be placed at the left of the line, indicating that the value of each space is *one hour multiplied by the index figure.* To show 34 hours, a line would be drawn through 8½ spaces prefixed by the figure 4.

Because the selection of a succeeding operation depends entirely upon the relation between its time and that of the preceding operation, the ratio between the two should be established in all cases.

The amount of work available in time should be shown by a line under "available." For starting operations this would equal the times entered under "this operation" unless some part of the material was not available. For succeeding operations the amount of work available in time would depend upon what was released from previous operations. For work done at any operation the amount available for a succeeding operation would be:

Hours of work done × Ratio = Hours of work available for succeeding operations.

If the ratio was 0.7 to 1.0, indicating that for every hour of work done 0.7 of an hour is released, and if the work completed in time

* By units is meant structural-shop units, such as 100 rivets, 20 feet caulking, 50 holes, etc.

was 6.7 hours, 4.7 hours would be available for the succeeding operation. If it is not safe to schedule succeeding operations, a check mark is to be placed under "No." When a job is safe to start, the approximate date and time are to be entered under "Yes." If this cannot be done, at least enter a check mark under "Yes."

As jobs are selected for starting, a line is to be drawn under the proper day opposite the item to be worked upon. The *starting point* is to depend upon previous work planned for the same day. Its *length* is to depend upon how long the shop management wants a gang or machines to work on the operation. Entries are to be made in pencil. If a change is necessary after the planning has been done, the line can be erased and a new one drawn.

Upon completion of work as shown by service cards turned in, entry is to be made on planning sheets. Entry will be on the principle that any work completed at one operation is available in whole or in part for the next operation. Therefore, for any given operation, the time as shown by the service cards is to be entered in the form of a dotted line under the proper line scheduled for the day, and then crossed from the line under "available," which will then show the net time now available. The number of pieces and units of work completed are to be deducted and correct balances shown.

Information under "next operation" will now be noted and transferred to the sheet covering the gang or machine that is to perform the next operation. The time turned in covering the operation just completed is to be multiplied by the ratio factor, and the result drawn under "available" in the sheet covering the "next" operation. Check marks are to be placed in front of the lines showing scheduling for the day, when the men start work.

From this detailed description, the entries on the planning sheet illustrated can be easily followed and understood. The sheet shows that the scheduling for Monday, Tuesday, and Wednesday was followed as planned. Further, on Thursday morning the scheduling has been arranged to carry through until 9 o'clock on Saturday morning.

An advantage in using the sheet as described is that it makes no difference in what order the various items are entered on the sheets. The lines under the proper day show the selections, and the relative positions determine the sequence of jobs. Further, if jobs have been scheduled and change must be made, no rewriting is necessary. *Simply rub out one line and draw it somewhere else.*

The question how the planning is done is now in order. There are three ways of planning:

1. To let the planning department do all the planning in an arbitrary manner, the shop simply performing the work as outlined.
2. To let the shop do all the planning, the planning department simply acting for the shop in a clerical capacity.
3. To strike a happy medium between the two.

A planning department will never know it all. Neither does the shop have a "corner" on all the knowledge that is available. A com-

Form 158-5-26-13-500-N

MEMO OF CHANGE IN SCHEDULE

TO PLANNING DEPT
NEXT JOB SCHEDULED FOR ______

MAN NO.	
MACHINE NO.	
GANG NO.	

IS ON ORD. NO.______ JOB NO.______ OPERATION______

FOR MAT'L ______ ON SHEET______ ITEMS______

CHANGE	INVESTIGATION
IT WILL BE NECESSARY TO CANCEL THIS SCHEDULING AND SUBSTITUTE IN ITS PLACE ORD. NO.______ JOB NO.______ OPERATION ______ SHEET ITEMS______ MATL.______ FOR THE FOLLOWING REASON: DATE SIGNED	REASON FOR THIS CHANGE HAS BEEN INVESTIGATED AND FOUND TO BE FAULT OF DATE SIGNED

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Fig. 25. Form for Authorizing Change in Scheduling

promise is therefore in order. The planning department should correct the planning sheets each morning from the service cards turned in by the men the night before, and *from its knowledge covering customers' orders, progress, congestion, etc., tentatively schedule the work for the next day.* At 9 or 9.30 a. m. have the shop heads meet the planning supervisor and dispatcher and discuss the plans made. If good reasons exist for making changes, they can be made with dispatch and the planning can in this manner be done in a minimum of time. At 4 o'clock each day the shop superintendent and the planning supervisor should meet and outline to the dispatcher the general procedure to follow the planning decided upon at the morning meeting. This is virtually

Form 160-5-26-13-500-N

OVERTIME AND NIGHT WORK

TO PLANNING DEPT.

IN ORDER TO MAINTAIN SCHEDULE OF

ORD. NO.________ JOB NO.________ OPERATION________

MATL.________ SHEET________ ITEMS________

IT WILL BE NECESSARY FOR

MAN NO.	
MACHINE NO.	
GANG NO.	

TO WORK { ALL NIGHT / ________ HOURS OVERTIME

FOR THE FOLLOWING DATES ________

SIGNED BY	DATE	ARRANGED FOR

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Fig. 26. Form for Authorization for Overtime and Night Work

Form 151-5-26-13-1000-N

MATERIAL MOVE ORDER

ORDER NO. DWG. NO. OPERATION

MOVE				FROM	TO
NO.	DESCRIPTION	SHEET	ITEM		
				MACHINE	MACHINE
				FLOOR	FLOOR
				BENCH	BENCH
				DEPT.	DEPT.
				WAREHOUSE	WAREHOUSE
				YARD	YARD

WANTED			RECEIVED			AVAILABLE	
DATE	TIME	A.M.	DATE	TIME	A.M.	YES	
		P.M.			P.M.	NO	

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Fig. 27. Form for Requisition for Moving Materials

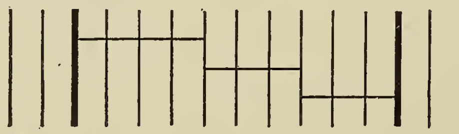
planning in the morning for the next day, and in the afternoon for the day following.

After the scheduling has been arranged for, any change desired in the plans before the next meeting must be on a requisition made by the shop. Fig. 25 is shown to explain the procedure. The reasons for the change are investigated by the planning department.

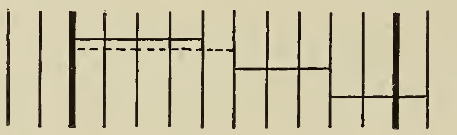
If overtime or night work is going to be necessary, the shop or the planning department can arrange for it on authority when the form shown in Fig. 26 is properly filled out.

Because the planning department must control the movement of material to starting operations in order to plan most intelligently, it must make out move orders (Fig. 27) from the planning sheets, sending these orders to the material supervisor, who will arrange for the moving of material from and to the proper place at the proper time.

Because there are bound to be variations in times worked as against times scheduled it may be well to explain how this is handled. Assume that scheduling is as follows:



and that instead of taking 4 hours on the first item the man takes 5 hours. The entries would be changed thus:



If he took 3 hours the arrangement would be:

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The thing to do is to assign the work where it should go, and as soon as congestion is noticed steps can be taken to relieve the situation.

Reference to the planning sheet will show the following information:

Operation	Work to do "this operation" Hours	Work Available Hours
A	83	83
B	38	9.5
C	45	6.8
D	30	17.0
	196	116.3

which shows that there is less than a day's work at machines B and C and over a week's work at machine A. Consequently, to relieve the situation, work on 5341, operation A, has been transferred to machine 724 as shown. This is not only extremely valuable in keeping close watch over congested places *but answers the objection often advanced by shop men that out of a number of machines they do not know to which to assign certain work.*

To keep in close touch with this important matter of congestion, an "operation control board" can be used to decided advantage. Fig. 28 is a picture of a control board. Machines and gangs are to be listed across the top. Down the left-hand side are to be shown hours,

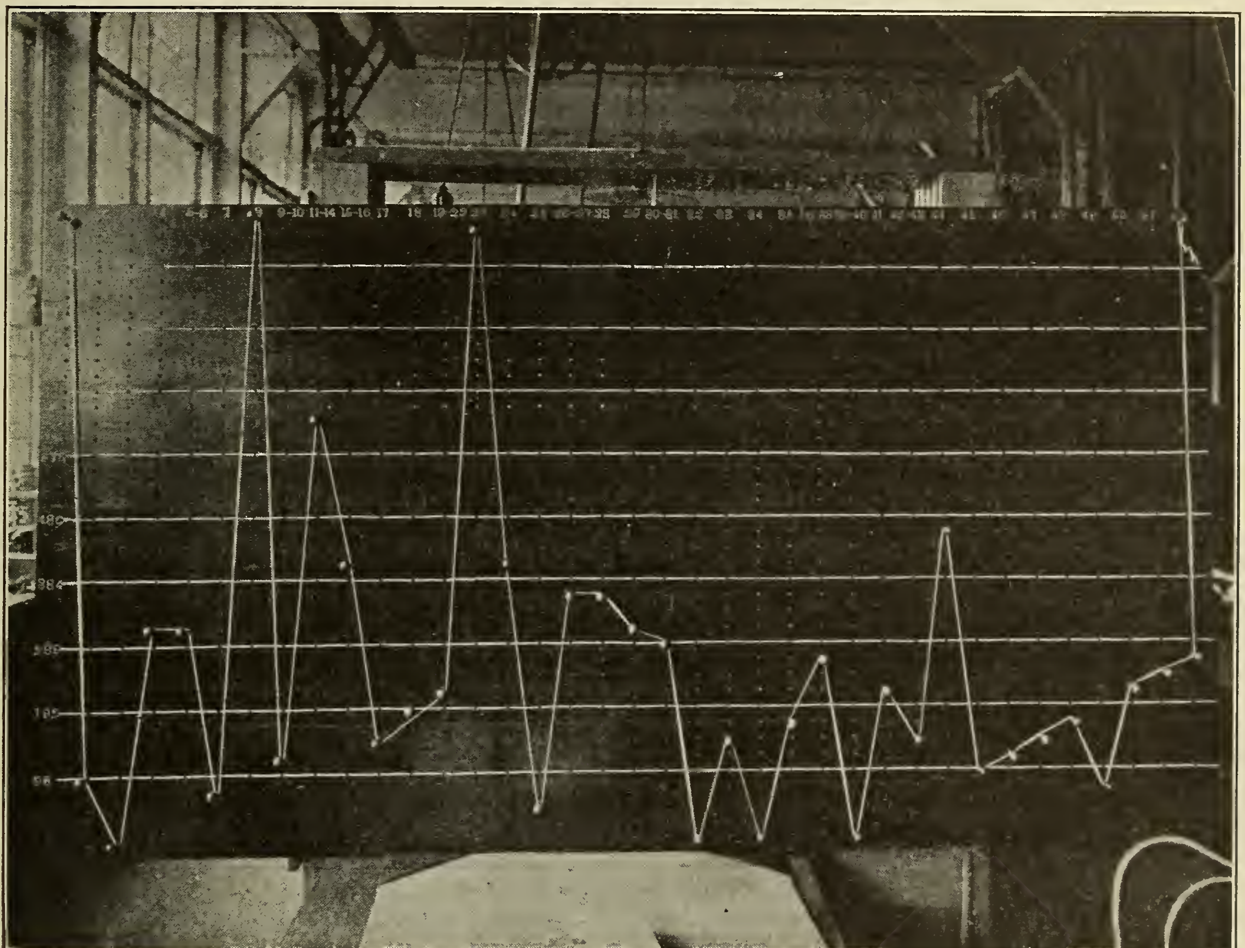
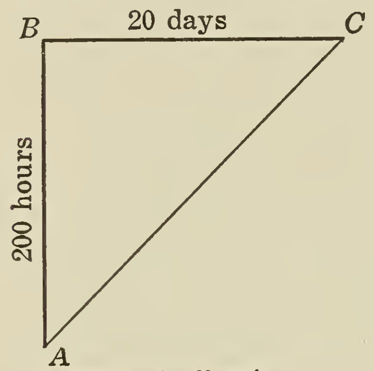


Fig. 28. Operation Control Board

with holes at regular intervals for inserting pegs. White elastic string is used to slip over the pegs. In the illustration it will be noticed that machines 1–8–23 and 52 are loaded to the limit, while 2–3–7–25–32–34–39 and 40–45–49 have practically nothing ahead of them. The board is to be rearranged at least once daily.

The reader no doubt has several questions in mind. What governs the planning? What shows that certain orders need crowding? Admitting that the charting advocated in the preceding chapter shows starting and finishing dates, how is the progress between these dates watched? Considerable thought given to these same questions has resulted in a method of control which will be found of pronounced value. My idea from the start was to ascertain if possible the "normal line of progress" or flow, against which could be measured the actual performance, which would disclose variations.

The principle finally adopted can best be explained by a triangle in which the horizontal line BC represents the days in which work can be done, and the vertical line AB the hours that the work will take. *The hypotenuse AC represents the normal line of progress.* If 10-hours work is done each day the actual line will follow the normal line. If more or less is done each day the actual line will be above or below the normal line.



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To show the practical application of this principle let us assume (Fig. 29) that an order is received October 2, is wanted November 20, and promised for December 1. Between October 2 and December 1 are 51 working days. By taking an ordinary sheet of profile paper to be called the "order control sheet" and letting each horizontal space equal one working day, lines D and D1 can be drawn to show date of receipt of order and date of promise. Assume that the time to make the order is 205 hours. Calling each vertical space 5 hours enables us to draw in E–E1–E2, the difference between E1 and E2 being a margin of 30 hours to use in case work should take more than 205 hours. So far we have drawn in but 5 lines. Assuming further that blue prints and bills of material are received October 11, that the job is analyzed October 12, that it is scheduled October 18, that material is ordered October 4 and received October 18, and we can draw vertical lines 1–2–3–4–5. Work is started October 20, so a heavy line is drawn fron A to B. This is the "working time" line. A heavy line is then drawn joining B and C, which is the "working days" line. A and C are then joined by a heavy line. This all becomes the "manufacturing angle" with line AC as the "normal line of progress."

As time is turned in each day against an order, it is entered on control sheet, the line X–X showing the actual progress. It will be noticed that on November 3 the work was 35 hours behind schedule. On November 10 it was practically 25 hours ahead of the schedule, while on November 24 work was 30 hours behind the schedule. *In other words, on any particular day a glance at the control sheets will show whether work is ahead of or behind the normal schedule.*

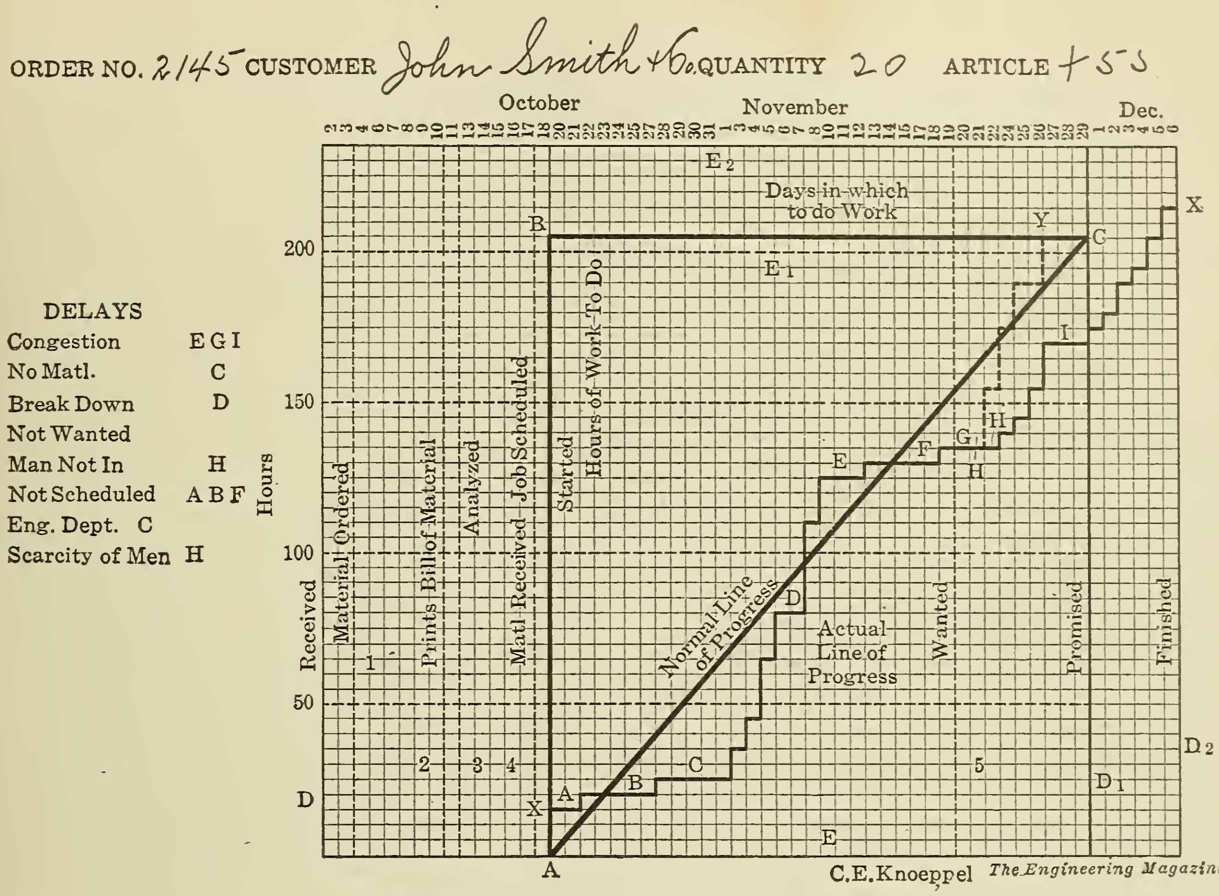

Fig. 29. Order Control Sheet

The dotted line ending at Y shows the amount of work scheduled so that work could be finished on time, as follows:

November	22	20 hours
"	24	20 "
"	25	15 "
"	27	15 "
		70 "

How well this schedule was maintained, however, is shown by comparing it with the actual line of progress beginning at the point when the dotted line started.

In order to keep in touch with all the facts in connection with the work it was also decided to show on the chart reasons why no work was done on certain days. A list of causes is placed at the left of the chart, and by using a key letter reasons can be inserted at the proper place. For instance, on October 21–22–23–24 and 25 no work was scheduled. On October 28–29–30–31 no work was done because of a lack of material due to error of the engineering department. On November 7 there was a breakdown. On November 11 and 12 congestion of work caused a stopping of work. On November 20 work could not proceed on account of congestion. On November 21 and 22 the workman did not report and owing to scarcity of men the work had to wait. On November 28 and 29 congestion again made it necessary to stop on the order.

It will be noticed that when D1 line was reached the work was 30 hours behind schedule, and that the job was not finished until 6 days after line D2, taking 10 hours more time than was estimated, an efficiency of 95.2 per cent (205 ÷ 215).

Each sheet is valuable in itself, but consider the possibilities when on file in one place are all control sheets covering work ahead of schedule and on file in another place are all orders behind the schedule. *It places one in control of the entire activities of a plant.* One manager went so far as to say that the control sheets were too valuable to be filed anywhere but right in his desk.

After completion of orders, the control sheets can be analyzed to advantage. In this case why did 15 days elapse between receipt of order and starting in the shop? Why did it take 12 days to get the material? Why did it take 8 days to get the prints? What caused the delay of 6 days before completion, when enough work was scheduled to finish the job on December 1? Wide variations between the actual and estimated times can also be analyzed.

In getting the work started the first thing to do is to get new orders analyzed and written up on the planning sheets, at the same time putting the time-keeping methods into operation. From the returns each day, cancel for times worked; from the planning sheets, enter work released to succeeding operations. Keep this up until the work on the planning sheets represents all the work in the shops. Then call the first meeting and start the real work of planning. Control sheets can be started with the first order analyzed. The essentials are as before outlined—analysis, material control, time keeping; and with these as a basis, the use of planning and control sheets will work wonders in the shop.

Chapter XIV

THE PLANNING DEPARTMENT—AUXILIARY DEVICES

THE aim of the two preceding chapters on the planning department was to describe as clearly as possible what planning is and how it is done. There may be many cases, however, where the procedure outlined does not exactly meet the peculiar conditions met with, or where additional records are necessary. In this supplementary chapter on planning it is the purpose to consider certain auxiliary devices that might be employed in the actual work of introducing better methods of scheduling and routing orders through the plant.

Production Order

It is often a good plan, in organizing the work of planning, to use a production order, for the purpose of systematically keeping in touch with work under way. A production order form is shown in Fig. 30, A, B, and C. The original is held in the office, the duplicate acts as a material requisition for the first lot delivered and as a move order for succeeding lots, while the triplicate is used as a routing card and accompanies the work as a means of identifying the parts in their progress through the works.

Boiler-Shop Material Card

The service card described in the preceding chapter usually covers one item or part. It often happens, as for instance in structural-shop practice, that a number of different items or parts may be worked upon at the same time. To cover this condition, a set of material cards (Fig. 31, thin paper) are written up, one for each operation; one for the planning department, one for the stock room and one covering the movement of material. A set would be covered by one labor service card. In other words, this material card is a bill of material showing just what is to be worked upon. Form 31 is shown on page 143.

PRODUCTION ORDER

ORDER NO.	NAME OF ITEM	TYPE
QUANTITY		
SYMBOL NO.	WANTED	FIRST OPERATION
DRAWING NO.	SHOULD START	FINAL DELIVERY
FOR ENGINE NOS.	OTHER ORDERS EFFECTED	
REMARKS:		

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R—MATERIAL REQUISITION MOVE ORDER —M

ORDER NO.	NAME OF ITEM	TYPE
QUANTITY		
SYMBOL NO.	WANTED	FIRST OPERATION
DRAWING NO.	SHOULD START	FINAL DELIVERY
FOR ENGINE NOS.	OTHER ORDERS AFFECTED	

MAT'L REQD. Date Time	R. or M.	IN LOTS OF	SIZE AND KIND	PCS.	FEET	LBS.

MOVE FROM		MOVE TO		MAT'L DELIVERED Date A.M. P.M.			
Machine		Machine		BALANCE TO SCHEDULE			
Floor		Floor		RECEIVED			
Man		Man		Date	Time	By	
Yard		Yard					
Dept.		Dept.					
Stk. Rm.		Stk. Rm.					

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ROUTING CARD

ORDER NO.	NAME OF ITEM	TYPE
QUANTITY		
SYMBOL NO.	WANTED	FIRST OPERATION
DRAWING NO.	SHOULD START	FINAL DELIVERY
FOR ENGINE NOS.	OTHER ORDERS AFFECTED	

MAT'L REQD Date Time	R. or M.	IN LOTS OF	SIZE AND KIND	PCS.	FEET	LBS.

MOVE FROM		MOVE TO		MAT'L DELIVERED Date A.M. P.M.			
Machine		Machine		BALANCE TO SCHEDULE			
Floor		Floor		RECEIVED			
Man		Man		Date	Time	By	
Yard		Yard					
Dept.		Dept.					
Stk. Rm.		Stk. Rm.					

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Fig. 30, A, B, C. Production Order. Made Out in Triplicate

A, the Production Order, and B, the Material Requisition, are thin paper. C, the Routing Card, is a stiff cardboard to make a back for writing upon. They are edge-gummed together in sets.

BOILER SHOP MATERIAL CARD			
ORD. NO.	DWG. NO.	GROUP NO.	JOB NO.
FROM	THIS	WANTED	NEXT
OPERATION NAME	OPERATION NAME	DATE TIME	OPERATION NAME
MACHINE	MACHINE	A.M.	MACHINE
GANG	GANG	P.M.	GANG

B.M.		PCS.	DESCRIPTION OF MATERIAL	LENGTH		MATL.
SHEET	ITEM			FEET	INS.	

MAT'L. RECEIVED BY	DATE	TIME	A.M. / P.M.

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Fig. 31. Material Card for Boiler Shop

Part Planning Schedule

It is often a good plan when a large number of parts are to be taken through the plant, to schedule these parts as shown in the form reproduced in Fig. 32. It shows what has been scheduled and what is finished from day to day, with provision for showing whether production is ahead of or behind the schedule, as well as the efficiency

MACHINE SHOP PLANNING SCHEDULE

UNITS		ITEM	QUANTITY
GROUPS		TYPE SYMBOL	ORDER NO.
PARTS		WANTED BY	DATE ISSUED

Requirements 1000	Days Allowed 10
On Hand 250	Rate Per Day 75
Balance to Schedule 750	Time Per Piece 0.3

SCHEDULE			FINISHED				EFFICIENCY			REMARKS
Date	Per Day	Total	Per Day	Actual Time	Total Pcs.	Bal.	Ahead	Behind	Percent	
9/1	75	75	75		75			—		
2	75	150	50		125			25		
3	75	225	50		175			50		
4	75	300	75		250			50		
5	75	375	—		250			125		
7	75	450	100		350			100		
8	75	525	25		375			150		
9	75	600	—		375			225		
10	75	675	150		525			150		
11	75	750	50		575			175	76.6	
			50		625			125		
			125		750			———		

Effy — $\frac{575}{750}$ = 76.67

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Fig. 32. Part Planning Schedule

SHOP ORDER

THE FOLLOWING WORK IS NECESSARY IN ______________________ DEPT.

NATURE OF WORK

SHOP ORDER NO. 8500 CHARGE ACCOUNT NO. ______________

NECESSARY WORK TO COMPLETE

DRAWINGS		MACHINE WORK	
PATTERNS		BOILER SHOP WORK	
CASTINGS		CARPENTER SHOP WORK	
FORGINGS		YARD WORK	

SIGNED	APPROVED
NAME	NAME
DATE	DATE

NOTE - To MADE OUT BY FOREMAN FOR WHOSE DEPARTMENT WORK IS TO BE DONE AND UPON APPROVAL, ORIGINAL FORWARDED TO PLANNING DEPARTMENT

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Fig. 33. Shop Order

EQUIPMENT REQUISITION

COVERING

MOULDING MACHINES		CORE BOXES	
METAL PATTERNS		JIGS AND TOOLS	
MATCH PLATES			

FOR DEPT. DATE

MAKE

FOR USE ON

PRESENT COST OF DOING ONE PIECE		IS WORK SPECIFIED	STANDARD / SPECIAL	
EXPECTED SAVING PER PIECE		IS DESIGN LIKELY TO BE DISCONTINUED	YES / NO	
APPROXIMATE NO. PIECES YEARLY		IF YES WHEN	HOW MANY PCS. IN MEANTIME	
YEARLY SAVING		DO YOU FAVOR DOING ABOVE	YES / NO	
EST. COST LABOR		REQUISITIONED BY		
" " MATERIAL		APPROVED BY	DATE	
LABOR + MAT. TOTAL		STARTED	FINISHED	

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Fig. 34

when the time is up. An examination of the entries will clearly indicate the method to follow in using this record. This method can also be successfully applied to foundry work.

Shop Order

It often happens, in planning, that work covering repairs and replacements interferes with the efficient carrying out of the plans made,

DATE 5/20 DAILY SCHEDULE ______________ FOUNDRY DEPT.

NAMES OR FLOORS: Jas Morgan

NO. PCS.	ORDER No.	WORK	PATT. No.	SCH. No.	STD. TIME	NO. PCS.	ORDER No.	WORK	PATT. No.	SCH. No.	STD. TIME
10	5140	Cylinder	2-14	213	2.5						
5	1620	Beds	X16	34	3.5						
1	1624	Bed	X20	37	5.0						
2	1426	Ends	316	40	2.0						
					13.0						

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Fig. 35. Planning Sheet for Foundry

because there is no systematic method of handling this class of orders. Too much repair work is handled on verbal orders and this often means changes in schedules at a moment's notice. To take care of this class of work in a systematic manner, the shop order, Fig. 33, can be profitably used. It is made out in duplicate by the person wanting the work done and sent to the manager or superintendent

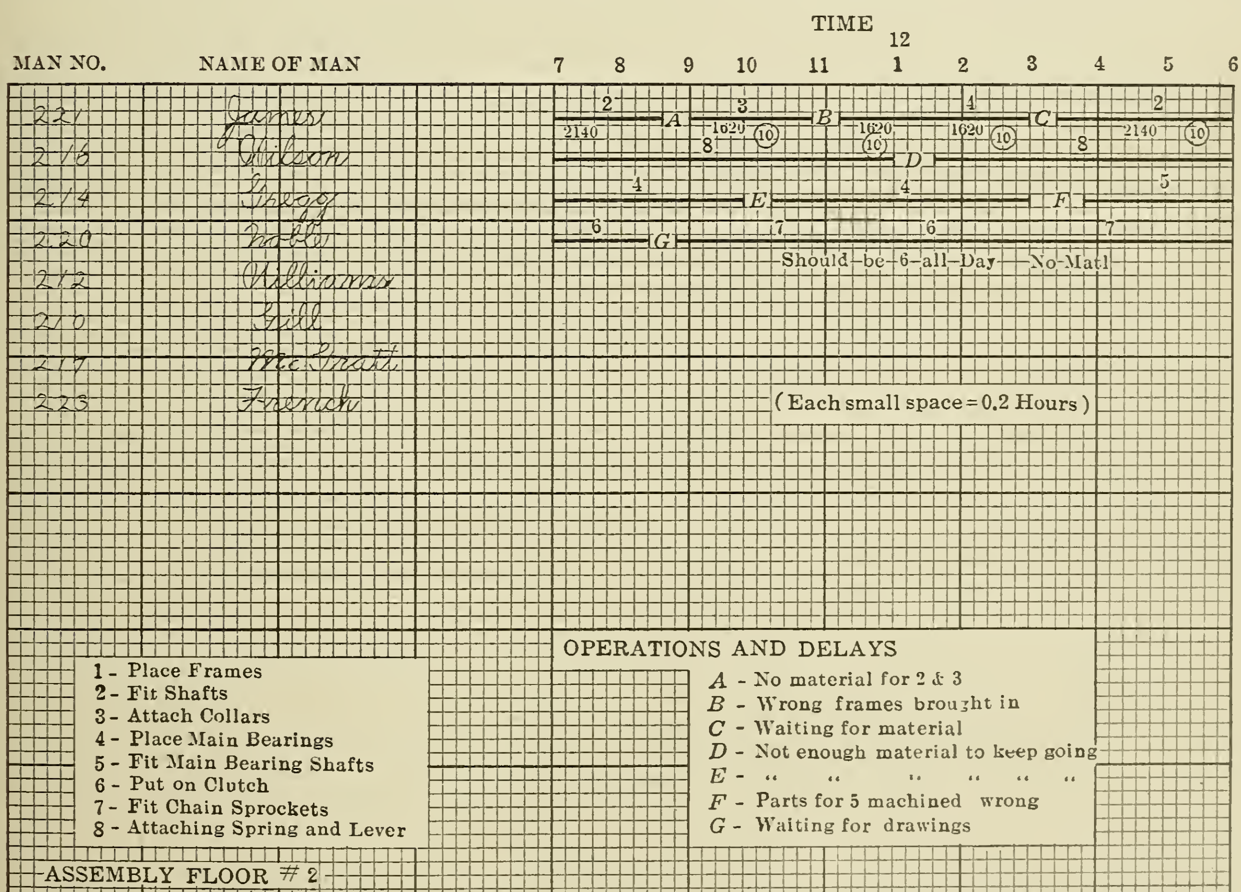

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Fig. 36. Record of Assembly Time

The small squares should be printed in light blue.

DEPARTMENTAL DELAY REPORT

FROM PLANNING DEP'T TO DEP'T DATE

WORK WILL FALL BEHIND SHOP SCHEDULE UNLESS FOLLOWING MATERIAL IS FURNISHED PROMPTLY

ORDER NO.	JOB NO.	SHEET	ITEM	PCS.	WORK	MAT'L	REASON	TO BE FINISHED

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Fig. 37. Delay Report

CONDITION OF ORDERS

NUMBER PIECES	ORDER NUMBER	NAME OF PIECE	PRINT OR PATTERN	DEPARTMENT	ISSUED	WANTED	NOT READY	READY	LOCATION

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Fig. 38. Progress of Work Report

NOTIFICATION OF NEXT JOB

TO ________ DEPT. JOB NO. ____

MAN NO.	
MACHINE NO.	
GANG NO.	

STARTED WORK ON ORDER NO. ____ AT ____ A. M. / P. M.

DATE ________ OPERATION ________ MATL. ________

AND IS SCHEDULED FOR ________ HOURS WORK

NEXT JOB

IS ON ORDER NO. ________ JOB NO. ________ OPERATION ________

MATERIAL ________ SHEET ________ ITEMS ________

WITH ________ HOURS WORK TO DO AND UNLESS CHANGE IS MADE IN SCHEDULE

EVERYTHING SHOULD BE IN READINESS FOR THIS JOB BY APPROXIMATELY ____ A. M. / P. M.

________ DATE

DATE PLANNING DEPT. BY

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Fig. 39. Notification of Next Job

for approval. If approved, the original is sent to the planning department and the duplicate to the one making it out. The planning department then arranges for scheduling this work. If not approved, however, the original and duplicate are returned to the source.

Equipment Requisition

What was said of repairs is equally true of additions and permanent betterments. It will be found that this work is often handled in a loose way. Fig. 34 shows an equipment requisition. It provides for requisitioning what is wanted, with a provision for showing the possible savings to be made and such additional data about design, etc., as to enable a manager to determine whether or not to approve the requisition. This record is handled in the same manner as the shop order.

Foundry Planning Sheet

In the preceding paper a planning sheet was shown that cannot be used in the foundry, as it was designed to cover work having a number of operations in sequence, like machine-shop and structural-shop work. Fig. 35, however, shows a planning sheet designed for foundry work. The names of moulders or floors are shown under which are placed the data concerning the work to be done. Entries are to be made in the order in which work should be made. The core room

ROUTING CARD						
ORDER NO.			DATE OF ORDER			
NAME OF PART				NO.		
QUANTITY			DRAWING NO.			
OP. NO.	NAME OF OPERATION	MACHINE	PCS. DELVD	PCS. FIN.	PCS. GOOD	RECEIVED BY
FINAL DELIVERY RECEIVED BY			PCS.		DATE	

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Fig. 40. Routing Card

can be scheduled in the same manner, if it is found necessary, but if the planning is done early in the morning, for the next day, a copy of this schedule given to the core room will be all that is necessary for the core room to make and have the cores ready when they are wanted.

Assembly Time

An excellent means of keeping close track of assembly time is shown in Fig. 36. An analysis of the entries will clearly indicate how valuable such a report is. The operations are listed at the bottom, in the order in which they should be performed. A provision is also made for showing the reasons for delays. Operations are indicated by numbers and delays by letters. For instance, man 221 (James) on order 2140, operation 2, was unable to finish his work because of a lack of material (a) and he could not go to work on operation 3 for the same reason. Note further that he worked on order 1620 from 9 until 3, starting on operation 3, then operation 1, and then on operation 4, finishing 10 pieces and being delayed 25 minutes at (b) because wrong frames were brought in. At 3.25 he began the completion of what he started on in the morning, fitting shafts on order 2140, completing 10 pieces. Note Wilson's delay of 30 minutes because he did not have a sufficient supply of material. Note Gregg's two delays, one of 25 minutes because he had no material and one of 50 minutes because the parts were machined wrong. It will also be noticed that Noble had to change his work three times because of lack of material, and was delayed on account of there being no drawing available. By setting down the date when work is started on an order, adding the hours worked upon it, reducing the man hours to gang hours, and subtracting the total from the total time elapsing between the time work was started and the time when it was finished, we shall obtain a difference representing the time the work was on floor without being worked upon—a most important thing to know.

Departmental Delay Report

It is an excellent plan to keep the shops advised when work falls behind schedule, as shown by the analysis sheets (Chapter XII), the control sheet (Chapter XIII), or the schedule shown in Fig. 32, this chapter. A delay report covering such cases is shown in Fig. 37.

Condition of Orders

Another means of keeping in touch with the progress of work is shown in Fig. 38. As orders are received they are entered in this record, the number of pieces being marked in pencil. Each day from the service cards turned in, the number completed is deducted from the number wanted, the old balance rubbed out and the new one entered. This constitutes a perpetual inventory of orders all grouped in compact form.

Notification of Next Job

It is often a good plan to keep foremen advised of what is to follow the work in process. After planning is decided upon, it will assist the foremen materially to keep them advised of the next jobs through use of the form reproduced in Fig. 39.

Routing Card

Good reasons may often exist for inability to use the move order suggested in the preceding chapter. When it cannot be used, a routing card is an excellent substitute. This is made out in the planning department and sent to the stock room when the order is released, and follows the routing prescribed. If the order calls for 500 pieces and the stock room delivers 100, the routing card would show this. If out of this 100, the first department finishes 50, the card should show this as well as accompany the 50 pieces. See Fig. 40.

Chapter XV

STANDARDIZING THE WORKING CONDITIONS

AT the top of the back of each seat in the Metropolitan Opera House, in New York City, is placed the number of the exit which the person sitting directly behind is to use in case of fire or panic. Each exit is prominently marked and can easily be located. *This is standardizing a condition, with the aim of preventing confusion and waste.*

To industry this standardization of conditions means much more than is at first apparent. Let me illustrate. Fig. 41 is a cut of a hand milling-machine, designed to mill the throats of the part shown by the arrow. The workman in operating the levers marked *A*, found that he could not see what he was doing because the ear *B* hid the milling cutter *C*. He also had to pick up a wrench from bench *F* to clamp the piece in the machine, and again when taking the piece out of the machine. Time studies revealed the following data:

	Minutes per Piece
1. Going around machine and looking at piece	.13
2. Number of looks per piece	1.65
3. Time looking at throats	.2145
4. Picking up wrench and clamping piece	.12
5. Picking up wrench and releasing piece	.09
Total of 3, 4 and 5	.4245

The total operation was made up of the following:

	Minutes per Piece
Looking and handling wrench	.4245
Cutting metal	.217
Piece in machine	.05
Piece from machine	.05
Total	.7415

Study was applied to 3, 4 and 5 in an effort to decrease the times on this part of the work. Two things were developed:

1. A mirror was attached (borrowed from the automobile) tilting

back and forth and sideways, enabling the operator to see what he was doing without leaving the levers. See *E*.

2. A lever and spring clamp, with the base of the lever riding on a curved boss, was installed, enabling the operator to tighten or release by simply pulling or pushing the handle. See *D*.

What was the result? Note the following comparison:

	Old Way Minutes	New Way Minutes
Piece in	.05	.05
Tightening piece	.12	.05
Cutting metal	.217	.217
Looking	.2145	.07
Releasing piece	.09	.03
Piece out	.05	.05
Total	.7415	.467

Efficiency of old way on complete operation:

$$\frac{.467}{.7415} = 62.9 \text{ per cent}$$

Efficiency of old way on the elements changed (3, 4 and 5):

$$\frac{(.05 + .07 + .03)}{(.12 + .2145 + .09)} = 30.6 \text{ per cent}$$

The first illustration shows *what standardization is;* the second outlines *how it is done*. The steps are:

1. Time study or careful investigation.
2. Analysis of data.
3. Finding the waste.
4. Devising methods to eliminate the waste found.
5. Installing the betterments.

With the above as a basis we are now prepared to go into the plant on a larger scale. Before we do so, however, a few words are in order regarding the distinction between conditions and operations. The term "operations" means the actual work of machining or moulding or riveting, as performed by man or machine. The term "conditions" means the arrangement of facilities and factors making possible the machining or moulding or riveting. There is no confusion about this; the distinction is clear cut. The work of setting work in and taking out of machines is, of course, part of the operations. So is the use of a jig and the adjusting of a machine to take the right cut at the right speed. But the designing of jigs and the determination of speed, feed, and cut combinations are not part of the operations according to the above definition, yet so closely associated as to make it next to impossible to divorce them from operations. The using of a cutting tool is clearly part of the operation. The forging, tempering, and grinding of this tool, however, are not. Considerable latitude must therefore be allowed in the definition, which after all is not nearly as important as the real work of standardizing. In this discussion matters will be considered as conditions which may come close to classifying as operations, leaving for the next paper the matter of standardizing the actual work connected with turning out production.

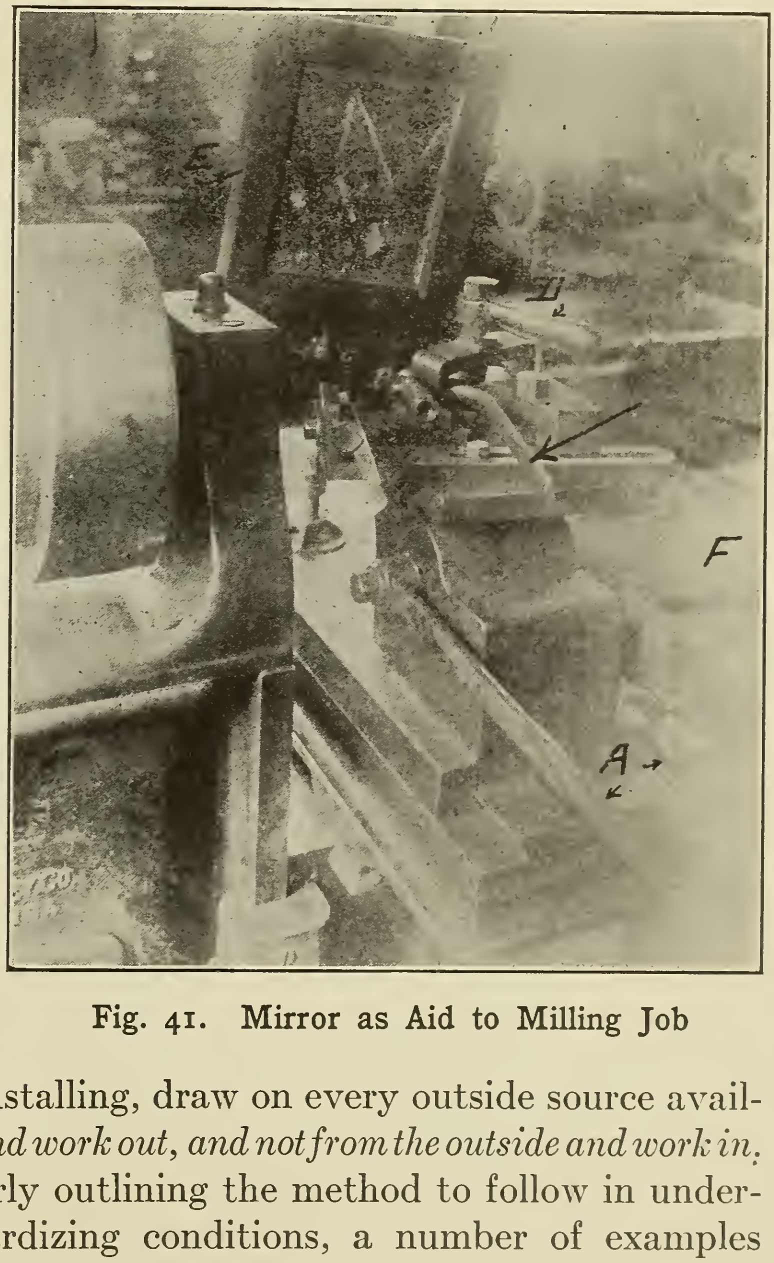


Fig. 41. Mirror as Aid to Milling Job

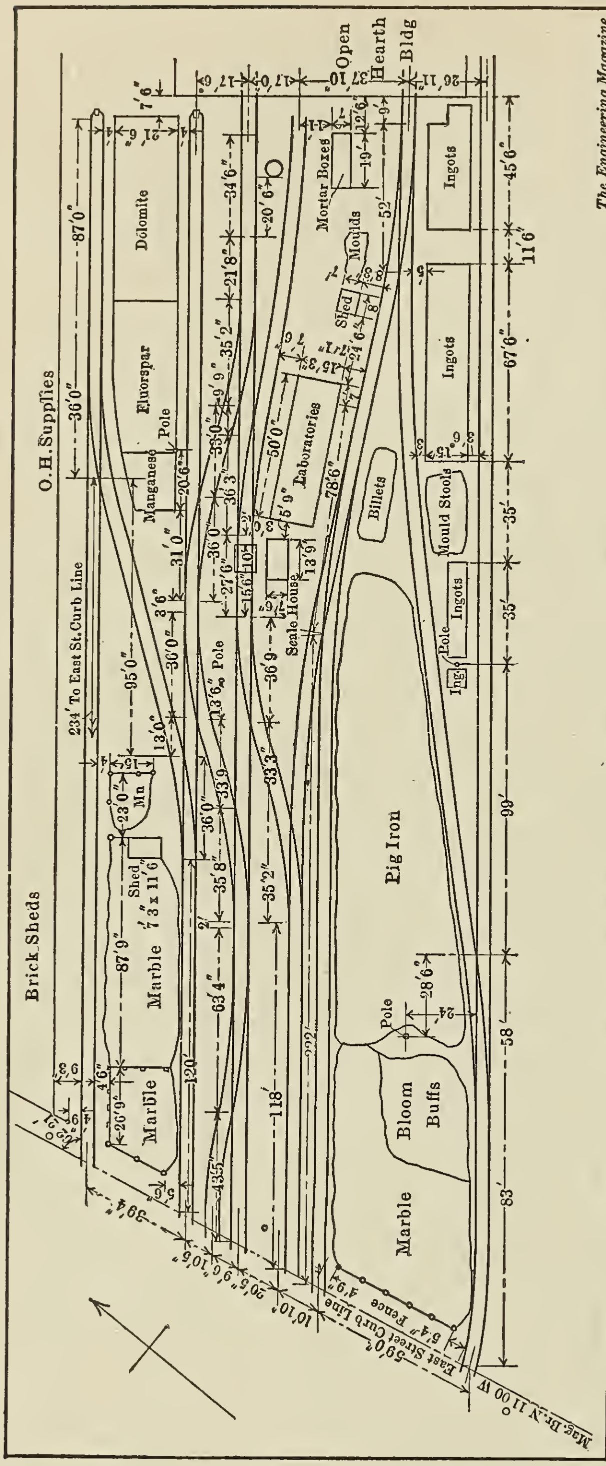
The whole aim in standardizing conditions is to arrange means to eliminate duplication of effort—to make things easier—to kill off waste—to facilitate, in every possible way. What someone else is doing in some other plant is not our starting point, so the question is not—"what can we use from the outside?" It is rather "what do our conditions reveal in the way of waste?"

Find out, devise such betterments as you possibly can, and *then* before installing, draw on every outside source available. *Start from the inside and work out, and not from the outside and work in.*

For the purpose of clearly outlining the method to follow in undertaking the task of standardizing conditions, a number of examples will be used as follows:

Track Arrangement

Take Figure 42, for example. Here we have a lay-out of tracks in a large factory yard. Naturally, to one possessing an analytical mind,



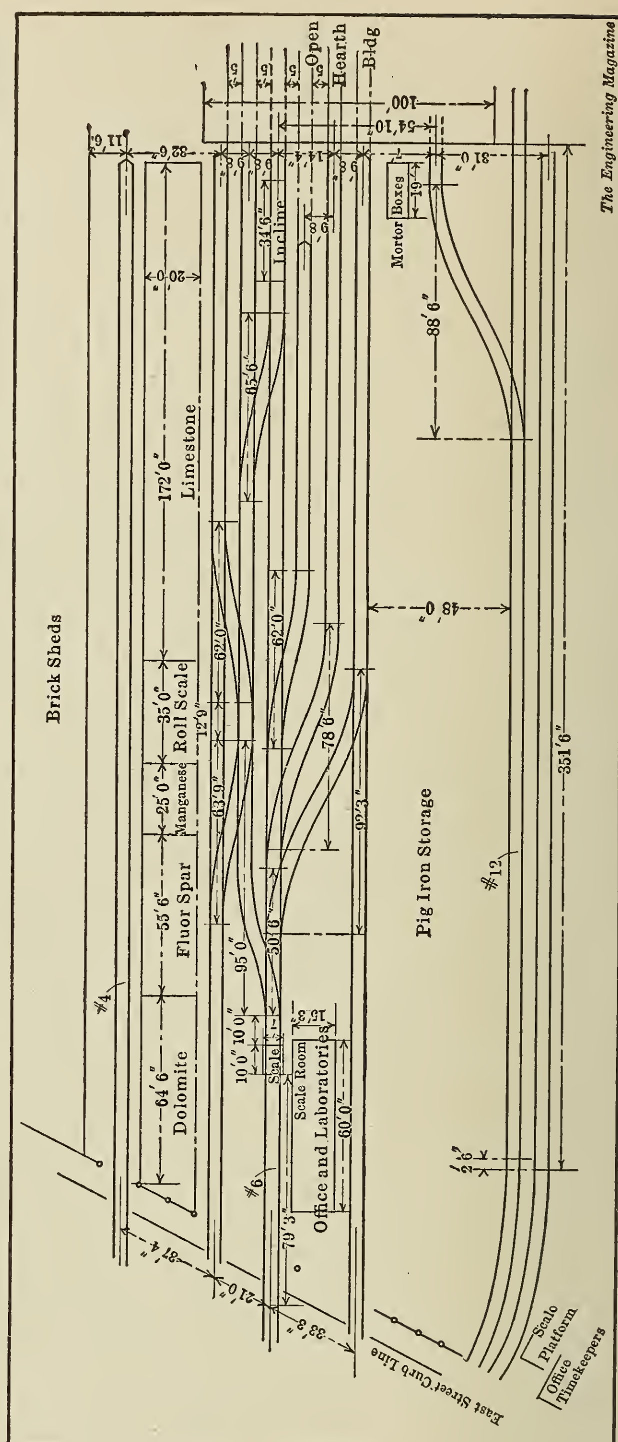


Fig. 42, on the left, is an Unsystematic Lay-out of Factory Trackage. Fig. 43, on the right, is a Standardized Rearrangement of the Same Yards

a walk around this yard would mean something. To one who never saw this yard the lay-out shows that the arrangement must necessitate much switching. It may be concluded also that maintenance of track must be high. Study would therefore be put upon devising plans for simplifying the arrangement, and Figure 43 shows a possible result from these efforts. We find here large capacity in handling cars, increased storage space, less switching, and decreased maintenance cost.

Grinding Gauge

On certain grinding operations study revealed that workmen were unable to grind the parts uniformly, and even after measuring there would be differences. To overcome this a gauge, Fig. 44, was made of tool steel, so that the operator by fitting the part into the openings would know when he had properly ground them to size. This means not only a saving in time but better and more uniform parts.

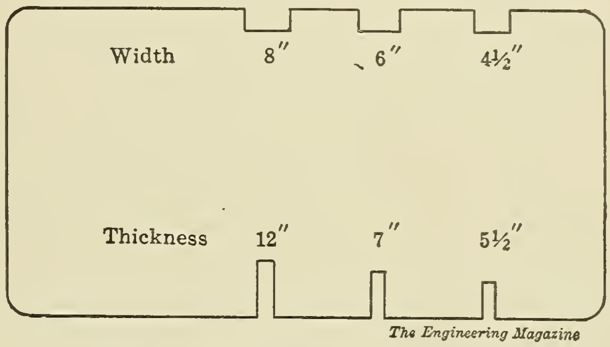


Fig. 44. Grinding Gauge

Piling Material

In a department of a plant making standard parts it was found extremely difficult to handle the parts in such a manner as to admit of accurate counting and at the same time facilitate handling. The following sketch shows the part:

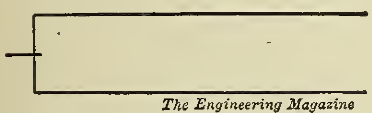


Fig. 45

The solution was found by making a number of boards, laying one on the floor and piling 24 parts on thus: A board would then be placed on top of the 24 pieces, another set of 24 placed on the second board, and so on. In handling, a board was picked up and carried. Count was made by the number of boards, and not pieces, as each board always meant 24 pieces.

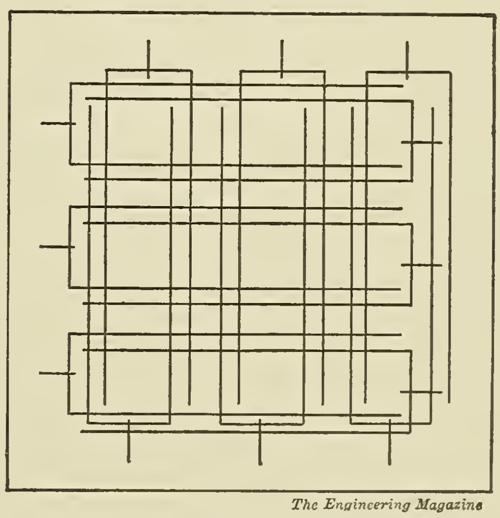


Fig. 46. Standardized Method of Piling Stock

Twisting Wire

In a plant twisting wire the requirements were for lengths of at least 200 feet. In twisting, short ends would be left, which either had to be thrown out or a new spool put in the machine and a splice made. The time studies revealed considerable waste in time and in material and as a result the foreman devised an ingenious scheme which was a combination of both planning and standardized conditions. He had the boys spooling the wire run it through measuring machines, marking on the tag of the last run of wire the lengths of the various runs in their order, as 550 feet, 400 feet, 700 feet, 300 feet. Instead of the machine operator putting in spools at random, he was given a number of spools from which he could select the lengths which would leave long ends. For instance, if he was twisting two wires about a third and he had four spools with the following lengths of wire:

	1 Feet	2 Feet	3 Feet	4 Feet
A	700	800	1,000	400
B	300	400	400	600
C	800	600	600	600

he would take 1 and 3, run 1A and 3A and have a balance of 300 feet, which he would run with 1B. Then he would run 1C with 3B with a balance of 400 feet, which he would run with 3C, leaving 200 feet of wire. Now taking spool 2 he would run this 200 feet with 2A and have 600 feet left. Putting in spool 4, he would run this 600 feet with 4A, with a balance of 200 feet which he would run with 4B, leaving 400 feet. This he would run with 2C, leaving nothing. 2C and 4C are both 600-foot lengths.

Fitting and Riveting

In a structural shop it was found through time-study methods that a fitting gang could fit twelve units in a day. Hence the riveting gang was correspondingly limited to twelve units per day, because it was able to rivet only what was furnished to it. *The stop watch indicated, however, that the gang could easily rivet twenty pieces per day.* Because it only produced twelve, therefore, its efficiency was 60 per cent (12 ÷ 20). The work consisted of riveting plates on I beams and required the riveting by hand of thirty-six ¾-inch countersunk rivets per unit. The matter was carefully discussed with the foreman, who instructed the riveting gang *to work on other jobs until about* 10.30 *a. m. and then to start in on the work illustrated.* He also had an excellent opportunity to ascertain what standardizing a condition meant, for the engineer suggested a plan for placing the work to facilitate the labor of the gang driving the rivets. Fig. 47 shows the arrangement.

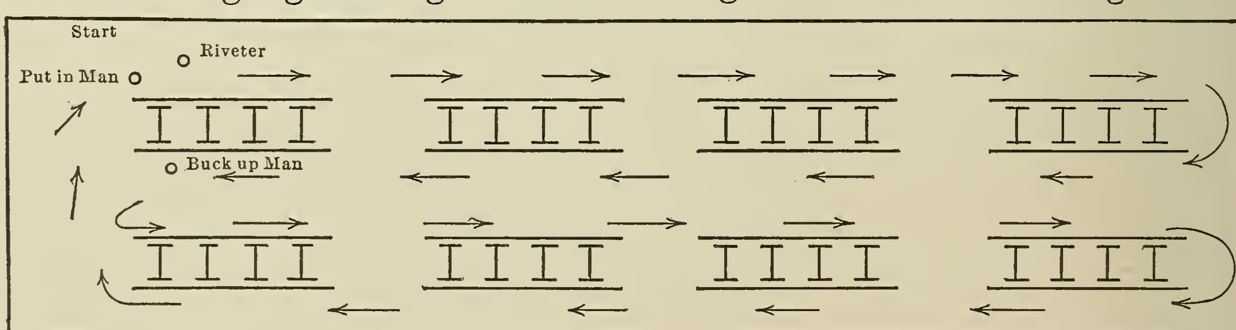


Fig. 47. Standardized Conditions on a Riveting Job

The riveter started at the first unit and followed the arrow. A reaming gang followed the riveting gang, taking out fitting bolts and reaming holes. The riveting gang in turn following the reaming gang, and riveting reamed holes. New units were placed as soon as work was riveted.

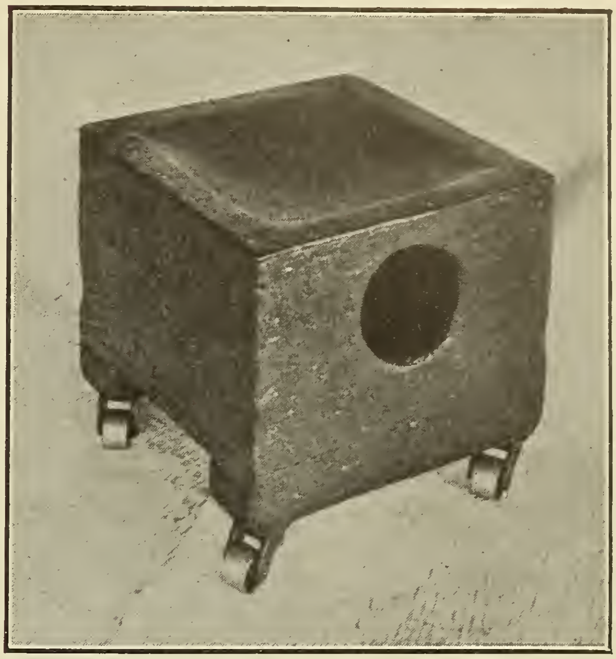


Fig. 48. "Cricket" for Machinery Erector

Assembly Work

Figs. 48 and 49 both show equipment which materially helps assembly men. The small stool (Fig. 48) on which the operator sits is called a "cricket," and having castors it enables the workman to move himself around by pushing away from it with his legs. As can be appreciated this facilitates the work of a man who in erecting machinery would otherwise have to sit or lie on the floor. The portable bench holding tools (Fig. 49) is for men who have to work at several places around a machine.

Belt Rack

Fig. 50 shows the method followed in standardizing the conditions of a grinding and polishing room. Previously the belts had been kept at the rear of the room, making it necessary for the workmen to leave their work, go to the place where the belts were kept, take what they wanted, return, place the belt on the machine, and start. After the studies were made the belt racks were moved, as shown in the picture, and a number of belts were placed on hooks for each machine, sufficient to last for the day. If a man needed additional belts, he had to take up the matter with the belt man, who would investigate and decide whether or not to allow extra belts to be used.

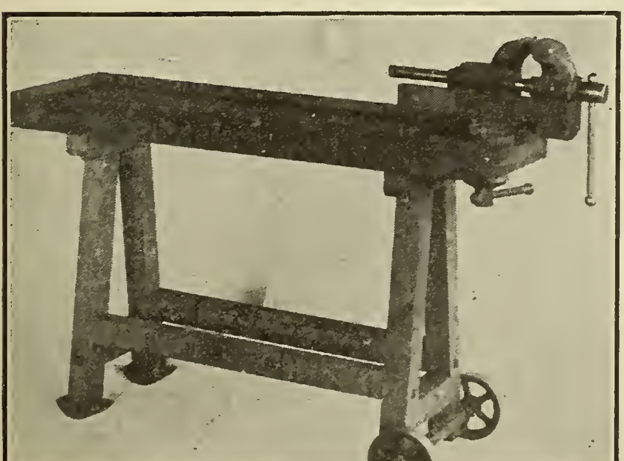


Fig. 49. Portable Tool Bench

Packing Boxes

In a factory which packed the pieces in small boxes by hand, the operators were found lining the boxes with paper before sorting in the pieces. After time studies were made, it was suggested that one operator be delegated to place papers in empty boxes, prior to giving them to the packers. This was done, and the time previously spent on this part of the work was devoted to putting in pieces, with considerable gain in time per box.

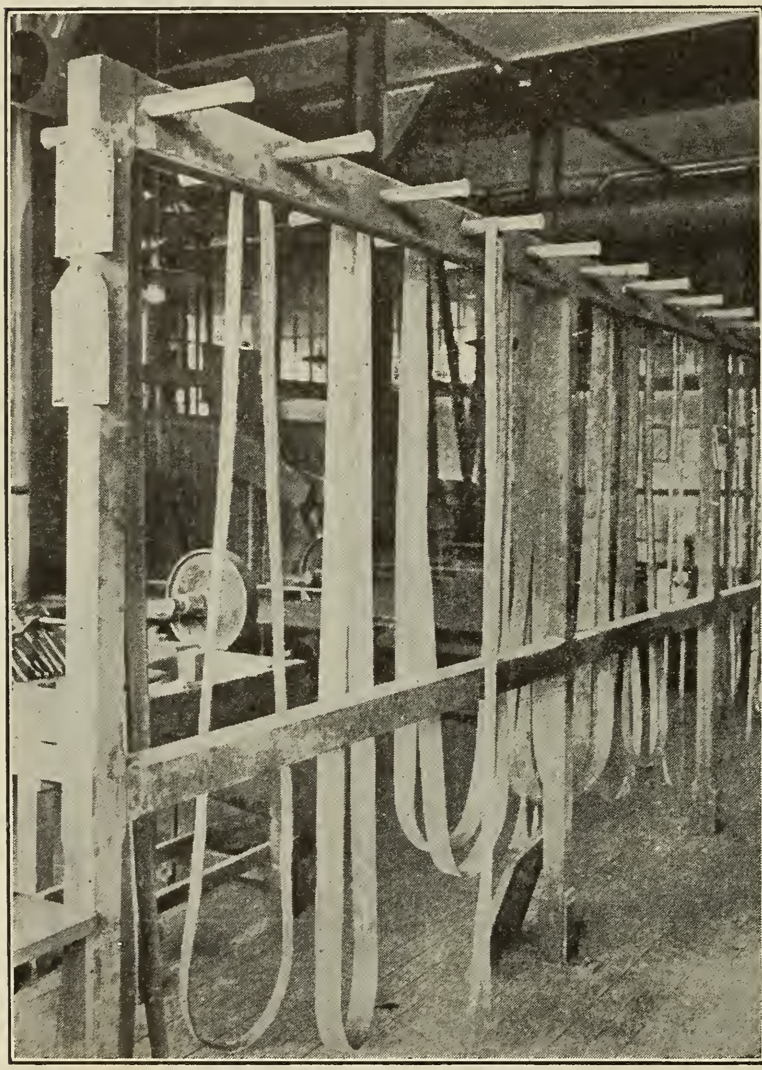


Fig. 50. Belt Rack

Placing Papers

In one case where girls were placing papers in machines, it was found that very often the papers were wrong-side-up and wrong-end-to, necessitating the turning of the paper around and over. The plan that was recommended was to place the papers properly *before* they were sent to the machines, *with right-side up and right end facing the girl.* In this way the girls could place papers with the fewest motions and in the least time.

Emery-Wheel Practice

In a plant operating forty emery wheels in one department, investigation developed that on thirty-four out of the forty wheels there was a loss in surface speed of 46,166 feet per minute. Progressions were figured out so that as wheels became smaller through use they would be moved to another stand, this to be done out of working hours. The speeds were figured so that approximately 5,000 feet of surface speed per minute would be attained. To determine the changes in wheels a gauge was designed. By placing the gauge on any wheel, the diameter would indicate the spindle speed at which the wheel should run, and the stand on which it should be placed. Changes would be made accordingly. These rules were outlined:

1. Sound each wheel before mounting to detect injury in transit.
2. Never force wheels onto spindles.
3. Use relieved flanges wherever possible.
4. Avoid unnecessary tightening of wheels.
5. Keep rests close to wheels.
6. See that each wheel is properly guarded.
7. Keep each wheel running true.
8. Look after adjustment of bearings once each week.
9. Keep bearings well oiled at all times.
10. Have stands on solid foundation.
11. Look each wheel over twice each week to detect cracks.
12. Delegate a responsible person to look after the above who is to make regular reports on same.

Machine Record

In the seventh chapter mention was made of getting or making a set of floor plans showing machines, floors, benches and vises. This is a valuable aid to the engineer contemplating the task of standardizing conditions and operations. In connection with these floor plans, the engineer should secure the data that will give him a complete inventory of the tools, showing what the equipment is, where it is, what it does, the conditions under which operation is carried on, etc., all of which is of value. Such a machine record is shown in Fig. 51.

MACHINE TOOL RECORD							DATE
MACHINE NO.	DEPT			BLDG.			FLOOR
NAME OF MACHINE				MAKE OF TOOL			
WEIGHT—HEAVY—MEDIUM—LIGHT				DATE INSTALLED			
LINESHAFT	SIZE	D. OF PULLEY			FACE		R. P. M.
COUNTERSHAFT	SIZE	D. OF PULLEY			FACE		R. P. M.
		1	2	3	4	FACE	POWER FEED HAND FEED
DRIVING CONES	SIZE						SPINDLE SPEED
DRIVEN CONES	SIZE						STROKES PER MINUTE
	R. P. M.						LENGTH OF STROKE
DRIVING F. CONES	SIZE						RETURN RATIO
DRIVEN F. CONES	SIZE						GRINDING TOOLS { MAN / TOOL ROOM
	R. P. M.						COOLING AGENT
FEED CHANGE GEAR TRAIN							

DRIVING BELT	S—O—T				
BELT POSITION					
	SIZE	NO. TEETH	STEEL	SPEED	TEETH
CUTTER					INSERTED / SOLID
IF LATHE TOOL—SIZE OF STOCK					
KIND OF STEEL					
SHAPE OF TOOL				SQUARE	ROUND
CUTTING SPEED—FT. PER MIN.					
FEED—INCHES PER MIN.					
DEPTH OF CUT					
WIDTH OF CUT					
METAL REMOVED PER MINUTE					

APP. NO. PER DAY	
MATERIAL	
PIECES MACHINED AT A TIME	
NO. CUTTING TOOLS	
TOOLS GROUND EVERY	PIECES
TOOLS GROUND EVERY	HRS.
IS WORK RATTLED—PICKLED—SAND BLASTED	
WORK MACHINED	
NAME	
PAT NO.	
ADDITIONAL DATA:	

Fig. 51. Machine-Tool Record, Face and Back

Anticipative Inspection

The conditions under which machines are operated are important.

Efficiency as to operations is largely dependent upon the efficiency of the working conditions, for which reason they should receive careful attention. In standardization of conditions, the aim is to

1. Minimize delays and breakdowns.
2. Keep maintenance costs at a minimum.
3. Secure greatest capacity out of equipment.

It is one thing to take care of trouble when it occurs and another to anticipate it by days and sometimes weeks. This branch of the work should be organized along the following lines:

1. Each piece of equipment should be considered as a unit.
2. As to each unit, the factors likely to cause trouble should be determined.
3. Each unit should have a record card on which is recorded its complete history.
4. For the various factors determined upon as requiring attention, limits as to time should be set for inspection purposes.
5. Men should be delegated to look after this "anticipative inspection."
6. These inspectors should be supplied with inspection reports, upon which to record their findings. These reports should be made out from the record cards covering the particular factors to be looked into, and sent to the inspectors. This would constitute an advance planning of this class of work.
7. The inspectors should take the inspection reports, make the inspections called for, note the conditions, advise as to the troubles developing, and state what should be done and when.
8. These reports should then be taken and the information contained thereon entered on the record cards.
9. Repairs to the units as made should also be entered on the record cards showing date and nature of the work done.
10. Because the time limits at the start will be more or less arbitrarily determined, it will be found as the work progresses that many of them would need adjustment. For instance, a factor may have a time limit of eight days, when every five days would be found to be the best limit. Another might have one of four days and every two weeks be found to be sufficient. Adjustment of limits is simply a matter of analyzing the information shown on record cards.
11. Delays should be recorded, investigated, and entries made on record cards, so as to make the information as comprehensive as possible.
12. Cost of repairs should also be entered on record cards.

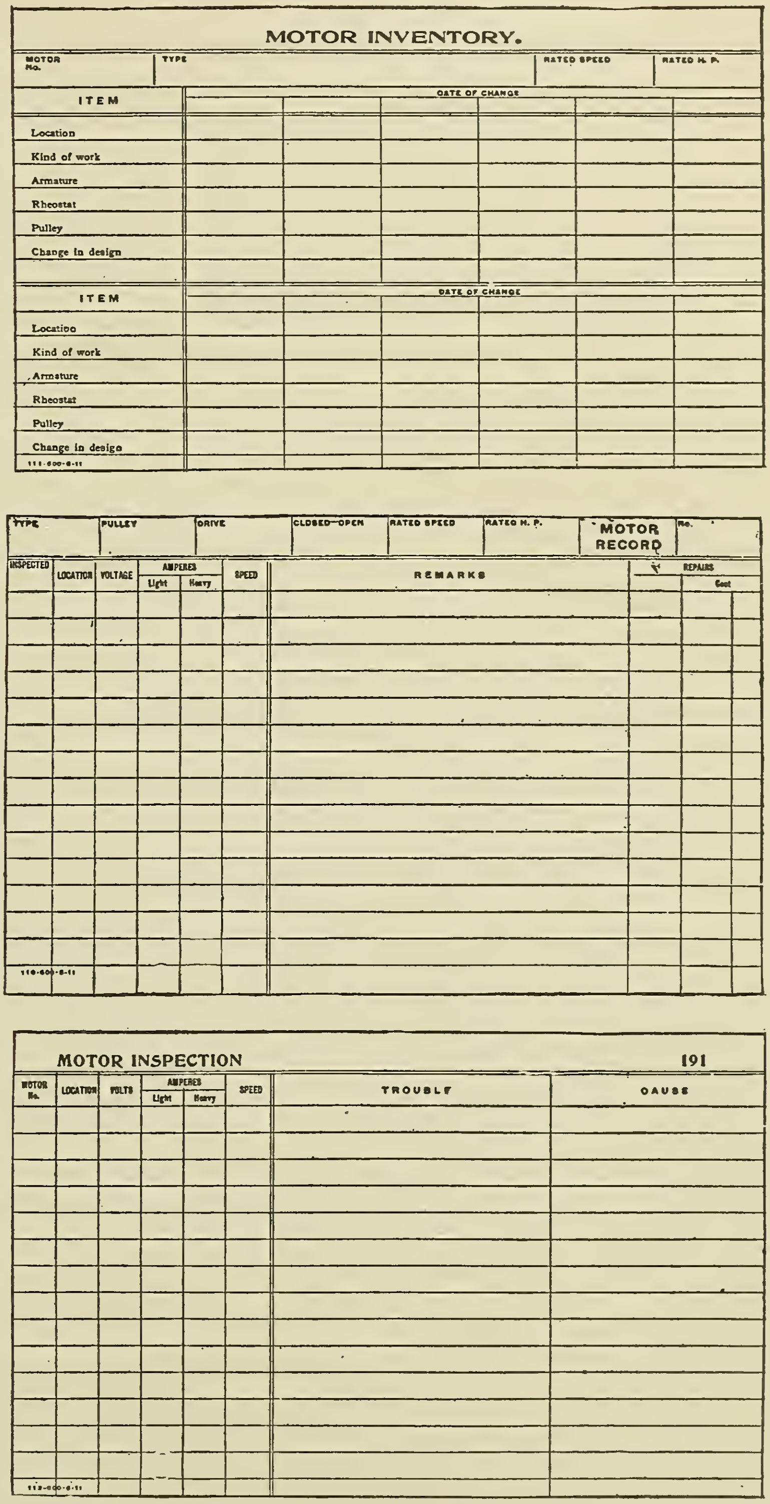
The forms copied in Figs. 52, 53 and 54 will show the kind of records that can be applied to motors, one for inventory, another for the record, and the third for the inspection report.

High-Speed Steel

The advice to cover this feature can be quickly given. Ascertain the current practice in the shop, as to kind of steels used; forging, tempering and grinding; shapes and sizes of tools; cooling agents; cutting speeds, feeds and cuts; how often tools are ground, etc. Then secure the best books and articles on this subject. Match the current practice with the practice recommended by these specialists. Begin the work of testing and experimenting to see what the tools and machines will accomplish, and the result will be a standard practice that will mean greater production.

Belting

A foreman recently asked me what I would do after a belt had been properly placed and the foreman of the department turned the belt with the hooks to the face of the pulley. I replied that the work should be carefully studied and standard practice drawn up and placed in the hands of an expert, or one who could be trained to handle the details. To talk about standard belting-practice is at first the occasion for a laugh and a protest from shop men, against red-tape and damn-foolishness. They are to be excused, however, because they do not know just what the most efficient belting-practice means.



Figs. 52, 53, 54. Motor Inventory, Record, and Inspection

It is a fact that in the average shop very few belts wear out through legitimate wear; they are ruined through accident and improper attention, usually the latter. A narrow belt properly maintained and the tension maintained at the right point, will transmit more power than a wide belt in poor condition and running as slack as they are usually allowed to run in the average shop. If the belt is too tight it means waste due to friction. If too loose it means loss due to slip. As an entire paper could be written on belt-practice, it will be impossible to do more than outline briefly a few fundamentals:

1. Do not run double belts on pulleys less than 6-inch and triple belts on pulleys less than 20-inch.
2. A pulley should be 25 per cent wider than the width of the belt.
3. Never let belts touch shifting devices or lap steps of cone pulleys.
4. Belts should run with hair side facing the pulley.
5. Outside point of splice should trail when running, to avoid opening by the action of the air.
6. Belts should sag onto pulleys and not away from them.
7. Run up-and-down belts on a slant.
8. Avoid very short drives.
9. Keep pulleys clean.
10. Clean belts at regular intervals and apply a dressing that will give the grain side a soft and adherent surface.

Maintain a belt record in the manner outlined under "anticipative inspection"; inspect the belts periodically so as to anticipate breakdowns; keep the belts clean and pliable; repair them *out* of working hours—and the result will be less cost of belt maintenance and longer and more efficient operation of machines.

Foundry Conditions

The matter of standardizing the conditions in the foundry may be of interest in connection with this general treatment. The idea is to point out the way rather than guide over the road. The following is therefore a suggested outline rather than a specific set of rules to cover all cases:

1. Bring in the small patterns on the afternoon previous to day work is to be made, placing them in racks provided for the purpose.
2. Large patterns should be brought in towards night and arranged in a convenient place.
3. After planning each day, the core-room foreman should have the important core boxes brought in.
4. Flasks should be looked up, and those necessary for the next day's work brought in.
5. Get and bring into foundry such riggings as may be necessary.
6. Special gaggers and rods, special mixes of sand, brick, etc., should all be made ready in advance.
7. The night gang should remove castings from floors to cleaning room. Gaggers

should be taken from the sand and placed on the back of the moulders' floors. Sand should be tempered. Flasks not needed should be taken from floors. Necessary pits should be dug.

8. After the regular night work is done, the night force should place on the moulders' floors the various large flasks that are to be used, *in which should be placed the patterns called for*. If pits are to be used, patterns should be placed near them.

9. About one-half hour before starting time in the morning, the laboring force, or part of it, should report, and distribute the smaller patterns and flasks.

10. As soon as work has started in the morning, whatever may be necessary in the way of rigging should be taken to the floors.

11. There should be a regular place for all supplies and a knowledge of their location in the possession of all.

12. Facing, which should be mixed in advance, should be kept at each moulder's floor and replenished before the men need more.

13. Labor foreman should carefully watch the needs of the men as to copes. There is no excuse for a moulder asking for his cope, only to find it at the bottom of the pile.

14. Moulders should be kept supplied with tools, and report their needs to the labor foreman.

15. Cores should be supplied the men in advance of requirements. They should never be made to go for them.

Standardizing Machine Conditions

In standardizing the conditions of one class of machines, the following rules were adopted, which will indicate quite clearly the plan to follow:

1. No machine is to start work until cone belts have been placed in positions decided upon.
2. No machine is to start work until proper change gears have been put in place.
3. Belt guides will be found in front of rear cones.
4. Gear boards have been placed on machines.
5. Change gears have been standardized as follows:

A—22/26	teeth for slow speed
B—21/27 C—20/28	" " medium speed
D—19/19	" " fast "
E—18/30	" " very fast speed

6. Do not use any 24/24 gears.
7. If board spaces 2, 3 and 4 have their gears on it means that the 22/26 gears are in the machine.
8. The 22/26 gears are to be used only for——work.
9. If 22/26 space is empty and also one of the 2, 3 and 4 spaces, the gears in the machine are the ones corresponding to the empty 2, 3 or 4 space.
10. Maintain speed of the machine at the point at which operators can feed pieces with minimum loss of space between pieces.

11. To increase speed of machines, without changing relation between pieces, operate cone belts.

12. To change relation between pieces, change gears as determined.

13. Use following change gears:

Work	Gears
A	22/26
B	21/27
C	20/28
D	19/29
E	18/30

14. Changes are to be made before machines make a new run.

15. One person is to be delegated to attend to belt and gear changes and to be held responsible for this part of the work.

Quality Inspection

The matter of inspecting work is not so much a matter of looking at the piece of work, studying the drawing, putting a "mike" or gauge on the piece, and passing it or throwing it out, as it is of first creating certain definite standards against which the finished production can be compared. The following will indicate what is meant:

1. Standard grades of finish, with allowable tolerance dimensions, must be indicated on all detail drawings.

2. Finishes will be of six different kinds.

3. Finish A consists in making the surface accurate and smooth, and in keeping the dimensions that locate the surface to within a plus or minus tolerance of .001 of an inch. This finish is to be used on the best class of machine work, such as pins and journals of crank-shaft bearings, etc.

4. Finish B consists in making the surface accurate and smooth, and in keeping the dimensions that locate the surface to within a plus or minus tolerance of .003 of an inch.

5. Finish C consists in making the surface fairly accurate and smooth, and in keeping the dimensions that locate the surface to within a plus or minus tolerance of .005 of an inch. This finish is to be used on ordinary machine work, such as line shafting, where a good appearance or a wiping surface is desired.

6. Finish D consists of making rough machining or filing to within a plus or minus tolerance of .025 of an inch. This finish is to be used on rough bored and turned forgings or on surfaces where a simple filed finish is desired.

7. Finish E is for forge finish on rough forgings where no machining is required. Work should be forged neatly to size.

8. Finish F or cast finish. Casting is to be cleaned of all sand and scale. All risers, gates and fins are to be cut off flush with and conforming to the surface of the casting. The metal of the casting is to be so distributed that when casting is completed and ready for assembly, no thickness of metal shall exceed that shown by drawing, plus or minus 5 per cent of that thickness. No dimensions from locating points or planes to cast surfaces to differ from the dimensions as given on drawing

by greater amounts than the following tolerances (outside dimensions to have plus tolerance and inside dimensions the minus tolerance):

Casting weighing 2,000 pounds and over			± 0.25 inch
"	"	500 " to 2,000 pounds	± 0.15 "
"	"	100 " to 500 "	± 0.10 "
"	"	less than 100 pounds	± 0.03 "

9. In addition to the above, when the surface of the metal is to be specially treated, such as polishing, buffing, browning, blueing, tinning, plating, painting, grinding, hardening, etc., the treatment is to be indicated in connection with the grade of machine finish.

10. The pattern and forge shop are expected to make sufficient allowances on pattern or rough forging, as the case may be, to insure the grade of finish required.

The various illustrations show *what* standardizing is, *how* it is done and it is hoped that the reader, if he did not before, will now see *why* it is done. No attempt has been made to go through a plant in logical order. This would be impossible in the short space of a single article. When books can be written about belting, the art of cutting metal, mill-wrighting, inspection methods, and the like, it is clearly out of the question to do more than to outline what can serve as a basis for saying "go thou and do likewise."

Standardization of working conditions is of the utmost importance, as a careful study of the various cases will clearly show. The work is intensely practical and means *facilitation.* Operations cannot be performed to advantage or efficiently if conditions have not first been properly adjusted.

In a general way the procedure is simple. There must first be a conception of the elements to be standardized. Then through time study or careful investigation, current practice must be ascertained. Following this there comes the task of developing a basic theory on which to begin work. Then from all the available sources—books, articles, discussions with practical men both in and out of the organization—there should be selected the points which have a bearing on the case in question. This should all be boiled down to make a systematic presentation of facts *pro* and *con.* Tests and experiments should then be made in an effort to ascertain what to do and how to do it. Procedure should be outlined and properly written up. Following this the work should be functionalized, and a responsible head selected who should render reliable and prompt reports covering his activities. The plans decided upon can then be carried out efficiently.

Chapter XVI

STANDARDIZING THE OPERATIONS

IN the coal mine they use a car which on the "man trips" will seat four persons, two sitting on a side, the four filling the car. If the men put their legs between the legs of the other men, each man sitting on the foot of the man opposite him, *eight men can sit in the car without discomfort and I have seen nine men in a car.* This is standardizing an operation.

In the outline of time-study factors shown in Chapter XI, there are three of the twelve which we will have to make considerable use of in standardizing operations, as listed below:

9. From the data compiled, standardize the operation as to sequence of elements and prescribe as far as possible the procedure as to the motions.

10. Set opposite each element or set of motions an allowed time which will consider rest, fatigue, and unavoidable delays.

11. Analyze the facts concerning waste and efficiency and outline constructive measures to correct the faults.

To proceed to the actual work of standardizing let us take as an example study No. 1 of the paper referred to. We will assume that a number of studies have been made of this particular work in order to establish differences as to time (which is most essential in determining a fair standard) and that the data have been written up in permanent form as illustrated and turned over to the standards division of the staff. The supervisor of this division is therefore familiar in a general way with the details.

In considering the facts before him showing necessary operations, delays, and comments, he will arrange the work into the following divisions and their natural complemental subdivisions:

1. The manual features................	Handling material. Setting jigs. Putting work in machine. Securing work. Hand feeding. Tearing down machine.

2. The mechanical features	Location of machine. Belting. Speeds and feeds. Jigs and fixtures. Tools and holders.

After due thought he should discuss the matter with the study supervisor and if any recommendations for betterment are forthcoming they should be made known to the chief of staff, who will present them to the proper committee (see Chapter IX). If improvements are to be made, standardization should be delayed until they have been put into effect and new studies made. The conditions are now changed and studies which reflect the latest practice are necessary in order to standardize with reference to these conditions.

The standards supervisor should take up with department and tool-room foremen, or others about the plant, the various points with reference to the work in question, soliciting their co-operation and getting their ideas. This can be done by seeing each one separately or in conference. In other words, the line is one hand, the staff the other. Their working must be in absolute harmony. No one-handed man ever accomplishes all that is possible.

With the new as well as the old studies before him, he should call the speed and feed supervisor into conference, for the purpose of determining the proper speed, feed, and cut to use, as well as the time necessary as determined by the combinations decided upon. The manual features should then be noted and a reasonable time allowed for each step. Procedure should be clearly defined. For instance, if the tools and jigs are wanted in a certain order, standardization would provide for bringing them in exactly in the order wanted. If three or four different kinds of castings were to be worked upon, requiring changes in the machines, the standardization would see to it that they were brought in so that the workman could finish all of one lot before starting work on the next lot. If drills and sockets are to be sent in, the standardization would arrange to have them delivered with drills in the sockets. If a jig is to be used and the work admits, standardization would provide two jigs so that the man could be inserting a piece in one jig while the other piece was being worked upon. If a difference is found in the sizes of tools used, standardization would determine correct sizes and record them, preferably on a sketch showing standard sizes.

From all the data in the hands of the standards supervisor, a tentative schedule is drawn up and presented to the chief-of-staff. If he rejects it, he turns it over to the study division for more facts or to the standards division for review. If accepted, however, it is presented to the "operations committee" for approval, or a separate committee known as the "schedule committee" can be formed, made up of superintendent, department foreman, tool-room foreman, study supervisor, standards supervisor, and chief-of-staff. If the tentative schedule is approved, it is written up in final form as will be outlined.

Calling a staff meeting, the chief-of-staff outlines the nature of the standardization, what particular weaknesses were found, what must be watched, and the duty of each one in connection. In other words, the operations are to have the best of staff advice until the planning, conditions, and the operations are all they should be. The standards supervisor, through the foreman, or directly if it is possible, should then discuss the work that has been standardized with the workmen regarding their part of it.

Getting back to time study No. 1 once more, the work of the staff after standardization would be to determine to what extent the planning as outlined in the seventh and eighth chapters will eliminate the delays due to planning. Having a "next job" will do away with delay A. The betterment of the tool-room practice and having the planning take care of delivering tools to men will cancel delays B and F. Reducing the operation to writing will take care of delay E. The staff will see to it that the tools are being ground and shaped as per the standardization of tool equipment decided upon; that belts are properly looked after so that there will be no serious delays from this source; that "anticipative inspection" (outlined in the previous chapter) is taking care of such delays as failure of the pneumatic hoist to work properly. As can be seen, the work of the staff, working in conjunction with the line, is three-fold in nature:

1. The work is carefully studied and analyzed.
2. Betterment and standardization are arranged for.
3. Supervision is exercised to enable the plant to attain the standards determined upon.

Take time study No. 2 for another illustration. In this the delays were:

	Minutes	Per cent
Due to planning	31.7	61.0
Due to conditions	17.2	33.1
Due to man	3.0	5.9
Total	51.9	100.0

With several readings of each step as a basis (and because the planning provides for getting ready in advance the things that are needed), with the staff in conjunction with the foreman keeping the men supplied with facilities and tools, the standards supervisor standardizes the operation, presents it to his committee for approval, calls a meeting of the staff for discussion, outlines the requirements to the moulder, and puts the schedule into effect.

In other words, the procedure to follow in standardizing an operation is:

1. Analyze time-study data.
2. Confer with both line and staff as to features.
3. Present recommendations for betterment to proper committee.
4. Prescribe practice as to speeds and feeds, belts, inspection and the like.
5. Standardize operation as to sequence of work, motions and time.
6. Write it up in a tentative manner.
7. Present it to the proper committee for approval.
8. Outline standardization to the staff.
9. Acquaint men with their part of it.
10. Put schedule into effect.

In the paper referred to on time study, a turret-lathe study was shown. The factors were:

1. Putting piece in.
2. First roughing cut.
3. Changing tool.
4. Second roughing cut.
5. Changing tool.
6. Square end.
7. Removing piece.

This takes care of the sequence of elements. Can the motions be bettered? Assume that the parts are placed to the left of the man; that he puts the parts into the machine with his right hand; that parts are placed on the floor and that he stands at his machine putting the pieces into the jig on a line with his waist. What takes place is this:

1. Turn to left.
2. Bend over.
3. Reach for piece.
4. Pick up piece.
5. Straighten up.
6. Turn to right.
7. Move arm to machine.
8. Insert piece.

If consideration is given to the above it will show that the plan is wasteful. We can therefore standardize this part of it. The parts should be placed on the right of the man, as it is just as easy to do this as to place them on the left hand. A bench should be provided so parts can be placed upon it. Then the steps would be:

1. Reach for part.
2. Pick up part.
3. Move arm to machine.
4. Insert piece.

Four motions have thus been eliminated.

A further refinement may be in order. In placing the parts we will say that the trucker dumps them on the floor or bench. Naturally the pile is a mixed, twisted, and confused mass. Consideration will show that if the parts, as they are placed, are piled in an orderly manner, the man can work to better advantage in picking them up, for they can be placed with reference to the manner in which the worker will reach for them.

Piling parts in a confused way or giving a workman mixed lots is oftentimes very inefficient. It is safe to say that in every case of the kind study and standardization would result in betterment. The chart shown illustrates this point. Study was made of an average lot as shown by the straight line. Two different lots of the same kind of work were then studied, each lot being worked upon separately by the operator, the work being more complicated than the average,

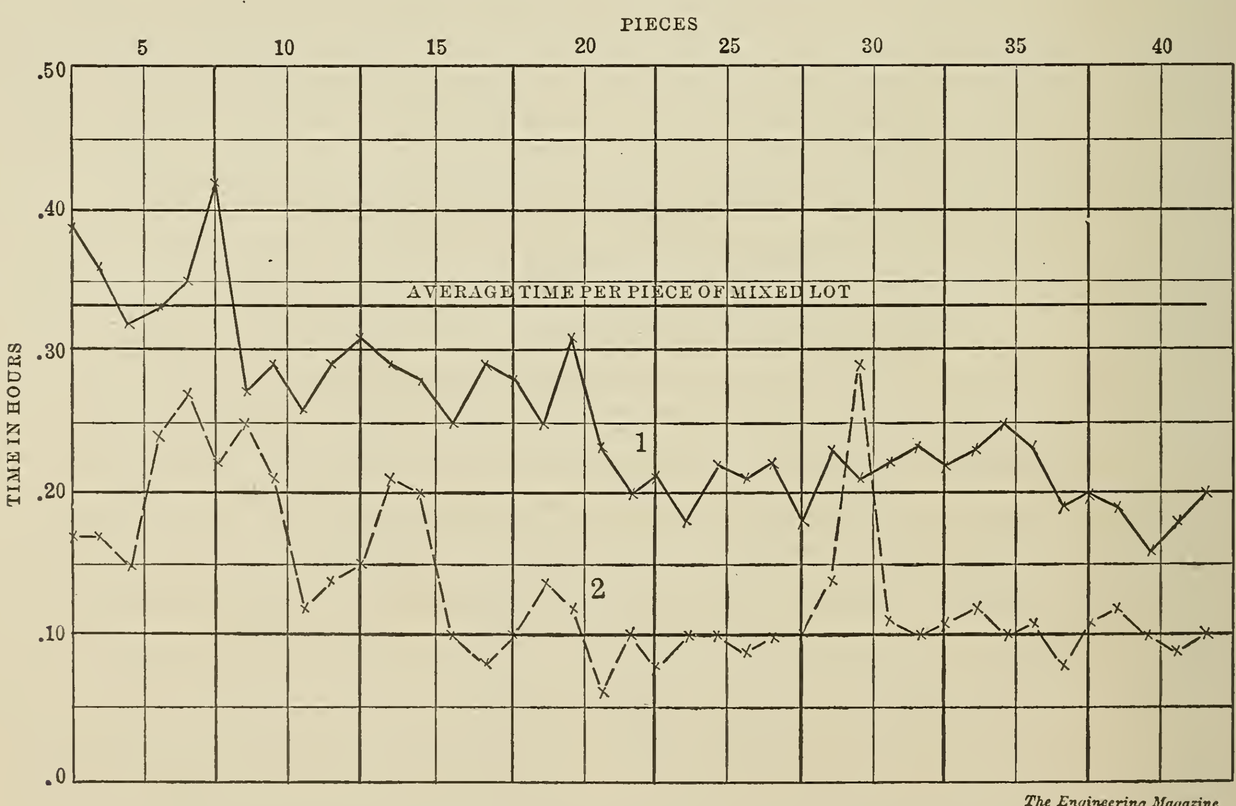


Fig. 55. Chart Showing Effect of Standardizing the Operation of Snagging

so as to not result in misleading conclusions. Note the consistent reduction in time per piece shown by lines 1 and 2 on the chart.

We are now ready to consider the matter of time. We know what must be done and how it must be done. The question is "in what time?" Reference to the turret-lathe study in question will show:

	Operation	Average time minutes	Best time minutes
1.	Putting piece in..........	.152	.130
2.	First roughing cut........	.318	.280
3.	Changing tool...........	.054	.040
4.	Second roughing cut......	.198	.160
5.	Changing tool...........	.054	.040
6.	Square end..............	.250	.190
7.	Removing piece..........	.125	.090
	Total..............	1.151	.930

If we allow the *average* time as the standard, the task would be

$$\frac{60 \text{ minutes}}{1.151 \text{ minutes}} = 52.1 \text{ pieces per hour.}$$

whereas on the basis of the *best* time shown the task would be

$$\frac{60 \text{ minutes}}{.93 \text{ minutes}} = 64.5 \text{ pieces per hour.}$$

A little consideration will show that it would be unfair to the man to ask him to perform a task in the best time shown, and that it would be equally unfair to the company to ask a man to perform a task in the average time. After considerable testing and study the writer has arrived at the following conclusions:

1. Where there are no pronounced variations in the readings, a fair standard may be determined by adding one-half the difference between best and average times to the best time.

2. Where there are pronounced variations in the readings, drop readings above the average and using the balance, add one-half the difference between best and average times to the best time.

In the study referred to there were no pronounced variations so our standardization as to the time factor (in minutes) is as follows:

Operation	1.........	.5 (.152 + .130) =	.141
"	2.........	.5 (.318 + .280) =	.299
"	3.........		.050
"	4.........	.5 (.198 + .160) =	.179
"	5.........		.050
"	6.........	.5 (.250 + .190) =	.220
"	7.........	.5 (.125 + .090) =	.107
Total	....		1.046

$$\text{Standard } \frac{60 \text{ minutes}}{1.046 \text{ minutes}} = 57.3 \text{ pieces per hour.}$$

The efficiency of the operator is approximately 96 per cent.

To illustrate the method in cases where the variations are noticeable, the following study is offered:

In and out	Glue	Cover and trim	
All times in minutes			
.09	.15	.35	.35
.12	.17	.30	.30
.13	.16	.32	.32
.105	.175	.37	.37
.13	.17	.45	
.135	.15	.37	.37
.16	.18	.45	
.13	.15	.43	
.12	.20	.41	
	.15	.41	
		.41	
.124	.165	.38	.34
.090	.150	.30	.30

The standard from the above would be determined as follows:

		minutes
In and out............	.5 (.124 + .09 =	.107
Glue..................	.5 (.165 + .15) =	.157
Cover and trim........	.5 (.340 + .30) =	.320
Total..........................		.584

$$\text{Standard } \frac{60 \text{ minutes}}{.584 \text{ minutes}} = 102.7 \text{ pieces per hour.}$$

Covering the work in question it was decided to allow 10 per cent rest so the standard would be found by the following rule:

$$\frac{60 \text{ minutes} \times 90 \text{ per cent}}{.584 \text{ minutes}} = 92.3 \text{ pieces per hour.}$$

The standard based on judgment and experience before the rule shown was developed was 93 pieces per hour.

Dropping the readings above the average, where there are variations in time that are noticeable, may at first glance seem unfair to the men. It should be remembered, however, that very good reasons usually exist for these high readings. *Further, it should be remembered that it is the intention to provide for rest and in addition to allow the man for delays beyond his control.*

From the riveting study on pages 97 and 98 of the chapter on "Time Study" we can work up the following standardization:

	Rivets	Time	Rivets per hour	Minutes per 100 rivets	
	5	7	43	139	
	10	12	50	120	
	10	6	100	60	60
	5	4	75	90	
	5	3.5	86	70	70
	10	11	54	111	
	10	7	86	70	70
	10	7.2	83	72	72
	5	3.5	86	70	70
	10	8	75	90	
	10	6.5	92	65	65
	10	6.7	89	67	67
	10	7.1	84	71	71
	5	4	75	90	
	10	6.1	98	61	61
	10	6.7	89	67	67
Total......	135	106.3			

The figures in the tabulation give the following factors:

Average...............	73	82	
Best..................	100	60	
Standard (60 minutes ÷ 71).....	84	71	
Average..............	89		67
Best..................	100		60
Standard (60 minutes ÷ 63.5)...	94		63.5

To anyone who has watched a hand-riveting gang all day, it is obvious that it should be allowed some rest as the work is intensely fatiguing, keeping the arm muscles rigid the greater part of the time, in addition to putting a severe strain on the back and shoulder muscles. Further, the rapid vibration of the riveting gun is a greater factor in setting up fatigue poisoning than anyone has any idea of. If therefore we assume a rest factor of 15 per cent, and on account of the wide variation in the column "minutes per 100 rivets" (the high readings being due largely to exhaustion), drop the readings above the average and use 63.5 minutes per 100 rivets as a standard, the task would be:

$$\frac{60 \text{ minutes} \times 85 \text{ per cent}}{63.5 \text{ minutes}} = 80 \text{ rivets per hour.}$$

In order to get the gang to accomplish this, it is necessary not only to see that sufficient work is supplied in advance, but that plenty of rivets are at all times at hand. This is planning. Reaming should be done by a separate gang following up the riveting gang, and the rivet boy should be instructed as to the kind of rivets to throw so as to eliminate the possibility of the riveter getting rivets too cold to head up. This is standardizing conditions. The gang must work together, and the riveter, buck-up man, put-in man, and the rivet boy must be taught to work as a unit. They must be given some incentive. Here again we have an example of planning, conditions, operations, and bonus. In connection read the fitting and riveting illustration in the previous chapter. The two go together.

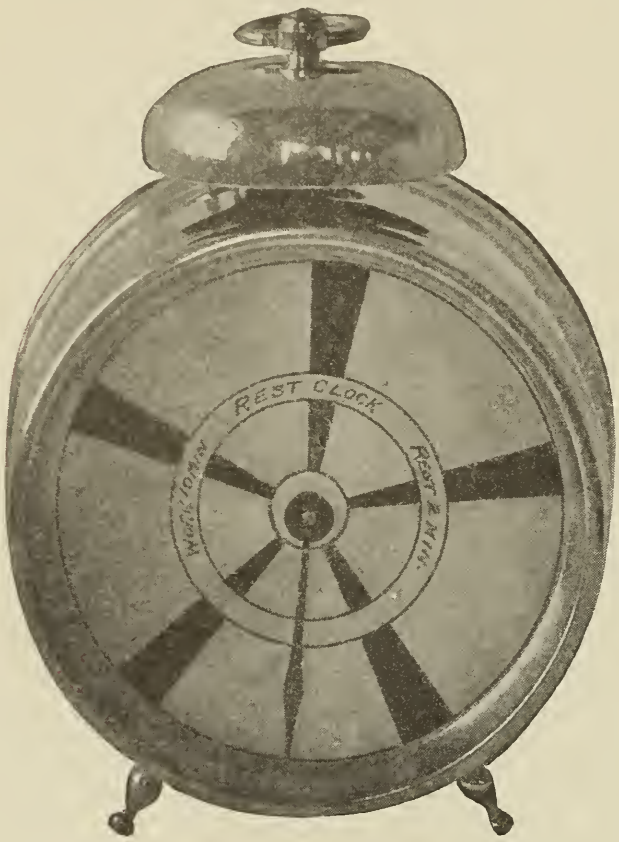


Fig. 56. Rest Clock for Periods of 2 Minutes in Every 12

You have read about Mr. Taylor's experiments in allowing rest to pig-iron workers. You have heard about the allowance of 10 minutes rest in each $1\frac{1}{4}$ hour to girls inspecting bicycle balls, which in connection with other betterments resulted in 36 girls doing the same work which had previously required 120 girls. I know of another case where the production was increased from 275 pieces to 550 pieces per day, through standardization and allowing 20 per cent rest to the operator. In the time-study paper referred to I showed how the efficiency of an operator was increased from 69 per cent to 100 per cent by allowing 2 minutes out of 12 as rest.

Prescribing a rest of 5, 10 or 25 per cent is one thing. It may be quite another to get the worker to take the rest when it should be taken and for the proper length of time. To meet this condition, I devised a "rest clock," easily made from ordinary dollar clocks with new faces put on and placed near the work. One clock can be used by a number of workmen. The man works when the hand is in the white space and rests when it is in the black space. Clock 56 covers rest periods of 2 minutes and work periods of 10 minutes. Clock 57 covers rest periods of 12 minutes and work periods of one hour. This in both cases equals 16 per cent rest, but arranged for in different ways. Clock 56 would cover an intensely fatiguing operation, while 57 would cover one not so tiring, one requiring close application rather than the use of muscular force. But you say the work may be special, or standard and only made once in a great while, and that study and standardization would be valueless. When time study is out of the question, an estimate should be made—not as it is usually made, but by first reducing the work to the principal factors, and then setting a fair time opposite each factor, this to be reviewed by another person than the one making the estimate. The "operation analysis" shown in Fig. 58 will indicate how to divide a job into its elements. The standards set in this way will not be far off. There is another side to it. Special work, as in the foundry for instance, is made up of considerable in the way of factors that are more or less uniform as to the work done. Study shoveling and ramming, for example, on various classes of work, and when a considerable body of data has been gathered, compile it conveniently and use this rule:

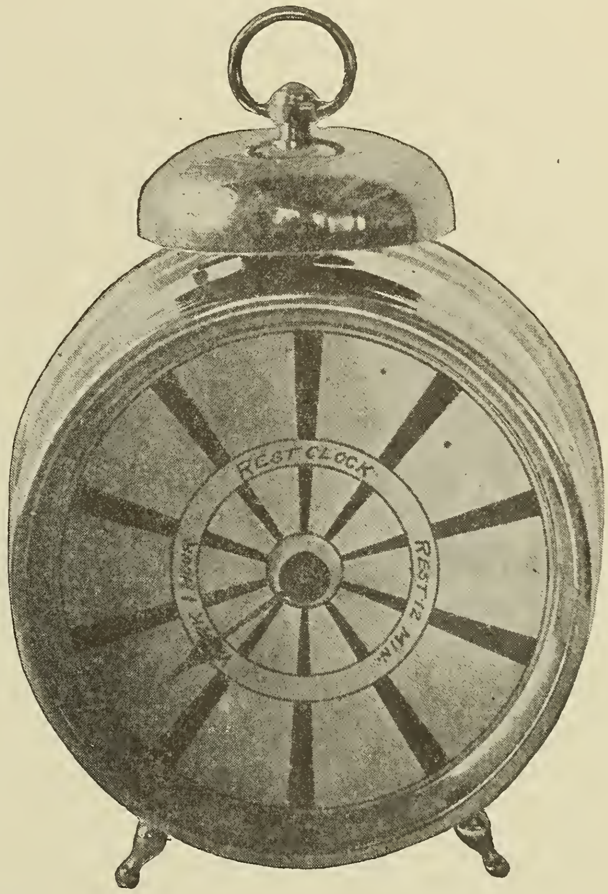


Fig. 57. Rest Clock for a Period of 12 Minutes After Every Hour of Work

C = Cubic contents of flask.
C_1 = Cubic contents of pattern.
F = Factor in hours per cubic foot of sand shoveled and rammed, for the various classes of work.
T = Time for shoveling and ramming.
Then $T = (C - C_1) \times F$.

As another example, setting gaggers can be used, for which two rules can be worked up:

1. B = Number of bars in cope.
   L = Length of bar in feet.
   F = Factor in hours per foot of bar.
   T = Time of setting.

OPERATION ANALYSIS				
OPERATION	UNIT	FACTOR	EST. TIME	
SHAPING PIT				
MAKING BED OF PIT				
PLACING BOTTOM BOARD				
" PATTERN-PIT-DRAG				
" DRAG				
" FACING AROUND PATTERN				
" RODS " "				
RAMMING TO JOINT				
VENTING				
MAKING PARTING				
ROLLING DRAG				
PLACING COPE SIDE OF PATTERN				
" COPE				
" FACING AROUND PATTERN				
SETTING HOOKS				
RAMMING COPE				
LIFTING OFF				
MAKING LOAM PLATES				
DRAWING PATTERN FROM PIT-DRAG				
" " " COPE				
FINISHING PIT-DRAG				
" COPE				
SETTING CORES				
" PIPES				
SECURING				
SKIN DRYING				
PLACING LOAM PLATES				
CLOSING MOULD				
MAKING RUNNER AND HEADS				
CLAMPING AND WEIGHTING				
POURING				
FEEDING				
TOTAL				

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Fig. 58. Operation Analysis

Then

$T = 2\,(B + I) \times L \times F.$

2. B = Number of bars in cope.
L = Length of bar in inches.
S = Spacing between gaggers in inches.
F = Factor in hours per 100 gaggers.

$$\text{Then } T = \left(\frac{2\,(B + I) \times L}{S}\right) \times F$$

The question is sometimes asked—"Shall we standardize on the basis of conditions as they are, or as they should be?" Part of the standardization contemplated improving the conditions, as was outlined in the preceding paper. In other words, in standardizing a machine operation, the machine should receive its share of attention. The speed, feed, and cut should be fixed at what the machine can properly do. Belts should be kept at proper tension and inspected periodically. Jigs should be considered. Prints or samples should be available and in condition to use. Cutting tools should be kept on hand in sufficient quantities and properly forged, tempered, and ground. With this as a basis, determine the elements in sequence, best motions, and fair time. It may be true that if a different machine be purchased or an altogether different way of jigging be introduced it will double the production, *but this does not mean that the operation is 50 per cent efficient.* The Twentieth Century train is 100 per cent efficient if it makes the trip from New York to Chicago in 20 hours. It has made the run in 18 hours and might be able to make it in 16 hours, *but so long as the officials of the road, after proper consideration, prescribe 20 hours as a fair and safe time, then the train attains standard when it leaves and arrives on time.*

Should this standardization be on the basis of studies made of what the best or average man was able to do? Study the best man by all means as he will work more uniformly, with less in the way of lost motion than the average man, and much of what he does can be taught to the other men. Make the task, however, so that the average man can by consistent effort attain the standard, thus allowing the best man to make more than the prescribed bonus offered for standard attainment. On this basis, as will be shown in the next chapter, the poor workman will make his daily wage and possibly 5 per cent bonus, the fair to average worker will earn from 5 to 15 per cent, while the best man will make from 15 per cent to 50 per cent in bonus. This is just and reasonable, for after all it is going to be a case of exertion, skill, and co-operation determining what the man is going to get as a bonus.

How about the "old man" and the apprentice? I have always felt and contend in my work that the "old man," as he is slightingly referred to, has a place in industry. His experience is valuable. He can be used as trainer and coach. He may not be fast, but he is sure. He may on the other hand prove to be both skillful and rapid on certain work. At any rate, for the sake of his past services, don't turn him adrift. If he is too old and cannot work, pension him. If he can work, find out what is best for him to do and give him a schedule with a sufficient allowance added thereto, to justify him in continuing to do his best. It won't cost much if anything. The apprentice should also have an allowance added to his schedule that will warrant him in exerting himself. The apprentice, the average mechanic, and the "old man" will have different wage rates, and as bonus is based on wages there is little likelihood of a clash on account of bonus earnings.

It therefore follows that once elements have been listed in sequence, motions considered, and times decided upon, the work can be defined in a comprehensive manner. Fig. 59, "Permanent Work Schedule," illustrates one means of defining the operation in detail, covering machine-shop work. The entries on the face explain themselves. The wording necessary to describe the operation is written under "opera-

Form 440-5M-9-27-11 **PERMANENT WORK SCHEDULE**

Part	Symbol	Group	Sch. No. P.
Mat'l	Department		Study No.
OPERATION TO BE PERFORMED			Machine
			Belt Motor
			Feed
			Speed
FOR SKETCH SEE REVERSE SIDE			Cut
Tool Steel	Tool Number	TOOLS IN USE	NUMBER MACHINED AT ONE TIME

STANDARD TIME					Jigs-Special Fixtures
Under existing conditions and as outlined herein Standard time for the above work will be					
	HOURS				
Time for setting up		A	Time in Man/Gang Hrs.	No. of Pcs. Per	
Time for operation		B		At Time	
Time for taking out work		C	For Pcs.	Per	
Total allowed		D	For Men	Is	
This is a permanent schedule and the time will remain in effect until design, conditions, equipment or method of manufacture are changed.					Approved
					Date Cancelled
D=Time for one piece. For more than one piece use rule Pcs. x B + A + C = Std-Time		Date Effective			See New Schedule

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Fig. 59. Form for Work Schedule

Form 378 McC-M.C.Co.P.W.	SCHEDULE												
	CONTRACT	DWG.	MARK	CLASS OF WORK		STUDY NO.				SCH. NO.			
	TOTAL ACT. T.	TOTAL STO. T.	EFFY.		FITTING / REAMING			PLANEING / DRILLING			RIVETING		
	OPERATION	Op No.	No. Pcs.	LENGTH	HEIGHT	RIVETS No.	H	M	Std Gang	Man Hours	Effy	S.T. Ea.	S.T. Total

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Fig. 60. Form for Boiler-Shop Schedule

tion to be performed," with a sketch on the reverse side (cross ruled). It is also well to know the tool number, kind of steel, number of tools at work at one time, and pieces machined at a setting. Jigs and fixtures should also be listed. The data as to standard time are given. Fig. 60 is a boiler-shop schedule, while Fig. 61 covers foundry work.

W 769 MMM 310	SCHEDULE		
	WORK		SCHEDULE NO.
			STUDY NO.
			DEPT.
			RIGGING
	PATTERN OR PRINT NO.	MACHINE NO. FLOOR NO.	
	OPERATION		
	SYMBOL	UNDER CONDITIONS AS THEY NOW EXIST AND WITH THE PRESENT EQUIPMENT THE STANDARD TIME ON THE WORK AS DESCRIBED, AND FOR THE NUMBER OF MEN LISTED, IS TO BE —	NUMBER OF PIECES PER ______ AT
	MOULDERS	______ GANG MAN HOURS PER ______ PIECES	TIME PER ______
	COREMAKERS		
	APPRENTICES	THIS TIME TO REMAIN UNCHANGED UNTIL CONDITIONS OR EQUIPMENT ARE CHANGED	IS ______
	HELPERS		
	DATE EFFECTIVE	APPROVED BY	SUPT.

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Fig. 61. Form for Foundry Schedule

It can be readily seen that after so thorough a defining, little room is left for a misunderstanding as to what is required, how it should be done, etc. For this reason it is a most essential factor. There would be few if any piece-work disputes if operations had been previously standardized and carefully written up in permanent shape.

WILLIAMS AND COMPANY
INSTRUCTION CARD

PART	SYMBOL
MATERIAL	DEPT
MACHINE	
TOOLS IN USE	PCS MACHINED AT ONE TIME

OPERATION		MACHINE			TOOLS
#	NAME	SPEED	FEED	CUT	

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Fig. 62. Form for a Simple Instruction Card

It sometimes happens, however, that there exist in a plant excellent opportunities for betterment, but that because of pressure of work on other parts of the proposition, no efforts can be made to start standardization in the right way. In cases of this kind special schedules can be made along the lines outlined for permanent schedules. The work is to be briefly studied and a fair time quickly determined. Such schedules should contain this wording:

> This is a special schedule and the management reserves the right to substitute a permanent schedule as soon as a careful study can be made of the operation.

In this way co-operation can be induced from the start, and later when operation study can be taken up systematically, permanent schedules can be substituted.

In order to acquaint the worker properly with what is expected of him, it is a good plan to give him a sheet showing the essentials. If some such means is not provided, especially with reference to machine-shop work, the man relies on his memory solely, or the foreman has to figure things out all over again each time the operation is performed. This notification can vary all the way from a simple statement of facts to an elaborate instruction card. An excellent means is to place this information on the drawing. A simple form of instruction card is shown in Fig. 62, while a more elaborate form is shown in Fig. 63.

Often a general schedule can be made to cover a variety of work after sufficient studies have been made. The general riveting schedule below will illustrate what is meant.

GENERAL RIVETING SCHEDULE

Standard gang—4 men

Riveting using pneumatic hand riveter as per the following table, all handling of material being included in the schedule:

Number rivets per piece	Symbol	Without crane: Rivets per hour	Without crane: Hours per 100 rivets	With crane: Rivets per hour	With crane: Hours per 100 rivets
1	A				
2	B				
4-6	C				
7-10	D				
11-15	E				
16-20	F				
21-30	G				
31-40	H				
41-50	I				
51-75	J				
76-100	K				
101-150	L				
151-200	M				

Painting, yard labor, shop labor, cranemen, shipping and the like can also be put on schedule. The foremen should have schedules based on cost and production or on the efficiency of the men under them. A yard schedule is shown in the following:

YARD SCHEDULE

Covering unloading box cars—loose materials, such as sand, silicate, etc.—throwing material to ground.

Tool—No. 3 contractors shovel.

Load—20 lb. per shovel.

Time per shovel—.30 minutes.

$$\frac{2240}{20 \text{ lb.}} = 112 \text{ shovels per ton.}$$

$112 \times .30$ minutes $= 34$ minutes per ton.

Tons per man hour—1.76.

Another schedule is shown in the following:

GENERAL SCHEDULE COVERING CUPOLA WORK

For properly attending to the cupola, as hereinafter provided for, a bonus of 20 per cent will be paid to the men employed in the cupola gang, on the basis of a standard cost of 50c per ton of good castings—the head melter to receive one-third of the bonus earned, the balance to be divided between the other members of the gang in proportion to their wages and time as shown for the pay period.

Work covered by the schedule is as follows:

Relining cupola when necessary.
Getting materials from yard to charging platform.
Weighing materials.
Charging and tending cupolas.
Cleaning and daubing ladles.
Removing cupola dump.
Preparing cupola for each day's heat.
Breaking stock when necessary.
Keeping charging platform clean.
General work about cupola not included in above.

Bonus will be paid on the basis of the following scale:

Cost per ton	Bonus per cent
$0.72	0.1
0.67	1.3
0.63	3.3
0.59	6.2
0.56	10.0
0.53	15.0
0.50	20.0

From the average weight of good castings cleaned and cost of cupola gang for the first two weekly periods following the introduction of this schedule, the rate per ton will be ascertained, which will be divided into the standard cost to get the efficiency. The result of each succeeding two weekly period will be added to the result for the preceding period and an average found until the 5th two weekly period is reached, when the 5th will be added and the 1st dropped. This will be the rule in all subsequent figuring—one will be added and one dropped.

Effective.........................Signed..............................

In standardizing the duties of persons in functional positions, the individual should be given a title, relations should be established, and the duties should be outlined. To give an idea of what is meant, the following is offered:

SPEED AND FEED WORK

1. Title of person in charge—Supervisor of Speeds and Feeds.

2. Relations: Member of Staff, Operations Division and responsible to the Chief-of-Staff as regards all work in connection with tests, experiments, study, standardization and preparation of instructions.

Member of Operations Committee of Line organization and responsible to its

SMITH JONES COMPANY

INSTRUCTION CARD

PART		DEPT	TOOLS IN USE
SYMBOL	MACHINE	MATL	PCS MACHINED AT ONE TIME

OPERATION		MACHINE			TOOLS				REMARKS	STANDARD TIME
#	NAME	SPEED	FEED	CUT	NAME	#	SYMBOL	SIZE		
									TOTAL	

SKETCH OF PIECE	TOLERANCE		
	SYM	PLUS	MINUS
	A		
	B		
	C		
	D		
	E		
	F		
	G		
	H		
	I		
	J		
	K		
	L		

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Fig. 63. Form for a More Elaborate Instruction Card

chairman, Mr. ——— as regards the actual work of instructing workmen in use of best combinations, seeing that these combinations are used, analyzing limits reached and outlining betterments.

3. Functions: Among the duties and responsibilities of the Supervisor of Speeds and Feeds are:

A. Study of the proper use and treatment of high-speed steels and cutters.

B. Arranging for design of tools as to shape, size, clearance and lip angle.

C. Determining best cooling agents.

D. Standardizing the forging, tempering and grinding of tools.

E. Determining duration of cut without regrinding.

F. Determining best combination of speed, feed and cut for any given piece of work.

G. Directing men as to use of combinations decided upon.

H. Study of machines as to pulling power, kind of work, position of work, position of tools and position of worker.

I. Responsibility for seeing that instructions are carried out by foremen and workmen, to the extent, if necessary, of demonstrating that the combinations are practical.

Effective........................ Signed..............................

Fm.459-500-3-14

REQUISITION FOR CHANGE IN SCHEDULE

JOB DATE

SCHEDULE NO.________ ON OPERATION________

NO.________ WITH STANDARD OF ________ HOURS PER 100 PIECES

SHOULD BE CHANGED FOR FOLLOWING REASON:

SIGNED ________

STUDY NO. OF SCHEDULE IN QUESTION________

AVERAGE EFFICIENCY OF OPERATION________

AVERAGE EFFICIENCY OF MAN ON ALL OPERATIONS________

LENGTH OF TIME IN EFFECT________

PROPOSED CHANGE________ HRS. PER 100

NEW EFFICIENCY ON BASIS OF PREVIOUS PRODUCTION________

CHANGE ADOPTED NO. ACTION / AS PROPOSED / ——HRS. PER 100

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Fig. 64. Form for Requisition for Change of Schedule

A schedule may have to be changed after being put into effect. The conditions may be different from those so clearly defined in the schedule. Changes may be made in method of manufacturing, in design or in material. Time may prove insufficient. To handle cases of this kind in a systematic manner, Fig. 64 can be used.

In brief, standardization of operations leaves nothing to guess work, to chance, to memory—it obviates the necessity for scheming things out each time a piece of work is done—it finds out what should be done and records it properly for all time—it serves to eliminate excuses as well as disputes. In the future standardization will have a far greater influence in industry than we have any idea of.

Chapter XVII

THE BONUS PLAN OF WAGE PAYMENT

THE engineer is now ready for another important step in his campaign. He has inaugurated planning methods. Time-study work has been started. He has taken steps to bring about standardized conditions and operations. He is therefore ready to go to the workmen, telling them that since conditions and planning have been bettered, they can assist materially by taking every advantage of the improvements introduced. To get them to do this he proposes the bonus plan of wage payment, based on these underlying considerations:

(1) Each man should see an ideal ahead of him that his mentality can readily comprehend, for just as surely as he attains the ideal, it is automatically replaced by one still higher. Thus standardization becomes not crystallization, but evolution.

(2) In all the world there are no two persons exactly alike, and remuneration should attempt to reconcile the differences.

(3) Effort, interest and exertion are just as important as reaching a goal, and should therefore be rewarded.

These propositions involve *definite standards of attainment, reward based on individual efficiency, and partial remuneration for partial attainment.*

Before we can proceed to a detailed discussion of the plan in question, which all will recognize as that developed by Harrington Emerson, we must first have a clear conception of just what the term "efficiency" really means. If a man walks two miles per hour when he could reasonably walk four miles per hour, his efficiency is 50 per cent, *because he only does one-half of what he can do.* Efficiency is therefore the ratio between what is done and what can be done—the relation between performance and the possible attainment, between the actual and the standard. The rules governing the calculation of efficiency are therefore essential to begin with. They are as follows:

(1) As to time:

A = Actual time

S = Standard time

E = Efficiency in per cent.

To figure efficiency with actual and standard times known:

$$\frac{S}{A} = E$$

To figure actual time with standard time and efficiency known:

$$\frac{S}{E} = A$$

To figure standard time with the actual time and efficiency known:

$$A \times E = S$$

(2) As to quantity:

A = Actual quantity

S = Standard quantity

E = Efficiency in per cent.

To find the efficiency with standard and actual quantities known:

$$\frac{A}{S} = E$$

To find standard quantity with efficiency and actual quantity known:

$$\frac{A}{E} = S$$

To find the actual quantity with efficiency and standard quantity known:

$$S \times E = A$$

If, therefore, comparisons are made between the standards determined as fair and within the reach of the men, and the actual accomplishment, a basis is provided for arranging for individual reward. The preceding paper on "operations" and the one on the "time study" will clearly show the methods to follow in determining these standards. The matter of reward is thus in order.

Reference to Fig. 65 will show the bonus curve used and advocated by me. The heavy curved line is the bonus line starting at 67 per cent efficiency, which means the workman is expected to attain two-thirds of a fair standard before he begins to earn anything additional in bonus. In other words, the man can take 50 per cent more time than that called for by the standard, for which he receives day wages only. Any reduction in time under this 50 per cent margin would be accompanied by a proportionate amount of bonus.

The bonus line is divided into three sections, A, B and C. Men of low efficiency do not become men of high efficiency over-night. They

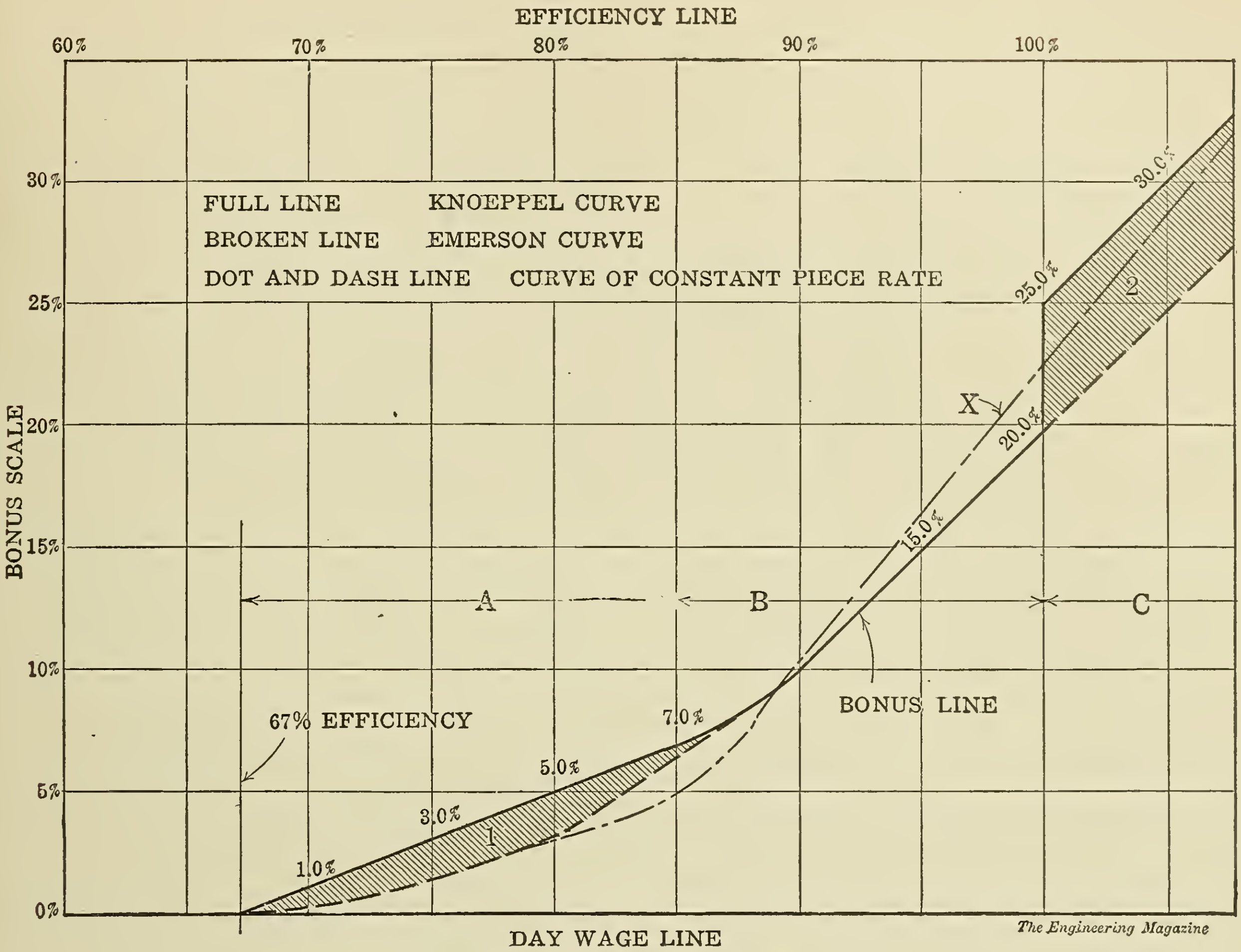

Fig. 65. Bonus Curves

sometimes feel that they cannot attain the standard determined upon. The aim is therefore to induce the men to work up the "A" incline from 67 per cent to 85 per cent efficiency. They then have the incline "B" ahead of them, with promise of additional earnings if they get into this class. Men are not satisfied with standing still, nor do they want to be considered as low-efficiency men. Finally when men are well along towards the 100 per cent mark they are attracted by the additional 5 per cent premium for qualifying as 100 per cent men. A bonus of 20 per cent plus 5 per cent premium seems worth the additional effort to the man who is within 3 per cent or 4 per cent of the goal.

For comparative purposes the Emerson curve has been shown by a dotted line where it varies from the curve recommended. The extra amount indicated by the shaded zone 1 is to warrant men, who might otherwise become discouraged in making the effort necessary, in attempting the attainment of efficiencies greater than 67 per cent, and the amount measured by the shaded zone 2 is a premium for those who average 100 per cent of the standards or better.

In one case the client complained because bonus did not appeal to the workers as it had on the start. The 20 per cent in bonus for 100 per cent efficiency did not seem to justify the effort, and as a result workers were content to earn from 5 per cent to 15 per cent. When the bonus plan was first considered in this case, the engineer urged the additional premium of 5 per cent for 100 per cent workers, as a means of eliminating this very tendency. The basic theory was that 5 per cent in one lump would attract the worker who might otherwise be satisfied with an ordinary bonus. The client could not see it. Who was to blame for the ultimate condition, the engineer or the client?

The chart in question shows a third line (dot and dash) which may be interesting to the student of bonus plans. The claim has been made that because the Emerson and Knoeppel bonus lines mean slightly decreasing costs per piece, they are unfair to the workmen; that the rate per piece should remain constant as in the straight piece work plan. Bonus paid on the basis of the "X" line does this, and its comparison with the other two lines will be found interesting.

The bonus scale which I recommend is as follows:

Efficiency per cent	Bonus per cent	Efficiency per cent	Bonus per cent
67	0	86	7.5
68	0.5	87	8.0
69	0.7	88	8.5
70	1.0	89	9.0
71	1.4	90	10.0
72	1.7	91	11.0
73	2.2	92	12.0
74	2.6	93	13.0
75	3.0	94	14.0
76	3.3	95	15.0
77	3.7	96	16.0
78	4.0	97	17.0
79	4.4	98	18.0
80	5.0	99	19.0
81	5.2	100	25.0
82	5.6	101	26.0
83	6.0	102	27.0
84	6.5	110	35.0
85	7.0	120	45.0

In the practical application of the bonus plan, from the basis outlined, the service card described in the chapter on "planning" should have the following spaces:

<table>
<tr><td>Schedule
No.</td><td>183</td><td>Number
of pieces
per hour</td><td colspan="2">31.2</td></tr>
<tr><td>Standard
Time per
100</td><td>For...
Men
3 2
Hours</td><td>Total
Standard
Time</td><td></td><td></td></tr>
</table>

Fig. 66. Service Card

As work is planned for men working on bonus, the schedule numbers should be shown, the standard time per unit, or 100 units, and the pieces per hour. The standard time is given to facilitate figuring. If the time were 3.2 hours per 100 pieces, and the man completed 54, the calculation would be:

$$54 \times .032 = 1.7 \text{ hours of standard time.}$$

The pieces per hour entry is for the convenience of the workman, who can more easily comprehend the task ahead of him when he knows that he is asked to do 31.2 pieces per hour, instead of being forced to reduce the standard of 3.2 hours per 100 pieces to understandable terms. A further advantage in favor of furnishing this information is that it enables the workman to keep in touch with the situation. If an error or change is made, the workman knows it immediately from his service card.

In this connection it is an excellent plan to give the workman, in addition to any instructions that may be prescribed, an outline of productions required at varying efficiencies. A standard expressed in terms of pieces per hour sometimes scares a workman. He feels it is an impossible task and as a result is discouraged before he even tries. The facts can be presented as follows:

Operation................Part No................Schedule...............

Pieces per hour	Efficiency per cent	Bonus in Cents
		0
45	67	
50	70	1 per dollar of wage
60	80	5 " " " "
68	90	10 " " " "
75	100	25 " " " "
83	110	35 " " " "

NUMBER 312 RATE 25¢

NAME John Smith BONUS RECORD DEPT. A

Date	Sch. No.	Men Nos.	Time				% Effy.	Bonus		Date	Sch. No.	Men Nos.	Time				% Effy.	Bonus	
			Act.		Std.								Act.		Std.				
3/10			10	0	9	3													
3/11			10	0	9	5													
3/12			8	5	9	0	A												
3/13			10	0	9	7													
3/14			10	0	9	2													
3/15			10	0	9	1													
			58	5	55	8	95.3	2	19										
3/17			10	0	9	2													
3/18			10	0	12	0													
3/19			10	0	11	0	B												
3/20			10	0	12	2													
3/21			10	0	10	5													
3/22			10	0	10	9													
B			60	0	65	8	109.6	5	15										
A			58	5	55	8	95.3	2	19										
Average			118	5	121	6	103.0	7	34										

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Fig. 67. Bonus Record

As can be seen, the operator first sees the 45 pieces per hour. *He knows he can do this.* He sees the 50 and 60 and feels that by a little extra effort he can turn out the required amount. He feels 68 would be hard, 75 difficult, with 83 out of the question, but he knows he can do enough to qualify as a bonus earner to begin with, *and this is an important consideration with many workmen.* As he becomes more familiar with the plan and the work he is not so afraid of the standards as he was to begin with.

Each day the service cards turned in, covering the previous day's work, should be sorted according to men and checked to agree with the time spent in the plant. The amount produced should then be multiplied by the standard times, and the product placed in the space headed "total standard time," on service cards. When all the service cards have been figured in this way the entries should be transferred to the "bonus record," each workman on schedules to have one.

Fig. 67 will explain fully the bonus record. Entries are to be made daily; at the end of the week the actual and standard times are added, the efficiency is determined by dividing the standard time by actual time, and the bonus is figured. In illustration A the efficiency is 95.3, paying 15 per cent bonus, so the calculation would be:

(58.5 hrs. × 25 cents, wage rate, × 15 per cent, bonus factor) = $2.19 bonus.

This information is then entered on a bonus check in duplicate,

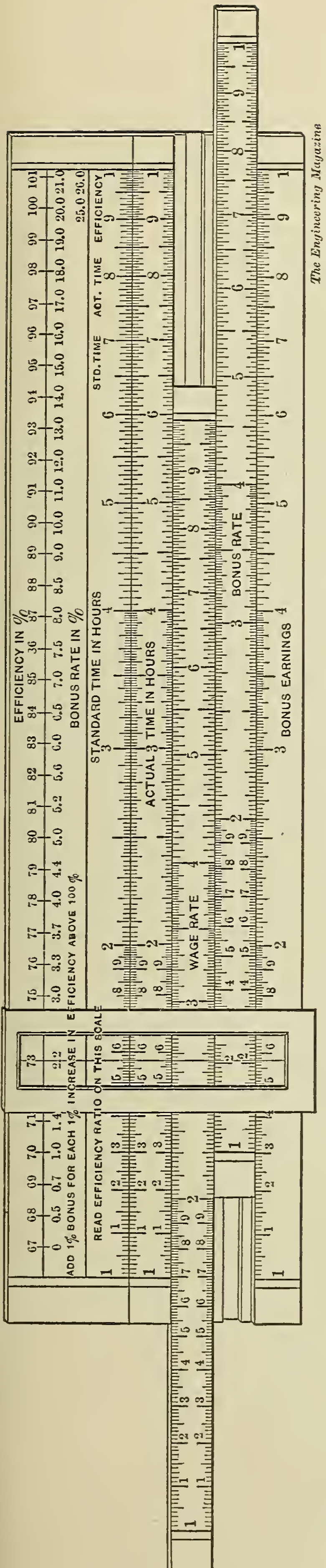


Fig. 68. Slide Rule for Figuring Bonus Corresponding to Any Efficiency at Any Rate of Wages and of Bonus Award

The position of the slides is that given in the final setting described in the text on this page

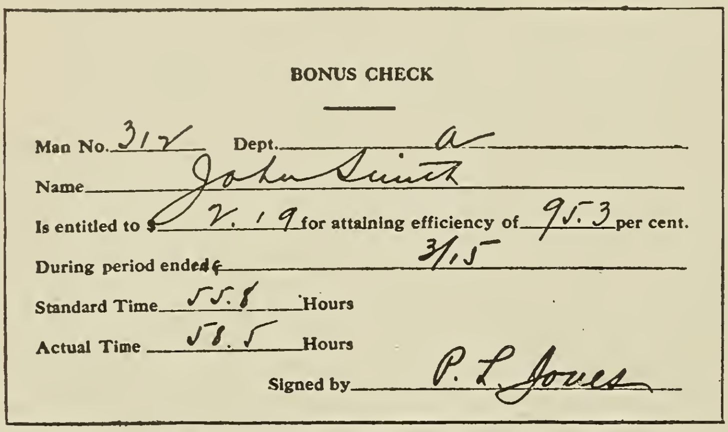
Fig. 69, the original to be given to the workman and the duplicate sent to the payroll department for making up the bonus earnings.

To facilitate the work of figuring bonus, a slide rule can be used to advantage. Fig. 68 shows one devised by the author. For example, assume that a 22-cent man has 54.8 standard hours and 59.4 actual hours. The rule to follow in explaining the setting of the rule in the illustration is as follows:

1—Set 59.4 on No. 2 scale under 54.8 on No. 1 scale.
2—Read 92.3 per cent efficiency from No. 1 scale.
3—Set x on No. 2 scale with x on No. 1 scale.
4—Set Y on No. 3 scale under 59.4 on No. 2 scale.
5—Set x on No. 4 scale under 22 cents on No. 3 scale.
6—Move slide to 12 per cent on No. 4 scale.
7—From slide read off $1.57 from No. 5 scale. This is the bonus.

In connection it might be well to say that bonus is figured on actual times spent on schedules, and not on standard times. Further, bonus is not paid on any one job or day's work, but *on the average efficiency of all jobs for a bonus period.* These periods should be no longer than one week in length, for the workmen are likely to lose interest if the period is too long, especially if they are not advised regarding their showing. It is an excellent plan for some little time after starting the bonus plan to notify the men each day what their efficiencies and bonuses are. This helps in keeping up interest.

Amounts earned are paid on regular pay days in separate envelopes. Wage and bonus are two distinct things, and should be divorced in all considerations of the subject. The separate envelope does this, besides giving the man what he considers and can use as his own. As several workmen have said to me, "The wage envelope is for the wife, but the bonus belongs to me for my spending money," and many have gone after bonus for the extra money. Others have said that they liked to go home with the bonus envelope as it shows they were able to make extra money. By averaging the efficiencies over a period it serves to reconcile any inaccuracies which may creep in through unforeseen or unpreventable contingencies. For this reason the same degree of painstaking and detailed study which would be required if bonus was paid on separate jobs is not necessary, making the plan more elastic, easier to install and productive of results in a shorter time. If a man is working on a schedule that is seemingly hard to attain, he does the best he can and takes every advantage of the opportunity to average up when working on the easier schedule.


BONUS CHECK

Man No. 312 Dept. a

Name John Smith

Is entitled to $ 2.19 for attaining efficiency of 95.3 per cent.

During period ended 3/15

Standard Time 55.8 Hours

Actual Time 58.5 Hours

Signed by P. L. Jones

Fig. 69. Bonus Check

If the workman shows an efficiency of 100 per cent or better, for the bonus period, his regular bonus rate is increased by a premium of 5 per cent. In the illustration B on the bonus record the efficiency is 109.6 per cent, so the bonus rate is:

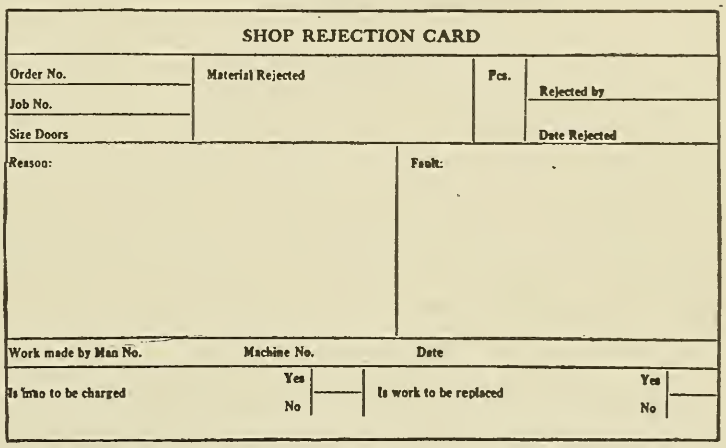
20 per cent for attaining 100 per cent efficiency
10 per cent for 9.6 per cent above 100 per cent efficiency
5 per cent premium for qualifying as 100 per cent man
35 per cent total bonus rate which gives the man—
(60 hrs. × 25 cents, wage rate, × 35 per cent bonus factor) = $5.25.

The bonus rates are in even percentages, the man getting the bonus factor for the next higher efficiency than the one attained if the fractional part of the efficiency is 0.5 or better.

The average of A and B (Fig. 67, bonus record) is then figured to get at the showing for the two weeks—in this case 103 per cent and $7.34 bonus.

In closing the bonus record, any time entered in the actual column against uncompleted work should be deducted and carried to the next period. If this is not done the efficiency of the men will be lowered, because of an entry of actual time against which there is no corresponding entry of standard time. This will not have to be done, however, if proportionate standard times on unfinished jobs can be figured and entered.

So far we have been crediting the man only with standard times. We must arrange to charge him back with rejection for which he is to blame. The workman reports a definite production, which is figured up at so much standard time per piece, *on the assumption that the work will prove satisfactory and pass inspection.* This does away with waiting until inspection before calculating the efficiencies, which in many cases would cause considerable time to elapse before jobs could be figured.


SHOP REJECTION CARD

Order No. | Material Rejected | Pcs. | Rejected by
Job No.
Size Doors | Date Rejected
Reason: | Fault:
Work made by Man No. | Machine No. | Date
Is man to be charged Yes No | Is work to be replaced Yes No

Fig. 70. Shop Rejection Card

As work is rejected a "shop rejection card" (Fig. 70) is made out fully outlining the reason and fault and whether or not man is to be charged back with the work. Two plans are possible:

(A) Deduct the amount of standard time credited to the man, leaving the actual time showing in the actual column.

(B) Deduct both actual and standard times for the rejection.

Suppose, for instance, that the man's actual time is 60 hours, and the standard time is 54 hours, making the efficiency 90 per cent, which would entitle him to bonus of $1.50 if his wage rate was 25 cents per hour, and that a rejection is reported of 5.0 actual hours and 4.3 standard hours. According to plan A the entry would be:

Actual	Standard	Efficiency
60	54.0	
	4.3	
60	49.7	80.2

Bonus would be 60 hrs. × 25 cents wage rate × 5 per cent bonus factor = 75 cents.

Under plan B the entry would be:

Actual	Standard	Efficiency
60	54.0	
5	4.3	
55	49.7	90

Bonus would be 55 hrs. × 25 cents wage rate × 10 per cent bonus factor = $1.37.

Plan B is not so severe on the men and can, in most cases, be used. When workmen continue to be careless, however, and are unwilling to co-operate in efforts to turn out good work, the company is then justified in resorting to plan A.

We can now take up the matter of allowances. If a man performs a 10-hour job in 12 hours, 10 hours of which have been spent on the work and two wasted because of conditions beyond his control, *his efficiency is 100 per cent, while the job efficiency is 83 1/3 per cent, the loss of 16 2/3 being chargeable to the management.* Instead of penalizing the man who did *just what you asked him to do,* the management has an excellent reminder as to where, how, and why it fell down. Because of this separation and because the work of planning and standardization is undertaken by the management, it can be readily seen that the responsibility of the management is just as clearly defined as that of the men. The rule to observe in connection with allowances is:

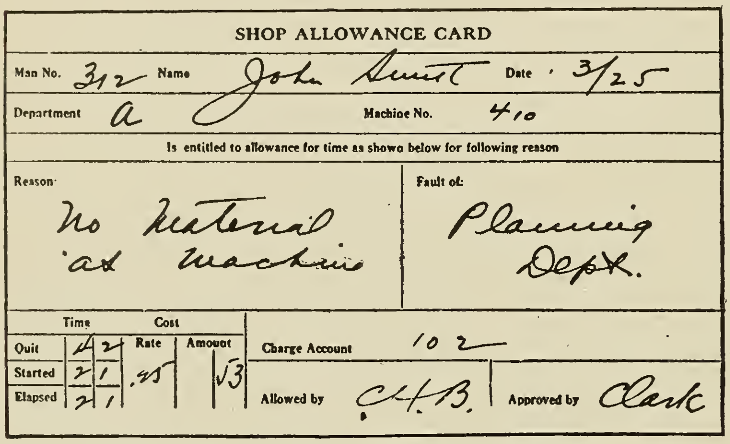

SHOP ALLOWANCE CARD
Man No. 312 Name John Smith Date 3/25
Department A Machine No. 410
Is entitled to allowance for time as shown below for following reason
Reason: No material at machine
Fault of: Planning Dept.
Time / Cost
Quit / Started / Elapsed / Rate / Amount
Charge Account 102
Allowed by C.H.B. Approved by Clark

Fig. 71. Shop Allowance Card

(1) If delay is fault of man, no allowance;

(2) If fault of company, full allowance for time lost to men;

(3) If fault of neither man nor company, each is to stand one-half of the time lost.

As soon as a man is delayed he should ring the annunciator, or report to the dispatching office, and get an allowance card (Fig. 71). When he is ready to resume the work, he is to again ring or report to station and cancel allowance card. The service card need not be changed at all, for the time as shown by all allowance cards can be deducted the next day from the service cards turned in. From this it will be seen that to bonus cards are entered *actual times less allowances.* Allowance cards are to be made out by dispatcher, and approved by foreman.

Records showing department and plant efficiencies are next in order. From the bonus record cards filed by departments, a recapitulation can be made out, after which a summary covering the plant is in order. Figs. 72 and 73 so clearly illustrate the method that no further explanation is necessary.

EFFICIENCY RECORD

DEPARTMENT *a* — [✓] PERIOD / [ ] MONTH — ENDING *3/15*

MAN NO.	MAN NAME	TOTAL HOURS WORKED		ACTUAL TIME ON SCHEDULES		STANDARD TIME		EFFICIENCY THIS PERIOD		EFFICIENCY PREVIOUS PERIOD		EFFICIENCY TO DATE		BONUS		WAGES		WAGE RATE PER HOUR	BONUS RATE PER HOUR	BONUS AND WAGES PER HOUR
310	Williams	60		60	0	54	8	91	3	89	5	90	5	1	32	12	00	.20	.022	.222
312	Peters	60		58	5	55	8	95	3	92	6	89	5	2	19	14	63	.25	.037	.287
313	Frank	60		45	0	46	2	102	6	85	5	87	7	3	15	11	25	.25	.070	.320
314	Smith	60		60	0	52	8	88	0	91	4	89	5		92	10	80	.18	.015	.195
315	Jenkins	60		20	0	18	2	91	0	87	3	85	6		48	4	40	.22	.024	.244
316	McNamara	60		55	5	30	5	54	9	51	2	49	5			14	85	.27	—	.270
317	Clark	60		50	7	42	9	84	6	82	5	81	5		89	12	67	.25	.017	.267
318	Gregg	60		48	5	54	7	112	8	105	7	98	5	5	53	14	55	.30	.114	.414
319	Brown	60		55	2	31	5	57	0	52	0	46	7			13	80	.25	—	.250
320	Jones	65		61	7	58	7	95	1	91	0	92	5	2	04	13	57	.22	.033	.253
	TOTALS	605	0	515	1	456	1	88	5	84	3	81	3	16	52	122	52	.237	.032	.269

RECAPITULATION	
TOTAL HOURS WORKED	605
HOURS MEN IN DEPT. NOT ON SCHEDULE	312
TOTAL	917
ACTUAL TIME ON SCHEDULES OF	
BONUS MEN TO TIME OF ALL MEN	56.1%
ACTUAL TIME ON SCHEDULES OF BONUS MEN TO THEIR TOTAL TIME	85.1%
PROPORTION OF MEN EARNING BONUS TO MEN ON BONUS	80.0%
BONUS PER MAN	1.65
HIGH — Gregg — 112.8 EFFY. — 5.53 BONUS	
LOW — McNamara — 54.9 EFFY. — —— BONUS	

INEFFICIENCY REPORT	
ACTUAL TIME ON SCHEDULES	515.1
ALLOWANCES FOR MONTH	75.3
TOTAL	590.4
STANDARD TIME	456.1
EFFICIENCY	77.2%
INEFFICIENCY DUE TO MEN (100-88.5)	11.5%
INEFFICIENCY DUE TO MANAGEMENT (88.5-77.2)	11.3%
TOTAL INEFFICIENCY	22.8%
PRINCIPAL REASON: Inability to Supply Material: 71%	

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Fig. 72. Efficiency Record of Individuals

The form shown in Fig. 74 is used for analyzing the efficiencies that are low, or below normal as shown in Fig. 72. The idea is not to do any driving nor forcing of workmen, but to get at the real facts that will assist in increasing the efficiency.

Men should not be forced to attain 100 per cent efficiency. This in a sense is up to them. The man is offered an incentive in the form of a substantial increase in income if he will take advantage of bettered conditions and improved planning. If he cannot, something is wrong. If he will not, no amount of force-and-drive tactics are going to make him. An efficiency of 75 per cent or 80 per cent can, of course, be expected of a worker, and any lower showing should be investigated.

EFFICIENCY RECORD

DEPARTMENTS *All #1 Shop* ☑ PERIOD / MONTH ENDING *3/15*

DEPTS	MEN ON BONUS	TOTAL HOURS WORKED		ACTUAL TIME ON SCHEDULES		STANDARD TIME		EFFICIENCY						BONUS		WAGES		WAGE RATE PER HOUR	BONUS RATE PER HOUR	BONUS & WAGES PER HOUR
								THIS PERIOD		PREVIOUS PERIOD		TO DATE								
a	10	605	0	575	1	456	1	88	5	89	2	82	5	16	52	122	50	.237	.032	.269
B	22	1400	0	625	3	495	2	79	2	85	4	76	5	5	21	138	19	.221	.008	.229
C	20	1200	0	800	0	740	0	92	5	90	5	85	4	31	20	160	80	.201	.039	.240
D	40	1800	0	1200	0	940	2	78	3	81	5	72	1	11	25	224	40	.187	.009	.196
E	25	1300	0	750	0	610	0	81	3	69	3	62	5	6	10	161	50	.214	.008	.222
F	30	1500	0	700	0	620	0	88	5	82	6	93	1	27	40	164	50	.235	.039	.274
G	40	1500	0	1200	0	1140	0	95	0	96	1	87	5	70	20	302	40	.252	.058	.310
TOTALS	187	9305	0	5790	4	5001	5	86	4	82	1	73	5	167	88	1274	29	.22	.029	249

RECAPITULATION			
TOTAL HOURS WORKED			9305
HOURS MEN IN DEPTS NOT ON SCHEDULE			4010
TOTAL			13315
ACTUAL TIME ON SCHEDULES OF BONUS-MEN TO TIME OF ALL MEN			43.5%
ACTUAL TIME ON SCHEDULES OF BONUS MEN TO THEIR TOTAL TIME			62.2%
PROPORTION OF MEN EARNING BONUS TO MEN ON BONUS			764%
BONUS PER DEPT			23.98
HIGH	G	95.0% EFFY	70.20 BONUS
LOW	D	78.3% EFFY	11.25 BONUS

INEFFICIENCY REPORT	
ACTUAL HOURS	5790.4
ALLOWANCES	620.5
TOTAL	6412.9
STANDARD HOURS	5001.5
EFFICIENCY	77.9%
INEFFICIENCY DUE TO MEN (100-86.4)	13.6%
INEFFICIENCY DUE TO MANAGEMENT (86.4-77.9)	8.5%
TOTAL INEFFICIENCY	22.1%
PRINCIPAL REASONS	
Inability to plan Jobs	53.1%
Machine Failures	36.2%

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Fig. 73. Efficiency Record of Departments

ANALYSIS OF LOW EFFICIENCIES

MAN		DEPT.	EFFICIENCY			LENGTH OF TIME IN BONUS	REASON FOR LOW EFFICIENCY	FOREMAN
	NAME		THIS PERIOD	PREVIOUS PERIOD	TO DATE		TO BE FILLED IN BY DEPT. FOREMAN	
316	McNamara	A	54.9	51.2	490	3 wks	work new to man	B.F.
319	Brown	A	57.0	52.0	47.0	2 mos	man has failed to show interest. Promises to do better	B.F.
340	Smith	C	62.0	75.0	72.0	3 mos	operating a new machine	J.F.D.
328	William	D	71.0	45.0	51.0	4 mos	man cannot handle work. Giving him trial before transfering to other work	C.R.L.
210	Barth	F	64.0	80.0	77.0	6 mos	man not in best health	G.C.L.
516	George	G	72.0	85.0	81.0	5 mos	Injured a week ago	P.L.J.
520	Collins	H	49.0	—	—	1 week	Just started on schedules	G.L.
543	Barnes	H	52.0	48.0	50.5	3 mos	man claims schedules are to tight & should be investigated	G.L.

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Fig. 74. Analysis of Low Efficiencies

Certain reasons exist for inefficiency, and there is no excuse for failure to ascertain what they are. This all helps the men as well as the company.

Low efficiency is due to one or more of three things:

(1) The men may make little or no effort to attain the standards;

(2) The schedules may be unfair;

(3) The conditions may not be as defined in the standardization.

If the first is true, then the man has no one to blame but himself if he fails to earn bonus. If either or both of the other two are true, the work should be restudied carefully and a proper adjustment made.

MANUFACTURING EFFICIENCY RECORD

Description of Work				Dept. 13
Turning Piston X 546				Matl. C.I.
				Std. Time for 1 Men
Schedule No. 243	Study No. 186	Estimate No.	Drawing No. 4320	Per 10 Pcs. is 28 Hrs

Date Made	By	Pgs.	On Order	Time	Effy.	Cost Act.	Cost Std.	Date Made	By	Pgs.	On Order	Time	Effy.	Cost Act.	Cost Std.
3/20	315	10	7540	3 2	87 5	64	56								
3/28	312	10	7415	3 6	77 7	79	56								
4/6	321	30	7804	8 1	103 7	1 77	1 83								

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Fig. 75. Manufacturing Efficiency Record

We now know the efficiency of departments and men, and to secure the facts regarding the efficiency of the work itself the form shown in Fig. 75 should be used. In this the cards are filed according to parts and operations.

Men should be encouraged to complain about what seems unfair or unreasonable. This makes for a healthy spirit and very often leads to considerable in the way of betterment. Rates considered unfair should be investigated, and if revision is necessary, it should be made as soon as possible, and not kept in force through promises and arguments. Changes in design, in equipment, or in method of manufacture, call for new studies and new schedules, for the very good reason that the basis is different from that previously defined and understood. This is not objected to by the men because they are

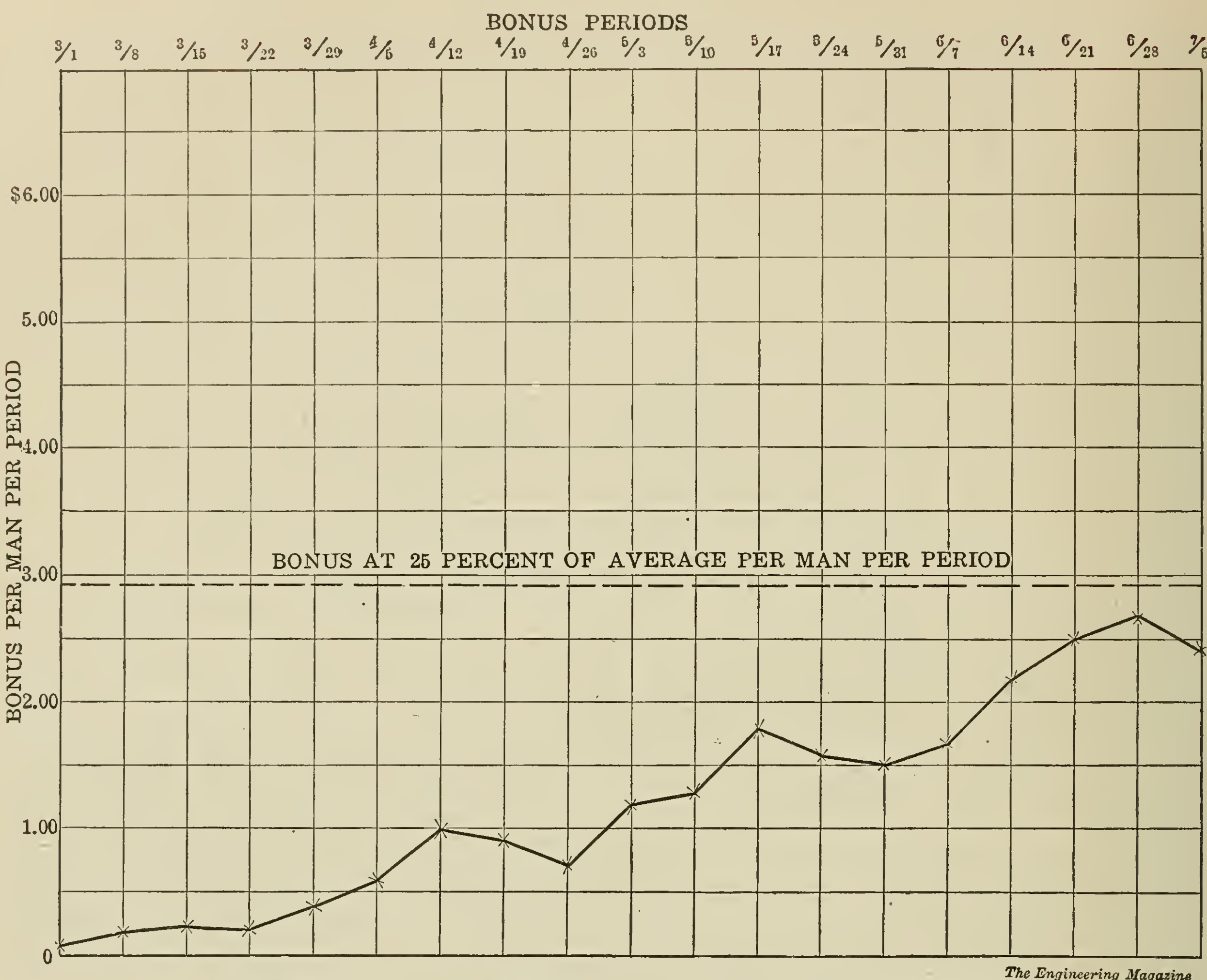


Fig. 76. Average Bonus Earned per Man per Period

not asked to work any harder, and their wages and bonus earnings are in no way decreased.

Rates should never be cut because the man through skill and effort materially increases his earnings. I know of one case where men are regularly earning 70 per cent bonus, but the cost of the work has been decreased 40 per cent. *Why cut this rate?* It is a suicidal plan and kills the goose which lays the golden egg. High-efficiency men encourage the other men. *Place no limit on amounts a man should earn as bonus.*

The matter of an intelligent and comprehensive control of the entire work is most important. To take care of this feature properly a number of charts can be used to decided advantage.

Fig. 76 is a record of the bonus earned per man per period. I was once bitterly accused of being too anxious for the men to earn bonus. *I am.* When men earn bonus it means that efficiency, and therefore production, is higher than if they were earning no bonus. It is a good plan to know what the standard earnings should be, which on the chart are shown by a dotted line. The actual bonus earnings come within 20 cents of the standard in period ending 6/28. The chart shows a healthy condition in that bonus earnings per man show a steady increase.

In order to keep in close touch with the progress of bonus men, the chart shown in Fig. 77 is suggested. Two things are essential—

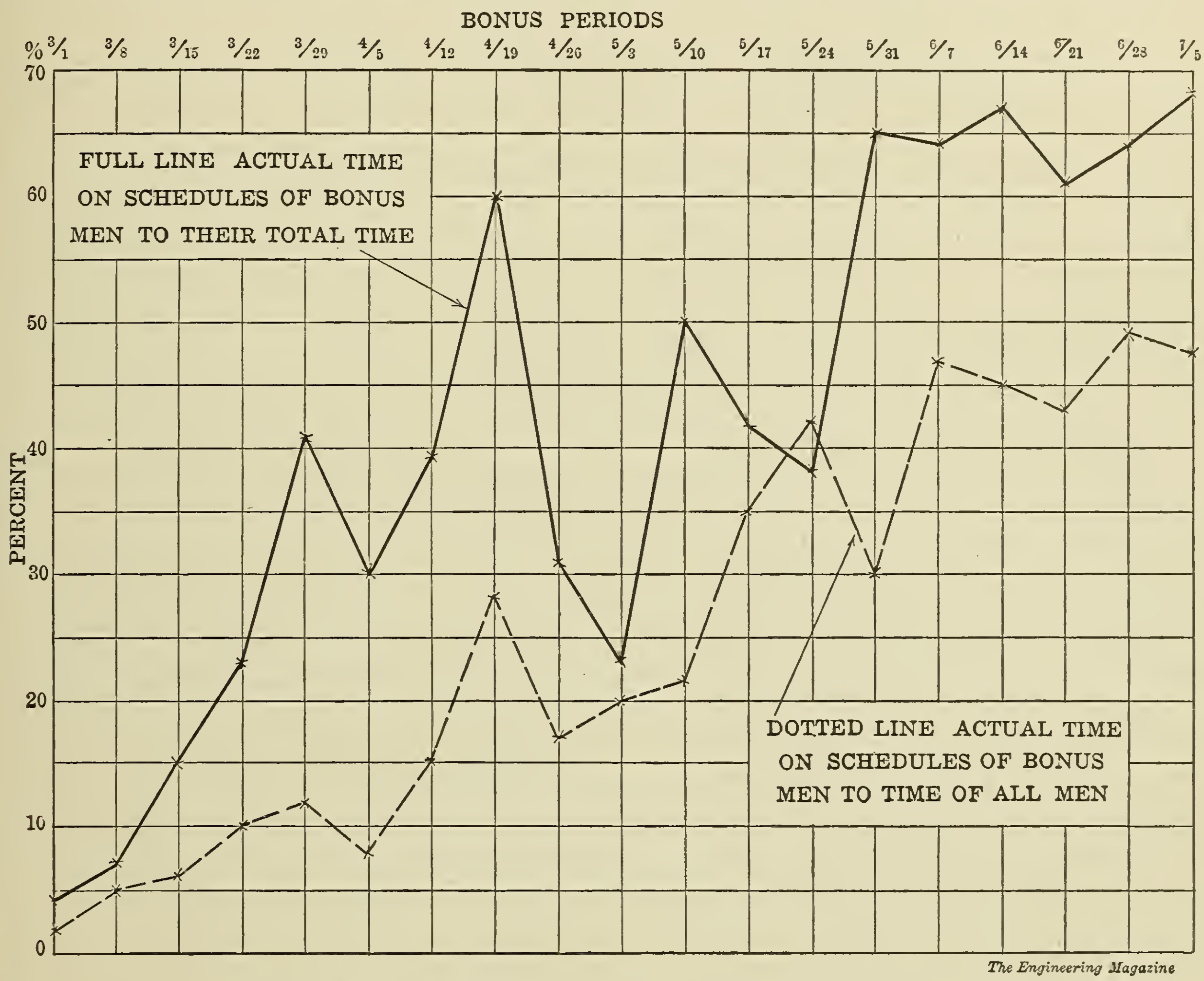


Fig. 77. Ratio of Bonus Time to Possible Time

(1) There should be a steady increase in the number of men put on bonus.

(2) Those on bonus should have as much of their time covered by schedules as is possible.

On the chart the heavy line shows ratio of the time of bonus men on schedules to the total time they work, while the dotted line shows the ratio of time of bonus men on schedules to the time of all men in the department or plant. Take the period ending 5/24 for example; more men were put on bonus, but the time on schedules was less than in the previous period. The dotted line for period 5/31 shows a falling off in the number of men on bonus, although those

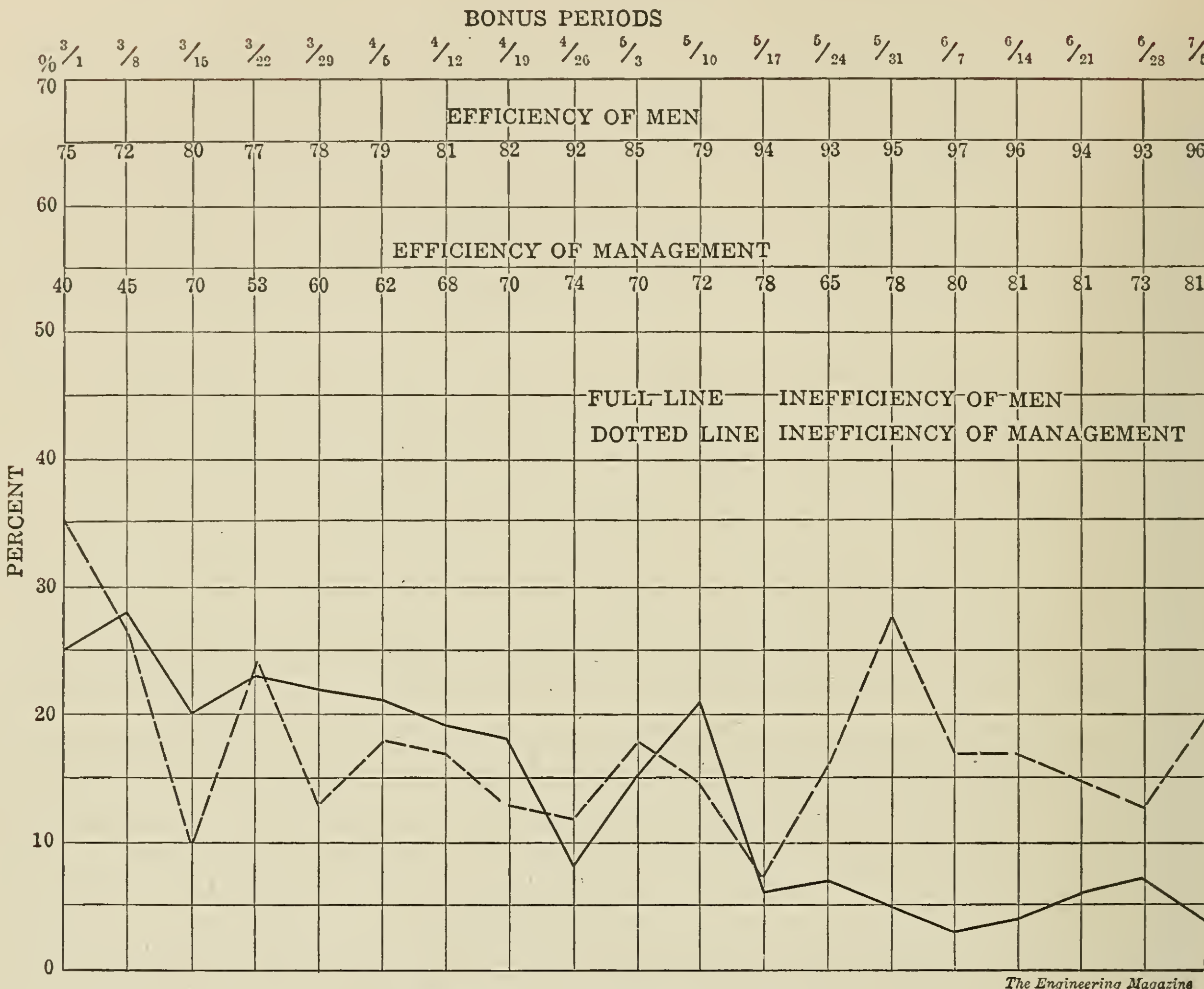


Fig. 78. Inefficiency Chart

who were on worked on them 65 per cent of their time. The heavy line for period 4/26 and 5/3 shows such decided drops as to warrant rigid investigation. Both lines, however, show an upward tendency, which is, of course, encouraging.

The "inefficiency chart," Fig. 78, is decidedly necessary. *My claim is and has been that inefficiency is the element to analyze, for we increase efficiency only through eliminating inefficiency.* Further, the inefficiency of management should be shown as distinct from that of the men. If this is not done there can be no true conception of what is at fault and who to blame. This is accomplished by adding the allowances to the actual hours, after the man efficiency for a department has been determined, and dividing the same figure for standard hours that was used in figuring the man efficiency, by the increased divisor in the form of actual hours. The full line, or man inefficiency, shows a constant decrease although in period 5/10 it increased noticeably. This increase might be due to putting new men on bonus, or old bonus men on new work, or other causes, like cutting a rate or arousing the

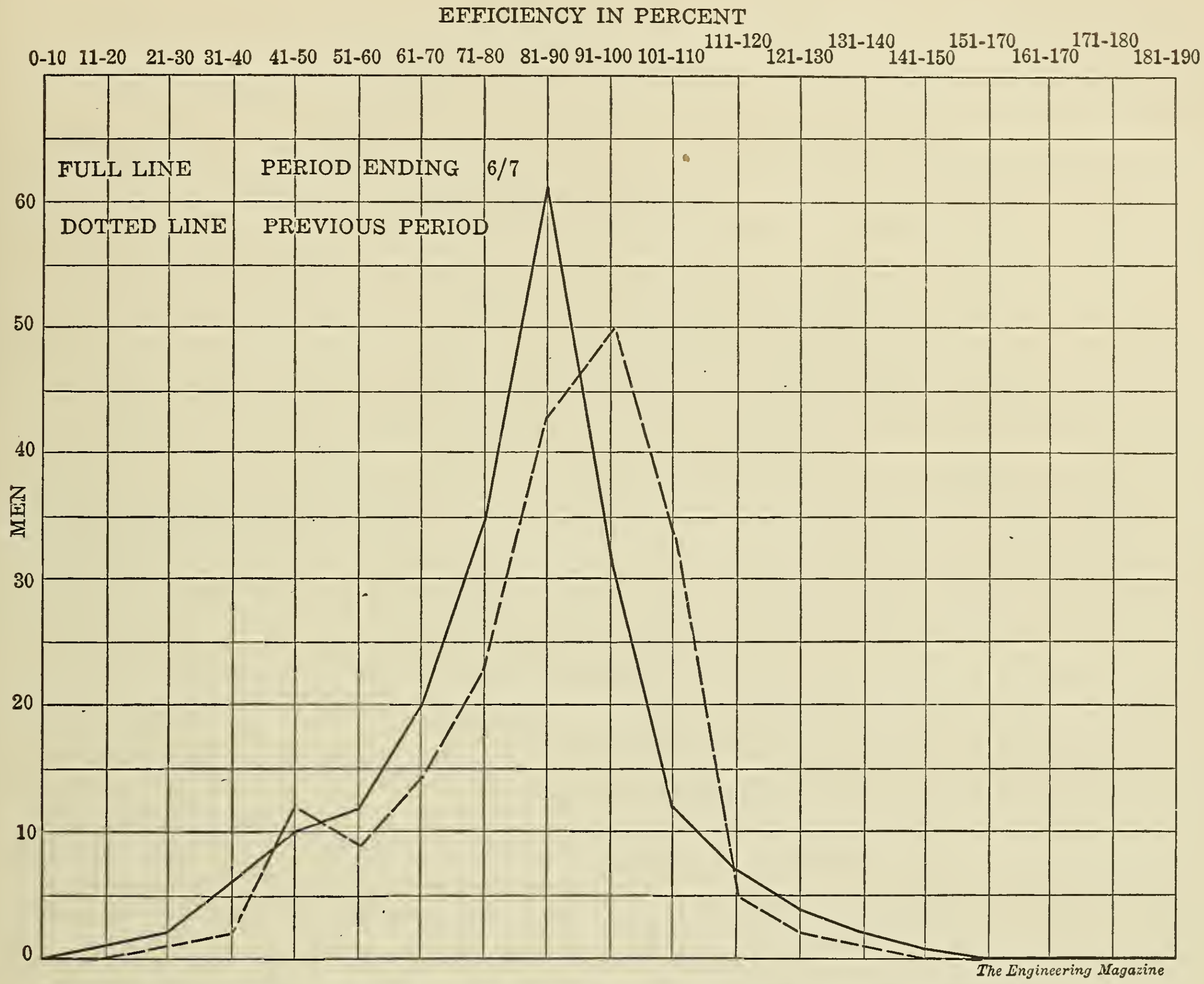


Fig. 79. Number of Men at Various Efficiencies

opposition of the men. From period 4/26 both inefficiency of management and men increased after several periods of decreases. Then comes the sudden drop in both for period 5/17. The significant fact in connection is that following period 5/17 the man inefficiency decreased while *the inefficiency of the management took two upward spurts.* Further the lines show that the men are making faster progress in eliminating their inefficiency than the management, the moral of which is—"*get after the management.*"

Fig. 79 is important in showing the number of men at classified efficiencies. For the period in question the chart shows that 127 men attained efficiencies varying from 71 per cent to 100 per cent, while in the previous period only 116 men attained these efficiencies. At the same time the general showing for the previous period is better than for this period, in that there were less men showing efficiencies from 51 per cent to 90 per cent and more men from 91 per cent to 110 per cent. The value of the chart lies in the ability to concentrate attention on the men showing efficiencies of 80 per cent and under, and ascertaining what interferes with their attaining greater efficiencies. Further, this chart is especially valuable in connection with Fig. 77 showing relative times. *The work of getting more men on schedules, keeping those who are thus employed on schedules for the greatest part of their time, and getting the men showing one class of efficiency into the next higher, can be planned from these two charts.*

An excellent means of keeping the showing before the eyes of all department heads is shown in Fig. 80. In this the efficiencies are so recorded as to facilitate a quick comparison of all efficiencies. A mere glance is all that is required. The showing of "record" and "previous record" efficiencies is stimulating. Progress can also be gauged by listing "previous-period efficiency" and "efficiency to date."

To assist further in the work of eliminating inefficiency a sheet should be prepared covering the efficiency of the workers for a period and posted in a place where it can easily be seen. One is shown in the following tabulation:

EFFICIENCY RECORD SHEET

Number	Name	Efficiency per cent
220	William Jones	103.7
182	John Smith	101.3
116	Thomas Brown	97.4
314	John Williams	92.7
412	Richard Cummins	87.6
514	George Jenkins	87.1
212	Frank Rogers	81.7
324	James Kirk	76.3
114	John Peters	69.4
210	George Olson	57.3

A good plan in keeping track of low efficiencies, is to maintain a graphic record of men whose averages are below 80 per cent. Such a record is shown in Fig. 81. The weekly or period efficiency is sometimes misleading as the variations may be such as to lead to wrong conclusions. A cumulative average is a much better gauge, the graph in question showing a downward tendency.

Before taking up the matter of starting the work, an outline of the effect on cost of the bonus curve suggested may prove interesting. The following table will clearly show this:

Standard—10 pieces per day
Wage rate 20 cents per hour

Production	Efficiency per cent	Wages	Bonus	Cost per piece
5 per day	50	$2.00		$.40
6	60	2.00		.333
7	70	2.00	$.02	.288
8	80	2.00	.10	.262
9	90	2.00	.20	.244
10	100	2.00	.50	.250
11	110	2.00	.70	.245
12	120	2.00	.90	.241
13	130	2.00	1.10	.238
14	140	2.00	1.30	.235
15	150	2.00	1.50	.233

Increase in earning from 50 per cent efficiency to 150 per cent, 75 per cent.

Decrease in cost, $.40 to $.233, after paying this increase in earnings, or 40.1 per cent.

In closing, a few words regarding the important work of introducing the bonus plan is very essential. Men will be suspicious at first. Some will refuse to have anything to do with the plan. The proposition will be viewed with distrust. A situation such as this calls

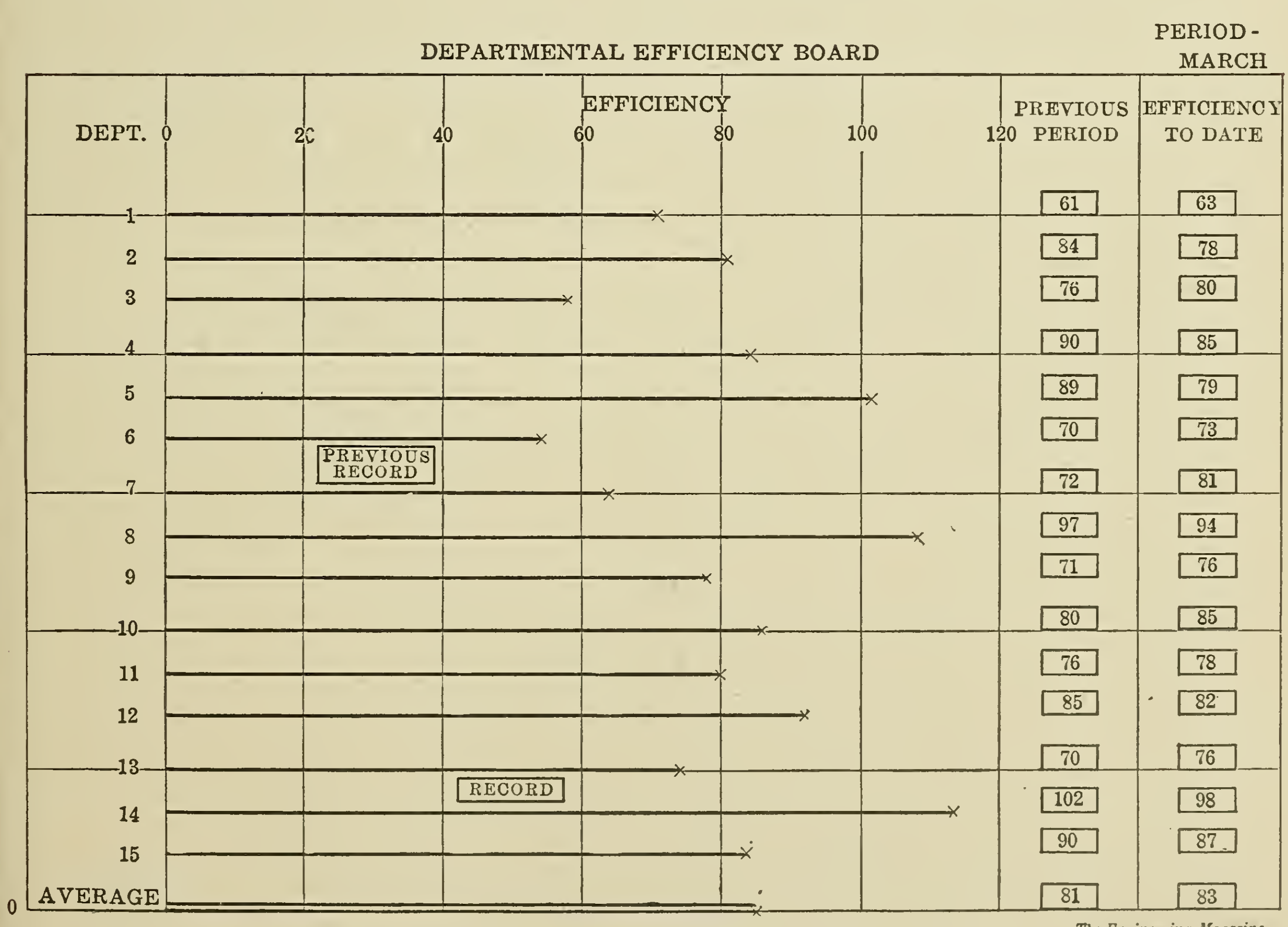


Fig. 80. Departmental Efficiency Board

for the exercise of considerable diplomacy and tact. In the first place some notification should be made to the men describing the plan, as follows:

(1) Getting all the men together and addressing them.

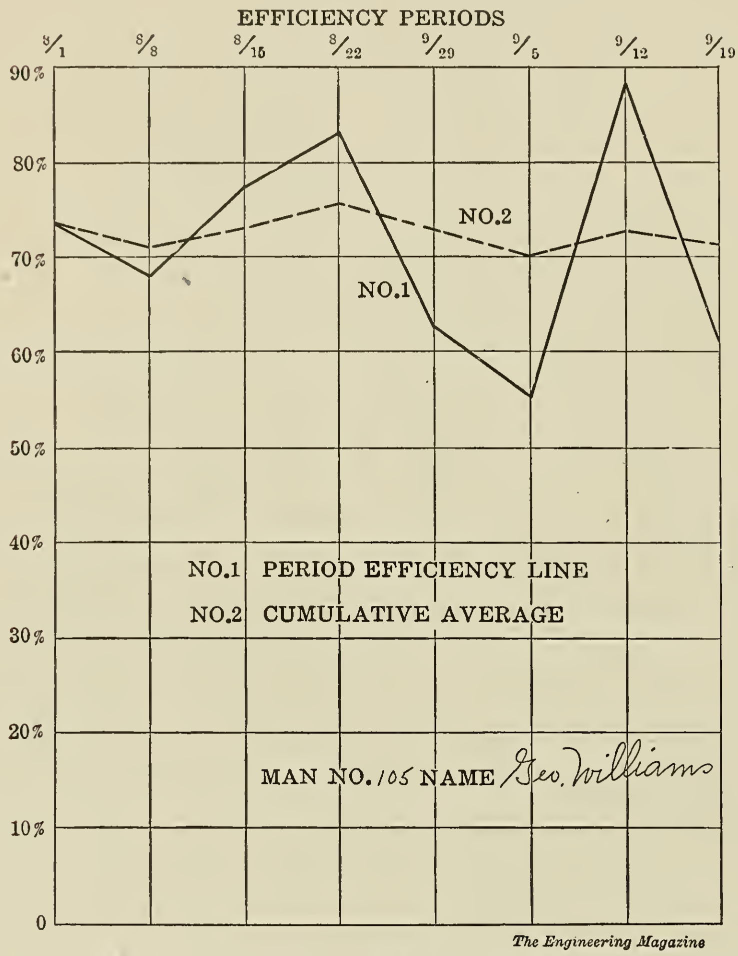


Fig. 81. Graphic Efficiency Record

(2) Calling a meeting of the best element in the shop and carefully explaining the plan, furnishing them with data so that they can in turn explain it to their fellow workers.

(3) Inserting in the pay envelopes of the men a little booklet describing the proposed methods. How to figure the bonus, the matter of allowances, and other essential points can be condensed to make a four-page booklet, which will assist materially in getting the men to understand the methods.

The men should be made to feel that they will have a voice in the matter—that no one will be forced to attain 100 per cent efficiency. The fact that bonus will be paid for all saved time should be pointed out through the following illustration:

Standard time, 10 hours
Actual time, 8
Wage rate 25 cents per hour

$$\frac{10 \text{ hrs.}}{8 \text{ hrs.}} = 125 \text{ per cent efficiency}$$

8 hrs. × 25 cents + 50 per cent bonus = \$3.00 (\$2.00 in wages and \$1.00 in bonus)

8 hrs. at 25 cents = \$2.00 in wages
\$2.00 at 25 per cent bonus, \$.50 in bonus
2 hrs. saved at 25 cents per hr., \$.50 in saved time
Total, \$3.00 (\$2.00 in wages, 50 cents in bonus and 50 cents in saved time).

They should further be told that day wages will be paid whether men earn bonus or not. It will also be well to advise them regarding the steps that have been taken by the management in improving planning, in standardization of the conditions and operations, all of which will enable the men to get some idea of the expense of introduction, which will assist in enlisting their support.

If men refuse bonus, as some of them might, place it in the bank to their credit. They will take it later. *If they don't, their wives will.*

Do not try to put too many men on schedules at first. Do not start with the operations which show the smallest possible gains. This will discourage the men. They will be won over by object lessons more quickly than by anything else, and the reader can imagine the influence of a 15-cent bonus to a man for one week's work.

Let the men kick and grumble at the start, to their hearts' content. It furnishes the opportunity to explain and prove the value of the plan. *One of the most important things is to show them their progress from day to day in efficiency and bonus. This will keep up their interest.* Investigate the complaints carefully, giving the men the benefit of the doubt. The medicine looks worse to the men than it really is. *They must be allowed to sip at it instead of taking it in drinks.*

Do not expect much in the way of results in the beginning. Some men won't even try to make the schedules, feeling that they are beyond all reason. Explain to them the method of analysis, and how the standards are arrived at. Show them the figures. Prove to them that the elimination of false motions and unnecessary work will enable them to attain the standards determined upon. This all makes for a healthy spirit, and if the work is undertaken properly, you will soon find men not on bonus asking for the opportunity to make some extra money under the very plan which acting under their misconceptions they at first so bitterly opposed.

If piece rates are found which are altogether too high, the proposition will prove somewhat complex to begin with. In this case speed should be made slowly. The effect of better conditions and planning will either result in surprising increases in production or there will be a noticeable tendency to hold back on the part of the men, and one by one the schedules can be made, and the men will see the justice of the change. They may not agree as to the required production as standard, but they can be made to see that the rates are excessive and need revision. Cutting out all piece rates and putting the men on day wages may work out, *but not if the men have been earning 25* *per cent to 50 per cent more than day rates.* Rates which come closest to conforming to the standards should be adjusted first, giving planning and conditions a chance to prove to the men the unreasonableness of the existing rates.

Do not for a moment think of ignoring the foremen when considering the matter of bonus. The co-operation of the foremen is an absolute necessity if the methods undertaken are to prove the success possible. In one plant I have in mind, the company decided to pay no bonus to the foremen, on the ground that they were receiving good salaries and should attend to business and perform their duties efficiently without any additional earnings. The foremen resented this, one saying that he could not see how the company could expect him to assist the workmen in earning from 5 to 20 dollars a month more and give him nothing for the extra work necessary to facilitate the workmen. His point was well taken. The effect of letting workmen earn good bonus and giving the foremen nothing is not a good one. The foreman gets discouraged and it may lead the men to wrong conclusions.

There are a number of factors influencing results which are more or less dependent upon the efficiency of the foremen, as follows:

1. Efficiency of men
2. Prompt arrival of men
3. Inefficiency of management
4. Rejections
5. Cost of production
6. Tonnage or units produced
7. Changes in machines for "forgotten" or rush orders
8. Absence of workmen
9. Proportion of men on schedules to men employed
10. Proportion of time of men on schedules to the time they spend in the plant
11. Planning
12. Condition of equipment
13. Good will of workmen
14. Facilitating time-study work
15. Analyzing records of low efficiency men

Most of these elements can be standardized, reduced to a definite schedule of attainment, on the basis of which an incentive can be offered to the foremen. The expenditure of $25 to $100 per month per foreman, depending upon the task set and the accomplishment, will mean savings aggregating thousands of dollars yearly.

The "legislative" type of management is in working order—planning is proving its worth—time studies are uncovering inefficiency all along the line—conditions and operations are being standardized—the men are working under the bonus system. Is anything left to do? There are six forces at work in a scheme so practical as to warrant the term "constructive management." Considered separately they are result producers, but the greatest attainment can be secured only when these six factors are harnessed and welded together and working as a single unit. To accomplish this the "Efficiency Clearing House" was created, and will be fully described in the next chapter.

Chapter XVIII

THE EFFICIENCY CLEARING HOUSE

Economy does not consist in the reckless reduction of estimates. On the contrary such a course almost necessarily tends to increased expenditures. There can be no economy where there is no efficiency.—Disraeli.

THE above is a most fitting text for this the concluding chapter of the series. *There can be no economy where there is no efficiency.* This statement means much to the engineer around whom these chapters have been written. He has considered organization, co-operation, planning, standardization and incentives, in his efforts to increase efficiency. *How does he know that it is going to be increased? Where are the places where there is no gain in efficiency?* These are the questions now confronting the engineer, which must be answered before he can call his task finished, if such a task is ever completed.

The Secretary of Commerce, Hon. William C. Redfield, in an address at Dayton, said:

> I have with me a report made by an engineer of an American shop to the salesmen of the company with which he is allied, showing the improvements in their methods of manufacture in the last six months of 1913. The works had been operated for years with profit, doing well in a competitive business, but the real spirit of efficiency had gotten into them and the results were amazing. This process improved itself to where 28 times more work was done than before.

In writing to a client, I quoted the above, feeling confident it would be met with a feeling of conviction regarding the value of the methods. It had about as much effect as water on a duck's back. Why? Surely an increase of twenty-eight fold would seem large enough to convince the most skeptical. It failed to, however, for no other reason than an inability on the part of the client to realize the exact situation. Refusing to approve the compilation of his pertinent data, he was in no position to appreciate the seriousness of a condition perfectly obvious to one making a specialty of analyzing industrial ailments. I read of a statement made to one concern that $1,000 could be saved per day and practically the same thing happened—the executive was not convinced.

To use a slang phrase—what is the answer? Two things seem necessary:

(1) Predetermination

(2) Analysis.

Our manufacturing is too much guess work. The chemist mixes a definite quantity of this and a definite amount of that, and he has what he knew would be the result of the combination of the elements. *The manufacturer mixes tons of this, feet of that, so many machines, some money, men, and knows absolutely nothing about the real outcome as regards cost and efficiency until the product is completed.* To find out he must try out and then look backward, dig into the past, in order to gather the loose ends that will give him some idea of where he is at. This is chance, rule-of-thumb, gambling of the worst sort.

The aim of time study, planning, and standardization is to see ahead—to unfold the mysteries the future holds—*to predetermine.* To check results properly against this predetermination, analysis of the most careful kind is necessary—a work so important as to warrant the statement that the success of the entire undertaking is more or less dependent upon it. A broad experience conclusively shows me that many otherwise excellent betterment campaigns have failed simply because the right kind of analytical work had not been considered in conjunction.

It is not enough, for instance, to tell an executive that he is wasting his coal. He may not think so. The statement does not convey any real meaning to him. The facts must be put in such form as to make a striking impression—to make him see that the dollars are literally being pulled out of his pockets. An example of what is meant is taken from a recent article on "Waste in the Furnace":

When you turn on the electric light over your desk, the little carbon filament gives you just one-half of one per cent of the latent power in the coal burned in your basement furnace or the distant power house.

Ninety-nine and one-half per cent of that power is wasted. It leaks away somewhere between the coal pile and your incandescent globe.

Were every bit of the energy in the coal used, when you turned on the little button over your desk, 200 lamps would have sprung into light.

Go to your elevator and pull the starting rope, or into the factory and throw the lever that starts the lathe. If your steam plant is the average, only three per cent of the energy originally in your coal has got as far as the lathe.

Where does the other ninety-seven per cent go? Fifty-five is lost in the firebox or boiler; forty per cent disappears in the engine; two per cent is used up in transmission; a sickly three per cent finally creeps out to drive the machine.

This is driving a lesson home with the force of a sledge. It means something and conveys to the mind a real loss, the essential truths, as a blunt statement without the support of facts could never do. This is the kind of analysis the engineer has in mind in connection with his work. Of course there are those who say, "I don't believe it," no matter how strong the supporting evidence, but this does not mean that the right kind of analysis is valueless. There will always be skeptics and pessimists.

The engineer must also be prepared to meet varying opinions in the organization about the same subject. These he can only combat through analysis. Take belt joints for example. Each of the methods used has its supporters and yet the testimony taken from a recent article is conclusive:

The following gives the results of experiments with new leather belting to determine the strength of different sorts of joints.

To tear new double leather belt	100 per cent
To tear the same belt at 5-inch scarfed and cemented splice	90 " "
To tear the same belt at riveted splice	60 " "
To tear out (patent) spiral steel wire joint with rawhide hinge	42 " "
To tear out brass-wire lacing	38 " "
To tear out ordinary rawhide lacing	38 " "
To tear out brass studs	30 " "

The cumulative effect of all the work that has been done as outlined in the previous chapters, is to furnish a steady stream of valuable data. In other words, the "by-product" of the efficiency work is *facts*, perhaps of no real value in themselves, but full of possibilities if used properly. The engineer is to be a "result chemist," whose work is to parallel that of the synthetic chemist, who analyzes in order to put together.

The first consideration should therefore be an outline of the elements which in industry are responsible for inefficiency, this serving as a basis for determining what to analyze.

1—Delays. Regardless of their nature, delays mean a loss of money. They interfere with the attainment of the highest efficiency. As most of them can be eliminated, study of their causes is worth while.

2—Rejections. Rejected work is a waste of the worst kind, the elimination of which will mean a greater production, hence the necessity for closely analyzing for reasons.

3—Changes in Manufacturing. Schedules have to be revised, machines broken up because of rush orders, incomplete or delayed designing, rejections or other causes. Loss is the result in each case, no matter how small it may be. We will therefore put the searchlight on this feature.

4—Idle Equipment Time. The object of every progressive manager is to keep his equipment working as continuously as possible. Idle machines mean that the share of overhead which would ordinarily be absorbed by them must be borne by those that are working. They also mean loss in production. The aim is to find out why and what will keep them running.

5—Inefficiency of Management. Inefficiency beyond the control of the workmen is something that should be closely watched, for so long as it is in evidence maximum results are out of the question.

6—Inefficiency of Workmen. What was said with reference to the inefficiency of management applies to the workmen as well.

7—Changes in Operation or "Task" Schedules. When changes are necessary in the tasks set before the men, the real reasons should be investigated in order to reduce them if possible to a minimum.

8—Purchase Failures. Waiting for material purchased is one of the most annoying things to contend with and is a much larger factor in manufacturing than many have any idea of. It means delayed shipments, rush and hustle, loss of business, night and Sunday work, interference with plans made and numerous extra machine changes. Such a form of waste needs looking into.

9—Delayed Shipments. Failure to ship as promised is always detrimental to business success. The reputation for prompt delivery is the desire of every concern. The aim is therefore to watch this in an effort to improve the shipping so as to enable the concern to retain the good will of the trade.

10—Faulty Movement of Material. Managers fail to realize how easy it is to waste money in moving material. The loss is greater than usually appreciated. To carry material long distances in piecemeal fashion is certainly not efficiency. Analysis is the only thing which will discover the loss.

11—Poor Arrangement of Equipment. While the desire of every manager is to have his equipment placed with reference to most efficient practice, cases are many where it is improperly located. The efficiency of each unit may be high, but when inter-relation is considered, loss due to faulty arrangement is apparent. This is another excellent field for analytical work.

12—Complaints. The study and analysis of complaints that can be secured from men or foremen will in many cases lead to the uncovering of sore spots which can be healed. While many men are unreasonable, the majority do not kick without having something to kick about. Where there is smoke there is fire, and analysis aims to find the fire.

13—Lack of Co-operation. Success in increasing efficiency is largely dependent upon securing the full co-operation of men and shop management. If there is an absence of this essential, the engineer should know it, and why.

14—Faulty Planning. Anything which interferes with the most efficient planning will cause loss, confusion, and delays. As these are the very things which the engineer must eliminate if his work is to be successful, he will have to find the faults preparatory to elimination.

15—Congestion at Machines. This often holds a shop back and blocks progress. Whether the trouble is lack of equipment or the fault of the shop is something the engineer can only ascertain through analysis.

Look at the "red tape" you say. *Just a minute!* Yelling red tape is a most excellent excuse, used by the industrial world to get out of doing something necessary but distasteful. Let us look at it in this way: if these records are compiled and looked over casually, then fed to the boilers, you are then justified in pronouncing it all red tape. If, however, they can be used to eliminate inefficiency, increase production, and better final results, *then it is NOT red tape nor even a near approach to it.*

The engineer therefore organizes his "Efficiency Clearing House," so as to pass all the data through one place, discard the non-essentials, and use the valuable for the betterment of the business. If you will bear with me to the end, you will not only be amazed at the possibilities, but at the failure of so many so-called efficiency campaigns that you know about to consider this part of the work. Let us therefore take the factors in regular order and determine what can be accomplished.

Delays

In compiling data regarding delays, the facts would be secured from the "allowance card," shown on page 196, Chapter XVII. On each card, the reason for the delay is given. As the cards are turned in each day, and after the data contained thereon have been taken care of, the cards are to be filed away and at the end of the month sorted according to causes, and the cost of the delays compiled as follows:

Delays—Department A—Month of............

Causes	This month	Previous month	Total to date
Waiting for jobs			
" " materials			
" " drawings			
" " tools and jigs			
" " crane			
" " inspection			
Having belt repaired			
" machine repaired			
Grinding tools			
Incorrect drawings			
Wrong material			
No power			
TOTAL			

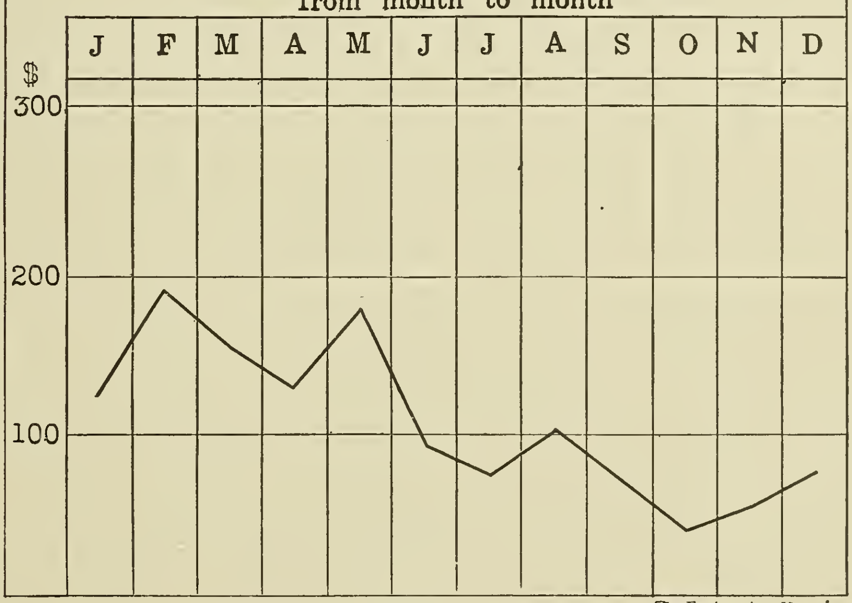
These various items would be totaled for all departments and charted as shown in Fig. 82. Before analyzing this chart, it might be well to outline the principle of charting adopted. There is no end to the amount of charting that can be done in this work. A chart could be made for instance, covering each one of the twelve causes,

DELAYS

All departments — Month Dec.

Cause	This month	Monthly Average
Waiting for jobs	$21.40	$25.03
" " materials	5.70	11.08
" " drawings	6.10	5.41
" " tools and jigs	3.20	3.35
" " crane	5.80	13.34
" " inspection	2.60	8.78
Having belt repaired	4.65	7.10
" machine "	5.25	6.37
Grinding tools	15.20	18.80
Incorrect drawings	3.10	2.08
Wrong material	2.40	2.91
No power	3.00	3.08
Total	79.50	108.33

Chart covering total of delays from month to month



The Engineering Magazine

Fig. 82. Chart of Delays

and each one could show current monthly results, previous monthly results, and the total to date; but as the engineer is going to cover a broad field, refinements would tend only to complicate matters as well as hamper him in his work. He wants prompt reports, not ancient history. What he wants to know is:

1. The general tendency
2. The monthly showing
3. The monthly average

If the general tendency is upward, reference to 2 will show him what is responsible, as would also be the case if the tendency was downward. The progress can be determined by comparing 3 with 2. If the monthly average is $50 and the current monthly showing is $20, he knows at once that progress has been made. All charts will therefore be made on this general basis.

Reference to Fig. 82 will show that while the tendency is downward, the current month's showing is not as good as that of the three previous months. At the same time there is no denying the fact that betterments are making themselves felt. Delays due to supplying material, waiting on crane, waiting for inspection and for repairing belts, are much less. The drawing situation is not all it should be; delays due to waiting for drawings and incorrect drawings showing an increase. As indicated by delays due to the assignment of jobs, the showing can only mean that the planning is not as yet performing its real function and needs "getting after." There is still too much money spent for grinding tools, although some betterment is noticeable. The general tendency is excellent, however, considering the January, February, March, April and May figures. As shown by the charted line, something was wrong in August; but the general showing from June to December reflects the efforts to cut out the "profit chokers." Just such a record as this is the very thing necessary to show to a skeptical client, who cannot see that any good is being done, when there are positive evidences of betterment.

Just how can such data be used in a practical way? Take, for instance, a foundry making heavy castings. It will be found that invariably while coring and closing moulds, considerable time is lost by the gangs waiting for the cranes. To overcome this a floor can be created in charge of one man to make large work that does not need crane service. Men waiting for crane (and I have many times noticed delays of a half-hour by two and sometimes three men) can be sent to this floor to help out until the foreman assigns the crane to a particular gang. Naturally, their efficiency would not be as great as if they were working on their regular jobs; but *it would utilize time that would otherwise be wasted*—the very aim of this efficiency work. Steps can also be taken to better the crane service by offering the crane men a bonus based on the showing of the moulders, or the reduction of lost time due to crane waits. Analysis might show that additional cranes are necessary, perhaps not of the traveling type, but wall or jib cranes.

Another illustration of the value of delay analysis. In a plant assembling engines, analysis revealed the following:

RECAPITULATION OF NINE STUDIES ON ASSEMBLING

Time units were worked upon	30.9 hrs.
Time units were idle	76.4 "
Total time units on floor	107.3 "

Efficiency—

$$\frac{\text{Time worked upon 30.9 hours}}{\text{Time on floor 107.3 hrs.}} = 28.8 \text{ per cent}$$

Delays	hrs.	per cent
No gang, or gang on hand, but idle	17	22.2
Lack of material	33.9	44.4
Waiting for motor	18.7	24.5
Extra reaming, crane, riveting, babbetting, no space to work in, and miscellaneous	6.8	8.9
Total	76.4	100.0

Would the lesson pointed out by the above be lost on the shop?

Rejections

One of the best fields for converting loss into savings, is the rejections in a plant. Analysis of this feature is made from the "rejection card" shown in the preceding chapter. At the end of the month they should be sorted by departments, and a report made as to causes, patterns or parts, and as to men. The general form would be as follows:

REJECTIONS IN FOUNDRY. ACCORDING TO PARTS AND MEN. MONTH OF........

Pattern		Men		
Name or No. of pattern	No. rejected	Man No.	Pieces rejected	Weight
X160	25	220	27	3425
R468	20	224	24	2540
L145	20	227	20	1580
R425	15	229	15	875
B1620	12	235	12	1120
R416	9	242	10	650
		254	8	920
		265	7	416
		271	5	2140

REJECTIONS

Foundry Department. Month Dec.

Cause	This Month	Monthly Average
Due to men	13155 lb.	22500 lb.
,, ,, material	8489	7500
,, ,, cores	2147	2000
Miscellaneous	2040	3000
Total	25831	35000

Chart showing total weight of rejections from month to month

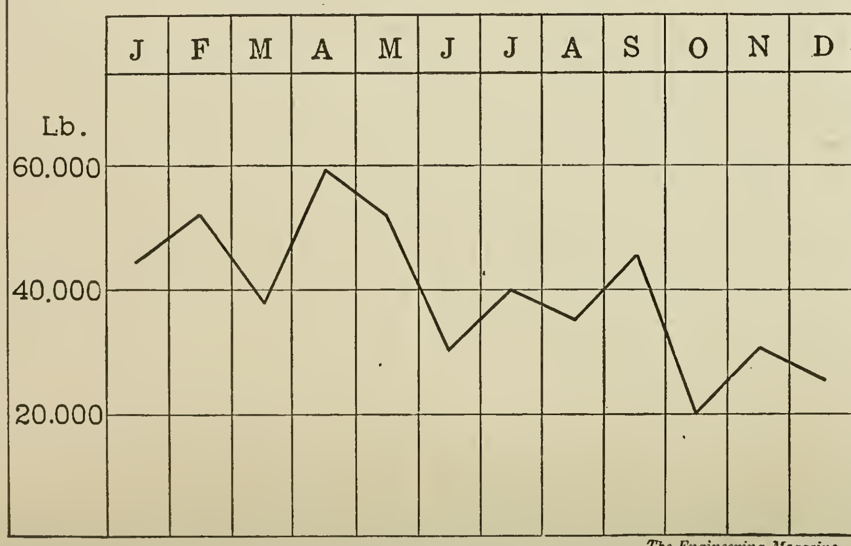


Fig. 83. Chart of Foundry Rejections

REJECTIONS

Machine Shop Month Dec.

Cause	This Month	Monthly Average
Defective material	$65	$125
Faulty design	20	24
Errors by men	142	210
Wrong drawings	21	40
Errors in drawings	17	25
Wrong jigs	12	17
Broken in handling	24	70
Total	301	511

Chart covering total cost of rejections from month to month

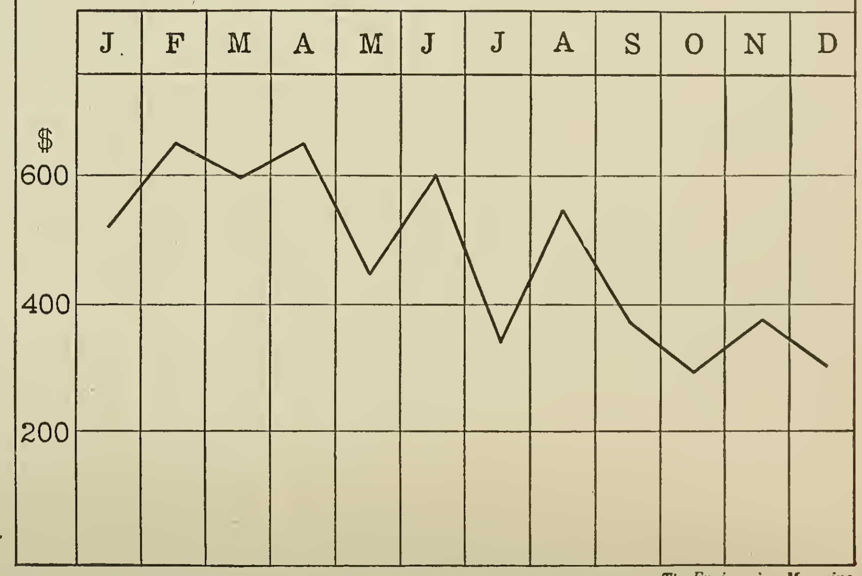


Fig. 84. Chart of Machine-Shop Rejections

REJECTIONS IN FOUNDRY. ACCORDING TO CAUSES. MONTH OF..........

Causes	Fault of									
	Men		Material		Cores		Mis.		Total	
	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.
Dirty castings..	3	392	32	3043					35	3435
Slag holes......			52	3288					52	3288
Cold shot.......	2	85	6	1400					8	1485
Crush..........	37	2625							37	2625
Fall out........	10	2446							10	2446
Blow...........	24	1032			17	1397			41	2429
Hit by ladle....	1	470							1	470
Scabs..........	11	2522	2	563					13	3085
Faulty closing..	2	105							2	105
Shrink.........			5	195					5	195
Broken gates...	4	2075							4	2075
Broken cores....	1	140			1	320			2	460
Wrong cores....					1	430			1	430
Hard ramming..	1	40							1	40
Run out........	2	645							2	645
Anchor moved..	1	425							1	425
Shook out too quick........	1	153							1	153
Pattern not right							1	120	1	120
Crack in casting							1	400	1	400
Pattern shifted.							28	685	28	685
Faulty machine molding......							9	275	9	275
Broken castings.							3	560	3	560
Total......	100	13155	97	8489	19	2147	142	2040	258	25831
Per cent....	50.9		32.8		8.3		8.0		100.0	

The machine shop can be handled in the same manner as was outlined for the foundry. It would be well, however, to show in addition the cost of machine-shop or structural-shop rejections in time and material. Charts 83 and 84 cover foundry and machine-shop rejections.

Analysis of rejections as outlined will result in steps being taken to reduce the loss in this direction. We not only know what causes are responsible, but what pattern or part is causing the greatest loss as well as the men who are responsible for the major part of the rejections. A knowledge of all this is but preparatory to betterment. One

MANUFACTURING CHANGES

All departments Causes	Month This Month	Dec. Monthly Average
Congestion at machines	24	20
No material	10	22
Awaiting bill of material	2	5
,, drawings	3	7
Break down in machines	6	12
Men not in	2	3
Error in drawings	3	5
Tools not ready	4	9
Rush orders	36	52
Forgotten orders	3	7
Repair orders	16	32
Total	109	174

Chart covering total number of changes from month to month

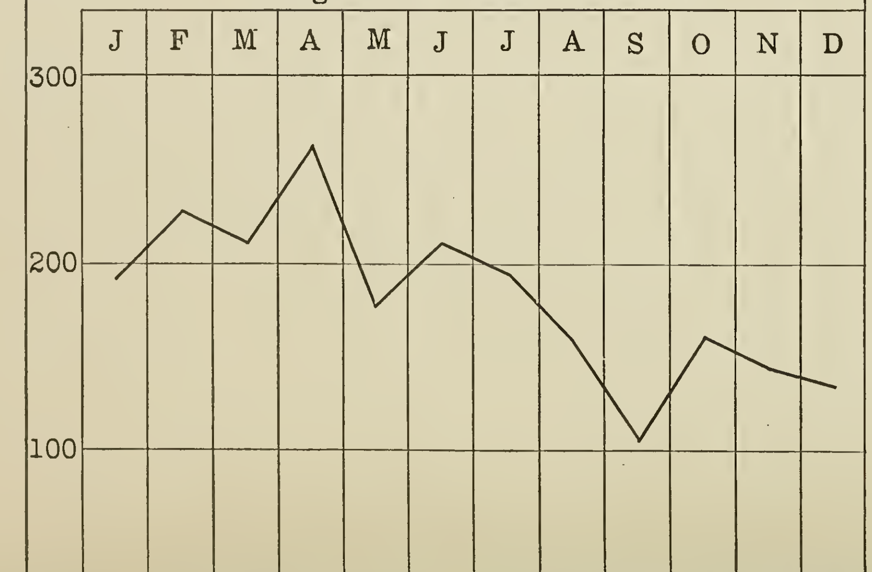


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Fig. 85. Chart of Changes in Planning

IDLE EQUIPMENT TIME

All departments Machines showing lowest efficiency	Month This Month	Dec. Monthly Average
101	38.8%	31.2%
107	52.3	42.1
112	42.8	32.5
121	39.7	36.5
126	62.7	43.7
132	43.5	31.2
135	55.8	48.5
138	51.6	55.0
140	42.4	34.9
Total	66.0	51.7

Chart covering time of all machines in use

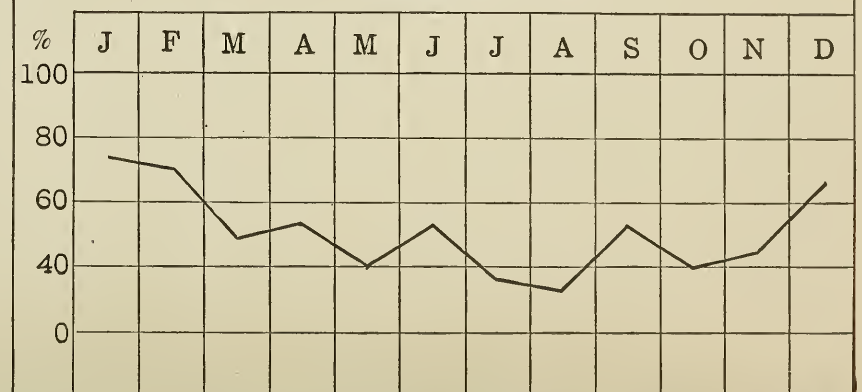

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Fig. 86. Chart of Idle Equipment Time

plan which can often be used successfully is to offer a bonus to men who work on parts where there are operations in sequence, for discovering bad work in material they receive. A bonus of 2 cents or 5 cents per piece will cause each worker not only to look for defects, but to make them known before the piece is finished and rejected.

Changes in Planning

In one plant where planning methods were introduced, 88 per cent of the scheduling for one week was followed as planned. Out of the planned jobs worked upon, however, *four out of every ten were broken up for other work*, showing that the shop had not planned carefully enough at the start. To show that it was not due to lack of work, it might be well to state that there was 4.1 weeks of available work ahead of the shop. *And yet the management felt that no planning was necessary.*

In another plant, on one hundred and ten jobs scheduled, forty averaged 6.7 hours per operation, while seventy of them averaged 22.2 minutes per operation. Of the seventy, forty-nine averaged 6 minutes per operation. On the basis of the average of 22.2 minutes, *it means twenty-six changes in a day.* IS THIS MANUFACTURING OR JOBBING?

In still another plant where the practice was strenuous rather than efficient, rush orders, forgotten orders, pounding to complete a scheduled production, forced repeated changes to enable assembly gangs *to strip completed units to make deliveries or keep up production, then later on, to replace the parts removed.* On eighty units analyzed to determine what would have to be replaced, the following was found:

PARTS NEEDED TO COMPLETE UNITS PREVIOUSLY FINISHED

Pieces	Parts	Pieces	Parts
54	A	90	O
9	B	45	P
3	C	15	Q
19	D	15	R
22	E	15	S
7	F	15	T
1	G	30	U
2	H	30	V
2	I	14	W
15	J	8	X
30	K	5	Y
45	L	1	Z
45	M		

INEFFICIENCY OF MANAGEMENT

All departments — Month Dec.

Cause	This Month	Monthly Average
Failure to plan properly	75 hrs	110 hrs
Faulty conditions	40	55
Repairs in work hours	65	80
Errors	20	35
Total	200	280

Chart showing hours lost through inefficiency of management from month to month

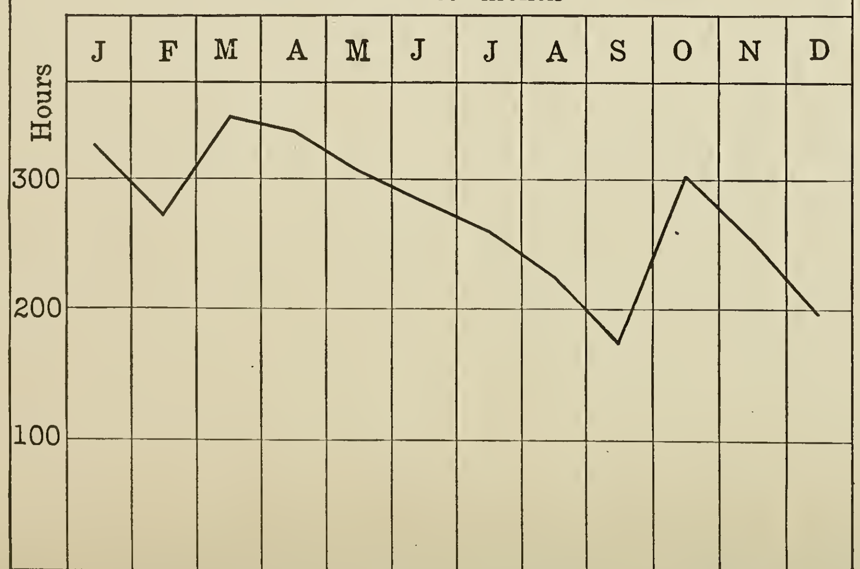

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Fig. 87. Chart of Inefficiency of Management

INEFFICIENCY OF MEN

All departments — Month Dec.

Time wasted by men

This month	Monthly average
500 hrs.	725 hrs.

Chart covering time wasted by men from month to month

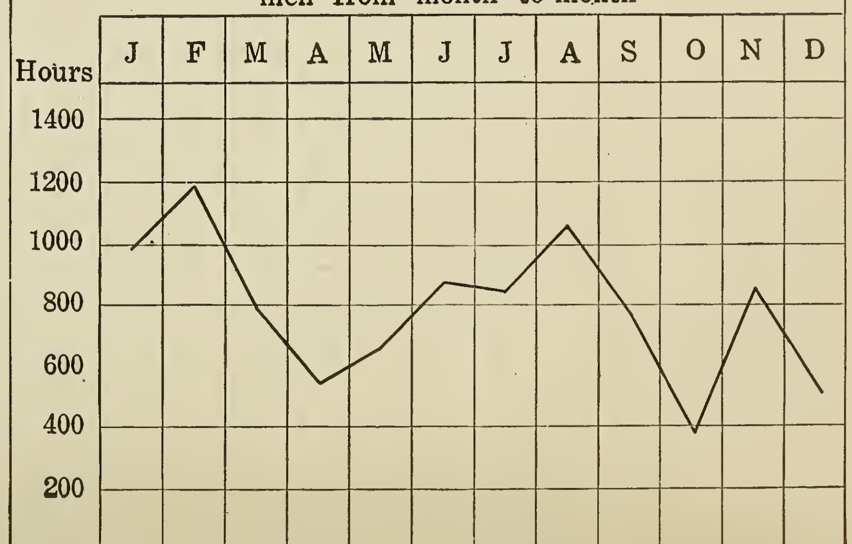

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Fig. 88. Chart of Inefficiency of Men

This makes a total of 537 parts on which work had to be performed twice, *plus* the labor of taking the parts off in the first place, an average of 6.7 parts to the unit. *What would the progressive manager call this?*

The real trouble is that managers, both shop and executive, have no real conception of the pernicious influence of changes on results, because with no planning methods it has been next to impossible to compile data as to changes. It is, of course, to be expected that some changes will have to be made, but the kind of analysis that is outlined here will show time and time again that many of them are without the slightest justification.

As was explained in Chapter XIII, on planning, a "Memo of Change in Schedule" is necessary before a change can be made. On this there is a place for placing the result of an investigation into causes. It is these which are analyzed monthly. Reports would be made up along the lines indicated, for delays and rejections, and a chart made as shown in Fig. 85.

Idle-Equipment Time

In one plant considerable idle-equipment time was in evidence. Analysis revealed the fact that transmission troubles were causing many stops in the machines. Here are the findings:

Main shaft in engine room, ½ inch out of line and ½ inch out of level.
Pulley on above shaft 1 inch out of center with engine pulley.
To get lights, plant had to shut down to put on dynamo belt.
Main shaft in machine shop ⅝ inch out of line and ½ inch out of level.
Countershaft for machine —, 1½ inches out of line.
Countershaft for carpenter shop, ⅝ inch out of line.
Countershaft for machine —, ⅜ inch out of line.
Countershaft for machines — and —, 1½ inches out of line.
Countershaft for machines — and —, 3½ inches out of line.
Countershaft for machine —, 4 inches out of line.
Countershaft for machine —, ½ inch out of line.
Machine —, 1 inch out of line and 1 inch out of level.
Machine —, ⅝ inch out of line.
Machine —, 2 inches out of line.
Machine —, 1 inch out of line.
Machine —, 1¾ inches out of line.
Machine —, ½ inch out of line.

In order to keep track of this feature, the "Service Card," shown in Chapter XIII, should be taken daily and entered on a record as shown at the head of page 225. See Fig. 86.

CHANGES IN TASK SCHEDULES

All departments — Month Dec.

Reason	This Month	Monthly Average
Changes in equipment	3	4
,, ,, design	5	7
,, ,, method of manufacture	6	10
Times too tight	8	12
Conditions not as defined in standardization	12	16
Total	34	49

Chart covering number of changes from month to month

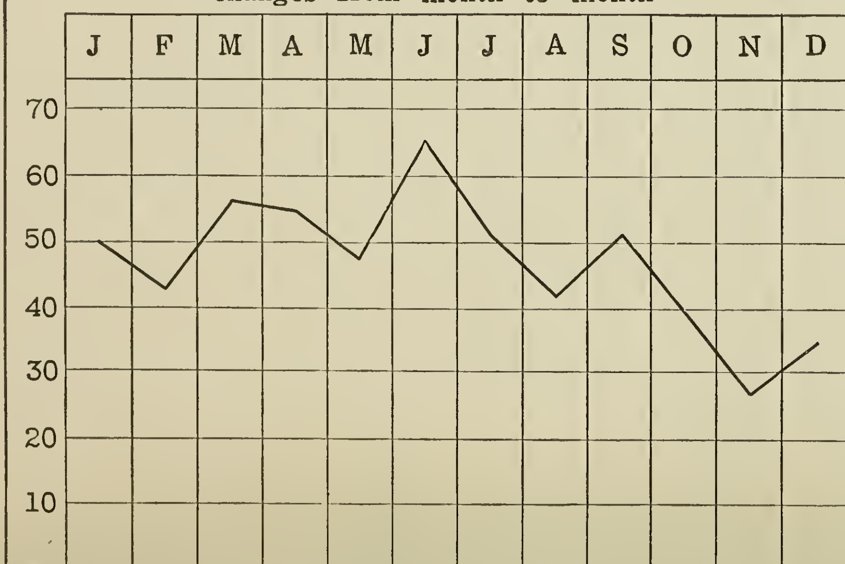

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Fig. 89. Chart of Changes in Operation Schedules

PURCHASE FAILURES

All departments — Month Dec

Item	This Month	Monthly Average
Number of purchase failures	75	89
Number of days behind requirements	10	14

Chart covering number of failures and days behind from month to month

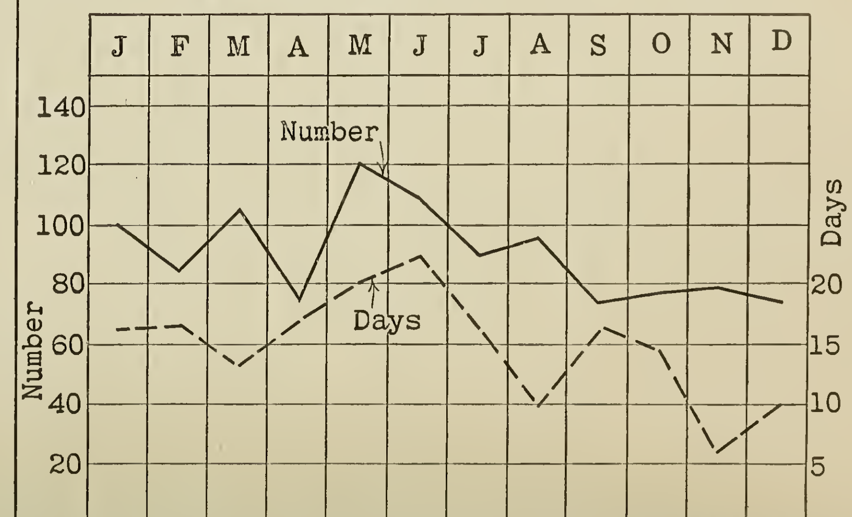

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Fig. 90. Chart of Purchase Failures

IDLE MACHINE TIME

Department A. Month of.......... Possible running hours, 250

Machine	Hours per day	Total	Effy. per cent
101	4-6-3-5-9-10-2-0-0-4-3-5-6-2-4-6-6-3-8-10-1-0-0-0-0..............	97	38.8
102	3-5-7-8-10-10-10-12-14-10-10-8-7-4-8-7-6-7-9-9-10-10-10-10-0.....	204	81.6
140	6-5-0-0-10-12-12-2-1-24-0-0-0-0-0-0-4-7-2-1-7-6-4-3..............	106	42.4
	Total..	6,600	66.0

$$\frac{\text{Actual hours, 40 machines, 6,600}}{\text{Standard hours, 10,000 hours}} = 66.0 \text{ per cent.}$$

Idle time..3,400 hours

NOTE—Machines 103 to 139 not shown on account of lack of space.

To cover this the chart would be drawn up as shown in Fig. 86.

Inefficiency of Management

As was shown in the preceding chapter, the efficiency of management is found by adding the time shown by allowances, to the actual time as shown by men on schedules, dividing this increased total by the standard time, as follows:

	Actual	Standard	Efficiency
Men....................................	2,500 hrs.	2,000 hrs.	80 per cent
Allowances..............................	200 "	....	74 "
Total.................................	2,700 "	2,000 "	

Inefficiency of men 100 — 80 = 20 per cent.

Inefficiency of management, 80 — 74 = 6 per cent.

Charting to cover this would be as shown in Fig. 87.

Inefficiency of Men

From the previous illustration it was observed that the inefficiency of the men was 20 per cent, the wasted time being 500 hours. In this case, however, it is impossible to determine the reasons for inefficiency, so that all we can do is to chart the per cent line and a line showing the lost hours. See Fig. 88.

Changes in Operation Schedules

In the sixteenth chapter, on "Standardization of Operations," a requisition was shown for changing operation schedules. These should be taken at the end of the month, a report made, and the results charted as outlined in Fig. 89.

DELAYED SHIPMENTS

All departments — Month Dec

Item	This Month	Monthly Average
Number of delayed shipments	85	97
Number of days behind schedule	13	16

Chart covering number of delays and days behind from month to month

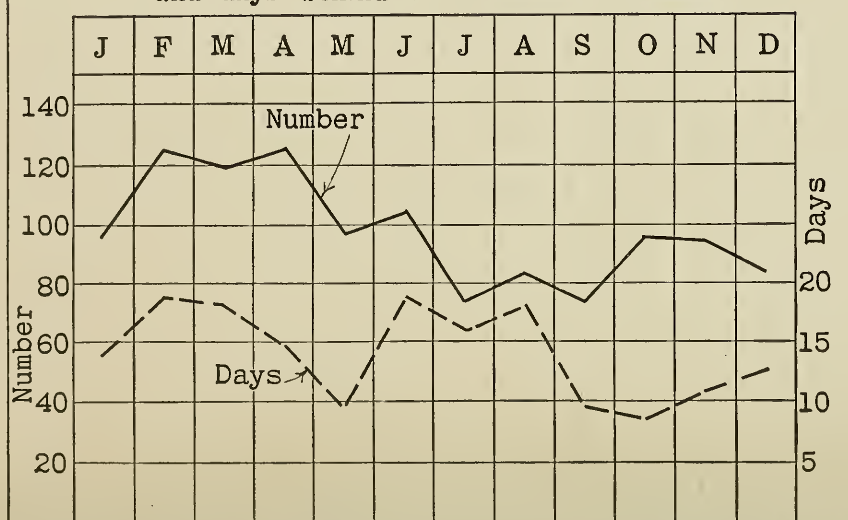

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Fig. 91. Chart of Delayed Shipments

FAULTY PLANNING

All departments. — Month Dec.

Item	This Month	Monthly Average
Number of machines changed daily	17	25
Average changes per day	11	16

Chart covering machine changes from month to month

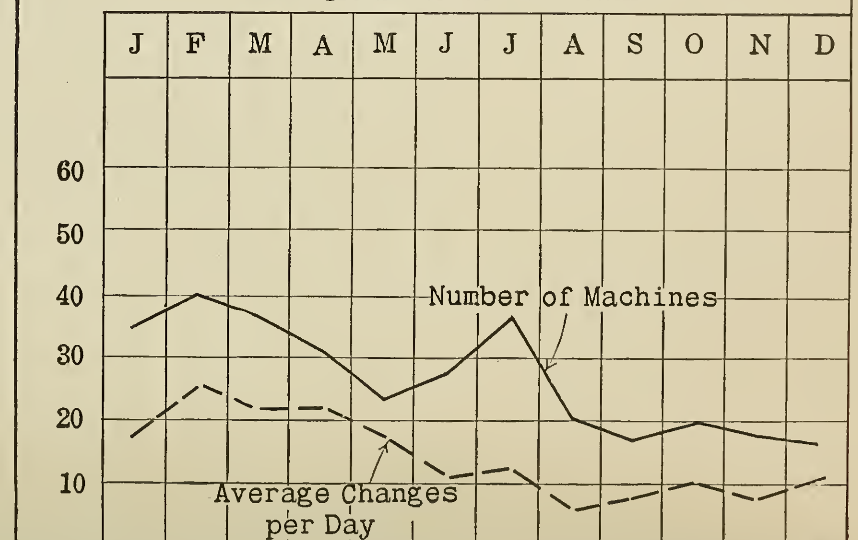

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Fig. 92. Chart of Faulty Planning

Purchase Failures

In the twelfth chapter, on planning, a purchase schedule was shown, which will show the number of days a receipt is behind that promised or wanted. At the end of the month, these sheets should be taken and a record made as follows:

DELAYED MATERIAL RECEIPTS

Department A. Month..........

	Days behind delivery promised	Number of such delays
	20	4
	15	10
	12	6
	10	3
	8	2
	6	12
	4	17
	2	21
Total.......	77	75
Average..	9.9	

This means that there were seventy-five receipts which averaged 10 days behind anticipated requirements. As it is extremely difficult to ascertain reasons for such delays, all that can be done is to show the tendency as indicated by Fig. 90.

Delayed Shipments

The order control sheets as shown in the thirteenth chapter on planning give the number of days the real completion or shipment is behind completion or shipment wanted. These data can be compiled in the same manner as was outlined for purchase failures, thus:

DELAYED SHIPMENTS

Month of...............Department A

	Days behind delivery promised	Number of such delays
	30	1
	20	2
	18	4
	16	7
	10	12
	7	12
	5	20
	3	27
Total.......	109	85
Average....	12.8	

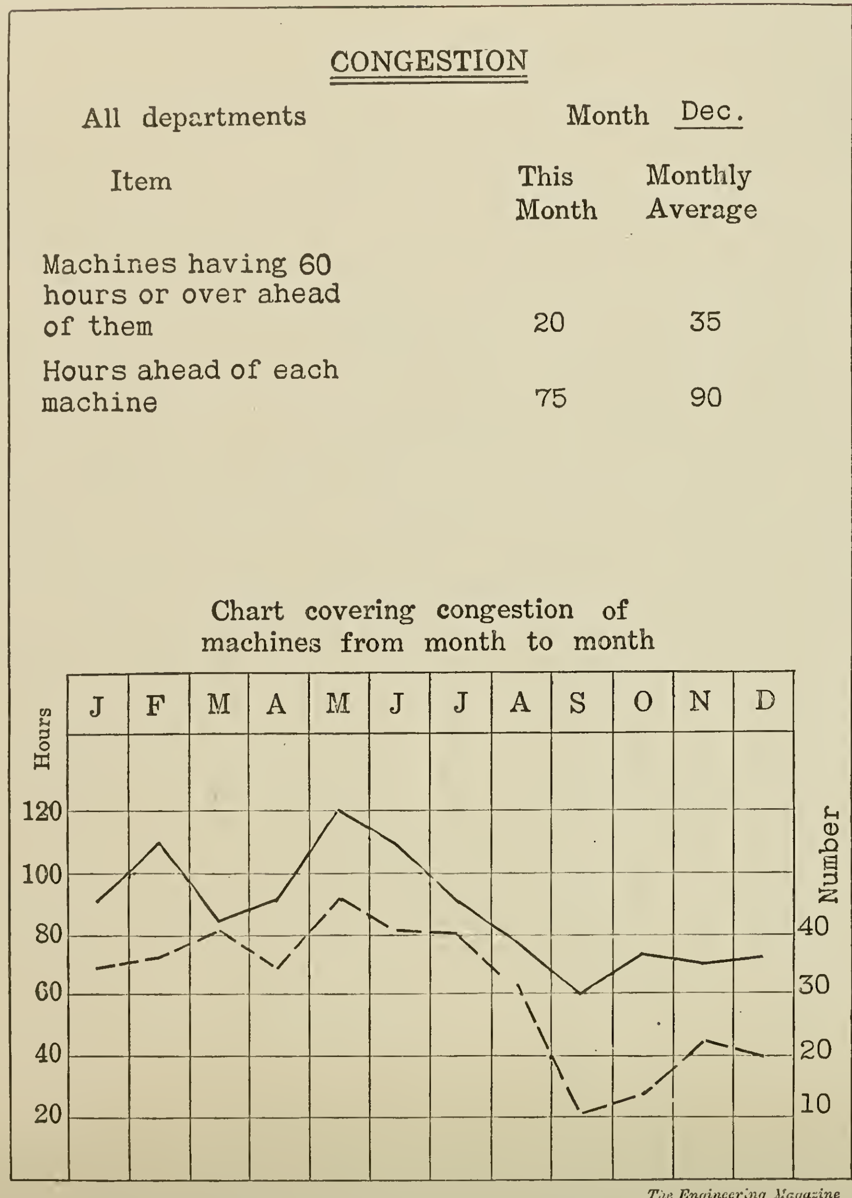

Fig. 93. Chart of Congestion at Machines

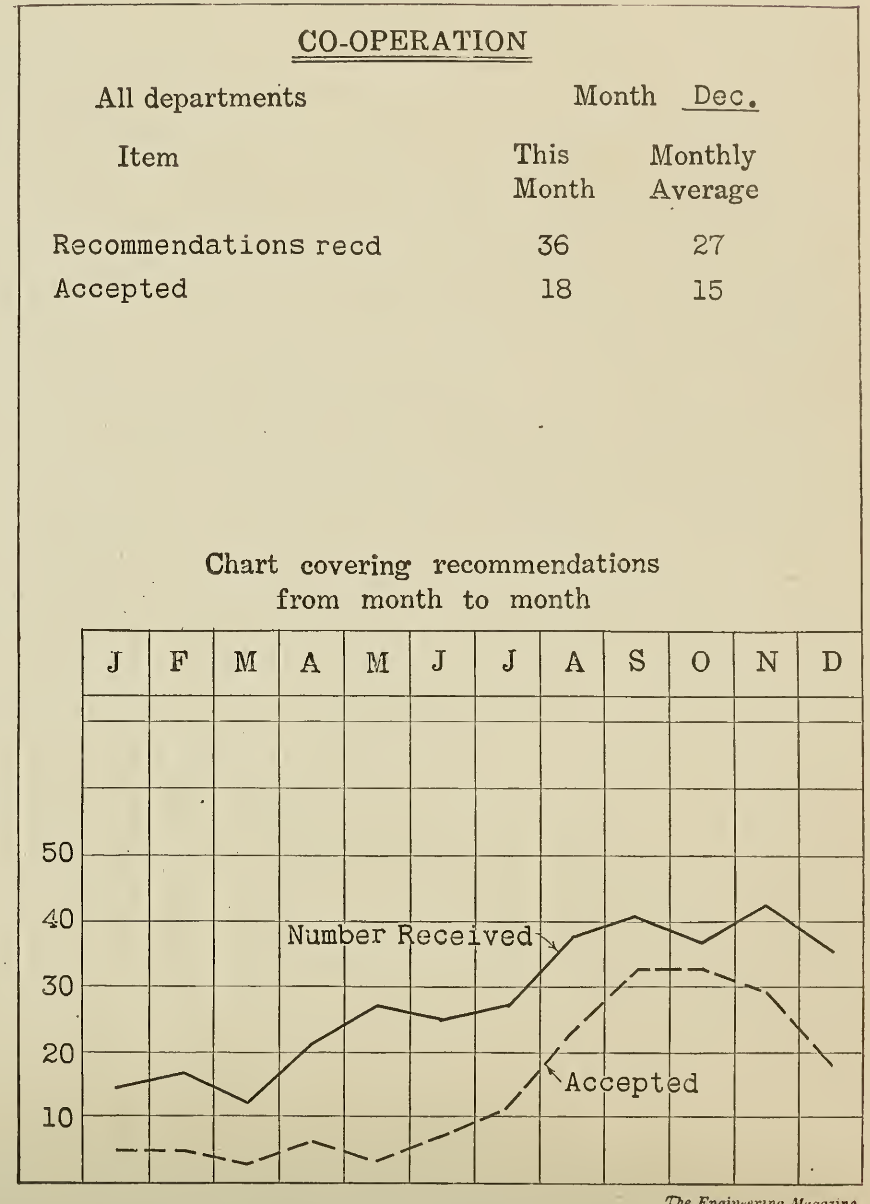

Fig. 94. Chart of Co-operation

This means that there were eighty-five deliveries which averaged 12.8 days behind schedule. See Fig. 91.

Faulty Planning

I was once told by the superintendent of a plant that the method of using service cards was "mighty red-tapey." I asked why? He answered that on the day previous the operator of a machine *had used* 40 *tickets*. He was highly indignant and hoped the whole thing would be pitched out the back door along with the entire efficiency outfit. We took the matter up with the general manager, who very wisely replied that *the fault was not in the service cards but in the management of the shop which permitted a condition to exist necessitating* 40 *changes a day in a machine.* He hit the nail squarely on the head.

At the end of the month, service cards should be sorted according to machines or operations. Those having a reasonable number of cards need not be considered. A report covering the balance can be made out as follows:

MACHINE CHANGES

Department A. Month of............................

Machines	Average daily changes	Total changes
106	24	24
107	20	20
108-140	15	30
110-120-114-161	12	48
134	10	10
116-118-121-130-133-129	8	48
124-125	5	10
Total 17		190

Average changes above 5, per machine per day, 11.1.

These data can be charted as shown in Fig. 92.

Congestion

It is just as important to watch congestion at machines, as it is to consider idle machine time. In one plant 15,000 parts were to be furnished in two years, under penalty. It was found, because the work to be done was charged in advance to the machines that would have to make the work, that 2,400 could be made in a year, or 4,800 in the two years, *which would be but 32 per cent of the order.* A day after the work was started, the facts were made known to the manager, who stated that if the methods did nothing else but bring just such matters

FAULTY MOVEMENT OF MATERIAL

All departments — Month Dec.

	This Month	Monthly Average
Pieces per move	14	10

Chart covering pieces per movement from month to month

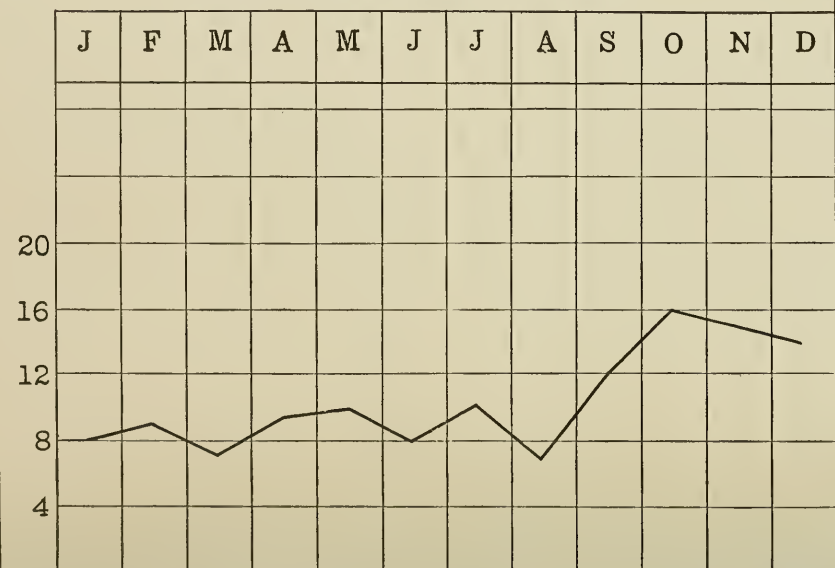

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Fig. 95. Chart of Faulty Moving of Material

COMPLAINTS

All departments — Month Dec.

Cause	This Month	Monthly Average
Schedules considered unfair	5	9
Conditions interfere with results	4	10
Methods looked upon as red tape	5	10
Wages not sufficient	10	24
Too much driving for results	7	12
Hours too long	4	6
Men forced to do things for which they were not hired	2	6
Work looked upon as reflection on ability	4	9
Too much work to carry on methods	7	12
Total	48	98

Chart covering complaints from month to month

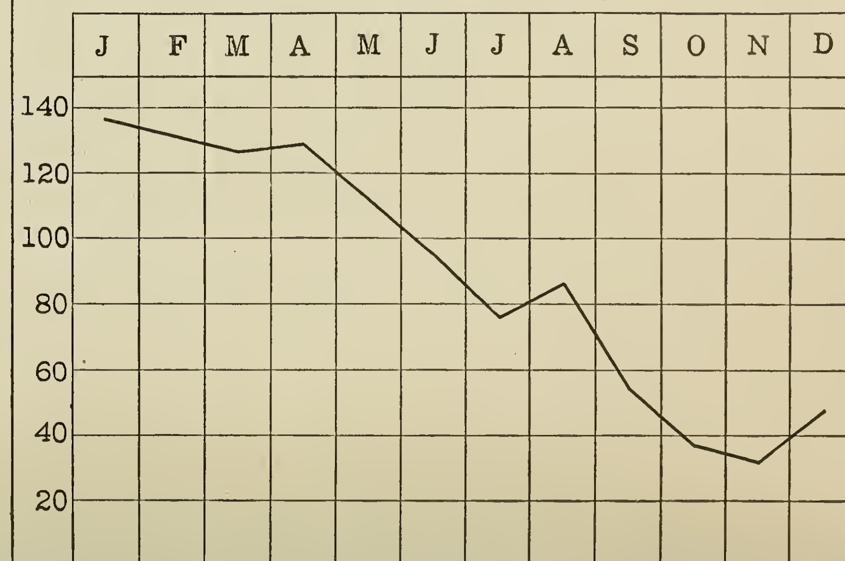

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Fig. 96. Chart of Complaints

to his attention, he would consider the money paid for the work well spent. More equipment and subletting part of the order was the solution, and the work was turned out in time. In compiling the data covering congestion, go through the planning sheets for the last day of each week and average the times ahead of machines showing 60 hours or more against them. The chart would be made as shown in Fig. 93.

Co-operation

The "Efficiency Recommendations" obtained as shown in Fig. 1 serve two purposes—to test for co-operation, and to secure valuable suggestions. Naturally, if few are turned in it means that the members of the organization are either opposed to the work and do not intend to assist, or are afraid that someone else will use, as theirs, the suggestions that would be offered. The facts should be compiled as follows:

RECOMMENDATIONS

Department A. Month of............................

Nature	Received	Accepted	Rejected
Design	2	1	1
Method of manufacture	4	3	1
Equipment	10	4	6
Systems	8	5	3
Conditions	12	5	7
Total	36	18	18

A record of this kind will show what departments are failing to co-operate. It will also show the way the organization is thinking and what it has in mind. It will indicate the weakest factors, for men think most about that which causes them the most inconvenience and trouble. The facts can be charted as shown in Fig. 94.

Faulty Moving of Material

The "move orders" described in Chapter XIV, on planning, should be taken monthly, sorted according to order, and compiled thus:

MOVEMENT OF MATERIAL

Department A. Month of............................

Pieces to order	Moves	Pieces per move
100	7	14.2
50	5	10.0
250	14	17.8
100	4	25.0
100	12	8.3
600	42	14.3

Chart 95 will show the method of graphically indicating the tendency.

Inefficient Arrangement of Equipment

This cannot be charted, but it is possible to analyze this important feature in a thorough manner. Take a set of move orders, or the routing card (if it is employed) covering an order, and placing a sheet of tissue paper over the floor plans showing machine layout, trace the movement of material from operation to operation. Unless the machines are properly located, this method will show up the inefficiency due to poor location.

Complaints

Every complaint made by a foreman or a worker should be reported to the chief of staff and recorded by him. Every member of the staff should encourage all about them to complain about the difficult, the unjust, or the unreasonable, as this assists mightily in revealing places where attention should be concentrated. A report of this nature would not of course be complete, as some would be afraid to complain while others would not consider it their business to say anything about what does not seem right. Kickers there would be, but it would not take long to catalogue them as such and take what they say with a grain of salt. As we are anxious to know the general tendency, a record of complaints would be valuable. A statement could be made out as follows:

COMPLAINTS

Department A. Month of............................

Causes	No.
Schedules considered unfair	5
Conditions interfere with results	4
Methods looked upon as red tape	5
Wages not sufficient	10
Too much driving for results	7
Hours too long	4
Men forced to do things for which they were not hired	2
Betterment work looked upon as a reflection of ability	4
Too much work to carry on methods	7
Total	48

All bosh, you say, this listening to complaints. Let me cite cases that will show that it is a wise plan to listen to complaints, which after all *are suggestions of a reversed nature.* In a coal mine, the practice when a man quit without cleaning out the rock after mining coal, was to have the new man hired and assigned to the room, blast it down, break it up and remove it before beginning to mine coal. The vein of coal being about 24 inches thick, necessitated removing 36 inches of rock, which was not paid for, as in the mine the price covered the coal mined, including the removal of rock. The unfairness is apparent. Miners who had to work hours for nothing were indignant, for they considered they were in no way to blame because the men before them purposely left the rooms without the rock taken out. Naturally they kicked and kicked hard. The practice was changed.

In a small town in which several hundred workmen were employed and where there was a saloon, the men would walk over a mile after supper to a neighboring town where there was a moving-picture house in addition to several saloons, the former being the added attraction. They would take in the "movies," meet old friends, take in the saloons one at a time, carouse for several hours, and then go home very much the worse for wear. Many of them would fail to report for work in the morning, or if they did report, they would be in no condition to do a fair day's work. Some of the better element complained, and as a result the installation of a moving-picture house was recommended, which would mean that the men would take their families to the show, send them home when it was over, go to the saloon, have a few drinks, and go home, reporting in the morning in better condition physically than under the old arrangement.

Men operating wet stones complained because of the water keeping their hands cold in the winter. The matter was taken up with the company and it was agreed to heat the water so as to make it more comfortable for the men. A complaint chart is shown in Fig. 96.

Focusing the Analysis Work

Morris Llewellyn Cooke, director of public works, Philadelphia, said:

> Scientific management is not something that can be bought in a box. It is not something in the nature of a drug that one takes and feels better. It is not a card index. It is dependent upon no single mechanism. Nor is it a combination of any number of mechanisms. It is not a system of keeping costs, nor is it a method of paying wages.

What then is this thing that has caused so much discussion in the industrial world? It is the search all along the line that reveals conditions which do not conform to definite law and principle, and having found them makes them conform to what is right. The aim of the preceding chapters has been to define and outline what will search out and correct the weak places. The aim of this chapter is to see that law is obeyed.

Therefore, for his own protection, and I say this advisedly, the engineer must carefully consider such matters as have been here outlined, or he is likely to have his task of increasing plant efficiency prove a top-heavy load. One unfortunate feature about this efficiency work is that very often a concern engages, at a high fee, an engineer, who has had a long experience and who is both competent and successful, and just as soon as he begins his work, the client says what he wants or doesn't want. The engineer's recommendations are brushed aside as if they were of no account, and he often has to give way to a man in the organization whose knowledge of the work is in inverse proportion to his activities and talk in connection therewith. Then again there are clients who balk and hesitate so over minor things, that are considered as tests, as to make it obvious that they are totally unprepared to consider the larger and more comprehensive features. What can the engineer do? Get out as soon as he possibly can, the same as the lawyer who when dictated to as regards how to try a case, withdraws rather than lose it through the interference of the layman. I have little sympathy for concerns who say they have "tried" this thing and that there is nothing in it, when investigation would show that the trouble was due to the inability of the engineer to carry on one-quarter of what he knew should have been done.

When a concern after engaging an engineer is unwilling to announce to his shop workers what it is desirous of doing—is opposed to a class of shop foremen being organized to consider efficiency methods—is not in sympathy with bonus—is opposed to planning because it looks like a lot of red tape—is opposed to a belt department—is unwilling to delegate authority—is opposed to service cards—is unwilling to consider burden and equipment time saved as a gauge of results—is unwilling to have costs compiled—is opposed to spending much on a tool room, and considers power the cheapest thing about the place—what possible argument can be advanced for asking the engineer, who has neither status nor authority, to get something substantial under way? The sooner he leaves, the better for all concerned.

It only goes to prove that manufacturing is too much guess work, as was stated in the beginning. It is hard to convince executives that law and principle can be made to operate successfully. As a manufacturer recently wrote me:

> We think what we really need more than anything else is a foreman who can produce results, and we are now trying out a man who thinks he can do this.

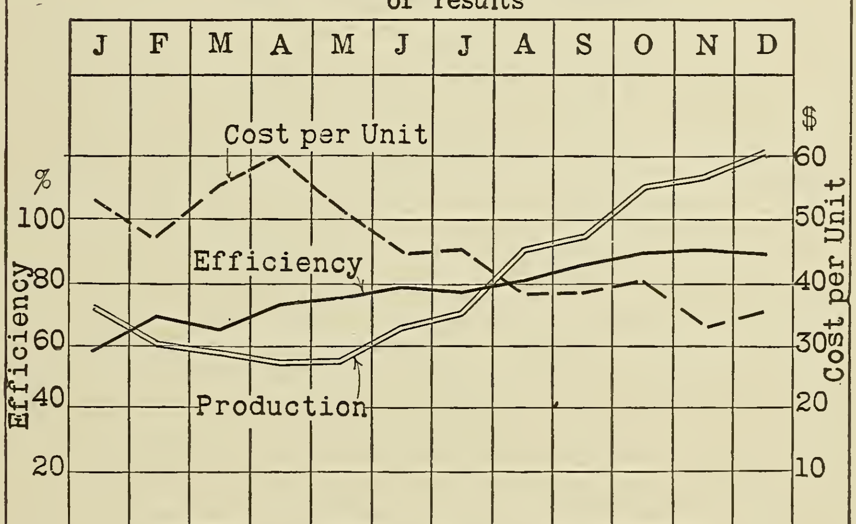
In other words the manufacturer doesn't know what he needs to secure results, so he proposes to "try" a man who in turn doesn't know that he can secure results. The phrase is the most eloquent summing up of the conditions existing in many of our manufacturing concerns that I have ever seen.

GENERAL RESULTS

All departments Month Dec.

Item	This Month	Monthly Average
Efficiency	90%	76%
Production (in units)	20.000	16.800
Cost per unit	$35	$50

Chart showing general resume of results



Note–No value shown for production line. Used to compare with cost and effy. lines

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Fig. 97. Chart of General Results—Production, Cost, and Efficiency

So, after a long experience with just such trials as I have outlined, let me advise the engineer for his protection and the protection of the client (who after all is hardly to blame because he is not familiar with the aims, ideals and devices), *to analyze from the start and feed the facts to the executives so as to guard against leaving with a letter which will "damn with faint praise."*

The charts shown, along with the others which would naturally suggest themselves to the engineer, should be placed together in a compact space, like a Babson desk sheet. Cost facts, production data, burden, can be charted. The charts shown in the previous chapter can also be added. Make a frame that will hold all the charts, each of which should not exceed 5 by 8 inches in size. Arrange them together in consistent order, in this way materially increasing the value of each chart. For instance, the chart on delayed shipments and the one on delays are very closely related. The one on purchase failures and the one on planning changes can be wisely considered in conjunction. Cost charts and the charts on inefficiency of men and management are worth considering together. A chart covering production compared with one showing the burden will show the trend of the business. With these two place the chart showing monthly efficiency. If the executive will not consent to having a duplicate set under a plate glass on his desk—the very best possible way for keeping them for reference and study—make a monthly abstract with conclusions and submit to the management.

Further, remember to do two things, from beginning to end—

1. Keep a diary showing daily all the essential things that happen. A thing may not seem important at the time but it might easily assume proportions later on, when some obstacle is met with relating to the very point that was jotted down.

2. Put everything in writing, all the time. Verbal discussions are questionable, for the memory is a most excellent "forgettery."

Conclusion

It is hoped that what has been said in this and previous chapters will convince executives that there is, after all, something of real and substantial value in this efficiency work. A writer recently said:

> As our industries are organized to-day, not one establishment in ten can have scientific management, because not one in ten is willing to live by its law.

If this is true, then the executives of our industries are to blame. Whether or not the work is to be the success possible; whether or not our industrialism is to be the most efficient on earth—is simply a question of the co-operation of executives and managers. The engineer has been and is doing his share. His work is exceedingly trying, calls for considerable travel, and demands much in the way of personal sacrifice. He is constantly forced to battle with trying situations back of which are skepticism and doubt. Certainly opposition will not make his task any easier. That he will win there is no question, for the history of every movement shows that the things which are now successful were forced to withstand bitter criticism and repeated failures, some having to fight for their very existence. The sewing machine, the cotton gin, the telephone, the introduction of machinery are examples.

Because we are quitters; because we are skeptical of anything new; because in America there is too much "each for himself"—the progress of the work to date is not all it should be. Industry and the community at large are the real losers—not the engineers and those who advocate what has been described in these pages. *As our industries simply must and will become more efficient before we can get away from the vicious cycle of higher costs and increased prices, it behooves industrial managers to cease condemning on general principles and to make a real and consistent attempt to find the meat that will prove to be the best kind of industrial nourishment.*

A few words to the executive therefore seem fitting in closing. In a small way, begin the introduction of some of the methods described. Put one of your own men or a good man from the outside in charge of the work. Seek such advice as will make what you undertake successful. Make the organization understand from the start that what is going to be introduced is not on trial, but part of a determined and consistent attempt to bring about greater efficiency. It is sincerely hoped that what has been said will enable you to better understand the ideals and aims of the methods advocated, as well as the measure of the men you must look to in the performance of the work—serving in addition to assist you in avoiding some of the pitfalls. *Here's to your success!*

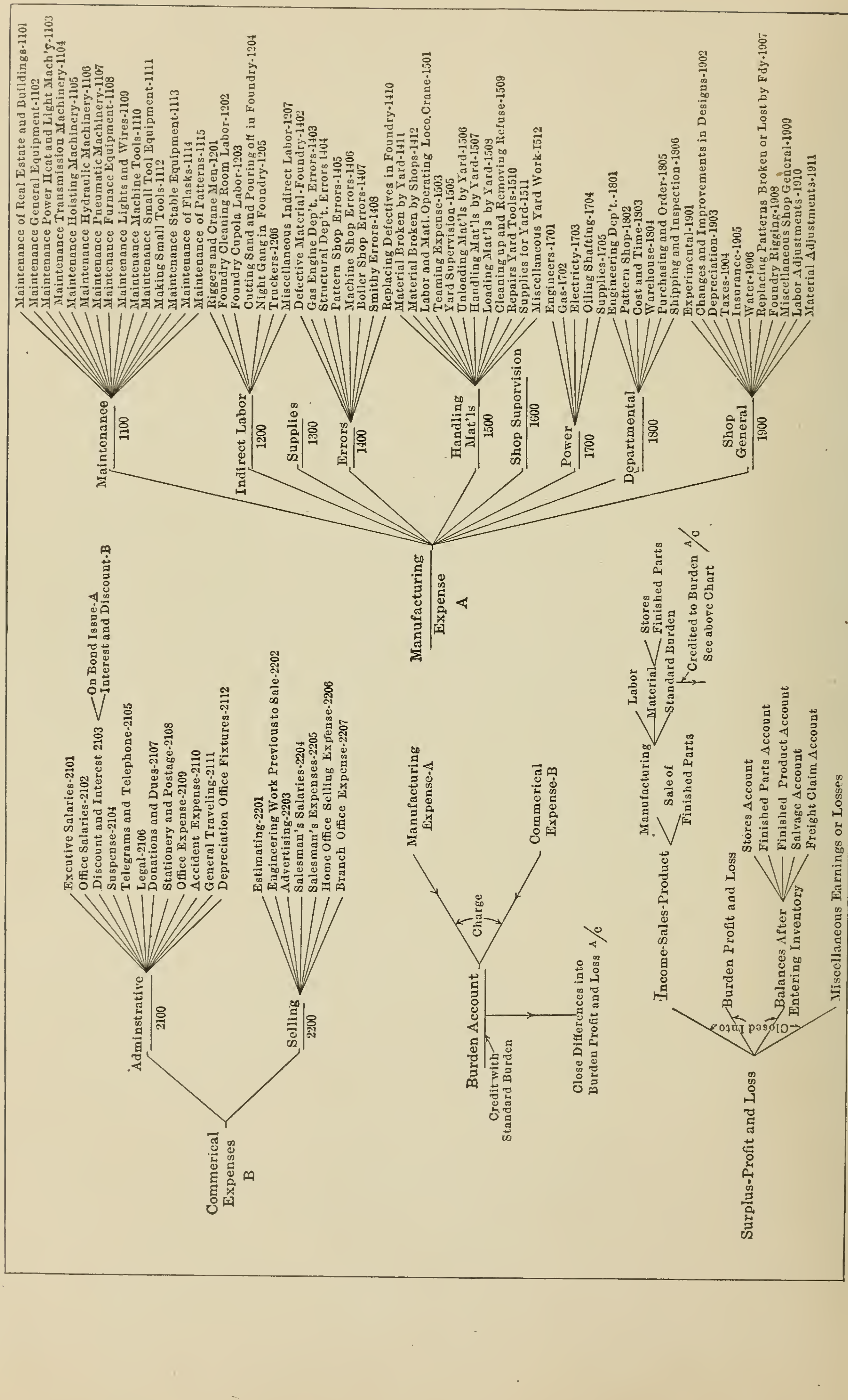

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Fig. 98. Graphic Chart of Relations of Accounts

Chapter XIX

MANUFACTURING COSTS

IN the graphic outline of manufacturing practice (Fig. 5, Chapter VII), efficiency practice and accounting practice were considered as ante-mortem and post-mortem processes, their functions being:

Efficiency practice, to outline standard practice;

Accounting practice, to criticize actual practice.

In order therefore to make this presentation as comprehensive as possible, it seems proper to add a supplementary chapter on manufacturing costs so as to enable the executive to cover the entire field if he feels so disposed. The outline of accounting practice is not of course universally applicable, but it will furnish such practical facts in connection with costing as to enable a manager to devise the kind of cost methods that will check his efficiency results and in addition furnish him excellent cost data.

The chart shown in Fig. 98 outlines fully the accounting that will be described. In case the reader desires more explanatory information, the author will gladly supply it. If the reader wants a more scientific method of cost-keeping, a careful study of "Production Factors," by A. Hamilton Church, will be found of pronounced value.

The discussion will be considered under the following headings:

(1) Manufacturing Expense
(2) Commercial Expense
(3) Sales and Stock Orders
(4) Production and Sales Accounting

Manufacturing Expense

Controlling Accounts

The controlling accounts making up the manufacturing expenses are as follows:—

Maintenance of Plant.............................account 1100
Indirect Labor.....................................account 1200
Supplies used in Plant...........................account 1300
Errors..account 1400

Handling Materials .... account 1500
Shop Supervision .... account 1600
Power .... account 1700
Departmental Expense .... account 1800
Shop General Expense .... account 1900

DEPARTMENTS

The same numbers are to apply to *all* departments; the following letters are to be used in identifying the department chargeable with an item of expense:

Machine Shop .... M
Boiler Shop .... B
Smithy .... S
Foundry .... F
Pattern Shop .... P
Carpenter Shop C
Warehouse .... W
Yard .... Y
Engineering Department .... E
Office .... O

MAINTENANCE OF PLANT—ACCOUNT 1100

ACCOUNT 1101—MAINTENANCE OF REAL ESTATE AND BUILDINGS

Charge with labor and material expended to maintain:

Tracks
Sewers
Paving
Sidewalks
Shop Buildings
Office Buildings
Air Lines
Gas Lines
Water Lines

ACCOUNT 1102—MAINTENANCE OF GENERAL EQUIPMENT

Charge with labor and material expended to maintain the general equipment.

ACCOUNT 1103—MAINTENANCE OF POWER, HEAT AND LIGHT MACHINERY

Charge with labor and material expended to maintain the equipment of machinery classified under above heading.

ACCOUNT 1104—MAINTENANCE OF TRANSMISSION MACHINERY

Charge with labor and material expended to maintain equipment of:

Bearings
Hangers
Shafting
Pulleys
Boxes
Belt Shifters
Belting

Account 1105—Maintenance of Hoisting Machinery

Charge with labor and material expended to maintain the equipment of machinery classified under above heading.

Account 1106—Maintenance of Hydraulic Machinery

Charge with labor and material expended to maintain the equipment of hydraulic machinery.

Account 1107—Maintenance of Pneumatic Machinery

Charge with labor and material expended to maintain equipment of pneumatic machinery.

Account 1108—Maintenance of Furnace Equipment

Labor and material expended to maintain equipment of furnaces.

Account 1109—Maintenance of Lights and Wires

Labor and material expended to maintain equipment of:

Incandescent Lamps
Arc Lamps
Globes
Cord and Guards
Fuse
Fuse Blocks
Sockets

Account 1110—Maintenance of Machine Tools

Labor and material expended to maintain equipment of machine tools.

Account 1111—Maintenance of Small-Tool Equipment

Labor and material expended to maintain equipment of small tools.

Account 1112—Making Small Tools

Labor and material expended in making new small tools, jigs, fixtures, templets, etc.

Account 1113—Maintenance Stable Equipment

Labor and material expended to maintain equipment of:

Horses
Wagons
Harness
Barn

Account 1114—Maintenance of Flasks

Labor and material expended in maintaining equipment of:

Iron and Wood Flasks
Making New Wood Flasks

Account 1115—Maintenance of Patterns

This account made up of the transfers from accounts 2412–2413.

Indirect Labor—Account 1200

Account 1201—Riggers and Crane Men

Charge with wages paid to those who operate cranes about plant (excepting locomotive crane operator) also wages paid to those who work with crane men.

Account 1202—Foundry Cleaning-Room Labor

Charge with wages of men cleaning, grinding, rattling and chipping castings in foundry

Account 1203—Foundry Cupola Labor

Charge with time of men:

Getting material from yard to charging platform.
Breaking stock.
Weighing charges.
Charging and tending cupola.
Cleaning and daubing ladles.
Preparing cupola for each day's heat.

Account 1204—Cutting Sand and Pouring Off in Foundry

Charge with time of men in foundry cutting sand in the morning and pouring off at night.

Account 1205—Night Gang in Foundry

Charge with time of men removing castings, flasks, clamps, etc., wetting down floors and getting same in condition for use by moulders.

Account 1206—Truckers

Charge with time of men trucking work around shops, from department to department, etc.

Account 1207—Miscellaneous Indirect Labor

Charge with time of men whose work is of a general character which cannot be charged to any other account.

Supplies—Account 1300

Charge with materials drawn from *Stores* for general use in various departments.

Errors—Account 1400

Account 1401—Defective Material—Purchased

Charge with purchased material rejected because of defects in the material.

(a) Value of Material—
Charge back to vendor, credit proper department.

(b) Value of labor if any—
Charge account 1909.

Account 1402—Defective Material—Foundry

Charge with material purchased from our own foundry rejected because of defects in material.

(a) Value of material:
1. Charge scrap account with scrap value.
2. Charge account 1402 with difference between value of scrap and price allowed foundry. Credit proper department with price allowed foundry.

(b) Value of labor, if any—
Charge account 1909.

Account 1403—Gas-Engine Department Errors

Charge with value of labor and material expended on work rejected because of errors in the gas engine department.

Account 1404—Structural-Department Errors

Charge with value of labor and material expended on work rejected because of errors in the structural department.

Account 1405—Pattern-Shop Errors

Charge with value of labor and material expended on work rejected because of errors in pattern shop.

Account 1406—Machine-Shop Errors

Charge with value of labor and material expended on work rejected because of errors in machine shop.

Account 1407—Boiler-Shop Errors

Charge with value of labor and material expended on work rejected because of errors in boiler shop.

Account 1408—Smithy Errors

Charge with value of labor and material expended on work rejected because of errors in smithy.

Account 1410—Replacing Defectives in Foundry

Charge with labor in foundry or core room replacing lost or extra work done on account of causes other than faulty design or construction of pattern.

Account 1411—Material Broken by Yard

Charge with material broken by yard gang.

Account 1412—Material Broken by Shops

Charge proper department with material broken by shops.

Handling Materials—Account 1500

Account 1501—Wages Locomotive Crane Operator

Charge with wages paid to locomotive crane operator.

Account 1502—Locomotive Crane Fuel and Supplies

Charge with fuels used by crane; also any supplies, such as waste, oils, etc.

Account 1503—Wages of Teamsters

Charge with wages paid to teamsters.

Account 1504—Team Supplies and Expense

Charge with feed, hay, straw, bran, corn, etc.; grease used on wagons or harness; tools, including shovels, forks, jacks, brushes, brooms, dusters, oil for lighting and any other expense not classified above.

Account 1505—Yard Supervision

Charge with wages paid to one in charge of yard gang.

Account 1506—Unloading Materials by Yard

Charge with expense of unloading materials received.

Account 1507—Handling Materials by Yard

Charge with expense of handling materials in shops, taking material from one department to another, etc.

Account 1508—Loading Materials

Charge with expense of loading materials for shipment.

Account 1509—Cleaning up and Removing Refuse

Charge with expense of cleaning up around plant and removing refuse.

Account 1510—Repairs to Yard Tools

Charge with labor and material expended to keep yard tools in repair.

Account 1511—Supplies

Charge with supplies used by yard gang such as hooks, small chains, hammers, sledges, shovels, picks, forks, pails, brooms, etc.

Account 1512—Miscellaneous Yard Work About Plant

Charge with yard work of a miscellaneous character which cannot be charged to some other account.

Shop Supervision—Account 1600

Charge with salaries paid to superintendent, foremen, and assistant foremen. Also amounts paid to shop clerks.

Power—Account 1700

Account 1701—Engineers

Charge with wages paid to engineers about plant.

Account 1702—Gas

Charge with invoices for gas.

Account 1703—Electricity

Charge with invoices for electricity.

Account 1704—Oiling All Shafting

Charge with time spent in oiling the shafting about plant.

Account 1705—Supplies

Charge with supplies such as oils, waste, oilers, paint, etc.

Departmental—Account 1800

Account 1801—Engineering Department

Charge 1801 G with balance from 2300 G.
Charge 1801 S with balance from 2300 S.

Account 1802—Pattern Shop

Charge with balance from account 2400.

Account 1803—Cost and Time

Charge with amounts paid to timekeepers and cost-department clerical force.

Account 1804—Warehouse

Charge with labor and supervision in warehouse; the supplies used by the warehouse; the taking of inventories, etc.

Account 1805—Purchasing and Order

Charge with expense of operating purchasing and order departments.

Account 1806—Shipping and Inspection

Charge with amounts paid to shipping clerk and shop inspectors; also any shipping expense which cannot be charged direct to an order or account.

Shop General—Account 1900

Account 1901—Experimental

Charge with labor and material expended by all departments because of experiments made by shops or Engineering Department.

Account 1902—Changes and Improvements in Designs

Charge with Engineering Department or Pattern Shop expense incurred because of changes or improvements made to correct a fault or better the product.

Account 1903—Depreciations

Charge with all depreciations to plant and equipment.

Account 1904—Taxes

Charge with taxes.

Account 1905—Insurance

Charge with insurance.

Account 1906—Water

Charge with invoices rendered for water rent.

Account 1907—Replacing Patterns Broken or Lost by Foundry

Charge with amount of account 2410.

Account 1908—Foundry Rigging

Charge with expense which facilitates the work in the foundry, such as labor and material making chills, core shells, anchors, lifting plates, loom plates and rings, matches, regating patterns, fitting patterns for machine moulding, etc.

Account 1909—Miscellaneous Shop General

Charge with expense of a miscellaneous character which cannot be charged direct to some other account.

Commercial Expenses

Controlling Accounts

The controlling accounts making up the commercial expenses are as follows:

Administrative Expenses.........................account 2100
Selling Expenses.................................account 2200

Administrative Expenses—Account 2100

Account 2101—Executive Salaries

Charge with salaries paid to the officers of the corporation.

Account 2102—Office Salaries

Charge with salaries paid to bookkeepers, stenographers and office boys.

Account 2103—Interest

Charge with:

a. Interest on bond issue.
b. Interest and discount.

Account 2104—Suspense

Account 2105—Telegrams and Telephone

Account 2106—Legal

Account 2107—Donations and Dues

Charge with gifts to charitable institutions and for other purposes—association charges, dues, etc.

Account 2108—Stationery and Postage

Charge with all printed matter excepting advertising; also postage, postal cards, stamped envelopes, etc.

Account 2109—Office Expense

Charge with supplies such as pencils, pen holders, pens, erasers, pins, rubber bands, blotting paper, pads, waste baskets, carbon paper, clips, inks, paste, rubber stamps, stamp pads, typewriter ribbons, rulers, shorthand books, etc.

Account 2110—Accident Expense

Charge with ambulance service, nurses and doctors' service, hospital care, medicine required and all other expenses incurred on account of accidents to employees.

Account 2111—General Traveling

Charge with amounts expended in traveling on company business when not chargeable to some other account, order or contract.

Selling Expense—Account 2200

Account 2201—Estimating

Charge with expense of the Estimating Department.

Account 2202—Engineering Work Previous to Sale

Charge with account 2309.

Account 2203—Advertising

Charge with periodical and circular advertising, photographing, cuts, etc.

Account 2204—Salesman's Salaries

Account 2205—Salesman's Expenses

Account 2206—Home-Office Selling Expense

Charge with expense of a miscellaneous nature that are chargeable to the selling branch of the business.

Account 2207—Branch Office Expense

Charge with expenses chargeable against branch offices.

Sales and Stock Orders

Sales Orders

Each sales or customer's order is to be numbered; the following numbers to be assigned to the Machine Shop and Boiler Shop:

Machine Shop.................................40,000–49,999
Boiler Shop.....................................50,000–59,999

The first figure of each group to be used as identifying the department which is to receive credit for the order.

Stock Orders

Stock orders will be of two kinds:

a. For finished product such as engines, boilers, tanks, etc.

b. For stock parts whether rough or finished and made for the warehouse or "stores."

Finished Product Stock Orders

Machine Shop and Boiler Shop to have "Finished Product" accounts which will be charged upon completion with finished product orders.

All stock orders for finished product are to bear numbers which correspond to the departments that are to be credited with sales from finished product.

Warehouse or "Stores" Orders

All orders for Warehouse Stock to bear numbers:—

30,000 to 39,999

The first figure showing this class of orders to be different from Machine or Boiler Shop Orders.

How Orders for Warehouse Stock Are to be Controlled

No department to manufacture stock parts without orders; requisitions for this class of materials to come from the Warehouse, the Order Clerk or Engineering Department to decide on what is to be carried.

STORES REPLENISHMENT

THE FOLLOWING ITEMS ARE WANTED FOR STORES

REQ'D	PATTERN NO.	PIECE NO.	DRAWING NO.	MAT'L.	DESCRIPTION	DEP'T.	WHEN WANTED	HOW WANTED			ORDER NO.
								F	FM	M	

REMARKS:

DATE STORE KEEPER

F.- CASTINGS FROM FOUNDRY ONLY F.M.- CASTINGS AND MACHINE WORK M.- MACHINE WORK ONLY

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Fig. 99. Stores Replenishment Form

How Warehouse is to be Notified Regarding What to Carry

Order Clerk or Engineering Department to use the form given in Fig. 99, "Stores Replenishment," when it is desired to create stock; listing information under proper headings; stating under "Remarks" that the material is to be carried as stock, and whether the material is to be carried as rough or finished, giving any other information that may be necessary.

The maximum and minimum quantities are to be given for guidance in reordering when stock is low.

After slips are made out they are to be sent to the Warehouse.

Warehouse Procedure

Warehouse upon receipt of "Stores Replenishment" slips from Order Clerk or Engineering Department is to open accounts for the material specified in the Stores Ledger, placing the necessary information under "Ordered," after which the slips are to be sent to the Cost Department.

Handling Stock Orders for Finished Product

If an order is entered for a number of units, as for instance, an order for three engines, the order is to be given a number beginning with 4 and each one of the units to be made is to be given an engine or unit number.

The stock-order number is to include the machining of the parts by item numbers and the assembly of the units by engine or unit numbers. If, for instance, the stock order for the three engines was 41,250, and the engine numbers 901-902-903, the time would be accounted as follows:

Machining—41250—Item No.

Assembly—41250—901-902-903, depending upon which engine was being assembled.

APPLYING STOCK ORDERS TO SALES ORDERS

If one of the units being made on a stock order is sold, a sales order is to be made out by the order clerk, *on which is to show the number of the stock order on which the unit is being made.*

If, when the Engineering Department gets the sales order, it is found that a number of special parts are necessary, *which do not replace regular parts made for the stock order,* a list of material is to be made out *for the sales order,* but instead of listing every item entering into the construction of the machine, the list is to read:

Take from Stock Order No. ——,

and under this wording is to be entered the special parts that are necessary.

The sales-order number is to cover the machining of the special parts, but their assembly is to be charged to the *Stock Order and Engine Numbers.*

Stock Orders to show to which sales orders a unit has been applied.

SPECIAL PARTS ON SALES ORDERS REPLACING REGULAR PARTS MADE ON THE STOCK ORDER

If the Engineering Department should find in checking over the stock order that some of the parts do not come up to specification, the sales order list is to read:

Take from Stock Order No. ——, with exception of replacements listed below, and when the special parts replacing the regular parts are listed, they are to be prefixed by the wording:

Replacing item —— sheet ——.

HANDLING PARTS REPLACED

It shall be the duty of the shop foreman to see to it that the regular stock parts replaced by special parts, are finished up and returned to the warehouse, accompanied by "Material Returned" cards, Fig. 101, so that the stock order can be credited for the parts not needed.

COSTING SALES—STOCK ORDERS

When sales orders are completed, which take units from the stock orders, the Cost Department is to transfer from the stock order the proper machining costs and the cost of assembly by engine or unit number, to which is to be added the machining of the special parts.

Stock orders to be credited with the parts that have been returned to warehouse because of replacements.

PRODUCTION AND SALES ACCOUNTING

SALES ACCOUNTS

The following will be the principal Sales Accounts:

(*a*) Machine-Shop Accounts:

.... Sales.
.... Sales.
.... Sales.
.... Sales.
.... Sales.

(*b*) Boiler-Shop Accounts:

.... Sales.
.... Sales.
.... Sales.
.... Sales.
.... Sales.
.... Sales.

MANUFACTURING ACCOUNTS

The following will be the accounts to which will be charged the labor and material entering into the production of whatever is credited in the form of a sale:

FOUNDRY MANUFACTURING ACCOUNT.

BOILER-SHOP MANUFACTURING ACCOUNT.

MACHINE-SHOP MANUFACTURING ACCOUNT,

and in addition there will be an account "WAREHOUSE MANUFACTURING ACCOUNT," which will be charged with the labor on finished parts by smithy, machine or boiler shop, and the material drawn from warehouse.

INCOME ACCOUNTS

There will be three income control accounts:

FOUNDRY INCOME ACCOUNT.

MACHINE-SHOP INCOME ACCOUNT.

BOILER-SHOP INCOME ACCOUNT.

INVENTORY ACCOUNTS

There will be four inventory accounts in addition to the Stores and Manufacturing Accounts, as follows:

MACHINE-SHOP FINISHED PRODUCT ACCOUNT.

BOILER-SHOP FINISHED PRODUCT ACCOUNT.

FINISHED PARTS ACCOUNT.

SALVAGE ACCOUNT.

KINDS OF MANUFACTURING

Manufacturing will be of three kinds:

a. For stock orders for:
   Finished parts.
   Finished units.

b. For sales orders.

c. For new construction or permanent improvement orders.

CHARGES TO THE MANUFACTURING ACCOUNTS

All charges will come from three sources:

Labor
Material
Burden or overhead expense

Journalizing of labor and material charges to be done by Cost Department. Journalizing of burden charges to be done by Accounting Department from data furnished by Cost Department.

CREDITS TO MANUFACTURING ACCOUNTS

All credits will come from three sources:

Completed orders for month
Returned material
Rejected material

The form shown in Fig. 100, "Report of Finished Orders," will constitute the authority for making journal entries, while "Material Returned" card, Fig. 101, and "Rejection Card" (see Fig. 70, Chapter XVII) will be used when journalizing returns and rejections.

Journal entries to be made by Cost Department.

MAKING UP THE "LABOR" CHARGES TO MANUFACTURING ACCOUNTS

There will be a "Report" sheet, Fig. 102, *each month* for each of the following departments:

Machine Shop
Boiler Shop
Smithy
Pattern Shop
Carpenter Shop
Yard
Gas-Engine Department
Structural Department

Each sheet to have the following written in the blank headings:

First column.................................Machine Shop.
Second " ....Boiler Shop.
Third " ....Warehouse.
Sixth " ....Expense.

The service cards from each of the various departments, which should cover the time of all the employees in the departments, are to be taken by the Cost Department, checked against payroll time, and after being posted to the proper orders or accounts, *re-sorted according to the department manufacturing accounts.* Those which do not affect a manufacturing account are to be placed in a pile by themselves.

The labor in hours and amount for each of the four divisions will then be computed and inserted opposite the date under the proper heading; the total for the day to be placed in the "Totals" column.

At the end of the month, the various columns (hours and amount) on the department sheets, are to be totaled and the percentages which the *Machine Shop, Boiler Shop* and *Warehouse hours* bear to the *total* department hours, are to be computed and inserted opposite "Department Hours to Total Hours."

REPORT OF FINISHED ORDERS

MONTH OF ______ *DEPARTMENT* ______ *SHEET NO* ______

CHARGE "FINISHED PARTS" A/C-"FINISHED PRODUCT" A/C WITH TOTAL OF COLUMN "E"
CREDIT "MANUFACTURING" A/C WITH TOTALS OF COLUMNS A. B. C. AND D.

	DATE FINISHED	ORDER NUMBER	LABOR		MATERIAL	BURDEN	TOTAL COST
			HOURS	AMOUNT			
	TOTALS						
			A	*B*	*C*	*D*	*E*

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Fig. 100. Report of Finished Orders

MATERIAL RETURNED			
CREDIT BECAUSE OF MATERIAL RETURNED			
ORDER NO.	**DEP'T.**		
QUANTITY	**DESCRIPTION**	**PRICE**	**VALUE**
DATE RET'D	**RET'D BY**	**REC'D BY**	

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Fig. 101. Material Returned Card

Making up Material Charges to Manufacturing Accounts

There will be a "Report" sheet, Fig. 102, *each month* for the following classification of material:

Stores Material
Finished Parts
Requisition for Material

"Material Delivered" cards, Fig. 103, and "Rejection Cards" are to be sorted each day according to the proper manufacturing accounts; all requisitions covering expense materials to be placed in a pile by themselves.

The value of the material is to be computed daily and inserted opposite the date under the proper heading; the total for the day to be placed in the "Totals" column.

Care will be necessary in sorting requisitions in order that the distinction between *Stores* and *Finished Parts* (parts manufactured by us for Warehouse stock) may be considered.

Making up Credits to Manufacturing Accounts

As orders are finished, whether shipped or not shipped, they are to be costed and entered on "Report of Finished Orders."

There will be three reports covering:

REPORT OF FOR DEPT. MONTH OF 19

DAY	TOTALS HOURS	TOTALS AMOUNT	HOURS	AMOUNT	HOURS	AMOUNT	HOURS	AMOUNT	HOURS	AMOUNT	HOURS	AMOUNT	HOURS	AMOUNT
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														
TOTALS														
Dept. Hrs to Total Hrs		%		%		%		%		%		%		%

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Fig. 102. Report Sheet

MATERIAL DELIVERED.					
WHEN DATED AND SIGNED BY FOREMAN, THIS CARD BECOMES A REQUISITION FOR THE MATERIAL SPECIFIED; IT BECOMES A "MATERIAL DELIVERED" CARD WHEN DATED AND SIGNED UPON DELIVERY OF MATERIAL AFTER WHICH IT IS TO BE SENT TO COST OFFICE SHOWING WEIGHTS. (SEE REVERSE SIDE.)					
ORDER NO.	FOR DEPT.	BY DEPT.	LIST OF MATL.	SHEET	
	DATE ISSUED			GROUP	
				ITEM	
REQ'R'D	PART NAME	DESCRIPTION OR DRAWING NO.	PIECES NO.	MATL.	
FOR	DATE WANTED	DATE COMPLETED			
DELIVER MATERIAL TO—					
FOREMAN		DELIVERED TO			
DATE	NAME	DATE	NAME		

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Fig. 103. Material Delivered Card

Machine-Shop Finished Product
Boiler-Shop Finished Product
Warehouse Finished Parts

At the end of the month, the various columns are to be added and journalized according to the instructions given at the top of the form.

Foundry Manufacturing Account

(*a*) Month's Production—

Charge Foundry Manufacturing Account with month's production at cost to produce.

Credit Labor, Stores and Burden Accounts with amounts making up the cost.

(*b*) Sale of Month's Production:

Charge Stores Account with sale of month's production to Warehouse at prices allowed the foundry.

Credit Foundry Manufacturing Account with sales price of month's production.

(*c*) Foundry Profit:

Charge Foundry Manufacturing Account, credit Foundry Income Account with the difference between charge and credit entries to Foundry Manufacturing Account.

(*d*) Foundry Loss:

Charge Foundry Income Account, credit Foundry Manufacturing Account with the difference between charge and credit entries to Foundry Manufacturing Account.

Machine Shop Manufacturing Account

(*a*) Month's Production:

1. Charge account with labor in:
   - Machine Shop
   - Boiler Shop
   - Smithy
   - Pattern Shop
   - Carpenter Shop
   - Yard
   - Engineering Department
   - Field

   when such labor is applied on Machine-Shop orders.
2. Charge with all material drawn from Stores for Machine-Shop orders.
3. Charge with proportion of Machine-Shop, Boiler-Shop, Smithy and Field burden applicable to Machine-Shop orders.

   Credit Labor, Stores and Burden Accounts with the amounts making up the cost.

(*b*) For material returned by shops after having been charged to Manufacturing Account.

Charge Stores Account.
Credit Machine-Shop Manufacturing Account.

(*c*) For rejections of material:

Charge proper Error Account.
Credit Machine-Shop Manufacturing Account.

(*d*) For Completed Work:

Charge Machine-Shop Finished Product Account.
Credit Machine-Shop Manufacturing Account.

Boiler Shop Manufacturing Account

Procedure same as for Machine-Shop Manufacturing Account

Warehouse Manufacturing Account

For Warehouse Manufacturing Account, the procedure is same as for the Machine Shop Manufacturing Account, with the exception of *completed work* which for the warehouse work is to be handled:

Charge Stores Finished Parts Account.
Credit Warehouse Manufacturing Account.

Finished Products Accounts (Boiler Shop and Machine Shop).

(*a*) Upon completion of Boiler and Machine-Shop orders:

Charge Department Finished Product Account.
Credit Department Manufacturing Account.

(*b*) When shipments are made and invoiced:
Charge proper sales account with cost.
Credit DEPARTMENT FINISHED PRODUCT ACCOUNT.

FINISHED PARTS ACCOUNTS
(*a*) Upon completion of warehouse orders:
Charge FINISHED PARTS ACCOUNT.
Credit WAREHOUSE MANUFACTURING ACCOUNT.
(*b*) When finished parts are issued to shops on orders:
Charge DEPARTMENT MANUFACTURING ACCOUNT.
Credit FINISHED PARTS ACCOUNT.
(*c*) When finished parts are sold:
Charge DEPARTMENT FINISHED PRODUCT ACCOUNT.
Credit FINISHED PARTS ACCOUNT.

SALES ACCOUNTS
(*a*) BOILER SHOP
1. For sales at sales prices:
Charge Customer.
Credit:
SALES under its proper sub-account.
2. For Sales at the *Cost* of the Sales:
Charge the above sales accounts with the cost of the sales.
Credit BOILER-SHOP FINISHED PRODUCT ACCOUNT.
(*b*) MACHINE SHOP
1. For sales at *sales prices*:
Charge Customer.
Credit:
SALES under its proper sub-account.
2. For sales at the *cost* of the sales:
Charge the above sales accounts with the cost of the sales.
Credit MACHINE-SHOP FINISHED PRODUCT ACCOUNT.

FOUNDRY INCOME ACCOUNT
For Profits:
Charge FOUNDRY MANUFACTURING ACCOUNT.
Credit FOUNDRY INCOME ACCOUNT.
For Losses:
Charge FOUNDRY INCOME ACCOUNT.
Credit FOUNDRY MANUFACTURING ACCOUNT.

MACHINE-SHOP INCOME ACCOUNT
For Profits:
Charge the various MACHINE-SHOP SALES ACCOUNTS with monthly income from sales.
Credit MACHINE-SHOP INCOME ACCOUNT with income from various sales accounts.

For Losses:

Charge Machine-Shop Income Account.

Credit various Machine-Shop Sales Accounts.

Boiler-Shop Income Account

Same procedure as for Machine-Shop Income Account.

Salvage Account

For recovery of materials:

All material recovered, with the exception of daily foundry recovery, to be *charged* at market prices to the above account; the proper department to receive *credit* for the material turned over to the Salvage Account.

For sale of salvage:

Charge Purchaser.

Credit Salvage Account.

For Materials Returned by Customer and Put into Finished Product

For price of material returned:

Charge proper Sales Account.

Credit Customer.

For cost of material returned:

Charge Department Finished Product Account.

Credit proper Sales Account.

On the basis of the accounting as above described, it will be possible to draw up a monthly trading or income statement, showing not only what each department has made or lost, but the profits or losses on the various lines manufactured by the separate departments. It should also be remembered that the value of cost data lies in their careful analysis, and this fact should not be overlooked.