(January 20th, 1913.)

Scientific Management.

By Mr. Frederick Winslow Taylor.*

AT a special evening meeting of the Canadian Club held on Monday, the 20th January, 1913, Mr. Frederick Winslow Taylor, of Philadelphia, said:

Gentlemen,—I am going to talk to you to-night a good deal about working men, and in what I have to say I have in mind merely that class of working men who are engaged in what may be called co-operative industries. I do not refer, for instance, to a coachman, who works by himself, but merely to men who work in certain groups, whose interests are common, and are therefore closely dependent upon one another. It is important to bear this in mind, because generalizations apply to all classes of working men, and allowance must be made for some very sweeping statements.

My subject will be the Principles of Scientific Management, and most of my facts relate to working men in this country. The average man believes it for his best interest to go slow, instead of going fast, to turn out as little work as possible, instead of as much as possible. Now that firm conviction, that it is for the interest of the working man to restrict output, is practically universal among working men. It is due to two principal causes, and I think I may say that for neither of these causes is the working man principally to blame; as I am going to try to show you, I think men of our class are much more to blame than the working men for the existence of these two very fallacious ideas.

The first of these causes is this: you have in Toronto a certain number of men working in a trade, and if you suggest that it would be to their interest to double the output by each man becoming more efficient or in any other way, there would not be a shadow of doubt in their minds that the only result would be to throw half of them out of work. For the average working man this is a self-evident fact, it does not demand argument, it is axiomatic, he would only laugh at anyone who would say anything else. Strangely enough, I find that the great majority, yes, four-fifths, of educated

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men, who read and study this subject, have the same idea, that to increase output would result in throwing a whole lot of men out of employment. Now this, as I say, is a self-evident proposition to the working men. Their labor leaders—there is hardly one of them throughout the country but is teaching them that it is to their interest to restrict output. There is hardly a labor union but has enacted legislation tending to this directly, or is contemplating it. And while this is the generally inherited principle, coming to them from the time they are small boys, and imbibed from everyone talking about it, yet there never has been a greater fallacy than this! To prove this, all that is necessary to do is to go back and look at the history of any trade, I don't care what, and you will find the directly opposite to be true: that any device or scheme to increase output, instead of throwing men out of work, has made more work for the men in that trade. There is one industry in which that is not true, viz., agriculture, the only one that I know of. In agriculture, during the past eighty years, the number of men engaged, in the United States, has been reduced from 80 per cent. to 35 per cent.; that of course is due to the introduction of labor-saving machinery; and the reason for that is that while we can eat a great variety of food we cannot eat much more food than the last generation, though perhaps the waste is greater. But that furnishes the only exception I know of any large industry in which an increase of output has not resulted in making more work for the men in that trade instead of less.

We have one instance before us, over which the fight was quite recent, I have no doubt you have observed it,—the case of the linotype and monotype composing machines. It was a fight at first to get them introduced, but now you won't find a union but will admit that there is work for far more men than before the machines were introduced. This is simply an illustration of this belief that is so ingrained in the working men. However, the real meaning of this phenomenon can be appreciated only by taking one of the older trades, as the linotype and monotype ideas are too recently introduced to be startling in their statistics. But take any old trade, the cotton industry, for instance. You remember, perhaps, the riots and labor disturbances in Manchester, England, when the old hand loom was being superseded by the power loom. The power loom was invented about 1780 or 1790, but did not come into general use till about twenty-five years later; but between the years 1825 and 1840 the power loom gradually was superseding the hand loom, and about 1840 things came to a climax,

and the weavers of Manchester, who knew all about what the power loom would do, realized that while there were five thousand of them then working at the hand looms in Manchester, when the power loom was really installed, there would be only fifteen hundred of them left. Now, gentlemen, I am not defending arson and murder, or any violence on the part of the unions, but we shall have to have a little charity in judging those men and their actions under those circumstances: they did just what you or I would do; we would not murder, or smash machines, or burn down establishments, but if any device or scheme were introduced which would throw two-thirds of us completely out of our trades—(and you must remember that those trades were almost closed,—they had cause to feel a grievance), and if you will put yourselves in the places of those weavers of 1840 you will have to look upon them a little more charitably than if you just look at the fact that when the machines were brought in they smashed them up, burned down the factories, and beat up the men operating them. They did everything in their power to prevent the power loom from coming in. And just note the effect of it. It had practically no effect! The power loom came along; I doubt if it was stayed a day by it. And more people are employed through it to-day than ever before.

That is almost the universal result of any device to increase output. And in spite of the opposition which scientific management is receiving it is coming. It has the opposition of the trades unions, the opposition of well-meaning philanthropists who have believed the lies spread abroad by the unions, the opposition of public opinion misguded by those who are talking against it, but it has never been delayed and it never will be, because any device for increasing human efficiency—and the history of all such devices is exactly the same—cannot be stopped by any opposition.

Now let us see what happened in Manchester, England, because it is typical: just what is happening all over the world, and will happen. It did throw men out of employment: there were five thousand cotton weavers previous to the introduction of the power loom; but in Manchester now there are two hundred and sixty-five thousand cotton operatives, as against five thousand! And each man is now averaging ten yards of cloth at the very least where each man formerly averaged one yard of cloth! And the population of England has not more than doubled in that time, but we will say it has trebled, just for argument's sake—and that five yards of cloth is going out of Manchester now where one yard went out in 1840: now

what is the real, fundamental meaning of this? There is something back of it, something far more important than efficiency or the market that it gives, one of the most important facts in this world, and that is, broadly speaking, and of course with certain limitations, that all you have to do is to bring wealth into this world and the world uses it; that is the fundamental fact. I speak now of things worth while, things that can be used by the people at large, not of luxuries, but outside of food—we cannot increase the use of food much—all you have to do is to bring wealth into the world, and the world will use it. What really happened in 1840 was that cotton goods, from being a luxury to be worn only by the rich, now came to be worn by every man, woman and child, and were believed a necessary, not a luxury,—even in the uncivilized world to-day, it is used.

Of course we know that it is necessary to restrict output; that the statement I have made is not absolutely, literally, true: we know wealth must be brought in in fairly even balance: if, for example, there is an increase in cotton goods without proportionate increase in other things, the world gets out of kilter in one direction. So there must be restriction of output in that respect, for a few years to come, all over the world, not in only one country, if we get going too fast, and there are more new undertakings than there is liquidated capital for. If we do not restrict output then we have a diseased condition of over-production, for a long time sometimes; but that nowhere justifies restriction of output on the part of any man or set of men, either manufacturers or working men, for any other reason. There could be no greater crime against humanity than this of restriction of output. The wealth of the world comes from only two sources: it comes from the ground, or is what man produces. All you do in restricting output is to cut off people from getting some of the means of progress of the world, and from increasing the use of things in the world.

And let me call your attention right here to another very important fact connected with this: that the working people of the world, the philanthropists of the world, and a great part of the thinking people of the world who are studying new problems, are coming to the conclusion that the working man is not getting anything like his share of the joint product of capital and labor, that capital is getting far too great a share; and I myself sympathize with this very largely. In the ordinary operation of our large trusts the working man does not get anything like his fair share. This becomes so

conspicuous, so prominent, that we are inclined to generalize and draw very broad conclusions. In the July "Atlantic Monthly" was an article by Mr. Norman Fay, who showed by the last census returns in the United States very conclusively that if the working people of the United States got an equal division of the property now belonging to the capital of the United States, they would get just thirteen cents per man per day more than they are now getting. Now what working man would be satisfied, even if he had an equal division, when that is all he would get? He imagines he would get four or five dollars a day more! That is startling. I had some faint notion the working man was wrong, but when you get statistics on a large scale you see how little chance there is for the working man to gain by an equal division of wealth. I am sufficiently progressive to believe that there is great injustice going on; but that the great hope of the working man lies there—most certainly not! It is a great deal worse in England in the matter of restriction of output. The Liberal party in England,—and I think if I were there I would be among that Liberal party,—are all engaged in a general scheme of taking from the rich people to hand over to the poor. Much of this I approve of, but a great deal of it I don't; much of it will tend to pauperize. But if they take it all away from the rich, supposing the same proportions held as in the United States, they would all get just thirteen cents a day more; that is not much to live for or to hope for! Whereas by increasing the output they would profit much more than that.

It is of great advantage to be able to go back, for confirmation of this, to a time not so very long ago, when a week's work was a fair exchange for a bushel of wheat. There is no more fallacious way of treating this part of economics than that of talking about wages: wages tell you next to nothing; wages might be a certain amount so many years ago, but it was the same in every part of the country; but statistics tell you that a few years ago a week's work purchased a bushel of wheat; now what man would be content to trade his week's work for ten bushels of wheat? He would hardly do it.

Now I am talking so long about this restriction of output, because it lies right at the root of scientific management. That is the chief source of the opposition of a great many thinking men, and practically all labor men, because scientific management has for its object the increasing of the output of every man. Yet, I repeat, the working men of the country are hardly to blame for this fallacy. I ask you gentlemen, has anyone ever spoken to you here in Toronto

against this? They are all in favor of restricting output. If we, who ought to know better, who have a fine opportunity of reading history, do not tell them differently and educate our working men along this line, those who have not leisure to read up on this matter cannot be expected to have any other view. If you have anyone talking along this line here in Toronto, you are the first city I have met with that has.

Now the second cause of the firm belief on the part of the working man that it pays him to go slow instead of going fast—and the working man is in no way to blame for this either—we will next see.

If you were manufacturing, for instance, an article of that sort, (a fountain pen), we will assume that it can be made by one man, and we will assume that a man is on the average making ten a day, and that he is making $2.50 a day throughout the year. If that man has a good foreman, he would say, "I think you would do better if you would make this pen by the piece, instead of by day work; and I will give you 10 cents apiece for the parts you make of 25 pens in a day." The working man is sure, of course, that in the course of the year, through his own ingenuity, through the help of his foreman, through talking to his friends about his work, and through working harder, he would find himself turning out 20 pieces instead of 10 whole pens in a day, and so would find himself earning $5 a day instead of $2.50. His foreman, if he is any kind of a man, would be pretty well satisfied with that: the man would be earning pretty high wages, and the company would be earning twice as much, because it would be turning out twice as many pens with the same plant and the same appliances. He should feel very well satisfied. But let us see whether we give the man that $5. The employer, or the Board of Directors, sends for the payroll. I am not blaming anyone for this: I am merely stating facts; and it is our duty, everyone of us, nowadays, to ask for the payroll, and see what our men are getting. I think I may say to our horror we see that our machinist is getting $5 a day, while a little while ago he was receiving only $2.50 a day. We feel this is a pretty serious matter, and it is almost the universal view that we can't afford this, that we are ruining our labor market. So the superintendent is sent for, or the foreman, and told in no doubtful way that he can't afford to ruin our labor market. If he is a risky man, the chances are he will cut that fellow down, so he won't earn more than $2.75 a day. Now there has a great deal been said in the past few years about the meanness of the working people, their degeneracy, and the

fact that they do become, in many cases, almost the scum of their country through their heartlessness and their greed. My experience has been, and I have had pretty wide experience of the working people, that man for man they are just about the same in character and integrity as the average man in the community, neither better nor worse. In a case where men are in a state of war we see them at their worst; but whether we look upon them as mean and heartless or not, there is just one thing the working men of our country are not—they are not fools! And it does not take more than one act like that, just one little object lesson like that, to make a working man "soldier" for the rest of his career. From that time forward, he says: "$2.75 a day is the most these fellows will pay me, so $2.75 is what I will earn and never turn out a single piece more." These are the principles of piece workers in the United States, and I have no doubt in Canada too. It is a miserable policy for themselves; they would do better to swallow their anger and go ahead; but their anger is so great that you can't blame them for restricting the output. That is the great reason for "soldiering." They must keep their employers ignorant of what they can do. Some people do not know what that word means. If you have seen a regiment drilling, —the men are told to raise their right foot, and they do so; then their left foot, and they raise it; so the drill sergeant gets them all working, but going nowhere—that is "soldiering!" (Laughter.) That is what working men in the United States do universally; and it is enormously worse in England! Every time they had to get an increase in work, the remedy was to go still slower. That is the cause of the poverty and the great unrest of England, through this "soldiering," this terrific restriction of output, turning out less things. They have just one-half of the trade with the outside world and with each other that they might have; and that means poverty!

Now, gentlemen, I have not gotten very far. I want to begin to talk about scientific management. (Laughter.) But my excuse is that this strikes at the root of it, and this part of it is not generally understood at all.

I think I may say here that scientific management had its origin, and that the very first step that was taken toward the development of what came to be known as scientific management was taken, in an earnest endeavor to remedy the evils of this "soldiering."

It was after a long piecework fight with the working men of the Midvale Steel Works, an intensely mean, disreputable

and disgraceful fight it was too, that an effort was made to correct this evil of soldiering. And I want to emphasize this statement, that every subsequent step taken in scientific management was taken in an equally earnest endeavor to remedy the palpable defects existing in the former kind of management.

A great many people have the idea that it is a kind of theory evolved by someone having tried it. This is not so. For thirty years scientific management has been in daily and successful use, but no one ever bothered to analyze it till within the last eight or nine years. It simply was an evolution taken step by step to correct the evils that were right before the men who did it; an evolution in which a great many men had their part. And it is to grow in area and to be worked out through the co-operation of many men. I emphasize this, because those of you who have had to do with engineering inventions know that as to new ideas the more you see of them the more suspicious you are. As an engineer myself, and a rather radical one, I have become profoundly suspicious of my own ideas, and more so of those of anybody else; in other words, if a new thing is tried, it may be better, but ninety-nine times out of a hundred it may be worse than before. Most men must have arrived at this same conclusion. What I want to emphasize is, that scientific management is not in that category: it is an evolution, not an invention; it has stood severe tests again and again; it has been tried by the worst kind of critics, those who were looking for dollars, and unless the dollars came they would not have anything to do with it.

About fifty thousand men were working under it in the United States a few years ago; now perhaps there are three times as many. It is very difficult to get statistics, because it is spreading in so many ways; but for those companies which have got under scientific management it is conservative to say that the output of the average man has been doubled. This has resulted in lowering the cost price of the articles produced, therefore giving larger profit to the company. Also, in many cases, when that has gone on long enough, it results in lowering the selling price, and in that way the general public has got the benefit of scientific management.

Now this is a pretty broad assertion, that scientific management has doubled the output per man, but in the sworn testimony taken before the House Committee last year, amongst a mass of testimony, covering more than two thousand pages, given subject to cross-examination, and verified

by members of this committee, I want to give you one of the small buried facts, about one of our establishments under scientific management. Members of the committee went to verify it. In this establishment the output had been trebled; this was with the same number of men, turning out three times as much as their former output. It had been asserted by labor leaders of this particular establishment that it had lowered the wages of the working men; but statistics presented to the committee in that regard showed that for all those workmen who had been working more than one year in the establishment, including even the colored laborers who simply moved the pieces on the floor, the men who swept, the janitor, every boy and man, and the skilled labor and unskilled alike, the average man was receiving seventy-three and a fraction per cent. higher wages than when he came to the company. And the selling price of the goods produced by this establishment had been lowered 25 per cent., so that the general public got the benefit of that. From having had a strike just about six months before the introduction of that system, the men had become so devoted to their employers that it was utterly inconceivable that there ever would be a strike again! As proof of that, during the street car riots, all the trades were called upon to go out on a sympathetic strike, and the men in one immense establishment near this one went out; so did the men in three others; but in the establishment under scientific management only one man went out, and he had been employed only fifteen days, and had not had time to get into the spirit of the company. Now that is a fair round-up of what takes place under scientific management.

Again, let me give you a case. I want to convince you gentlemen that what I am talking about is not theory, but can be verified by statistics, and is not loose talk. Only within the past four days, at Watertown Arsenal, Gen. Crozier gave statistics up to last June, showing that the men in that arsenal, doing not repeat work but all new work,—it is hard to find subjects of comparison, but he found some eighty or a hundred articles that were made last year and this year, and the workmen struck for only four days, because of the very foolish way of dealing with them—averaged 29 per cent. higher wages, and were turning out two and a half times as much work as before; and the Arsenal had saved that year $363,000. No Chief of Ordnance or other public official would dare to give those figures unless they were true.

To show you that I understate the matter, in saying that the average establishment when put under scientific manage-

ment will turn out twice as much per man, while more good comes to the manufacturer,—I am perfectly free to say that I am not interested in that, so much so that it occupies my whole time and I give all my spare money to the cause, because it is the cause of the working man. A few stockholders benefit by it; and I am glad of that; but who would spend his life for a few stockholders? Not I! I have something else to do! The workingman, in my judgment, gets far more out of it than the stockholders. If the average increase is from 37 to 100 per cent. in wages, surely that is a good thing for the boys; and automatically their wages do go up. If a brother goes there into that establishment, and in three days gets an increase, they understand his talk. And that is well worth while for the working men, while this stimulus given to the workman makes the man gradually come to look upon his employer as the best friend in the world. The old idea was that your employer, though he might be a personal friend, was at least your tactical enemy, and in general a person who would bear a large amount of watching. This great change from enmity to friendship is the greatest good that comes to the working man.

Scientific management has been used in a great range of industries; there is hardly a type of industry in which it has not been introduced in the past thirty years. Nineteen out of twenty of them have been severely competitive industries, such as the steel and cotton industries. There has never been but this one strike, and then it was thoroughly unjustified. A week or so ago I went to see those moulders—you couldn't drive them back to the old system with a club; and they are all union men! The unions have been trying to bring them back; but of all the men employed at the Watertown Arsenal just three men attended the last call to a union meeting.

Now, what is scientific management? I think I can clearly describe it somewhat by pointing out what it is not, because there are very great misapprehensions about it. Scientific management is not any efficiency device of any kind, or is it any group of efficiency devices. For example, it is no new scheme of figuring costs; it is not having buying men, or a buying system; it is not a differential rate; or piece work; it is not studying masses of men, or time system, with functional or divided foremanship; it is not printing or unloading a ton or two of blanks upon a company, and saying, "There's your system; use it!" (Laughter.) I am not sneering at efficiency devices. I have great respect for every one of them, except for the one with a ton or two of blanks! I have respect

for cost systems, and for buying systems; and for the application of time study on a large scale to industries. New time study is being used in a great many establishments running under scientific management, but scientific management is more, far more enduring, and of far greater importance, of an importance far more serious than mere devices. These devices will everyone be superseded by something better in a few years; but the great broad principles of scientific management, I feel, have come to stay.

Scientific management cannot exist, and does not exist, till there is a complete mental revolution on the part of the working man as to his attitude towards those who employ him, and his whole outlook on the trade; and it does not exist until there is an equally complete mental revolution on the part of the employers and those on the management side. I dare say that is very blind to you, but I hope before the evening is done to make it clear to you; at least to make plain this mental change on both sides, so you will have no doubt of what I mean.

But let me call your attention to one thing. If you are manufacturing, say, an article of that sort (a fork). Into the cost of that article goes a certain amount of raw material, and aside from that, what are called variously "overhead expenses, "general expenses," or "indirect expenses," such as taxes, insurance, depreciation, salaries of the higher officers, sales expenses, stores and supplies. You have to add its proper share of these general expenses. If you will add the cost of materials and the proper proportion of general expenses, you have the total cost price of the article, and if you subtract that from the selling price you have what is called the surplus. And it is over the division of this surplus that almost all the quarrels of capital and labor have been. The workman wants what he thinks just and right as payable in wages, and the employer wants his share in dividends. And it is over the division of this surplus that the great wars of the past have been waged between capital and labor. Now the new mental outlook that comes to both sides under scientific management is, that both sides come very soon to realize that if they stop pulling apart, look at the division of this surplus in wages to the workman and dividend to the employer, and both push together as hard as possible in the same direction, they can make that surplus so large that there is no occasion for any quarrel over its division: labor gets an immense increase in wages, and still leaves a large share for capital. That is a great change, from looking upon the division, which means

war, to turning and making the surplus so large that there is no occasion for war.

As an illustration of what is taking place all along the line, I want to try to make clear to you what this change is, and that it is not an invention or a device, I think it will make it clearer if I compare conditions under it with the older types of management, for a company of say five hundred or a thousand men. The men of these trades have learned practically all they know about them by themselves watching others at work. They have been taught next to nothing and have learned next to nothing. They learn trades now, just as they did in the middle ages, by watching the men around them, and accepting what has been handed down by tradition from time immemorial. When I served my two apprenticeships, as a patternmaker and as a machinist, I think two and a half hours covered the reading I did; and I had the advantage over some of the boys because I had entered college, and read a little easier than the rest. No one studied the trade from books. I presented my own boy with a fine collection of books on the machinist trade, but I never saw him open one. There was some excuse for him, though, for he got up at five o'clock in the morning, and cooked his own breakfast, and did not get back home till seven o'clock at night. So I don't regret his not reading. But I watched him to see if boys were learning trades better than I did; my impression is that things are just the same.

In spite of this fact, that trades are learned now little better than they used to be long ago, his trade still continues the greatest possession of every workman, of every mechanic, his greatest asset, his capital; and any employer who knows anything about his business, any manager who knows about his business, knows that the first thing is to get the true initiative of his workman. I mean, that man's hardest work, his ingenuity, his determination to do the best he can for his employer, his well wishing towards his employer, his talking and doing everything he can to serve his employer's interests. How far they fall short of it! Those of us who were working men did just as little as we could, to make that man think we were doing a day's work. There are a few employers, one in thirty, or forty, or fifty perhaps, though I doubt if there are more than one in a hundred, who deliberately set out to pay their men more than the competitive rate around. That represents the highest type of employer; because in the long run, if he keeps it up long enough and just has gone ahead in full sight of the men and of the community, so they will know there is

no trick behind it, they will respond by giving him their best output. Under scientific management the best output of that man is increased. There are a few of those employers.

It is the employer who gets the best initiative of his men whom I want to contrast with scientific management. Even with that highest type of manufacturer, while there will be a growth of output under the old system, there is not the slightest hope of that man competing with scientific management, because under scientific management the initiative of every workman is obtained with absolute regularity, because the workmen invariably work hard and give their ingenuity and best thought; there is nothing spasmodic about it, it does not depend upon public opinion. This is not accomplished at once, because it takes from two to five years to introduce scientific management, and no man, whether a faker or anything else, can do anything for you in less, but while it is coming in, and after they have come under it, the stimulus of two kinds operates: one is the new and absolutely unheard-of unloading of a large part of the work, and the duties of this kind voluntarily assumed by the men on the management side; this produces a far greater effect in increasing the output and diminishing the cost of the article produced, with the initiative of the workmen.

These new burdens and duties assumed by the management fall into four large groups, called the principles of scientific management, and it is with these new duties or principles that I want to deal. I have got there at last; it has taken me a long time! (Laughter.)

The first of these new duties, is the gathering in of that great mass of traditional knowledge which in the past has been in the heads of the working men, as a knack or habit, regarding it, tabulating it, and in almost all cases reducing it to laws, rules, in many cases to mathematical formulae, in place of rule-of-thumb; this science and exact knowledge diffused through the mass of workmen produces an enormous increase in the daily output of the workmen.

The second of the principles of scientific management is, the scientific study and selection of each workman in the place, with a view to the progressive development of that workman. I say both the study and the development of the workman are progressive. It becomes the duty of each manufacturer to study every workman just as thoroughly as in the past it was his duty to study each one of his machines. Every one of us in the past has had that duty for years to study machines, but this new principle demands the careful, detailed study of every

workman in the place, to find in the first place all about the man's capacity, his weak places and his strong points, what the man can be developed into, and then the deliberately setting out to train each man so that ultimately he will be doing higher and more profitable work.

The third principle is, bringing the scientifically trained and selected workmen and science together. I say "bringing"—that has a stiff, hard sound to your trade union man, but there is so very little of it that he has done; the management has done a little of it. But I say deliberately, making the workman work in the cause of the science. That can be done, when they realize that nine-tenths of the trouble in bringing over from the old management to the new lies in making the management do its share of the new duties; there is little trouble with the workmen, but there is never-ending trouble to make the men on the management side change his ways. It has a very curious effect sometimes, when you try to introduce the new management. You go to the man, and suggest something. "Oh, no, I don't want this," he will say, "nor that, I want that other department looked into, it is very poorly managed by that man, you had better change his ways." Artemus Ward expressed the feeling of the average man on the management side very accurately when he said he was "ready to sacrifice his wife's relations to any extent on the altar of freedom!" (Laughter.)

The fourth of the principles of scientific management is perhaps the blindest, the least obvious of all these principles, and unless one has almost worked in the establishment, he can hardly realize its importance. The fourth of the principles lies in the fact, that under this new scheme, the work which was originally done all by the workman is divided into two great groups, and one of these is turned over, deliberately turned over, to the men on the management side. A great slice of it is handed over,—so great is this slice of the work that I am sure you will feel astonished and maybe horrified when I tell you that in a well run establishment doing miscellaneous work there will be one man on the management side to every three workmen!

Now, gentlemen, again let me remind you, that this is no theory. I know what you are saying to yourselves: "no establishment can live with all this overhead expense; it is a waste of labor, non-productive." But let me remind you, that these establishments that started and have gone under it are all more prosperous than their competitors; there is no exception; those companies in which they have one man on the

management side to every three workmen are making vastly more money than under the old system. Don't get theory mixed up with your facts!

Under this great division of labor, it is due to that principle more than to any other that there has never been a strike under scientific management; because you have there team work, and of the highest order. This is literally true: in the establishment I spoke of, a machine shop, hardly an act on the part of a workman is not preceded by an act on the part of some one of the management; that involves not only co-operation but co-operative team work of a very high order. Instead of one man doing a job on a lathe or a planer, perhaps eighteen men are doing a little bit each for that one job. When men came to realize that it means earning 33 to 100 per cent. more than without that team work they can possibly earn, that makes for friendship. The old idea of master and man has entirely disappeared. It is literally true, that the work becomes so much of a democracy, that the complaints on the part of the workmen that some man on the management side has failed to do his part are vastly more numerous than those on the part of the management against the men for not doing their part. That is democracy! It is pretty hard for a manager to have a man come in and "cuss him out," and the workman doesn't hesitate to do it for one minute! Now you may talk or laugh about it if you like, but it is a great revolution. You can't have a fight among men on the same team. When both sides realize that neither one can work without the other, they won't fight. You will have lots of scraps when it is coming in, but when they are once co-operating and see the benefits of it, then you have no further squabbles. I don't mean to say that workman will stop grouching,—for gracious sakes no! it would be a very unhappy state if he could not; or that the manager will never cuss any more; but grouching and cussing do not indicate that you are not the very best of friends; you can complain to each other all you want, and sass each other, and be pretty good friends.

Now, I believe I have finished with the theory of scientific management. And I want to try to convince you of the value of scientific management, that it is not in mere theory, but I will give you some samples, some concrete illustrations of how it works, and will tell you several stories of how these four principles are applied.

Let me go over the four principles again: the first is the development of science to replace the old rule-of-thumb that was in the heads of the workmen; the second, the scientific

study and selection and the progressive development of the workmen; the third, the bringing these together; and the fourth, the equal division of work between workmen and management.

I am quite sure you will find in the stories I am going to tell you much to criticize and perhaps to complain of, but I hope you will not forget to look for these four principles, because it is the application of these principles I want to illustrate. While something else may strike you as interesting, please look for the application of the principles, because that is what produces the results.

I ordinarily begin by showing the application of these principles to pig iron handling, because that is a most elementary form of human effort: a man steps up, takes a piece of iron, without any other implement than his hands, walks a few steps, and drops it on a pile. I can see you smile when I say there is science in handling pig iron, a science so great that no workmen can understand it! The story is too long; there are others shorter and quite as effective, because what I want to do is to begin with the most elementary form of human effort, and gradually go up the scale to the more difficult, showing the application of these principles to the most elaborate trade that is known; it is only by a series of object lessons of this sort that I can convince you of the value of scientific management, and that the older management cannot compete with it.

The first illustration will be that of shoveling. I dare say you men will smile when I say there is a big science in shoveling, not a small science but a big one. I say it without hesitation; for if any of you men were to place before yourself a stunt of digging, you would be developing the science of it; you would be on the track of studying a great many elements in the science, for it is certainly of the most important. I want to show you what this most important element is, and let you see how far-reaching in its consequences it is when it becomes the duty of the management to tell the workman how to do his work, how far-reaching even in very elementary work. When I first went to the Bethlehem Steel Company I saw those big, powerful shovelers, so devoted to the profession that they would not let the company furnish the shovels, they wanted something just suited to their work. I saw them go to the car of coal—the company was using rice coal—and unload that car with a load of 3½ to 3¾ pounds of coal per shovel load. These same men then went to work to handle Mesaba ore, and did it with 38 and a fraction pounds to the

shovel! It does not take very profound reasoning to conclude that either the 3½ pound load or the 38 pound load was wrong. A man could not do his largest possible work with both loads; that is perfectly evident, it does not require any argument. Now I want to show you the different mental attitude. Under the old form of management you would send for the manager, and ask him what was the proper load for a shovel; and if he knew his trade, he would be startled, maybe, but he would give you some answer. Under scientific management you never ask a man anything, you have to know facts from your own investigation; there is no authority, you have to know the facts from scientific inquiry of your own. It becomes the duty, under scientific management, to investigate. What we did was to send for two big, powerful shovelers, well suited for their work, good hard-working fellows, call them into the office, and say, "Now, Pat and Mike, we are going to ask you to do a whole lot of fool things, and a young chap with a board and pencil is going to make notes of what you do. We would like you to do this, but we want you to understand that this is no joke; we propose paying you fellows double wages all the time this thing is going on, but in return we want to warn you, if you throw any of your monkey business of any kind you will go over the fence, and that right off; there is to be no nonsense about it. Do just what these fellows tell you, or let it alone; they will be onto you, and they have orders to throw you over the fence; take it or leave it as you please." They take it, and I find they are just as square as any other fellows too.

And let me tell you, labor leaders to the contrary notwithstanding, it is no part of scientific management to overwork any man, or to underwork any man. Of course there are mistakes made; occasionally we demand too severe tasks from men; but all they ever have to do is to point it out; if they do too little it is up to us to find that out! The characteristic of all our establishments is a tendency to underworking. They don't loaf, but they don't hurry; we don't allow them to hurry, it makes too much nervous strain. All the work is done evenly, but every false movement is cut out, every slow movement is cut out; this is how we get our game.

We first started that experiment with a very heavy lift, perhaps 38 pounds, we will say it was so much. Then we cut that shovel off. We counted the number of shovel loads per day the men handled, and weighed the whole tonnage shoveled in a day, so we found out the average weight of each shovelful. We found that in three or four days they would

average a little over 38 pounds to the shovel, and we will say they shoveled a pile that high. Then we cut off the shovel, so that it would hold 34 pounds; immediately the tonnage went up. Again we cut an inch or so off the shovel, so it now held 30 pounds, and so on, to 26 pounds, and at 21½ pounds the tonnage shoveled reached its maximum. At 18 pounds it fell down, at 14 it fell away down, at 12 and at 10 it fell lower than at 28! So we found that a shoveler well suited to his work will do his biggest day's work with a load of 21 pounds or thereabouts to the shovel. Don't take this too literally: I don't mean that any shovelers will take 21 pounds, but that is the average. All this work is not an exact science, it is not mathematics, but it is the best approximation you can get to it.

Those men had all owned their own shovels, but when we started this experiment we furnished the shovels, so we had to build a large tool room at the Bethlehem Steel Company's works, and equip them with different implements for the sand, the ashes, the ore, the spiegel, all the various materials used in the steel works. They had to have an implement to hold about 21½ pounds. In order to know what each gang of four or six men could do, they had to measure each man's work, so as to get to an individual basis. We made it a rule that no man should work in that gang who could not earn 60 per cent. higher wages than any others, so it became necessary to measure and compute a great deal. That meant a large labor office, with clerks, and men who play chess with those four or six young men on a large map of the works, for they were spread over land two miles long, and one and a half wide. We had to devise methods of measuring up all the work. I am trying to show you how far-reaching the effects of this one element of scientific shoveling were. Each man on coming in in the morning took one of two pieces of pasteboard; if it was white, he was all right; but if it was yellow that meant that he had fallen below 60 per cent. ahead of other men, and he could not stay in that gang long unless he improved. When a man would get four or five or six yellow slips in succession, a man would go from the office, a teacher, to talk to him about it. Under the old way, a man like that would be sent for, and told, "You are no good: get out of this." I have heard that said by labor foremen many a time. But this is what takes place under scientific management: a teacher goes down, and says, "Here, Mike, something has gone wrong with you: you have had four or five of these yellow slips. Are you sick? What has happened to you? If you are, we will try to give you an easier job. That's what I have come down to talk to you about. You look like a mighty good workman, and a fine shoveler. I have showed you how to do the work. If you don't know how to shovel, we will show you. Have you forgotten?" There is a good deal of science in shoveling: if you are going to push your shovel into the heap of sand or ore with your arms you are not doing it the best way and you will soon get tired. You should put your shovel handle against your right hip, and throw your body forward, then draw back and throw the shovelful. Particularly in the steel works the material is a good deal tangled up, and that one thing counts for a good deal; a man shoving his shovel in with his arm gets tired far more quickly, and does not do so much work. I want to make it clear to you that there is a new mental attitude: if a workman goes wrong, that is our fault on the management side, not his; we have failed to teach him how to work right. Of course there are loafers, many of them, but you can redeem about four out of five if you keep at them long enough. There are some incorrigibles, and there is no place for them under scientific management.

A question that is vital is, does this thing pay? I have outlined the average amount of work it entails. At the Bethlehem works they have a tool room; they have two or three college men who for three years have devoted their whole time to studying the movements of the workmen; they had to pay the salaries of these men; they had to have clerks in the tool room; they had to have a telephone system, and a messenger system, and teachers. There was a whole lot of night work that had to be done, to be able to tell those fellows the work for the next day. But scientific management has absolutely nothing to do with philanthropy: if it does not pay a great deal better than the old system there is nothing to it, and no system which hinges on philanthropy is worth anything.

Does it pay? In the past three years, at the Bethlehem Steel Works, when they all came under it, all the work had been studied, and all the mechanism was ready to be put in operation, we were ready to test it. We fortunately had records at the Bethlehem Steel Works of the cost of materials under the old system of management, and we had several million tons of ore that would be handled in a year; under the old system it cost at least between 7 and 8 cents a ton. Those of you who are accustomed to the business know that the cost of handling such materials on the average railroad is from 8 to 10 cents a ton. But we found that after adding

the cost of all these things I have mentioned, the new cost of handling a ton of material was between 3 and 4 cents! So that during the last six months there was a saving by the Bethlehem Steel Co. of between $75,000 and $80,000 a year. That is what the Steel Works got out of scientific management! What did the men get out of it? We made very careful investigations. The number of workmen doing a certain work was reduced from four to six hundred to a hundred and forty men. They are receiving some 60 per cent. higher wages than before. We found only two men among them to be drinking men. They were saving money most of them where before they spent almost all; they were living well, and were vastly more contented than before. And always we have lots of men wanting to get onto that gang. There is never a time but there are forty or fifty men wanting to get on that gang, to see if they are higher-priced men or not. That justifies the method of scientific management, those two facts, and nothing other than that will justify it. Any scheme which makes more money for the manufacturer and doesn't make any more money for the workingman is a rotten scheme! And any scheme which makes more money for the workman and not for the manufacturer is also a rotten scheme. It has to be mutual, a fair division between the two, to be worth anything.

Now to jump to a type of work at the top or the upper end, the work of the higher-class mechanic, that of a first-class machinist, a finely educated machinist. What I want to show you gentlemen is that it is an almost universal fact, so nearly so that the exceptions are very few, that the science of doing any class of work is so great, that the man that is fit to work at his trade cannot possibly understand the science of that trade. As you go up in the scale and the work becomes more important and intricate, that fact becomes all the more true: he cannot possibly understand that work; it needs another man to teach him. That explains in a broad, general way why you have to have so many teachers, so many men on the management side.

Take the case of a repeat shop, a machine shop where the work is mostly of the repeat kind. Especially I have in mind one shop where my friend Karl Barth systematized the work. It is a noted shop; its product is sold right here in your town, a great deal of it; it is one of the most noted in the United States. The head of it built up his own works from twenty-five men to something like four hundred men. He sent for my friend to introduce this system into one department, making a certain article. These things are standard, thousands of them are made every year, and between three and five hundred men were engaged in that department. So the work was very greatly subdivided: one man would make only four or five different kinds of parts in the year. My friend, the owner of the establishment—I knew him, had worked for him,—was stubborn, but a fine character. You have to look out: if you would teach your system, you have to have an understanding, to have a little discrimination. At the start if you come out and say what you expect to do in the way of increasing output it may startle a man. My friend called Mr. Barth into his office and said he wanted him to see if he could do anything in that department. He said right away he thought he could increase its output to twice as much. You can imagine the row there was! That lasted a few minutes. However, the owner went out with him to the department in question, and showing it to him asked him if he thought he could do anything to make it more productive. He replied, certainly he could increase it two and a half times, may be three times! The establishment had been going on several years. It had patented machines, high class tradesmen and engineers. Of course there was another explosion. But it didn't go very far. Mr. Barth asked the owner, "Wouldn't you like me to show you what I can do with any one of your men?" "Certainly," he said. So he picked out a very fair machine, a representative machine, with a man who had been running that machine there for twelve years, a high-class mechanic, who had done very good, skilful work, with the help of his foreman. It was a fair test. I want to show you the methods, what is done in a case of that sort.

Here I have four different implements to study machines. This one takes care of all gear problems, the velocity of lathes, weak links, the range of teeth, and the safe limit. These instruments were not used before; they have been developed from scientific management. This one has to do with belt problems; anyone who has figured on belt problems knows that it is quite a little trick, not something you can tell off the bat; this instrument will solve in a few seconds a problem that would take a good many minutes, sometimes an hour, to do in the old way! This one tells just how fast you can run a tool, how many feet of chips you can remove in a minute with all kinds of tools. This tells how many pounds pressure will be exerted on the nose of your tool without cutting the metal. With these instruments you have analyzed the effect of your work and the capacity of your machine, and

you are then in a position to see just how fast that machine should be run to do its work right. Not one in fifty of the machines are speeded right. They are away off, in many cases two, three or four hundred per cent. off. I gave that challenge once to a number of machinists, and not one of them took it up. This is so because they have been speeded all by guess, not with regard to the science of cutting metals. Mr. Barth found the machine selected for his test something like 300 per cent. wrong. That workman couldn't do his work right; he didn't know that, but it was not his fault that he didn't.

Now after writing the prescription for the proper speeding of that machine Mr. Barth went home and came back in about a week, by which time he had made a slide rule of this sort. Under scientific management an instrument of this sort has to be made for every machine, in order to tell your man how to do his work. This looks like frightful red tape and extravagance. But every shop that has come under scientific management has paid better than before, a great sight better. This is not theory, it is fact. Mr. Barth had never seen the work done; but he made a gain of two and a half to nine times in the work done. It took about three and a half to four years to make over that shop entirely. Is it possible with an implement like this for any man to make that immense gain, as against the years of experience of a high-class mechanic who had the help of his foreman and his superintendent? Because it sounds like a fairy tale. It is possible, for this reason: the science of cutting metals is a great science; that of shoveling is a small science.

In 1881, I had had three years' fight with the machinists of the Midvale Steel Works, (I went there as a laborer after having served my two apprenticeships, and finally came to be foreman of the shop). I had a most wretched fight for three years, in forcing the men of that shop to do halfway decent work. It was not a new game; they knew I knew they were restricting output to about one-third of a day's work; they thought they would be treated just the same as others and have their wages cut down. They came to me and said: "See here, you have got to be foreman; we think all right of you, but you are not going to be a piece-work hog, are you?" I told them I was going to get the output out of those machines. "We will have you over the fence inside of six weeks, then," said they. So that fight started, they did their best to get me over the fence, and I did my best to keep inside it, but after three years of perfectly wretched, abominable fighting, we had

increased the output to nearly double what it had been. It was not yet where it ought to be, but it was well along. I realized that those men were my superiors; they knew vastly more than I did about the work of that shop. So I went to Mr. William Sellers, one of the most noted steel workers, and asked him to experiment, to get the knowledge of the workmen on our side. I kept on insisting on reasonable work, and as a reward for having driven those fellows into this work he let me make a long series of experiments, on many lines. Every mechanic had an idea that if he could find the proper cutting angle for tools he could do a great deal faster work. You all know the three cutting angles: the clearance angle, the side slope, and the back slope. We had perhaps the only shop in Philadelphia fit for such an experiment, as we had a lot of scrap tires, locomotive tires, which we could use for it. By mere accident we had this material, and it takes a lot of material to reduce anything to a law in cutting metals. In six months, so far as cutting speed was concerned, we gained only about five per cent. That was only one element of the whole twelve great elements that go to make up the art of cutting metals. Every one thought it would be a greater gain, so in that respect the experiment was fruitless; but it unearthed a gold mine. All I had to do was to show Mr. Sellers the possibilities ahead, and he allowed us to go ahead with those experiments. The simplest of elements in cutting metals is to keep your tool cool. We found that if you throw a heavy stream of water right on the nose of the tool and the chip, the cooling effect was so great that you could increase the cutting speed by 40 per cent. There are two causes that prevent good work; the friction drawing the temper of the finished tool, and the heat making the chip clog the edge. It was necessary to see Mr. Sellers. The whole world had used a trickling stream for ages in cutting metals, but no one had used a heavy stream. So he gave us permission, and we tore down the machine shop, set every machine in a concrete water bath, and built a whole machine shop to go after that 40 per cent. And what happened? Only one company in twenty years followed us in that! Our competitors said, "Oh pshaw, you can't have a slop like that around!" and they did not gain that 40 per cent.!

To justify scientific management, in the Midvale Steel Works, which was bought for $75,000 in 1873, and not a new dollar has gone into it, it is now worth $17,000,000 or $18,000,000. And scientific management is doing just such things as that, thousands of them, just as staggering as that, they pile up like snowballs!

Those experiments went on continuously all the time I was there, from 1881 to 1890, without intermission; as long as we were able to show results we had men cutting chips, and others watching them, writing down results. The method of financing had to change. We had to take out enough work to offer any man or shop that would build us machines; we would furnish the people, the labor, the tools and the materials. This work went on through a period of twenty-six years, and during all that time, I want to emphasize this, it was carried on not because someone was interested in the science or art of cutting metals, but because it was making money for the people investigating this thing.

I want to give you a glimpse, a look, mark my words, at what is going to take place in every industry in this country: not only the study of physical facts, but the study of men is now going on at an immense rate. I suppose there are five thousand men making this microscopic study of men.

Throughout a great part of the time, whenever we found a fact, whenever we wanted to use that fact, we had to develop a method, a formula, to express that law. So we had to employ professors, mathematicians, who were employed for this one problem. They were paid because they earned money for the company. Whenever we ran against a great applied mathematician we went to him with our results and we placed the problem before him; we offered him his own money, if he would offer to solve the problem. "What!" he would exclaim, "solve a problem with twelve unknown quantities! one might solve a problem with four, or five, or even six unknowns, but with twelve you will have to solve it by the method of 'trial and error.'" Now no doubt you have come to the conclusion, "This is about the most conceited thing there is; he just wants to brag how great he and his friends are!" I want to try to convince you—the ordinary man, the average—that you can solve very difficult problems, anything that comes in your way, if you will only pay the price in time and hard work; it doesn't require any more brains or ability than the ordinary man possesses. Only one man has betrayed more ability, and has come near the thing, the problem was almost solved when he came to the company, but I don't want to belittle his work. After eighteen years of work, and after the ridicule of the men in our profession,—engineer after engineer heard of our work and came and appraised our work, then would come into the office and sit there and roar with laughter at the ridiculousness of the thing, and so it was ridiculous perhaps at that time, because the thing had not gone

far enough,—well, a problem that it takes a good man through "trial and error" from four to eight hours to solve in the old way, with this implement you can have it solved by an ordinary machinist in twenty seconds! (Laughter.) That brings the thing right down to a practical basis.

Just one thing more before I close. I have no doubt you men are saying, many of you, "What is going to become of our high-class workmen, if all this work is taken out of their hands and turned over to the men on the management side? Will it not dwarf our workmen, our thinking men?" I say without hesitation, that if the answer is that it is going to dwarf our workmen, if it is going to be bad for them but good for the companies, this whole scheme will fall to the ground, because anything that is not going to develop them and make them a higher class of workmen is not going to survive, and ought not to survive! No doubt the thought is going through your heads, "You are taking away his judgment; when he had the problems to solve he had to use his judgment." That is the rankest kind of guessing; you might about as well toss a penny. I believe I am as good a guesser as any man in the United States, when it comes to machine work: give me the materials and the tools and leave me to guess the result, and my guess will be as good as that of any other mechanic; I have had my judgment trained in the old-fashioned way; but my guess won't come within 300 per cent. I have spent forty or fifty years doing this, and I know how big a liar my guess would be. But let me try to convince you, that this is not going to dwarf our workmen, by calling to your attention the greatest mechanic in the world: how does he teach his apprentices? The greatest mechanic in the world is the modern surgeon: he combines the most manual dexterity with intellectual knowledge, good nerve, and knowledge of implements, I believe, in the world. "Now do you see," he says to his apprentices! "What we want is your initiative, your ingenuity; of course we older surgeons have our prejudices, and we have developed instruments, but don't let that interfere with your originality and your perfect development; we older surgeons use a saw to take off a bone, but if you prefer a hatchet or an ax, chop away!" (Laughter.) Is that what he says? Not on your life! He says, "You boys, don't perform the simplest operation there ever was till you have learned not only what implements to use,—you have to use the implements handed down through three or four generations of surgeons just as they are; you have to learn how to handle them; not a stroke till you learn how to handle them! We want your ingenuity,

but start where we leave off! Learn the best there is, and when you have learned our way, if you see some defect in it, and think there is a better way, then invent, but upward, not downward; start where we leave off, and work upward!"

Scientific management says to the man in a trade: "We don't know it all: the implements we have and the methods we use will be superseded; but we do know a good deal; we have been many years selecting these methods; we want you to start here, practise our methods; we won't hear a word from you till you have done things in our method; then if you have a suggestion, come and give it to us." Most of our suggestions come to us from our workmen; and when one is given, we conduct a carefully tried series of experiments to see whether it is quicker and better; if it is, then we adopt it, not only for that man, but for every man in the establishment. (Applause.)