would play so vital a part in a future Taylor System and be the storm center of a raging controversy!

The next step was to make due preparation for such time studies. They must, Taylor saw, be done under standard conditions.

It was evident that a workman's speed must depend largely on his surroundings and equipment, and that time studies would be valueless unless the workman studied was first assured of a continuous and convenient supply of the material worked upon, with standard tools and machines, sufficient light, freedom from interruption and innumerable other preparations to secure the best conditions under which his work was to take place.

Clearly, preparation must precede time study; many of the half-informed "efficiency engineers" who have too often counterfeited Taylor's thorough work have made some of their worst blunders by attempting time studies prematurely.

So Taylor virtually turned his shop, or parts of it, into an industrial laboratory to set up the standard conditions for measuring a day's work. This measurement was accomplished by dint of thousands of careful experiments.

Transfer of Functions

In order to secure such laboratory conditions for his experiments, he found it necessary himself to arrange many details formerly left to the workingman. This transfer of function from worker to management proved to be one of the most essential elements in scientific management.

Instead of the workmen owning the tools they used, in all sorts, sizes, and degrees of repair, the management ultimately established a tool room with tools duly assorted after scientific tests to discover the best tools for each job. These tools were supplied as needed and were sharpened, repaired and replaced through the management.

For instance, Taylor's experiments disclosed the surprising fact that few shovellers know how to shovel, or even know what muscles to use or what size of shovel. His tests showed that a shovel holding 21½ pounds is ideal. This led to supplying different sized shovels for different materials to be shoveled instead of one shovel for all. Taylor was not content to accept the shovels then standard in trade. After his young assistant, Gantt, once reported that for a certain job no shovel big enough was on the market, Taylor said:

"You would be damn fool enough, would you, to fix a task that would last perhaps for twenty years at 14½ pounds, when you know 21½ pounds can be done, rather than pay $1,000 for fifty shovels to be made?" [Volume II, page 72.]

Task and Bonus

After a day's work in, say, shovelling had been duly determined under certain conditions, the next step was to so remunerate the workman as to induce him to live up to the higher standards thus ascertained. This led to various sliding scale ideas, especially to the "Task and Bonus" (a suggestion of Gantt's). This is a system of payment by which every workmen doing his allotted task within the normal time should be paid a "bonus" of from 30 per cent to 100 per cent above current wage.

All previous [plans for management] advocated the payment of ordinary wages to give workmen an incentive for doing more or better work, but Taylor paid such wages to induce workmen to accept the standards determined by the scientific method. [Volume I, page 409.]

Under the former plans the stimulus failed to work because of soldiering, and the employer was often none the wiser. Under the latter system, such deceit was impossible.

It now should be recognized that here, coming into being, was an entirely new thing in management, the "central idea" of which, as Taylor came to describe it, was this:

"a. To give each workman each day in advance a definite task, with detailed written instructions, and an exact time allowance for each element of the work.

"b. To pay extraordinarily high wages to those who perform their tasks in the allotted time, and ordinary wages to those who take more than their time allowance." [Volume I, pages 261-262.]

"We have found for economy that the record which is made up early on the morning of the day following the work, which shows how many men in each department failed to earn their bonus, is the most helpful record in promoting economy. It becomes possible, then, the day after bad work has been done by anybody, to chase it right home, either to the foreman, the teachers, the tool department, planning department, or to the workman himself, and prove right then and there to the men or the department just what they have done that is wrong." [Volume I, page 368.]

"Two-thirds of the moral effect, either of a reward or penalty, is lost by even a short postponement." [Volume I, page 318.]

One by-product of Taylor's measurement of work was to enable him definitely to buy and pay for *work* as such, not the workers' time.

Undoubtedly his suggestion that those clerks be permitted to go home when they had finished the daily tasks he proposed for them was found nothing less than sensational. [Volume I, page 451.]

Planning

Constant planning was necessary to control and maintain the standard laboratory conditions year in and year out.

This daily planning led to a planning room to schedule the work of each employee and machine.

Really it all comes down to the homely old adage: first plan your work, then work your plan. [Volume I, page 286.]

To "prepare" fully a shop in the first place, i.e., to place the machinery in the most effective way, to set up a tool room and planning room and to create other conditions such as would enable workmen to work at their best, often required a year or two for its accomplishment.

Taylor's Exception Principle

A well-planned shop will separate the routine from the exceptional. Many an employer is swamped by details because he does not make this separation. Through scientific management, 95 per cent of the mass of letters, reports, etc. (routine matters), never pass over the desk of the employer, so that his time may be devoted to the exceptional 5 per cent.

This daily planning of the work for each individual workman and the daily measurement of their accomplishments led at once to a sifting and selection, better fitting the various men to the various jobs.

So that, under the plan which individualizes each workman, instead of brutally discharging the man or lowering his wages for failing to make good at once, he is given the time and the help required to make him proficient at his present job, or he is shifted to another class of work for which he is either mentally or physically better suited. [Principles of Scientific Management, page 70.]

For each type of workman, some job can be found at which he is first class. [Volume I, page 180.]

Functional Foremen

The vast increase in the functions of management required sub-dividing and more functions.

What Taylor did as he found that he could not thoroughly discharge all of his foreman's duties was the most natural thing in the world: he employed assistants. And it was as he pursued this course that he developed a new type of organization . . . what is now termed the functional type of organization to distinguish it from the military type.

It is permissible to call it new only in the sense that a difference in degree can amount to a difference in kind. [Volume I, pages 284-285.]

All along he had been moving unconsciously—that is, wholly in natural response to the conditions he met with—in the direction of functional foremanship and its full development, the planning department, and at Bethlehem he became fully conscious of this thing as a definite principle. [Volume II, page 19.]

The difference between a country road and Broadway, between a dug-out and the Woolworth Tower is simply one of degree.

Barth's Slide Rule

Taylor soon discovered that even the simplest problem involved numerous independent variables, and was therefore never really simple. In algebra even equations of one variable may tax the resources of the best mathematician. When two variables are involved, the complications are likely to be enormously multiplied.

But Taylor's problems almost always involved over half a dozen variables. It was Carl Barth to whom Taylor finally turned for mathematical help of a practical kind.

One day while he was still helping to run the experimental lathe, Barth happened to see the plot on Gantt's desk, and was told by him that he had tried in vain for about six weeks to construct a mathematical formula to represent its curves. Unhesitatingly and abruptly, Barth declared: "I'll eat my hat if I can't work up an acceptable formula this evening and bring it in in the morning." [Volume II, page 32.]

Copley tells us that Barth did not have to eat his hat. The outcome was Barth's wonderful, famous slide rule.

Magic instrument, that slide rule. By it the most complicated mathematical problems are solved in a minute. An abolisher of guess work, opinions, arguments, debates. A determiner of the law! [Volume II, page 35.]

Writing to General William Crozier in 1909, Taylor, referring to Carl Barth, said: "He is one of the most brilliant minds I have ever met." [Volume II, page 26.]

The most startling discovery of Taylor's was the tremendous difference between the rule-of-thumb solutions of those "simple" problems of industry, solutions often accepted without question for generations, and the true scientific solution with the aid of experiment and of Barth's slide rule.

In one case there was a lively controversy, the slide rule indicating one course of action and "common sense" of the old rule-of-thumb operators a very different course. Both were tried, the result being that all agreed that "the slide rule knew what it was talking about."

We thus see that while Taylor set out merely to stop soldiering, he ended by creating a general system aiming to get the best not only out of workmen, but out of all elements involved in the problem.