

allowed was far less than time previously taken.

On the first five wheels everything went well, but then two of them in succession proved so hard that nothing could be done with the cuts and speeds set; the speed boss wanted us to agree to cut the speed down for the rest of the wheels to meet the hardness of these two. However, when appealed to, I objected, and insisted that every one of them be tried as we had started out, and as we had successfully proceeded with the first five—and, as it subsequently proved, we could do with all the rest. Had the shop had its own way, all these wheels would have been turned at speeds suitable only for the hardness guessed at by the shop, which, as everyone knows who has had much experience in these matters, would be bordering on the hardness of previous adverse cases.

A concern that for over two years had used high-speed steel in the shops without getting any material benefit from it wrote to me to come to their shop to show them what high-speed steel would do when fully understood and properly handled. This I agreed to do, stating that the best way of doing it would be by means of a slide rule for one of their best lathes, for which I then requested that they make me a diagram showing all its speed and feed mechanism, and countershaft with pulleys and line-shaft speed. On receipt of this, I found the lathe entirely underspeeded, and made suggestions whereby to increase its speed two and one-half times, telling them also to have ready for me various samples of their customary materials, from the softest to the hardest, in steel, cast iron and brass.

The performance that followed was witnessed by some twenty foremen, who then and there were made to realize that their rule-of-thumb methods counted for nothing as against the science of my "guessing sticks"; for they were made to understand that I had never seen the lathe itself before then, and had become acquainted with its properties only by a study of the diagram sent me. The result was that I was immediately retained by the company.

Later on, in one of the shops of this same company, I had one of my most interesting experiences with a slide rule. After a number of machines had been respeeded and slide rules made for them, but before they were taken into use or the calculations for them even gone over by myself, I happened to

see a performance on a lathe that for efficiency was about as bad a case as I had ever observed. Though the time for my interference in a case of this kind was not as yet at hand, it was too much for me, and I somewhat undiplomatically addressed the operator (who was considered, by his foreman, the best mechanic under him) as follows:

"That tool seems to me to be doing very little work; so don't you think it would be well to 'speed her up' some?"

"Oh, that tool is running all right," he answered. "What criterion have you," said I, "for concluding that a tool is doing what it should?"

"Oh, that tool is running all right," he replied. "You see, it is pretty hard steel."

"I have a very simple, but reliable, criterion," I then told him, "by which I judge whether a high-speed tool is doing what it should or not, in turning steel of any degree of hardness. Your tool is not doing anything like what it can, if it has been properly treated and has not been burned on the grindstone; and if it has, it has no business to be in the shop, but should at once be returned to the tool room."

His huffy rejoinder was: "Well, I understand that you have made the boast that you can show an experienced machinist how to run a machine better than he can, even if he has been at the same machine for ten years, so let me see you do it."

This challenge was rather unexpected and uncomfortable, for, while I had attempted to explain the workings of the slide rules to some of the foremen, and had impressed upon them the fact that the determination of the most economical feed and speed to use in rough-turning a given piece of material is an exceedingly complex mathematical problem, the correct solution of which no man can determine by a guess, except by an occasional providential grant of good luck, still I had done my best not to convey the very thought implied by this man, to whom my little talk to the foremen had evidently gotten around in this perverted fashion, or near enough so, for him to feel justified, when a little annoyed, to "throw it back" at me in this form.

However, realizing at once that it would not do to argue the case, and to try to tell him that I had never said anything of the kind, I unhesitatingly took up his challenge, and said, "Well, I can and I will." Immediately I procured the slide

rule for his machine, though not without a good deal of misgiving; for if the tool happened not to be up to standard (which was not so unlikely to be the case, as we so far had only a reasonable assurance that the tools given the men in the shop were all right), and if there had been any mistake made in working up the data for the slide rule for this machine (which, as stated above, had not been verified by me), then I might have made a miserable failure, without any fault of mine or of the slide-rule method of running machines, but yet without much chance of ever setting myself straight with this man, or probably with the whole shop.

However, both the tool and the slide rule proved loyal to me on this occasion as will be realized from what happened next.

After ascertaining the diameter and the depth of the cut of the work, and guessing at the hardness class of this alleged "hard" steel as bordering on that of a very soft grade of machine steel (which I correctly judged it to be by the pulling and tearing action of the tool upon it at the slow speed run by the operator), I set the "guessing sticks" to their proper respective positions, and reading off the feed and speed shown, I turned to the operator and said:

"You have the belt on the middle cone step, with the triple gear in. Leave the belt alone, but throw the triple gear out and put the back gear in; that will increase the speed six to one. Next, you have the feed belt on the slowest feed cone; put it on the fastest. You have the feed push pin in; pull it out, and your feed will become just eight times coarser." He unhesitatingly did what I told him, and I continued:

"Now set the tool to take the same depth of cut and go ahead."

Thereupon he turned to me in the most astonished manner and said:

"But you don't mean that?"

"Indeed I do," I replied, "there is nothing extraordinary about it if only the tool is what it is supposed to be, and I have to take my chance on that."

Giving me a pitying sort of a look, he started the cut off, evidently expecting something terrible was going to happen either to the tool or the machine, and feeling convinced that among all the fools and bluffers he had ever seen "come down the pike,"

I was the biggest.

However, nothing happened except what always happens when an engineer fully understands his work and has no slip up. The result was what it should be, namely, that the tool ran the full length to be cut under a beautiful blue chip, of a kind which, to be sure, our first-class machinist had never seen before, though by this time high-speed tools had been in use in that shop for over two years, and most of the machinery had for some time been respeeded to make full use of them. All of which counted but for little, as the ordinary shop does not possess the initiative, unaided, to take up with radically new ideas.

As I not only took great pains not to "rub it in" on this man, but also spent considerable time in explaining to him the slide rules to the extent that he was capable of following me, in addition to giving him an idea of their history and development, including my own connection with them, we at once became good friends, and there was never any further trouble in that shop with skepticism regarding the value of the slide rules.

I look upon this case as one of my best samples of the triumph of science over the rule-of-thumb methods of the unscientific worker, who just because he is unscientific further reduces his efficiency by never doing his best; for in this case there was not the slightest doubt that the man knew that he could do a great deal better than he did, even though he did not suspect that he was doing only one forty-eighth of what his tool and machine were capable of.

The three cases cited above happened during the early history of the adoption of high-speed steel, but the following took place less than three years ago. I was called into one of the large navy yards to make an investigation of its machine shops and to report verbally to the commandant as to what improvements I thought it advisable to recommend, and particularly to see if the high-speed tools were being used to advantage.

As usual, I found all belt-driven machines far underspeeded, and as for the motor-driven ones, the few I looked into were the most sickening examples of lack of the knowledge needed to speed machine tools successfully in any manner, that I have ever come across.

As usual, in order to show what tools can do, I picked out a fair lathe and made a slide rule for