destroys many great cities of the United States. But the Chicago drainage and the Niagara dam together mean the absolute ruin of Montreal as an ocean port. It will be no more an ocean port than Lachine or Valleyfield, and Buffalo will maintain its position as the chief centre of the grain carrying trade.

MATHEMATICS IN THE MECHANICAL TRADES.*

BY J. S. PLASKETT, B.A.

The subject of this paper may be considered from two standpoints. The first, and to undergraduates the most familiar point of view, is from the standpoint of the student entering or intending to enter any of the mechanical trades. A graduate of a School of Science, about to put his knowledge to the test of practical application, being a good example of this class. The second is from the standpoint of the mechanic, who, ambitious to improve his standing, determines to apply himself to those studies most likely to be of benefit to him. At the outset, however, let me disclaim any intention of touching upon the subject of technical education. I will confine myself principally to discussing the subject from the second standpoint, giving examples of the application of mathematics to the mechanical trades. Examples will also be given in which mathematical methods are justifiably superseded by mechanical ones.

The question that naturally arises in the first place is what constitutes a mechanic, or what are the mechanical trades. According to the generally accepted definition, a mechanic is "one who works with machines or implements; one skilled in shaping or uniting materials, as wood, metal, etc., into any kind of structure, or machine, or other object requiring the use of tools or instruments." The mechanical trades then would embrace those occupations at which mechanics are engaged. The ordinary use of the term seems, however, to confine the mechanical trades to those in which metal is worked, and these are what will be considered almost entirely in this paper.

The mathematical knowledge of the average apprentice or journeyman in these trades is comprised in a short and inadequate Public School training in arithmetic. They have not even touched any other branches of mathematics, while their knowledge of arithmetic is very limited and quite insufficient to meet many of the demands that will be made upon it. Many of the operations which mechanics have to perform are done without being fully comprehended, while many others cannot be done unaided, simply from failing to understand, what would seem to even the tyro in mathematics a very simple problem.

In consequence the mechanical trades are burdened with innumerable rules and formulae, bearing on the difficulties most likely to arise, and in the hope of overcoming the lack of mathematical knowledge on the part of the operators. A very familiar instance, at least to machinists, of such rules is that relating to the cutting of screws on engine lathes. Screw cutting on a lathe depends, as no doubt most of you know, on the motion of the tool carriage at a rate definitely proportional to the revolutions of the spindle and work to be screwed. As the carriage is moved by the revolution of a screw, called the lead screw, of a pitch which is usually 4, 6, or 8 threads to the inch, the problem resolves itself, in simple gearing, into finding two gear wheels among the set which accompanies the lathe, the numbers of whose teeth are in the ratio of the pitch required to the pitch of the lead screw. Thus, if a screw of 14 threads to the inch is required, and the lead screw is 6 threads to the inch, the gears must be in the ratio of 14 to 6. The gear on the spindle generally remains constant, say it has 36 teeth. Then on the lead screw will be required a gear of 14-6 x 36, or 84 teeth. The intermediate gear that connects the spindle and screw gears has no effect on the rate of motion, but simply serves to communicate the motion. This does not form a very intricate piece of calculation, and yet nine times out of ten you will see the machinist consulting his screw cutting tables, which, by the way, are always attached to the lathe, whenever a thread is to be cut.

If the gearing is compounded, that is if an extra pair of gears fastened to the same axle is introduced between the spindle and the screw gear, instead of the intermediate gear, the calculations are not quite so simple, although performed on the same principle, and

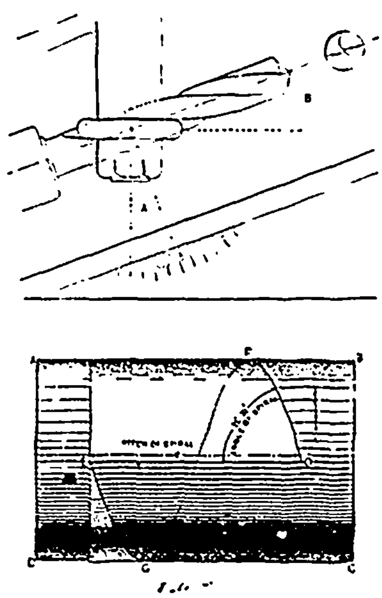

Fig 1.

are more intricate still when spirals are required to be cut on the milling machine, a familiar example of such a spiral being the groove in a twist drill. This groove is produced by a rotating cutter somewhat similar in principle to a small circular saw, only having teeth properly shaped to produce the groove. It is evident from the upper half of Fig. 1, that the work must rotate and move longitudinally at the same time, and that these movements must bear some definite ratio to one another. When we consider the fact that the longitudinal motion is given by the rotation of a screw, that the rotary motion of the work is produced by the rotation of a worm gearing into a worm wheel to whose axis the work is fastened, and that these two rotary motions are combined (Fig. 2), by connecting the worm shaft and the screw by gears, some idea of the trickiness, I can hardly call it difficulty, of the problem dawns upon us. In addition to this, the work and the cutter must be set at an angle to one another (Fig. 1), this angle depending on the diameter of the work and the pitch of the spiral; a spiral, technically speaking, being nothing

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