PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.

By Richards, Philadelphia.

Introduction.

In adding another to the many treatises relating to mechanics, and especially to that branch called mechanical engineering, it will be proper to explain that the purpose is to supply a want that none of the many text-books thus far seem to have supplied—that of assisting the engineering apprentice in forming a true estimate of that which he has chosen as a profession, and pointing out the means of study that will lead to his understanding the principles, as well as the routine, of a shop course.

Aside from the fact that no books have been prepared with an especial view of assisting apprentices, and adapted to the first stages of what we may call a mechanical education, there is the further fact that such books as are available treat of mechanical principles as consisting in mathematical formulæ and theoretical propositions only, overlooking the fact that such data are merely the symbols of mechanical principles, and not the principles themselves, and that a true understanding of mechanics is the result of a system of logical reasoning, which is only to be aided, and not supplanted, by rules, tables and formulæ.

A person may be a master of computations, or conversant with physics, and know little or nothing of practical mechanics, or may be a competent mechanic with but little knowledge of mathematical propositions, such as can be presented in books, and the great work of the apprentice is to connect and assimilate theoretical with applied mechanics.

It may be claimed that text-books can go no further in treating of applied mechanics than general principles will reach—a very true proposition if the writer of mechanical books has no power of dealing with the subject further than it is reached by theoretical deductions; but this furnishes no proof that the great share of a technical education, which consists in what may be called special knowledge, cannot be generalized and systematised the same as that part which is now explained on general principles.

Between physics, geometry, and mathematics, and their practical application to industrial processes, or, to state it more plainly, between theoretical principles, and the finished product of an engineering establishment, there is a wide space, filled in with intricate processes, with which text-books deal but sparingly, and sometimes not at all. This space has to be bridged over by the apprentice as best he can, and it is that part which calls for his greatest efforts.

He may, for instance, study the geometry of tooth gearing; the construction of trains of wheels and the principles that govern their action; he may learn the principles of cycloidal and epicycloidal curves, but between all this and a finished wheel are the processes of pattern making, founding, and fitting, either of which require as much or more thought and study than the geometry of gearing, which subject furnishes page after page in our text-books, yet the latter are almost silent on the shop processes named.

The same rule applies in most classes of machinery; in machine tools, for instance, the apprentice has only to open a modern work on the subject, and he will find tables, formulæ, and drawings to show the construction of machine tools, but seldom anything said upon the principles of their operation.

The apprentice, as soon as he enters the workshop, is at once brought in contact with machine tools of all kinds, and but little is gained in spending time in studying drawings and descriptions of them when the tools themselves are before his eyes, but connected with the operation of these tools are many intricate conditions that cannot be understood nor even conjectured by merely examining the machines, and much less from drawings of them. The conditions of operation, or principles of operation, are the points that the apprentice most needs to learn; what is meant by these principles of operation will appear in the course of these articles.

Referring again to the books which are available to an apprentice, they are too often filled with tables, rules, formulæ, and ready made computations, which, like a list of gear wheel combinations stamped on a lathe, tend to relieve the learner's mind of that which is most important for him to study. The apprentice who runs to a table to select wheels for screw cutting will perhaps never learn to make the combinations mentally, and by using tables and rules to define mechanica questions, the principles may be entirely overlooked. Rules and tables have their places, and are merely records of what has been determined and proved by crucial experiment or by mathematical demonstration, but the less the engineering apprentice deals in them the more he is likely to know of the principles upon which such rules are founded. With books of an elementary character, until quite recently, the engineering apprentice has been no better supplied

When it is considered how strong first impressions are and how they cling to the mind, it is easy to conceive how important it is to lay a proper foundation on which to rear a mechanical education, and when we examine school books that treat of natural philosophy and mechanics, and compare them with modern science and modern practice, it must be conceded that they furnish a bad foundation indeed for the learner to build upon.

As a first lesson in what is called mechanics, the student is taught to compute the power of levers, screws, wheels, wedges, and other devices, which he is taught to call "mechanical powers," whatever that may mean; he is told that there are "three kinds of levers," and the terms used throughout are such as to confound power with mechanism, and prevent a comprehensive idea of force and motion, or the means of transmitting them. The student finishes such a study of mechanics with false conceptions of power and mechanism, which, as many will bear witness, cling to the mind for years, and may never cease to be a hindrance to acquiring a true appreciation of forces and the relations between power and mechanism.

A want of treatises that are especially adapted to the requirements of apprentices, is due in a great measure to the fact that practical engineers who have passed through a successful experience, and have gained that special knowledge which the apprentice most needs, as a rule have neither the inclination nor the incentive to write out the lessons that they could impart to others. The changes of mechanical manipulation are so frequent, and the apparent conflict that might arise between their opinions and established data would lead to adverse criticism, which such men do not care to invite; the result is, unfortunately, that the great mass of special knowledge gained by individual experience is lost, and mechanical text-books, of necessity, consist mainly in generalities that may be arrived at by theoretical deductions and inferences.

The purpose of these articles will be, in some degree at least, to supply this want of a medium between theory and practice, and to point out to the apprentice engineer that part of his education which may be termed special, and which must be acquired mainly by his own efforts; to urge upon him the value of analytical reasoning, about even the most simple matters, instead of depending upon rules, tables and formulæ.

It will also be attempted to show the relations between principles and practice, not between figures and practice; for it must continually be kept in mind that figures are but the symbols of principles; the plan of tracing every process in the workshop to some general mode of operation as an antecedent, will be urged upon the learner, as the only means of cultivating the habit of reasoning, which alone can lead to a complete knowledge of practical mechanics. The articles will contain no drawings, no figures or computations; these are already supplied in forms that leave nothing to be desired, and may be studied from other sources in connection with what is presented here.

The author, in preparing these articles for engineering apprentices, brings to his aid an experience of 25 years devoted to the construction of machinery and general engineering practice; and, as a considerable part of this experience has been devoted to the instruction of apprentices in applied mechanics and what is termed mechanical engineering, the plans of study which will be pointed out here are such as this experience has proved to be the most successful.

The articles have been prepared with a full knowledge of the fact, that what an apprentice may learn, as well as the time that is consumed in learning, are both to be measured by the personal interest that is felt in the subject studied, and that a strong personal interest on the part of an apprentice is essential to permanent success as an engineer. It is to be regretted that the difficulty of a statistical dryness and want of interest must always be a characteristic of any writing devoted to mechanical subjects. Some of the subjects treated