LITERATURE.

The Kinematics of Machinery; Outlines of a Theory of Machines. By F. REULEAUX; Translated and Edited by ALEX. B. W. KENNEDY, C.E. With numerous Illustrations. London: Macmillan and Co. [Price 21s.]

A MACHINE, according to Reuleaux's definition, is "a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motions." Starting from this statement the study of machinery may be divided into several parts, each large and important enough for separate treatment. The arrangements for bringing natural forces to act on the machine are investigated under the theory of prime-movers; the giving to the different parts of the machine the required quality of *resistance* is based upon the study of the strength of materials; the combination of these parts—their dimensions having been previously fixed—so that they may have certain determinate motions, forms what Willis called the "Science of Pure Mechanism," and Rankine the "Geometry of Machines," and what Reuleaux treats in the work before us under the name "Kinematics of Machinery." This work is not a text-book of machine design, like its author's well-known *Constructeur*, but treats design only as far as it is determined by the motions required in the machine. The subject is treated theoretically, but with a recognition of the claims of practice such as Englishmen do not generally associate with the writings of a German scientific professor. "The right application" of theoretical laws, he says, "demands certain special qualities in the designer of a machine besides a mere knowledge of its theory, if his work is to be what is called *practical*. . . . This art of making practical work can be but very partially communicated by teaching, it can only be made quite clear by example. The scientific abstraction only serves to show the possibility of the machine, it affords no means whatever of judging between *practical* and *unpractical*. . . . The attitude of theory and practice to each other, in connexion with the machine, must be one of mutual respect." (p. 54). Such a confession of faith affords excellent promise that the theoretical treatment will not be too abstract to be useful, and this promise is amply fulfilled.

By describing the work as theoretical, however, we must not be understood as meaning that it is full of formulæ. Indeed, there is scarcely an equation in it from beginning to end. The first two or three chapters presuppose in the reader the faculty of realising some geometric conceptions which may be unfamiliar to him, but they are very fully explained and illustrated; for the rest there is merely required that "mechanical instinct" which, whatever our shortcomings, is seldom wanting in English engineers.

It would occupy too much space were we to give here even an outline of Reuleaux's method of treating his subject, which is both novel and original in a high degree.* We shall content ourselves by merely pointing out a few of its leading features. One of the points which will probably most strike the English reader will be the throwing altogether overboard of the treatment of a mechanism as a means of "converting" one motion into another. Reuleaux analyses mechanisms into their "elements," that is the geometric forms (pins and eyes, screws and nuts, &c.,) which primarily determine the motion of each of their members or "links," and classifies them according to the arrangement of these elements, subdividing them according to the particular link of the mechanism which is fixed, or made stationary. In this way he certainly obtains some results which are very striking, and of great practical interest. Thus the driving mechanisms of the direct-acting and the oscillating engines contain exactly the same elements arranged in the same way, the only difference between them being in the link which is fixed; the universal joint is shown to be essentially identical with a common drag-link coupling, &c. A mechanism for "converting circular into rectilinear" motion is shown to be equally a mechanism for converting rectilinear into circular, rectilinear into swinging, swinging into circular, and a host of other "conversions." The whole combination, or "kinematic chain," may be identical in each case, the difference being merely in the link which is fixed. Having once determined what constitutes the essence of a pair of elements in a machine, it becomes comparatively easy to trace them out and recognise them in all sorts of constructive disguises. This is, of course, a part of the matter which directly concerns the engineer, and it is one to which Reuleaux devotes a great deal of space. There is scarcely one of the mechanisms whose abstract forms he makes a special object of study of which he does not mention some application, and he seems to have spared no trouble in hunting through English, French, and German books and technical periodicals for illustrations. By way of showing the applicability of his method of "kinematic analysis" to actual machines, he examines in detail a long series of engines (chiefly rotary), pumps, ventilators, &c., and shows how they are repetitions of a very few simple kinematic combinations in extraordinarily different constructive forms. The results of this application of his analysis are very interesting, and in many cases throw unexpected light on complex and unintelligible looking combinations.

Another point of interest is Reuleaux's treatment of the action of fluids (liquid or gaseous) in machines. "In examining mechanisms," the translator says, "we consider the motions of each body as a whole, ignoring altogether its molecular condition, or, more strictly, assuming that it is so arranged that its molecular stability is not disturbed during the motion. This pre-supposition is made tacitly in the case of 'rigid' bodies, where molecular stability is independent of the application of external force. It is made also in the case of ropes, belts, &c.; for when these occur in machines, it is always assumed that they are kept in tension by some force external to themselves: in any other case their motions would be quite indeterminate. With fluids it is not necessary to make any other assumption than this; but the external force must be a pressure instead of a pull, and must be supplied in directions other than that in which motion takes place." Reuleaux points out that engineers have continually acted upon this view of the matter, transmitting motion by columns of air or water, or by a rod or a rope, just as might be most convenient. Fluids, however, have never before been treated in their proper place in the "science of pure mechanism." Willis, indeed, explicitly excluded them from the subject. Engineers have long ago recognised in practice, as we have said, what theory refused to recognise; but even those most familiar with the subject will probably be surprised at the completeness of the analogy that Reuleaux is able to point out between machines having only rigid organs and those working with fluids. The comparison, for instance, between ratchet gear and pump work (§ 126) is very striking.

In order to utilise his kinematic analysis, Professor Reuleaux has devised and worked out a "kinematic notation," which is fully explained in his book, and of which he makes continual use. It is very simple and easily learnt, and as far as we have been able to test it, is of great assistance in ascertaining the real (kinematic) constitution of complex or apparently complex mechanisms. There are many cases in which it will doubtless prove of considerable practical value in machine design, by enabling the designer to take in at a glance the nature of mechanisms which it is extremely difficult to "see through" on the drawing-board, and thus to arrive directly at improvements and simplifications which otherwise would only be reached in a roundabout way after many trials.

Professor Reuleaux is not content with *analysing* machines, but in his concluding chapter gives a somewhat elaborate sketch of a *synthetic* method applied to mechanism. He looks forward to the time when invention shall be to a great extent a scientific process, conducted along fixed lines to arrive at a definite result just as in a mathematical or chemical investigation, where still, of course, individual capacity or genius shall influence the result as before, but through somewhat different channels. Without going as far as this with the author, it may be admitted that it is certainly in this direction that we seem to be moving. His treatment of this portion of the subject does not commend itself to us so much as the former part of the work. The classification of the pairs of elements, as well as the notation used for some of them, seems open to simplification and improvement. Judging from the specimens Reuleaux gives, however, the kinematic synthesis furnishes results which are at least interesting, and which may be of considerable practical importance when his synthetic method has been further worked out.

As regards the manner in which the work of translating the book under notice has been performed by Professor Kennedy, we cannot but speak most favourably. Professor Kennedy has evidently gone most heartily into his task, and not content with merely giving his readers an able translation of the original text, he has added numerous notes and references tending to materially increase the value of the work to English readers.

In taking leave of the book before us, we may say that it is one which we should like to see in the hands of every student of mechanical engineering, while we may add that it is one which engineers of mature experience will find to contain much that will be new to them and well worthy of careful study. The work is a valuable addition to English scientific literature, and we hope that its publishers will follow it up by the issue of translations of the other treatises by the same author, which have already made their mark on the Continent.

* Some account of it will be found in a lecture given by Professor Kennedy, at South Kensington, in May, which we have had in type for some time, and shall publish shortly.

MACHINE TOOLS AT THE PHILADELPHIA EXHIBITION.—No. VIII.

DRILLING MACHINES.

HEARING a drilling machine spoken of as a "drill press" brings to mind some remarks upon the nomenclature of machine tools which will not be out of place here. Constant vigilance on the part of educated writers and speakers of the English language has not prevented the introduction of metaphor and slang into our literature, and it is not strange that in the industrial arts, where new manufactures, processes, and products are continually being added, that irrelevant names and phrases should be adopted.

It requires some temerity on the part of any one to assume what is right and what is wrong among the new names which are being invented and used, but still there are some vagaries in the terms employed by Americans in connexion with machine tools which seem strange enough to warrant criticism. Thus we find that a drilling machine is generally spoken of in the United States either as a "drill" or a "drill press" but never as a driller, while planing machines are as a rule dignified with the personal substantive *er* and become "planers." Lathes are not called "turners," but shaping machines are often called "shapers." A gear-cutting engine is labelled as a "gear cutter," and a "compression pumper" in the Exhibition has its name affixed.

The difficulty felt in not having some proper impersonal terminal to define machines as agents is much felt, and the use of the personal substantive *er* is working its way into use not only in America but in England also, where it often appears, especially in advertisements. A fair compromise would seem to be to employ *er* for the personal and *or* for the impersonal. The participle with "machine" attached, planing machine for example, is too long to find favour in America, where labour saving extends to words as well as work. Boring augers are frequently called "bits." A wood-moulding machine to plane one side is called a "sticker," probably a corruption of the term "strike," as applied to forming mouldings for sashes. Razeeing machines are continually called "raising machines;" band wheels are called pulleys, which is certainly better than "rigger" but means something else; driving clamps for turning are called "dogs," and boring of some kinds is spoken of as "chucking." Such examples could be continued to hundreds where names are different from our own, and it is to be regretted that no one whose philological attainments would command respect has attempted to supply technical terms for new things. A pulley or rigger, for example, should certainly have some name belonging to itself and relevant to its form or use.

One feature of American drilling machines wherein they differ from European practice is in the proportion of the gear wheels which connect the horizontal or driving shafts with the spindles. These wheels are generally so arranged that the horizontal shafts run from one-third faster to twice as fast as the spindles. In European machines which generally have mitre wheels for spindle gearing, the horizontal shafts have no object except to change the motion from a vertical to a horizontal plane, and thus permit bands to be applied from horizontal driving shafts. In America these horizontal shafts on drilling machines have a further object in increasing the power of the belts, and for a considerable range of work take the place of back gearing. The step pulleys employed are, as on European machines, generally made to correspond in size to those for