likely that the greater number of earthquakes felt in the world belong to this latter class. All of them represent a relief of stress, and the discussion on the sources of earth stresses, commencing with the contractional hypothesis and concluding with the results of investigations by Prof. George Darwin, are attractive not only to seismologists but to all who wish to learn something about the inside of the world on which they live.

Some fifty pages are given up to descriptions of seismoscopes and seismographs, attention being particularly directed to those which record unfelt teleseismic movements. We cannot say that the concepts relating to seismic wave motion put forward are generally accepted, but such as they are we may say that they represent modern views. About the amplitudes and periods of earthquake waves seismologists have certain definite information, but about the magnitudes of these elements, particularly for waves which have travelled over long paths, much has yet to be learned. For this latter class of movement it is pointed out that discordant results are found in tables showing the speeds at which they were propagated. The author inclines to the view that the differences which have been noted are due to variability in the delicacy of instruments employed to pick up a wave or wave group. In great measure this may be true, but it seems to us that marked errors may also arise in consequence of inaccuracy in determining the time at which waves were generated at their origin.

Then, again, there are those who incline to a belief, which they sustain with arguments deserving close consideration, that within our earth convection currents exist; it would follow from this that along similar paths, or even along the same path, earthquake speeds should vary.

Notwithstanding these uncertainties, the author holds the opinion that remarkable and unexpected results which fit well within errors of observation have been reached.

Two serious difficulties, for the explanation of which we are asked to wait patiently, relate to the lengthening of wave periods and the total duration of a disturbance as it radiates. We will suggest that the former phenomenon may perhaps be at least partially explained by assuming that in the vicinity of an origin the records refer to forced vibrations, while at a distance the motion represents a periodic natural movement of the crust which varies with its heterogeneity. With regard to the second difficulty, now and then we have evidences that a disturbance recorded at a station far removed from an origin may be reinforced and lengthened by a repetition of the first disturbance which has reached the station by travelling in an opposite direction round the world. Generally, however, the record from a horizontal pendulum near to an origin appears to move as long as, if not longer than, a similar instrument at a distant station, which means that in certain instances the author's difficulty is non-existent. Finally, it must be borne in mind that a single impulse at an origin results in the birth of a series of waves which reach a distant station along different paths and with different speeds, with the result that a blow at an epicentre may at a distance from the same be recorded as a long train of waves.

When Major Dutton suggests to his readers that the Seismological Investigation Committee of the British Association carries on its work in consequence of financial aid received from the British Government, we recognise that he shares a widespread misapprehension.

Much is said relating to the elasticity of rocks, in connection with which an elaborate table, the result of investigations made by Prof. Nagaoka, of Tokio, is reproduced. A second long table is that drawn up by M. Montessus de Ballore relating to the distribution of seismicity.

The illustrations, of which there are sixty-three, are for the most part excellent, but there are one or two photomechanical reproductions of instruments which we imagine will give more delight to their authors at the sight of their own shaky caligraphy than to the ordinary reader.

Taken as a whole, the work is one to be read by all who wish to know what is known respecting the propagation of wave motion in our earth since the invention of the seismograph, and it is destined to receive a hearty welcome.

TECHNICAL MECHANICS.

Die technische Mechanik: elementares Lehrbuch für mittlere maschienentechnische Fachschulen und Hilfsbuch für studierende höherer technischer Lehranstalten. By P. Stephan, &c. Erster Teil: Mechanik Starrer Körper. Pp. viii+344. (Leipzig: Teubner, 1904.) Price 7 marks.

IN the very early part of this excellent work there is a certain lack of system, inasmuch as, although the author very properly treats first of the equilibrium of a *particle*, he assumes the nature of the stress exerted in such rigid bodies as the bars of a framework, the crank and connecting rod of an engine, &c. The nature of such forces is never properly appreciated by the student who is truly a beginner in the subject of dynamics—and, indeed, there is no part of statics in which students of even very considerable experience are so apt to go wrong as that relating to the forces exerted by jointed bars. The author treats from the outset the equilibrium of forces acting in space of three dimensions without having previously disposed of the simpler two dimensional case, a course which meets with the approval of many teachers, although it seems to the reviewer to be the less simple method. Herr Stephan enunciates the parallelogram law for the composition of forces (or vectors generally) at the outset, and assumes it as a result of experiment—which, on the whole, is perhaps the wisest plan for a teacher. Near the end of the book, however, he gives the ordinary Newtonian proof of the proposition.

He gives very early and very clearly the method of determining the resultant of a system of coplanar forces acting on a body (other than a particle) by means of the force and funicular polygons—a subject in which English students are, as a rule, extremely weak. There is a section on the determination of the centres of gravity of all the bodies usually figured in our

English books, followed by a discussion of all the ordinary simple machines—with this difference, that Herr Stephan's figures are much better than those of our text-books. Then follows a discussion of friction, in which, although the author almost invariably solves his problems by introducing the normal force N and the friction μN, he does not omit to point out the utility of the *total resistance* and the angle of friction. He underestimates this utility, however, in solving a simple problem by the N and μN method, and in his final results (p. 118) substituting the angle of friction —a process which simply obscures the merit of the second (and much shorter) method—with the remark that the example shows the advantage which the introduction of the angle of friction " occasionally offers." The truth is that in the hands of a skilful student the geometrical method founded on the employment of the angle of friction and the total resistance is almost always more neat, direct, and simple than the analytical, or N and μN, method. It can be conceded, however, that for engineering students, and technical students generally, this analytical method is the safer, although the longer, and requires less of the *esprit mathématique*. The nature of rolling resistance, which seldom finds mention in our English books, is well explained and illustrated by several applications (pp. 147, &c.). Indeed, the whole of Herr Stephan's treatment of the machines (screw presses, cranes, friction band-brakes, &c.) commonly discussed is excellent, and occupies a very large part of the treatise; it is, in fact, the best and most useful portion of the book.

The only kind of catenary treated of in this volume is the parabola of suspension bridges, to which only two pages and two illustrative examples are devoted. Doubtless the subject will receive more consideration in some subsequent volume.

Herr Stephan is very careful to avoid errors in his figures, and to represent the lines of action of three forces when they keep a body in equilibrium as meeting in a point—a very elementary condition not always observed in our text-books. Once, however, he overlooks this necessity, and represents the lines of action of three forces acting on a bar in a framework (Fig. 164) as forming a triangle of very respectable area.

In the section dealing with the equilibrium of frameworks of jointed bars, he directs attention to the obvious fact, which is not usually mentioned in our books, that even if the bars are loaded throughout their lengths (by their own weights or otherwise) the stresses can be calculated by taking any of the bars as unloaded and weightless, and then superposing the calculated results (p. 197). This simple principle he applies in a special case, and it is one which on many occasions might be employed with great advantage.

The last hundred pages are devoted to kinetics of an elementary kind—including the theory of direct collision of spheres, the compound pendulum, &c.—together with a section on the moments of inertia of various figures and solids. There is no mention made of the very simple and useful rule that a triangular area can be replaced by three equal particles placed at the middle points of its sides—a rule which saves an enormous amount of trouble in the calculation of moments of inertia for all plane areas bounded by right lines. In the absence of this simple rule, a ponderous application of the integral calculus is the only refuge of the student. A somewhat similar " particle rule " saves reams of ponderous calculus work in hydrostatics; but these rules are not widely known.

Herr Stephan very properly makes short work of D'Alembert's principle, deducing it directly from Newton's axioms ii. and iii., so that, although he employs the term " centrifugal force," he is careful, except in one instance, to show that it is a force exerted *by*, and not *on*, a moving particle. The exceptional instance occurs at p. 281, where he is calculating the tension in a driving belt which passes over the surfaces of two revolving cylinders. Here he speaks of a small element of the band as " experiencing " a centrifugal force, which is duly represented, in the usual way, by a centre-flying arrow. His subsequent teaching, however, removes the erroneous notion herein contained.

The book is wonderfully well printed and illustrated, as well as free from mistakes. On p. 15 " Punkte " should clearly be " Kräfte," and on p. 187 the reference should be to Fig. 131 and not to Fig. 135. The theory is illustrated by nearly 200 examples.

To all students who desire to attain a real and physical conception of the subject Herr Stephan's work can be very strongly recommended.

GEORGE M. MINCHIN.

OUR BOOK SHELF.

Machine Drawing. By Alfred P. Hill. Pp. 83. (London: P. S. King and Son, 1904.) Price 2*s*. 6*d*. net.

IN this text-book the author presents a course of instruction which he considers suitable for students attending elementary drawing classes who are unable to spare more than one evening per week, and whose technical training is thus confined to the one subject of machine drawing. Three dozen plates are given, affording a choice of examples to be copied to scale from the dimensions figured, some of which are proportional dimensions covering a range of sizes. Accompanying the plates are descriptive accounts of the construction and uses of the machine parts drawn, with sets of questions founded thereon. At intervals, where space is available, formulæ and physical data are introduced and used in making calculations illustrating machine design. This crude attempt to teach applied mechanics along with elementary machine drawing seems to us a mistake, as, in the absence of a knowledge of mechanical principles, such formulæ as are given become mere rules of thumb, and any attempt to apply them independently cannot fail to be disastrous, as, for instance, in the author's method of estimating the limiting speed of a fly-wheel on p. 42. The time wasted on these premature calculations might very profitably be spent with rule, callipers, and squared paper, in measuring and making careful and complete dimensioned sketches of actual machine parts, and so cultivating the habit of closely and accurately observing constructional details.

Errors abound throughout the book. The author is not a safe guide even in such a small detail as the projection of a hexagonal nut, while his statement on p. 44 that " heat and work are mutually controvertible " is a fair index of the scientific value of the work. The volume is somewhat redeemed by a few