

suggestions as to their improvement. The account of the British and Irish rivers is rather depressing reading. Almost everywhere, save in a few favoured counties, there is the tale of pollution. We agree with Mr. Hodgson that this is preventable. The crude by-products of various manufactures need never be turned into fishing rivers—such a thing, for instance, as the reckless discharge of sawdust into a stream, and the consequent destruction of hosts of trout, ought certainly not to be permitted. With modern methods of septic purification it is a scandal that salmon rivers and streams should still be the repositories of crude sewage; but local sanitary authorities are difficult to move, and so far as the prevention of the pollution of rivers is concerned the law "is a hass."

The book is excellently printed and illustrated. Particular praise should be given to the series of seven plates at the beginning of the volume illustrating eighty typical salmon flies. The colouring and printing of these plates leave nothing to be desired. Altogether Mr. Hodgson's book should be a very welcome addition to the sportsman's library.

In "Dry Fly Fishing" Mr. F. G. Shaw makes a creditable attempt to make clear that which he terms the "science" of trout fishing. Chapters i. and ii. give directions how, when, and where to cast a trout fly. Chapter iii. deals with the selection of the fly, and includes a discussion of the range of vision of the fish. Chapter iv. gives a useful account of some aspects of pisciculture, and chapter v., "The necessities of the trout fisherman," is devoted to a consideration of the "gear" necessary for the craft. The book is abundantly illustrated. If the niceties of trout fishing can be taught by means of diagrams and practical directions, then Mr. Shaw's book ought to be very useful; but, as he says himself, "It is of no use to read books in order to determine your actions when actually fishing. Common sense is the most valuable guide." Nevertheless, the experience of others is always interesting, and no doubt the tyro, and even those of greater knowledge, will learn much from this work.

J. J.

PROF. LUDWIG BOLTZMANN.

ONLY two years ago Dr. Ludwig Boltzmann, professor of physics in the University of Vienna, celebrated his sixtieth birthday. On that occasion a "Festschrift" was presented to him containing papers by about 125 physicists from all parts of the world. The announcement of Prof. Boltzmann's death, which was reported in the London papers of September 8, will be received with regret, not only by physicists of repute, but by every student who has attempted to gain an insight into the mysteries of molecular physics.

Ludwig Boltzmann was born on February 20, 1844. Before he was twenty-two years old, on February 8, 1866, he read a paper before the Academy of Sciences of Vienna entitled "Ueber die mechanische Bedeutung des zweiten Hauptsatzes der Wärmetheorie." The opening sentences of the paper may be freely translated as follows:—

"The identity of the First Law of Thermodynamics with the principle of *vis viva* has long been known, on the other hand the Second Law occupies a peculiarly exceptional position, and its proof is based on methods which are not only uncertain here and there, but are in no case obvious. The object of this paper is to furnish a purely analytical and perfectly general proof of the Second Law of Thermodynamics, as well as to investigate the corresponding principle in Mechanics."

Little did the young Boltzmann imagine that the task he had thus set before himself would occupy his whole lifetime.

A year later, after having obtained the doctorate, and having been appointed assistant in the physical institute at Vienna, we find him writing on the number of atoms in a gas molecule and the internal work of gases.

In 1868 he published his first important paper on the law of partition of energy under the title of "Studien über das Gleichgewicht der lebendigen Kraft zwischen bewegten materiellen Punkte." The problem had been previously attacked by Maxwell, but Boltzmann soon found difficulties and objections arising out of Maxwell's treatment, and it was one of the objects of the paper to place the theory on a more satisfactory basis. A second paper on the same subject ("Weitere Studien") was published in 1872, and in it the important theorem now known as Boltzmann's "minimum theorem" or the "H-theorem" first saw the light. That this theorem is not independent of assumed hypotheses has been amply shown by discussions in NATURE and elsewhere in which Watson, Burbury, and other physicists took part early in the 'nineties; but, granting these premises, it is proved that in a system of molecules a tendency exists to assume an equilibrium distribution of energy analogous to the tendency to heat equilibrium in a material gas. It was not until 1892 that Boltzmann published a third part to his "Studien." In it he deals with difficulties that had been raised in the discussion referred to in connection with the assumption that the kinetic energy of the system could be reduced to a sum of squares, and he also examines certain test cases of the kinetic theory proposed by Lord Kelvin.

In 1875 Boltzmann, then a corresponding member of the Vienna Academy of Sciences, treated the problem for the case of a system of molecules in a field of external force.

From Vienna Boltzmann went to Graz, where he was appointed professor in the university. After going there he wrote, in 1876, a paper on the integration of the equations of molecular motion, and several other minor papers on the kinetic theory. A fresh line was started in 1877, although the underlying idea had been suggested by Boltzmann in 1871, and employed by Dr. Oskar Emil Meyer in his book of 1877. This was the application of the theory of probability to the problem of energy-partition. The method of treatment adopted is highly instructive; Boltzmann starts with considering a system of molecules the energy of each of which can only have one or other of a series of discrete values—a series of counters marked 1, 2, 3 . . . might be used in illustration—and he investigates the most probable distribution of energy for a number of them drawn at random. From this simple case he is led by gradual stages to the more complicated case of a gas the molecular state of which is specified by generalised coordinates.

In 1880 to 1882 Boltzmann published long and important papers on viscosity and diffusion of gases, in which the consequences of Maxwell's assumption of the "inverse fifth" law of intermolecular force were fully discussed. In 1884 he was evidently attracted by Helmholtz's work on monocyclic systems, and lost no time in applying the method to the kinetic theory. In this connection the possibility of building up statistically monocyclic systems was considered. But a further application suggested itself in the possibility of representing thermodynamic and other phenomena by means of mechanical models. In his "Vorlesungen über Maxwell's Theorie," pub-

lished in 1891, Boltzmann makes use, not only of monocycles, but also of what he calls "bicycles," illustrating the phenomena of mutual induction of electric currents.

In 1885 Boltzmann was raised from "corresponding" to ordinary member of the Vienna Academy. He remained at Graz until about 1891, when he was called to Munich. A year or two later he visited England and called on the present writer at Cambridge, and thus a personal friendship sprang up. In 1894 the British Association meeting at Oxford, with its memorable field-day on the kinetic theory, came simultaneously with Lord Rayleigh and Sir William Ramsay's announcement of the discovery of argon. The part which Prof. Boltzmann took in these discussions will long be remembered. He received an honorary degree, and expressed some amusement at being made a Doctor of Laws. "It were better they made me Doctor of Science," he remarked. It was, however, pointed out that as an authority on the laws of thermodynamics the title was a fitting one.

In 1895 Boltzmann was transferred from Munich to Vienna, where he resided until his death, with one exception. In 1904 he was called to the University of Leipzig, and actually went there for a short time, but the change did not suit him, and he was back again in Vienna almost immediately.

In 1899 he was elected corresponding fellow of our Royal Society, and allusion has already been made to the universal and widespread enthusiasm shown over his diamond jubilee five years later.

Those who knew Boltzmann will remember the pair of heavy, highly-powerful spectacles resting on a deep groove in his nose. For many years his eyesight had been failing, and he found it increasingly difficult to complete the many researches which were on his mind. He appears to have ended his life during a summer holiday at or near Abbazia, a neighbourhood which he frequently visited with his wife and family.

We have alluded to some of Boltzmann's earlier writings more or less in chronological order. One of his most important later works is his book "Vorlesungen über Gastheorie" (Leipzig: Barth), the first volume of which bears the date 1895 and the second 1898. It fills an important gap in the literature of the kinetic theory, and renders much of Boltzmann's own work more accessible to general readers than it would be if his separate papers had to be consulted. While Boltzmann's chief energies were concentrated on the difficult problems of the kinetic theory, other branches of physics were by no means neglected. In evidence we have his book of lectures on Maxwell's theory, papers on Hertz's experiments, and an address on the methods of theoretical physics. Artificial flight also interested the Vienna physicist, who some years back gave a discourse on the subject, illustrated by models. Among his recreations allusion may be made to music. His thick fingers descending on the keys of the piano well knew how to produce those variations in timbre which are understood in Germany, but the want of which makes English people often say that the piano is devoid of soul. He would often play in trios with his son and eldest daughter.

It may be that the kinetic theory of gases is even now regarded as being less complete and perfect in itself than many other physical theories, such as the electromagnetic theory of light. But the study of irreversible phenomena stands on a far higher order of difficulty than that of purely reversible effects. If it has been impossible to build up a statistically irreversible system out of reversible elements without

making *some* assumptions, we are, at all events, in possession of theories of molecular phenomena in which the assumption in question is of the simplest and most self-evident character, and the agreement with experiment as close as could be expected. These theories are in a very large measure results of the labours of Ludwig Boltzmann.

G. H. BRYAN.

NOTES.

THE results of the Gordon-Bennett balloon race, as announced in the daily papers, show that the sixteen competitors who started from Paris on Sunday afternoon all landed within a belt comprised between the meridians of 1° east and 1° west of Greenwich. The longest and most northerly journeys were those of Lieut. Lahm (U.S.A.), who landed near Whitby—about 400 miles from Paris—after a journey of $23\frac{1}{2}$ hours; Signor Vonwiller (Italy), near Hull; Comte de la Vaulx (France), near Walsingham, four miles from the Norfolk coast; and the Hon. C. S. Rolls, near Sandringham. A second group landed in the south of England, this group comprising M. J. Balsan (France), at Singleton, near Chichester; Prof. Huntington (Great Britain), at Sittingbourne, Kent; and Captain Kindelan (Spain), near Chichester. The next group were carried from Paris in directions between west and north-west, and landed on or near a strip of the French coast extending from Dieppe to near Caen. These were Herr Scherle (Germany), near Dieppe; Mr. F. H. Butler (England), Comte de Castillon (France), and Señor Salamanca (Spain), all three at Blonville, near Trouville; Baron von Hewald (Germany), at Coudé, near the mouth of the Seine; Captain von Abercron (Germany), at Villers-sur-Mer; and Lieut. Herrera (Spain), at Cabourg. A little south of this group, M. Santos Dumont landed at Broglie, after having met with an accident to his arm. A different course was followed by the Belgian competitor, M. van den Driesche, who landed at Bretigny, a place $19\frac{1}{2}$ miles south of Paris, soon after midnight.

SIMULTANEOUSLY with this competition, another of the same character, in which seven balloons took part, started from Milan. This was one of a number of aeronautical competitions organised during the month of September in connection with the exhibitions, other contests being arranged for aeroplanes, machines, and models, both with and without motive power. Whether owing to this clashing or to other causes, the aeronautical pavilion at the Milan Exhibition shows a remarkable dearth of exhibits, the only really successful attempt at a complete and well-organised exhibit being that of the Prussian Aeronautical Observatory in Lindenburg. These exhibits mostly illustrated apparatus for the meteorological study of the upper layers of the atmosphere, and their systematic display under the charge of Prussian officials in their smart military uniforms only made the absence of other important exhibits the more conspicuous.

THE second International Conference on Wireless Telegraphy, which is now sitting in Berlin, is likely to prove of great interest and importance from both the national and commercial points of view. Delegates from nearly all countries have accepted the German Government's invitation, and are now in Berlin. The preliminary conference of 1903, which was also convoked by the German Government with the hope of securing general support for its contention—that intercommunication between ships fitted