motion Maxwell's law of distribution of energy would fail, assuming that law to consist in the ultimate equality of the energy of different parts of the system. He has thus shown the necessity for more accurate language than is commonly employed in the enunciation of that law, and a consideration of his problem may help to determine the limits to which it is subject.

The following statement, whether co-extensive with Maxwell's law or not, will probably be accepted as true as far as it goes—

If there exist a very great number of material systems, the state of each being defined by certain co-ordinates and momenta, and if at a given instant all combinations of the co-ordinates and momenta are represented among them with frequency proportional to $\epsilon^{-h(\chi+T)}$, then that distribution will be permanent—that is, will not be disturbed by the mutual action of the systems, or by any forces in the field of which they are placed, provided all the forces concerned be conservative.

The further question as to how far the solution thus found for the permanent state is unique, has been treated by Boltzmann. He shows that a certain function, which in stationary motion must be positive and constant, necessarily diminishes with the time, so long as any small deviations exist from the above described state. It is obvious that this proposition of Boltzmann's cannot be applicable to all cases of stationary motion. Periodic motions are exceptions, and so is the system described by Lord Kelvin. The question is what assumptions underlie Boltzmann's demonstration. It will be of great advantage if one speaking with Lord Kelvin's authority will assist in defining the limits to which the proposition is subject.

Maxwell, although he may at times have expressed himself incautiously, was aware that the theory was subject to limitations. The statistical, as distinguished from the historical, method was from his point of view of the essence of the theory. A distinction may be drawn between systems, such as Lord Kelvin's, to which the statistical method is inapplicable, and those in which the stationary motion, when attained, is what is called thermal motion—that is, the relative motions are in all directions indifferently, and of that irregular character in which heat is supposed to consist.

It may be that we shall be driven to the conclusion that Maxwell's law has no application except to this class of systems; that it is, in fact, only the limiting state to which a material system approaches as we increase indefinitely the number of its degrees of freedom.

It does, at all events, appear that in cases where the law fails, its failure is due to the introduction of some restrictions on freedom of motion, especially as regards direction. Maxwell pointed out that dæmons—or, shall we say, beings endowed with free will—might by directing the courses of individual molecules cause a system to violate, not only the law of distribution of energy, but even the second law of thermodynamics. What these beings might be supposed to do, that Lord Kelvin in fact does once for all for his system, by prescribing *a priori* the directions of motion and other conditions of the problem to suit his purpose.

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The Former Connection of Southern Continents.

WITH reference to the very interesting question treated in Mr. Mellard Reade's letter of your issue of May 26 (p. 77), as to the former connection of southern continents, it may be worth while calling attention to the fact that a great circle, which I may call the Kaffraria Great Circle, connects that coast line with the Falkland Island and the South Georgia Island. It may be presumed that these two islands are the remaining summits of what was once a chain of mountains in connection with the continent of South America. Some of the points through which or near which this great circle passes are as follow — the above-mentioned islands, Port de Sta. Cruz, Patagonia; it traverses the Pacific, runs parallel to the southern branch of the Aleutian Islands, and cuts Kamtchatka somewhat south of Klienchewskaia Volcano, and traversing Asia emerges by the Island of Cutch, so interesting on account of the earthquakes which occurred there. It is of interest to note that South Georgia Island is antipodal to the northern extremity of Saghalian Island.

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ON THE RELATIVE DENSITIES OF HYDROGEN AND OXYGEN.[1]

IN a preliminary notice upon this subject (Roy. Soc. Proc., vol. xliii. p. 356, February 1888), I explained the procedure by which I found as the ratio of densities 15·884. The hydrogen was prepared from zinc and sulphuric, or from zinc and hydrochloric, acid, and was liberated upon a platinum plate, the generator being in fact a Smee cell, inclosed in a vessel capable of sustaining a vacuum, and set in action by closing the electric circuit at an external contact. The hydrogen thus prepared was purified by corrosive sublimate and potash, and desiccated by passage through a long tube packed with phosphoric anhydride. The oxygen was from chlorate of potash, or from mixed chlorates of potash and soda.

In a subsequent paper "On the Composition of Water" (Roy. Soc. Proc., vol. xlv. p. 425, February 1889), I attacked the problem by a direct synthesis of water from weighed quantities of the two component gases. The ratio of atomic weights thus obtained was 15·89.

At the time when these researches were commenced, the latest work bearing upon the subject dated from 1845, and the number then accepted was 15·96. There was, however, nothing to show that the true ratio really deviated from the 16 : 1 of Prout's law, and the main object of my work was to ascertain whether or not such deviation existed. About the year 1888, however, a revival of interest in this question manifested itself, especially in the United States, and several results of importance have been published. Thus, Prof. Cooke and Mr. T. W. Richards found a number which, when corrected for an error of weighing that had at first been overlooked, became 15·869.

The substantial agreement of this number with those obtained by myself, seemed at first to settle the question, but almost immediately afterwards there appeared an account of a research by Mr. Keiser, who used a method presenting some excellent features, and whose result was as high as 15·949. The discrepancy has not been fully explained, but subsequent numbers agree more nearly with the lower value. Thus, Noyes obtains 15·896, and Dittmar and Henderson give 15·866.

I had intended further to elaborate and extend my observations on the synthesis of water from weighed quantities of oxygen and hydrogen, but the publication of Prof. E. W. Morley's masterly researches upon the "Volumetric Composition of Water" (*Amer. Journ. Sci.*, March 1891) led me to the conclusion that the best contribution that I could now make to the subject would be by the further determination of the relative densities of the two gases. The combination of this with the number 2·0002,[2] obtained by Morley as the mean of astonishingly concordant individual experiments, would give a better result for the atomic weights than any I could hope to obtain directly.

In the present work two objects have been especially kept in view. The first is simplicity upon the chemical side, and the second the use of materials in such a form that the elimination of impurities goes forward in the normal working of the process. When, as in the former determinations, the hydrogen is made from zinc, any impurity which that material may contain and communicate to the gas cannot be eliminated from the generator; for each experiment brings into play a fresh quantity of zinc,

[1] "On the Relative Densities of Hydrogen and Oxygen. II." Abstract of a paper by Lord Rayleigh, Sec.R.S., read at the Royal Society on February 18, 1892.

[2] It should not be overlooked that this number is difficult to reconcile with views generally held as to the applicability of Avogadro's law to very rare gases. From what we know of the behaviour of oxygen and hydrogen gases under compression, it seems improbable that volumes which are as 2·0002 : 1 under atmospheric conditions would remain as 2 : 1 upon indefinite expansion. According to the formula of Van der Waals, a greater change than this in the ratio of volumes is to be expected.