

said, "will be found to contain a connected account of everything essential to a first course of modern electrical theory."

But in chapter vi. the definition of potential is a mathematical one. The distinction between scalar and vector quantities is drawn, and it is pointed out that in many cases the line integral of a vector between two points is independent of the path, and that in this case the vector is said to have a potential, the value of the line integral being the difference of the potentials at the two points which are taken as the extremities of the path.

A number of mathematical propositions connected with the theory of potential are then proved or illustrated in a very interesting way ; but the application of the theory to the fundamental facts discussed in the earlier chapters is hardly attempted.

The beginner might be given some idea of the nature of potential without being asked to grasp the meaning of a line integral. Faraday's and Maxwell's notions as to the tension along the lines of force and the pressure perpendicular to them which occurs in a dielectric medium may be used, without the introduction of symbols, to explain the simple attractions and repulsions described in the earlier chapters ; the link between the ancient observations and the modern theory is wanting, and the loss to the reader is very marked.

The same want is illustrated in the two following chapters. The quantity  $K$ , the specific inductive capacity of a medium, is defined in the usual way in §70, and a footnote tells us "it is identical with the permittivity or dielectric co-efficient  $K$ ." This statement is repeated in the next chapter, on electric action in dielectrics, but the author does not explicitly establish the connection ; a few words at the end of §86 would do it, the words, however, are wanting.

Or again,  $K$  is defined as the ratio of the polarisation, or the intensity of the electric displacement, to the force. Now the force has a perfectly definite meaning, and the inductance  $K$  can be defined in unambiguous terms ; why then make it depend on "a peculiar distortion called electrical displacement" which is "roughly represented by supposing every tube of force to be divided into cells by elastic membranes firmly attached to the tube, these cells being completely filled with incompressible liquid. The distortion does not displace the sides of the tube, but it displaces the liquid a little way along the tube, in the direction of the force  $F$ , further displacement being prevented by the elastic resistance of the membranes."

The inductance of a dielectric is too important a physical quantity to be defined in terms of something which can only be explained by an incomplete analogy ; it is surely better to say that the force between two given charges is found to depend on the medium in which they are placed, so that the complete law of force is  $F = ee'/Kx^2$ , where  $K$  is a constant for a given medium, and is known as the permittivity or inductance of the medium. Then the statements in §80 as to the modification of fundamental formulæ follow naturally ; as it is, they seem to the reader to depend on the analogy between the flow of a liquid and electric displacement, and not to rest on an experimental basis.

The earlier chapters on magnetism are clear and good, §148, giving the reason why a bar of soft iron sets

parallel to the lines of force, may be specially commended. Chapter xiii. gives a useful development of magnetic theory ; the proof of the relation, however, between  $B$  and  $H$ , §158, might be given in fuller detail, and a reference to §83 as well as to §90 would not be misplaced.

The rest of the book is taken up with the theory of electric currents and electro-magnetism, and can, on the whole, be warmly commended. The description of instruments, ammeters, voltmeters and the like is brought up to date. At times, possibly, almost too much is attempted for the space available, e.g., in the very condensed account of the ballistic galvanometer in §200. Again, some preliminary account of a voltaic cell is needed before §213, which begins "In a circuit consisting of a battery of four similar cells."

In places the book would be improved by a more distinct reference to the fundamental experiments on which the various laws are based. Thus in chapter xix., after a reference to a statement as to the force exerted on a wire carrying a current in a magnetic field, we pass on to "two fundamental formulæ." These formulæ give the electrical and mechanical forces on a conductor carrying a current when in a magnetic field, and various important deductions are drawn from them in an admirable manner in the following paragraphs. But we miss any clear indication of the method by which these two fundamental formulæ are deduced from experimental results.

The chapter on dynamos is specially good ; there is sufficient detail to enable the student to grasp the principles which underlie the action of the various forms, while at the same time the book is not overburdened with accounts of small differences of construction which, though they are of great importance to the student of dynamo design, have no place in a general text-book.

Enough, perhaps, has been said to show the value of the book. Prof. Everett has rendered a real service to his readers by his new edition ; the book is one which is sure to become popular and to be valued alike by teacher and by student.

#### AN ESSAY IN CRITICAL BIBLIOGRAPHY.

*The Periodic Classification and the Problem of Chemical Evolution.* By G. Rudorf. Pp. xvi + 228. (London : Whittaker and Co., 1900.) Price 4s. 6d.

THE object of this work, as stated by the author in his preface, is one which should command hearty approval. The author aims at presenting a summary of the work done and the speculations advanced in the particular field indicated in the title. The publication of such summaries has long been customary in Germany, and it is to be hoped that the custom may become more common in England. Most text-books published in this country suffer from one or other of two defects. Either they are very elementary in scope and wholly didactic in treatment, or they are diffuse in treatment and of unmanageable size. This work certainly does not fall under either condemnation. It deals with a difficult subject, and is rather suggestive and argumentative than didactic. On the other hand, it is neither unreasonably long nor over-elaborate in treatment. Indeed, it sometimes errs in the other direction.

The first part deals with the history of the periodic law and the experimental evidence for periodic variation of properties with atomic weight, and in many cases information is given in so condensed a form that it must be well-nigh unintelligible to those whom the author has avowedly sought to benefit, students "who may not have either time or opportunity to refer to the original literature." This is particularly the case in the portions which deal with various attempts to formulate numerical relations between the atomic weights.

In the second part of the book the author seeks to establish the theses (1) that "the elements have a fixed, definite structure," (2) that "the elements are complexes of some primary material," and (3) that this primary material is hydrogen. Dealing with the first of these, the author gives a sketch of the evidence to be derived from stereo-chemistry which is so short that it amounts to little more than a series of references, but which is useful so far as it goes. The inference that the elements in any one group of Mendeléeff's table should all have the same shaped atom is somewhat sweeping, but is opportunely supported by the recent work of Messrs. Pope and Peachey on optically active tin compounds.

As to the second, the arguments which have been advanced in support of it are fairly well presented, but the author misses altogether the point that the "meta elements" of Crookes supply an essential link in the chain of reasoning by which it is possible to reconcile the discontinuity implied in the atomic theory and the periodic law with the continuity predicated in the hypothesis of protyle.

In support of the third proposition, that protyle and hydrogen are one, the author adduces several well-known arguments, many of which, particularly those based on stellar spectroscopy, are fairly well stated and of acknowledged cogency. But his answer to the obvious difficulty that the atomic weights are not whole multiples of that of hydrogen is, though not unfamiliar, decidedly unsatisfactory. That the third law of motion may be valid only where molar masses are concerned is, of course, a legitimate suggestion, but it is a suggestion in support of which no fact save the difficulty under discussion can at present be adduced. It is surely as reasonable to regard that difficulty as fatal to the hypothesis that hydrogen is protyle as to find in it a reason for doubting the universal applicability of the third law of motion.

The author, moreover, minimises in an extraordinary way the remarkable evidence which has been accumulated through the study of ions produced in gases by the action of Röntgen rays, Becquerel rays and ultraviolet light. "The portion of this book dealing with chemical evolution was," we are told, "submitted to Sir Norman Lockyer," and some of the notes which he made upon it are prefixed to the volume. In them attention is drawn, more than once, to the importance of this work on gaseous ions in relation to the problem under discussion. The author does, it is true, add to these notes a brief abstract of one of Prof. J. J. Thomson's papers. But the matter is far too important to be thus disposed of in a prefatory note. The fact that the negative ion in gases has a mass which is very small compared with that of an atom of hydrogen is well established, not only by the researches which the author quotes, but by other and later work of Prof.

Thomson on the negatively charged particles given off when ultraviolet light falls on a zinc plate, and also by the experiments of MM. Becquerel and Curie on the radiations emitted by radium. The conclusions to be drawn from these researches, while they are in full accord with the view that the elementary atoms of the chemist are themselves complex aggregates of yet smaller particles, require that these particles should be of an order of magnitude so far inferior to that of a hydrogen atom that they cannot fairly be described as "hydrogen" at all.

If, as may be expected, a second edition of the work is called for, it is to be hoped that the author will take the opportunity of incorporating these results, and with them the still later work of Prof. Townsend on the variations of conductivity in rarefied gases, the results of which also emphasise in a remarkable way the extreme smallness of the negative ions.

In conclusion, it must be said that the author has occasionally suffered unduly at the hands of his printer. There are a number of ordinary misprints which might be expected in a work of the kind, but a worse piece of printing than that of the numerical expressions illustrating the summary of Dr. Dulk's paper (on p. 71) it would surely be difficult to find.

A. F. W.

#### OUR BOOK SHELF.

*Der Gesang der Vögel.* Von Dr. Valentin Häcker. Pp. 1+102. (Jena: Gustav Fischer, 1900.)

THIS is an exceedingly interesting and useful contribution, and may be regarded as perhaps the most accurate and complete summary of this subject extant.

The author devotes the opening pages of his work to purely anatomical details, illustrated by numerous text-cuts representing voice organs of the passerine type. He introduces, for purposes of comparison, a short description and a figure of the tracheo-bronchial region of the reptile, the tortoise being selected as the most suitable.

The second chapter opens with a reminder that the variety of tone and range of vocal power depends largely on the modification of the upper ends of the bronchial tubes and the lower end of the syrinx. This is supported by a brief survey of the simpler types of syrinx ending in the very perfect voice organ of the Passeres, with its complicated muscular system and fusion of tracheal rings—the tracheo-bronchial syrinx.

That muscular development, however, does not necessarily imply great powers of song is, as he rightly remarks, well shown by the fact that the muscles of the raven and thrush are precisely the same in number and distribution. Furthermore, the muscular system of the raven is the better developed of the two; but there can be no doubt, in spite of this, which is the better songster! Again, though the songs of the true Passeres are extremely varied, yet there is no perceptible variation in the muscular system; indeed, such variation is obviously unnecessary, for the same bird may, and does, repeat the song of numerous other birds as proficiently as the birds to whom the songs rightly belong.

It is interesting to note that Dr. Häcker seems to have shown that sexual distinctions in the syrinx can undoubtedly be demonstrated, that of the female being always more feebly developed. This being the case, one would scarcely have supposed that the female, as in the case of the bullfinch, for instance, would sing as well as the male, but so it is.

Castration acts directly on the syrinx, much as on the horns of deer, for instance; the capon having a syrinx