it should have been stated on p. 91 that the original idea of the spectroheliograph was due to Dr. Janssen, who first suggested it at the Exeter meeting of the British Association in 1869. Again, with reference to the first observation of the spectrum of a nebula, it is stated (p. 242) that "it was seen at a glance that the spectrum consisted of a few bright lines," though the observer at first attributed what he saw to some possible derangement of his instrument.

Looking forward, Prof. Turner believes that, among other changes, the transit circle will be gradually superseded by the almucantar for star observations, and by the heliometer for observations of the positions of planets, and in celestial photography he predicts a great future for the portrait lens.

The illustrations, some thirty in number, are of indifferent quality, and that of Eros, on p. 109, is almost unintelligible.

Chemistry an Exact Mechanical Philosophy. By Fred. G. Edwards, Inventor of Atomic Models. Pp. xii + 100. (London: J. and A. Churchill, 1900.)

"THE object of this work is to determine the exact shape of the atoms, to find their relative position in space, and to show that chemical force is purely a function of matter and motion." Further, "the shapes obtained for the different atoms is the subject-matter of a British patent (atomic models) dated 1897." Again, "the conclusions herein deduced (when accepted as true) will form a fitting climax to the discoveries of a century which has produced the atomic theory of Dalton, the theory of heat as a mode of motion, and the discoveries of the correlation of physical forces, and that force, like matter, is indestructible."

For the scientific reader there is little need to add any comments to these quotations. There is, however, always the possibility that an author may have a good idea but an unfortunate way of presenting it, and one does not forget that "the law of octaves" was received with something like ridicule. It is necessary to add, therefore, that a careful examination of the present work, made with every desire to find precious metal in it, has failed to reveal anything that seems likely to aid the advancement of science.

In dealing with the *exact shape* of atoms, the author starts with the assumption that the lightest known element, hydrogen, consists of two tetrahedra placed base to base, and that the atoms of the whole of the remaining elements may be similarly formed by tetrahedra built up symmetrically, every two tetrahedra representing one unit of atomic weight. It is practically impossible, without the models before one, to judge whether there is any outcome from this view of things that compensates in any degree for its arbitrariness and complexity. There can be little question, however, that as a whole the book and its doctrines will not command the serious attention of men of science whose leisure and patience are limited.

A. S.

The Chemists' Pocket Manual. By R. K. Meade, B.S. Pp. vii + 204. (Easton, Pennsylvania: The Chemical Publishing Co., 1900.)

A LARGE amount of information of use to professional chemists is brought together in this pocket book. The tables include almost everything to which occasional reference has to be made in chemical laboratories; and with the formulæ, calculations, physical and analytical methods, should be of service not only to chemists, but also to assayers, metallurgists, manufacturers and students. Among the points worthy of special mention are the applications of graphic methods to conversion tables; and the descriptions of select methods of technical analysis.

LETTERS TO THE EDITOR.

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The Use of the Method of Least Squares in Physics.

THE application of the method of least squares to physical measurements is described in several standard text-books—to wit, Kohlrausch's "Introduction to Physical Measurements" (third edition, 1894), Stewart and Gee's "Elementary Practical Physics" (1885), and others. In none of these is it pointed out that the method *as set forth* offers in certain cases a choice of results, and that the solution is practically unique only if a sufficient number of observations be taken. Nor is any indication given how the method is to be applied when none but a small number of observations is available. Since the method is intended for use only when a high degree of refinement is aimed at, these points are of practical importance.

As illustrating the necessity for examining the matter, we may take the example given by Kohlrausch on p. 13 of the book referred to above. The object is to determine the law connecting the length L and temperature θ of a standard metre bar from the following four observations :—

θ . . . . =	20°,	40°,	50°,	60°
l (the excess over 1 metre) =	·22mm.,	·65mm.,	·90mm.,	1·05mm.

The law deduced is

$$L = 999{\cdot}804 + 0{\cdot}0212\theta.$$

It is not, however, pointed out that the law would be different if the equation connecting x and y, in this case θ and l, were written to begin with in a slightly different form. On the contrary, the above solution is presented as if it were altogether beyond doubt.

In the working of the example as given by Kohlrausch, the equation is written

$$y - ax - b = 0;$$

but if it be written

$$cy - x - d = 0,$$

and exactly the same procedure as that adopted in evaluating a and b be followed in determining c and d, the law thence deduced from the observations becomes

$$L = 999{\cdot}800 + 0{\cdot}0213\theta.$$

It will be seen that the constants in these two laws differ by one in two hundred, or 0·5 per cent., as regards the significant figures; and that from the precisely similar way in which they are obtained, they are each equally entitled to recognition.

In fact, corresponding to the values for a and b usually given, viz. :—

$$a = \frac{\Sigma x \Sigma y - n\Sigma xy}{(\Sigma x)^2 - n\Sigma x^2}; \; b = \frac{\Sigma x \Sigma xy - \Sigma x^2 \Sigma y}{(\Sigma x)^2 - n\Sigma x^2},$$

there are always another pair of values, giving the second form of the law, viz. :—

$$a' = \frac{(\Sigma y)^2 - n\Sigma y^2}{\Sigma x \Sigma y - n\Sigma xy}; \; b' = -\frac{\Sigma y \Sigma xy - \Sigma y^2 \Sigma x}{\Sigma x \Sigma y - n\Sigma xy}.$$

The first pair of values corresponds to the supposition that the x measurements are guaranteed correct, and the experimental errors are all confined to the y measurements; and the second pair corresponds to the supposition that the y measurements are correct and the errors are all in the x measurements. The two lines

$$y = ax + b$$
$$y = a'x + b'$$

intersect at the centre of mass of the system of points obtained by plotting the observations.

The question naturally arises: How shall a relatively small number of observations, or a series of observations which are relatively discordant, be made to furnish the best mean result obtainable when no other observations are available?

In order to answer this question, we may recur to the remark above that differences in the result are obtained by writing the equation in different forms. The various forms of the equation correspond to the several directions in which the divergencies of