most remarkable experimentalists of the time. The next two Fullerian professors were Dr. Odling and Dr. Gladstone, and the fourth was Professor Dewar, the present occupier of the chair, who was appointed in 1877. Continuing the work initiated by Faraday on the liquefaction of gases, he has succeeded in proving by experiment that, as indicated by theory, there is no such thing as a 'permanent gas;' for, since his recent liquefaction of fluorine, helium and hydrogen, no known gas remains that has not been reduced to the liquid state. His work has opened up an entirely fresh field of physical research, and, rich as the first results have been so far, they are in all probability only small in comparison with those which will be obtained by further investigation of the properties of matter near the zero of absolute temperature.

The Institution has undoubtedly been fortunate in the professors who have worked in its laboratories. But even genius cannot do much without opportunity, and, therefore, some of the credit is deserved by the long succession of officers and members of the Committee of Managers, who have for a hundred years looked after its business affairs and guided it safely through many vicissitudes, not only without fee or emolument, but at the expense of much time and not infrequently of much money. In this connection it is interesting to note that the presidency almost seems to have become an hereditary appanage of the Dukes of Northumberland, for, with the exception of the years between 1865 and 1873, when it was held by Sir Henry Holland, it has been in their hands continuously since 1842. Mention, too, must be made of what the members themselves have done. Over and above their regular subscriptions, they, with their friends, have contributed since 1863 something like £13,000 to the fund for the promotion of experimental research, and it is safe to say that had it not been for this fund English science in general would have been the poorer, and the Royal institution in particular would not possess the international reputation it bears to-day—a reputation won, be it remembered, in the good old English way, without state subvention or government aid. Modern scientific research daily becomes more costly, because apparatus grows in delicacy and complication, on the one hand, and in size and weight, on the other, and thus there arises a proportionate increase in the need for individual generosity. The fact that such pecuniary aid has been forthcoming in the last century warrants the expectation that the stream of benefactors to the Royal Institution will not fail in the next, and that they will enable it to point to as proud a record on its second centenary as it now does on its first.

SCIENTIFIC BOOKS.

The Elements of Practical Astronomy. By W. W. Campbell. New York, The Macmillan Company. 1899. Second Edition, Revised and Enlarged. Pp. xii + 264. Price, $2.

This second edition of a work favorably known to American astronomers who are charged with the duty of instruction appears in bulkier form and better mechanical execution than its predecessor, but with its general character not very greatly altered. Its merits and defects are to be estimated from the standpoint assumed by the author, who assures us that "My experience in presenting the elements of practical astronomy to rather large classes of students in the University of Michigan led me to the conclusion that the extensive treatises on the subject could not be used satisfactorily, except in special cases." In this opinion we heartily concur and, absolving the author from obligation to deal with the more specialized and recondite parts of his subject, we find his self-imposed task properly expressed in the words "It is intended that this book shall contain the elements of practical astronomy with numerous applications to the problems first requiring solution." For this

purpose one may properly enough select the conventional material and methods found in such authoritative treatises as those of Chauvenet and Bruennow, and for the most part this has been done in the present work with great fidelity, although the author has found room for some few ameliorations of astronomical practice. The material selected for presentation is that leading up to the determination of time, latitude and azimuth with portable instruments, together with a brief treatment of the meridian circle and equatorial telescope and a welcome chapter, not usually found in such works, upon the surveyor's transit. This really efficient instrument has been strangely neglected by astronomers, and its astronomical capabilities find scant appreciation even in the present work, whose author, doubtless through a slip of the pen, appears to consider the accuracy attainable with it to depend upon the least count of the verniers. A further most welcome innovation, which the author has not seen fit to make here, but which we bespeak for a future edition, would have been the introduction of an elementary treatment of the spectroscope considered as an adjunct to the equatorial telescope.

As a whole the work may be cordially commended, but its general excellence is marred here and there by sins both of omission and commission. Opinions may differ as to the author's wisdom in appending to the text a bald exhibit of the principal formulæ of the method of least squares, with no pretense at their derivation and with but little explanation of their use, but surely 'the best modern practice of observing' does not justify the giving up of four per cent. of the entire treatise to such antiquated matter as lunar distances and the ring micrometer, nor does the scope of a beginner's book seem to call for giving up another four per cent. to diurnal parallax as affected by the earth's compression, although precedent for such treatment may be found in the standard works.

The author's methods of observation and computation are for the most part those of Chauvenet, an excellent model for half a century ago, but one which now admits of improvement in respect of formulæ to be employed for the reduction of observations. The general introduction of addition and subtraction logarithms into all the better logarithmic tables in common use has removed that supposed necessity for 'adapting formulæ to logarithmic computation' under which the older writers labored, and in many cases permits their formulæ, and those of Professor Campbell, to be considerably simplified. An instance in point may be found at p. 107, where the author derives the hour angle of a star from its measured altitude through the formula for $\tan \frac{1}{2} t$ and is obliged to write down seventeen numbers for this purpose. The same result may be derived through $\cos t$ and the addition and subtraction logarithms with thirteen numbers, and the latter result is in no wise inferior to the former in respect of the unavoidable errors in logarithmic computation. In this particular case the two methods, when applied with five-figure logarithms, give results which differ by only one second of arc, after correction of two errors in the the author's computation which make his printed hour angle $74''$ wrong.

A similar case occurs at page 199, where the author introduces the parallactic angle into the formulæ for determining the azimuth of a circumpolar star when its declination, hour angle and the latitude are given. In the example given to illustrate these formulæ and solved at p. 201 with six-figure logarithms the author writes down nineteen numbers in order to pass from t to A, where the ordinary formula which furnishes $\tan A$ directly in terms of the data permits the transformation to be made with eleven numbers. In respect of precision the short method has an even greater advantage, and when applied with five place tables will in general give results as precise as can be obtained with six place tables by the method of the text.

Throughout his entire work the author appears to have ignored the advantage offered by addition and subtraction logarithms, with results distinctly unfavorable to his formulæ. Another example of correct and conventional but cumbrous methods of reduction may be found in connection with the readings of a spirit level, p. 80. By the use of diagonal differences the result may here be found and checked without writing down a single figure.

The rather tedious treatment of the transit instrument in 45 pages contains no reference to two innovations, the most important since the invention of the chronograph, which have been successfully introduced into modern European practice with this instrument. The invention of the transit micrometer has furnished a simple and effective means of almost perfectly eliminating the influence of personal equation in transit observations, and the practice which has come into vogue in connection with this micrometer, of reversing the instrument upon every star observed, equatorial as well as polar, is revolutionary in its effect upon work with a portable transit. This reversal may be employed equally well with any good form of transit, and furnishes the very great advantage of automatically eliminating from the observation of each star a host of errors, such as the effects of collimation, flexure, ineqality of pivots, etc., and the further signal advantage that the number of unknown quantities in the observation equation furnished by the star is reduced from the three or four recommended by the author to two. A work in which these advances are ignored is of doubtful service in 'illustration of the best modern practice' with the transit instrument.

The most serious general criticism to be brought against Professor Campbell's treatment of his subject is illustrated above; that he has not chosen methods and formulæ with sufficient reference to economizing the time and labor of the computer, although for the guidance of the latter, in matters left to his own judgment, there is furnished in Appendix A an excellent series of hints on computing.

Other points at which the author nods in varying degree from obscurity of statement to absolute error are the foot-note to p. 207 relative to projecting the sun's image upon a screen by 'focusing the eye-piece so that the images of the sun and wire are seen on the paper' and the statement, p. 75, that in the determination of the value of a revolution of a micrometer screw from transits of a star 'the effect of refraction is inappreciable if the observations are made near the meridian.' The first quotation is technically correct, but few students would infer from it that two distinct operations are to be performed, one of which in the ordinary type of instrument consists in moving the objective. The second quotation is quite wrong if more than three significant figures are required in the result and in the illustrative example given by the author, by neglecting the refraction he has vitiated the final result to an amount twice as great as the probable error which he assigns to it.

An error made with all the emphasis of italics requires that an altitude measured from the sea horizon shall be corrected for refraction before the dip of the horizon is taken into account, and another error occurs at p. 160 (and also in the first edition of the work) where the rate of a chronometer is represented as a linear function of the temperature, although experience and theory alike indicate that the relation between these quantities must be expressed by an equation of at least the second degree.

It is very doubtful if a consensus of astronomical opinion could be brought to sanction the method of reduction of zenith telescope latitudes recommended by the author, viz: a least-square solution in which the value of a level division is introduced as an unknown quantity. Under all ordinary conditions the observations should be so conducted that the direct determination of this quantity shall far outweigh any value which can be derived from the latitude observations.

The mechanical execution of the work is excellent; it is provided with an adequate index and illustrated by cuts which are in the main well chosen, although here we regret that the author has selected as 'an excellent form of the prismatic (broken) transit' an instrument which is a complete failure and has been consigned to oblivion by the government bureau for which it was constructed.

G. C. C.

Infinitesimal Analysis. Vol. I., Elementary: Real Variables. By William Benjamin Smith, Professor of Mathematics in Tulane University. New York, The Macmillan Company. 1898. 8vo. Pp. xvi + 352. Price, $3.25.

The book in hand is the initial volume of a treatise in course of composition which is to