or the expenditure on laboratories and equipment which the work would entail. He has had no experience of co-ordinating research work with the operations of the factory or of estimating the progress made. In short, though the pamphlet does not say so in so many words, the manufacturer is accused of ignorance of the scientific side of his industry.

Having thus presented the difficulties on both sides, Mr. Humberstone, the author of the report, proceeds to formulate Dr. Duncan's scheme of industrial research fellowships.

"Under this scheme a contract is entered into between the manufacturer and the university in which the object of the research is precisely defined. The contract provides that the fellow selected to conduct the investigation desired shall devote his whole time to the research with the exception of three hours a week, which he may devote to instructional work in the chemical department. The fellow is a member of the university, and pays all the regular fees with the exception of fees for laboratory and supplies, for which the instruction he gives in the university is accepted in lieu, unless in the opinion of the university his demands become excessive, in which case the manufacturer who provides the funds for the fellowship is expected to reimburse the university.

"In some instances the manufacturer makes a specific grant for expenditure on apparatus. The contract further provides that the fellow shall work under the direction of the professor of industrial chemistry, and shall forward to the manufacturer periodically through the professor reports on the progress of the work. The manufacturer agrees to pay to the university an annual sum for the emoluments of the fellow during the tenure of the fellowship, which ordinarily extends to two years."

A clause follows relating to the proprietorship of inventions made by the fellow, providing usually for a payment of ten or some other percentage of the net profits arising from discoveries, to be commuted at the desire of either party for a sum fixed by arbitration, and there are certain other details in regard to the publication and use of the discovery.

The advantages claimed under this scheme are that the university profits by the presence of men engaged in researches, which, though utilitarian in their object, may often throw light on questions of purely scientific interest. The university also secures the services of post-graduate students as instructors, and the influence of such a body of men who are keen on their particular work and enthusiastic as to the value of research, is an asset of considerable value. The manufacturer derives advantage from the resources of the well-equipped laboratories, museums, and libraries, and from the facilities offered to the fellow for consulting the staff of his own and other departments of the university when unforeseen difficulties present themselves, whilst at the same time the manufacturer is free from the responsibility of selecting the specialist (which is done by the university) or of supervising his researches.

The advantages of the scheme to the selected fellow are obvious. He is brought into direct contact with a manufacturer and a specific problem, and carries on his investigation under the advantage of being free from interference by foremen or managers. He has also opportunities of consulting a well-appointed library, of obtaining assistance from colleagues, and occasion to test his process under industrial conditions. Moreover, the researches may be put forward in his candidature for the doctorate of the university. The report concludes with an account of the practical working of the scheme, and the remarkable variety of problems which have been submitted to investigation.

The only point which the writer regards as open to serious criticism is that the industrial research of whatever character, whether connected with organic, inorganic, or physical chemistry or physics, is conducted in a special laboratory under the absolute jurisdiction of the director of the industrial research laboratories, instead of being carried out in that department which is specially concerned with the particular problem. Apart from this, the scheme appears to offer many advantages in the present condition of the scientific industries in this country, as well as in America. Whether it is an ideal scheme is another question. It is true that in Germany there are chemists working out in the university laboratories problems which have an industrial object, but the great bulk of such research is restricted to the splendidly equipped works laboratories. The reason for this is a simple one. The managers are trained men of science (as many are in this country) who know the methods of research and the value of the research chemist. They have no need of a director of industrial research. They are in a position to direct it themselves.

J. B. C.

CONSTRUCTIONAL DATA OF SMALL TELESCOPE OBJECTIVES.

THE National Physical Laboratory has recently published through Messrs. Harrison and Sons a pamphlet with the above title. This has been prepared at the request of the Director-General of Munition Supplies, and is primarily intended for the assistance of manufacturers of optical instruments who are engaged in the production of optical munitions. The glasses on which the calculations are based are in all cases taken from the most recent catalogue of optical glasses issued by Messrs. Chance Bros. and Co., of Birmingham (February, 1915). The comprehensive character of the tables may be gauged from the fact that all the dense flints of this catalogue are severally combined with all the crowns, two dense barium crowns of high refractive index alone being excepted.

Although the theoretical conditions which it is desired to satisfy in the case of these small objectives are identical with those which determine the construction of large telescope objectives, other considerations which are of little importance in the one case can by no means be neglected in the other, and it thus happens that the

objectives described in these tables are not given the forms determined by the astronomical telescope conditions—freedom from colour, central spherical aberration, and coma—but one of these is deliberately sacrificed to enable the crown and flint components to be cemented together. This leads to the consideration of six forms of objective, three of which have the crown lens before the flint and three with these lenses in the reverse order, two forms of each set of three being free from colour and from central spherical aberration, and one free from colour and from coma. Each of these forms is described in a separate group of tables.

With most of the glass combinations one of the forms with the crown lens placed before the flint has the two surfaces of the crown lens of nearly equal curvature, and a set of tables is included devoted to lenses in which these curvatures are exactly equal. Such lenses offer the very considerable advantage when rapid output and low cost is of importance, of requiring only two sets of tools for their production, one set corresponding to the equal curvatures of the crown lens and the surface of the flint lens which will be cemented to a face of the crown component, the other set being, of course, for the second surface of the flint lens.

To each group of tables giving the constructional details of its own particular type of lens is added a table showing the amount of the aberration—coma or spherical aberration, as the case may be—which has unavoidably been retained in consequence of the restraint imposed by the condition that the two components are to be cemented to one another. A glance at these tables shows which form of objective and what combinations of glasses are the most suitable to employ in various circumstances. The physical interpretation to be placed on these quantities is explained in a note which prefaces the tables. For convenience in reference all the tables relating to one form of objective are placed on a single opening of the pamphlet.

The fundamental tables relate to lenses in which the thicknesses are negligible. A second set of tables is added, showing the alterations in focal length produced by standard thicknesses, which are taken to be $1/40$ th of the focal length for the crown component and $1/80$ th of the focal length for the flint lens, and also the corrections to the curvatures which are necessary to give the thick lenses the same focal length as those of negligible thickness. For convenience in making such corrections the principal set of tables give the curvatures of each lens surface in addition to their radii of curvature. The foregoing particulars suffice to show that the pamphlet should not only be of immediate use to those for whom it has more especially been prepared, but should prove of permanent value to all who are engaged in the construction of small objectives. It may be obtained from the publishers, Messrs. Harrison and Sons, 45 St. Martin's Lane, London, W.C.; price 2s. 6d., plus postage.

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The laboratory authorities state that it is hoped later to supplement this publication by a further paper dealing with the corrections which may be necessary for object glasses of somewhat larger size. They may also undertake further optical calculations needed to perfect instruments required by the naval and military authorities if it seems to them desirable.

T. SMITH.

R. W. CHESHIRE.

JEAN-HENRI FABRE.

IT is more than half a century since Darwin quoted Fabre in his "Origin of Species" and called him "that inimitable observer." Yet he has been with us and working till the other day—a resolute veteran, in spite of his extraordinarily hard and strenuous life, from which he wrung out the joys of discovery and devotion. In this sense he lived a successful life, and he had other rewards—the appreciative esteem of expert entomologists; the admiration of those who have enjoyed his intimate descriptions of the life and work of insects and his singularly vivid style; the encouragement of good friends, such as John Stuart Mill and Mistral; but one cannot escape the regret that, through imperfections in contemporary social organisation, his genius, which was marked by a unique blend of observing power and sympathetic insight, was through a large part of his life unduly distracted and inhibited by the cares of keeping up the supply of daily bread. Perhaps on his own side he carried the spirit of independence to an extreme. In any case there is a pathetic ring in his own words, a short time ago, about his life, that it "had not been exempt from many cares, nor very fruitful in incidents or great vicissitudes, since it had been passed very largely, especially during the last thirty years, in the most absolute retirement and the completest silence." The ten volumes of the "Souvenirs Entomologiques," many of the best chapters of which have been translated into English, remain as Fabre's lasting monument. They show us an observer of insects, second only to Réaumur, who was able, in a way all his own, "instinct pursuing instinct," as has been well said, to get at the insect's point of view.

After a somewhat disappointing early struggle as a professor at Ajaccio and Avignon, Fabre recoiled from conventionalities and settled down on a little desert corner near Orange, in the lower Rhone, and subsequently at Sérignan, and gave himself up to entomology. His studies were occasionally anatomical and physiological, and he watched many life-histories; but he was pre-eminently the student of animal behaviour. His work is marked by strong vitalistic convictions, organism to him transcending all mechanism; by a belief in instinct as a big underivable fact, quite different from intelligence; and by a strong prejudice against Darwinism, even against evolutionism. "The facts that I observe," he said, "are of such a kind that they force me to dissent from Darwin's