included. The information is mainly put in the form of tables and curves, and the latter have been reproduced in such dimensions that accurate interpolation of values on them is possible by the use of a rule graduated in decimal parts of a centimetre. The probable degree of accuracy of data is indicated, or implied, by the number of significant figures in the values given.

It is somewhat surprising to note that pure copper which has been cast and rolled and afterwards annealed at 500° C. to normalise it does not have its ultimate tensile strength stated more closely than 35,000±5000 lb. per sq. in., when it is remembered that after this treatment there is less variation between different samples than in any other condition. Such copper has no detectable elastic or proportional limit; *i.e.* annealed copper takes a permanent set with the slightest loads. On the other hand, when it is cold worked, rolled, or drawn, it does acquire a limit of proportionality, depending on the degree of work. Experiments at the Bureau have shown that modern hard-drawn copper wire is equally affected by drawing throughout the section, and that no hard or exterior skin exists. This has been corroborated by Peirce. The publication is a most useful one. H. C. H. C.

INTERFEROMETER DETERMINATION OF REFRACTIVE INDICES.

PROF. CARL BARUS has recently developed and extended certain of the methods described by him in 1916 in connection with the spectroscopic resolution of interferences obtained with interferometers of all classes from the simplest to the most complicated type.[1] Cases of special interest arise in which the interfering spectra are reversed or inverted relatively to each other.

Obviously, such methods may have a number of valuable physical applications, and among several examples to which Prof. Barus has given attention is the possibility of the determination of refractivity irrespective of form by immersion methods. In the method developed for this measurement (chap. iv., part ii.) the interferences produced by white light in a slightly modified type of Michelson interferometer are viewed with a telescope and prism-grating. Elliptical interferences are seen in the spectrum, which may be moved relatively to spectral lines by a micrometric change of path in one of the beams. A trough containing a liquid of adjustable refractive index, in which the solid under test may be immersed, is placed in this beam, and attempts are made to recognise equality in refractive index of solid and liquid by the fixity of fringes on immersion. Naturally, the fringes in the spectrum are distorted owing to unavoidable differences of dispersion, but it is disappointing that the method should have failed to give a sensitive indication of equality. It has, however, long been recognised that interference methods in most cases are inconvenient for direct refractometry; in reality, the recognition of the point of equality is the crux of the matter, for other more simple and direct methods are available for the measurement itself. In this connection an expedient used by the present writer in attacking the problem (Trans. Optical Soc., December, 1916)—that of varying refractive index in the liquid by differential evaporation while homogeneity is secured by mechanical stirring—might possibly lead to success. The fringes could then be observed continuously and the necessity for separate steps avoided.

The detection of *variations* of refractive index in unworked glass is one of the most important problems for modern optics. These variations, which are due to irregularity of composition, frequently affect the fifth decimal place, but cannot at present be detected until optically worked surfaces have been given to a specimen. It seems possible that the difficulty may be overcome by an interferometer-immersion method. It is too often assumed, however, that interferometer methods are of great delicacy in comparison with "definition" tests or the Töpler knife-edge test. Remembering Lord Rayleigh's rule, that disturbances should meet in an image with not more than a quarter wave-length difference of phase, it may be realised that the formation of a well-defined image is a fairly severe test of the homogeneity of the media of the system, having granted sufficient freedom from aberrations due to the form of the surfaces. If, in addition, the direct image is screened so that only the effects of irregularity are perceived, the test may apparently be made as sensitive as is desired by increasing the intensity of the source of light.

In conclusion, it may be remarked that the method of spectral interferences, although appearing to be exceedingly useful, has not yet been studied so exhaustively in this or other connections as to enable a final judgment to be passed upon it. L. C. M.

1 "The Interferometry of Reversed and Non-reversed Spectra." By Carl Barus. Parts i. and ii. (Publications of the Carnegie Institution of Washington, 1916 and 1917.)

FERN NOTES FROM PRINCE BONAPARTE'S HERBARIUM.

UNDER the title "Notes Ptéridologiques"[1] Prince Roland Bonaparte is issuing at irregular intervals fascicles of a publication dealing primarily with the fern collections in his private herbarium in Paris. The herbarium already contains about 300,000 specimens coming from all parts of the world. These have been derived partly by purchase or exchange from public or private herbaria or from individuals, and partly from Prince Bonaparte's own correspondents or from collectors and travellers with whom he is in touch. Thus many of the collections are represented in other herbaria, and the publication of the names of specimens which have hitherto been undetermined will be of service to other workers in the field of pteridology, while a systematic account of new collections will add to our knowledge of the ferns and of their geographical distribution. Prince Bonaparte is also pleased to receive on loan collections for determination, and will publish lists of the species.

The general arrangement is geographical, and each collection is treated separately under the heading of the continent from which it has been derived. The systematic arrangement and nomenclature adopted are those of Christensen's Index. A list of desiderata is printed at the beginning of each fascicle.

In an introductory note the older practice of relying solely on external characters for the determination of genera and species is adversely criticised. In the future more use must be made of anatomical characters; thus the scales and hairs, which are becoming increasingly important for systematic distinctions, may appear alike when viewed superficially, but on microscopic examination will reveal well-marked characters useful for specific delimitation. These characters, with those of nervation, will be found more trustworthy than those derived from the indusium, a transitory structure.

These little brochures should prove of considerable value to botanists who are interested in the systematic study of the ferns. We note that the Prince does not follow the rule of giving a brief Latin diagnosis of the new species, though there is often a good description

1 Paris: Imprimé pour l'auteur.

in French. There is, however, nothing to be said in favour of publishing lists of new species with no description or reference to such, as is done, for example, in the case of a number of Spruce's specimens from tropical South America. The fascicles are separately paged, and an index to each would facilitate reference.

SCIENTIFIC RESEARCH AND NATIONAL PROSPERITY.[1]

MANY, no doubt, do not comprehend what functions the research chemist can exercise in South Africa, and what scope the country can offer for his labours. Following the United States principle of the best men in the best posts, where, they ask, can we place him so that the country may, through his instrumentality, reap the greatest advantage? To answer such questions one needs, first of all, to consider how scientific research—and therefore, inferentially, chemical research—may be distributed. As a matter of convenience a threefold grouping is adopted—university research, industrial research, and national research. Adopting the definitions given by Mr. C. E. Skinner a few months ago at a meeting of the American Institute of Electrical Engineers, we may say that university research includes the pure scientific research, which naturally finds its home in the university, and all other research done there for the purpose of training men. Industrial research comprises all that done by or for industrial concerns with the purpose of advancing industry. National research is that carried on by the Government for the purpose of benefiting the people as a whole. Now it is plain that between these three types of research there can be no sharp lines of demarcation, but university research is often the stepping-stone to industrial advancement, while national research is repeatedly industrial in its objects.

Mr. Skinner rightly holds that the primary function of the university in research should be the training of research men, and that universities should be equipped to turn out research men just as they are now equipped to turn out men with academic and engineering degrees. Prof. G. G. Henderson has laid down the principle that the training of the chemist, so far as that training can be given in a teaching institution, must be regarded as incomplete unless it includes some research work.[2]

The demand for research in almost every field is growing with a rapidity wholly unprecedented, and to the universities alone can we look for men able and ready to take their places in the strenuous effort that is bound to be put forth on every side. We have just inaugurated a triple university system: Prof. Crawford, in his presidential address to this association at Maritzburg, asked, and sought to answer, what South Africa expects from its universities, and referred, in particular, to the need of encouraging the study of science and of furthering research. In developing this theme he asked us to remember that the highest form of research is not made to order, and that there is more in genius than industry and opportunity. It would benefit us to bear this in mind and, in juxtaposition with Prof. Crawford's words, to place a sentence from Mr. Skinner's address:—

"If it takes a genius to recognise a genius yet undeveloped, and properly to stimulate and direct that genius, how necessary it is that we place men of genius at the head of the research departments of our universities!"

It comes to this, then, that we should see to it that our universities are well equipped with scientific research workers, and it is pre-eminently desirable that a system of research professorships should be instituted, the chairs to be occupied by men of enthusiasm, men who will inspire a like zeal and devotion amongst those of the younger generation whom they gather around them, men of personality and character, who will kindle in the breasts of the research students feelings of admiration and respect for them and their work.

"In training research men," says Mr. Skinner again, "the university will naturally become the custodian and the promoter of pure scientific research." Here is the fountain-head whence we shall ultimately draw our men for industrial research and for national research; how important is it, then, that the source of all our supplies should be of crystal purity! Whatever more utilitarian form of research one may afterwards take up, research in pure science is invaluable in the earlier part of the research student's career, for it will give him a zest and a stimulus that will remain with him throughout, enrich his scientific imagination, and adorn all his later work.

At the same time, university research may lead to the most utilitarian results; some of the most important dyes, artificial alizarin, the phthaleins, indigo, and such drugs as phenacetin, antipyrin, and aspirin, were all discovered in university chemical laboratories.

Now why have we so few persons doing research work in South Africa? Is it in part because no research geniuses are born, or is it that we fail to recognise them, and neglect to provide them with the essential facilities?—youths, maybe, on whose humble birth fair Science frowned not, flowers born to blush unseen and waste their sweetness on the desert air, mute, inglorious Miltons whose genius remained latent because we took no trouble to draw it out?

Dr. P. G. Nutting about a year ago said that some writers have spoken of the investigator as a rare individual, to be sifted out from educational institutions with great care for a particular line of work. My personal opinion is that a large percentage of the men students are fitted for research work if properly started along the right line.

What we in South Africa lack—next to the facilities for research—is not so much the research students as the men to start them on right lines. I think that Principal Beattie, at the inauguration of the University of Cape Town three months ago, sounded the correct note in observing that the youth of South Africa did not lack enthusiasm or ability for research, but they lacked opportunity, and, he added, much depended on the men they had as professors. That is the secret of it all. In this dread war South Africans have more than once exhibited a physical courage and a pertinacity equal to anything that Australia or New Zealand could show; why should not South Africa, then, produce a Bragg or a Rutherford as well as Australia and New Zealand, seeing that intellectual courage and pertinacity are two indispensable qualities in a successful research worker? The position is analogous to that which war has developed in Europe and America: there the opportunity has made the man. An American chemist said that "the German General Staff has learned, if others have not, that German chemical achievement, which is great indeed, is no sign that equal ability does not exist elsewhere. The Allies and America improvised a munitions industry in two years to match their machine of forty years' preparation"; and then he

[1] From the presidential address delivered by Dr. C. F. Juritz before the South African Association for the Advancement of Science at Johannesburg on July 8.

[2] Report British Association, Newcastle-upon-Tyne, 1916, p. 374.