

series with stars of the "Orion" type, which by transitional stages were succeeded by the Sirian and solar stars, and then by stars with fluted spectra. An important advance has now been made in establishing the place of the bright-line stars of the Wolf-Rayet class as immediately preceding the stars of the Orion type. The spectra themselves do not indicate whether the series begins or ends with the bright-line stars, but that it begins with them is probable from their general spectroscopic resemblance to nebulae. One piece of evidence on this point does not seem to have been followed up as closely as its importance calls for; on p. 141 it is stated that the green line  $\lambda$  5007, which has hitherto been regarded as specially characteristic of nebulae, is sometimes present in the Wolf-Rayet stars. If this be the case there would seem to be no possible doubt that the bright-line stars are the first results of nebular condensation; but we find no further reference to this interesting point in the detailed description of spectra.

A considerable part of the volume is occupied with detailed accounts of typical spectra which are exceedingly valuable, and the descriptions of the various classes of bright-line stars will be especially welcomed by other investigators. The discussion apparently indicates that the forms most closely resembling the planetary nebulae are those in which there are no dark lines in the spectra, while succeeding stages are represented by stars in which dark lines are gradually introduced, until finally the Orion type of spectra, usually consisting wholly of dark lines, is reached.

Three catalogues are given. One of them brings together the stars belonging to each of the spectroscopic groups; another is a general catalogue with the stars in order of right ascension; and still another is an index to the stars, both northern and southern, which have letters assigned to them. In the last named, the nomenclature previously employed for the spectra of the northern stars has been converted into the new system adopted for the present volume. It will thus be seen that no pains have been spared to provide every convenience for those who may have occasion to use the catalogues for purposes of reference.

Besides the catalogues there are several tables of the wave-lengths and intensities of the lines in the various sub-groups of the bright-line stars and stars of the Orion type, and in some cases the wave-lengths extend into the visible spectrum as far as  $D_{\beta}$ . It is only in the more obvious cases, however, that an attempt has been made to assign origins to the lines, but the determination of origins is perhaps wisely avoided unless the work of a laboratory goes hand in hand with that of an observatory. Still, one cannot help regretting that the tables of enhanced lines published by Sir Norman Lockyer have not been utilised in this connection, especially as there are distinct indications that some apparent difficulties might thus have been removed. Thus, on p. 186 it is stated that in the spectrum of  $\alpha$  Cygni there are two lines of greater wave-length than  $H_{\beta}$ , which are "well marked and agree in position and intensity with the helium lines 4922 $\cdot$ 1 and 5015 $\cdot$ 7 as present in the spectra of the Orion stars. It appears far more probable, however, that these are solar lines." The probability is that these lines, like so many others in  $\alpha$  Cygni, according to Sir Norman Lockyer, are enhanced lines of iron, their wave-lengths being 4924 $\cdot$ 1 and 5018 $\cdot$ 6, which are curiously near to two prominent lines of helium. It seems very likely also that a reference to enhanced lines would throw much light upon such spectra as that of  $\eta$  Carinae (Argûs) and possibly upon other "peculiar" spectra.

Again, the descriptions of typical spectra clearly show that among the first additional lines introduced in passing from the Orion to the Sirian stars are 4233 $\cdot$ 6, 4173 $\cdot$ 6, 4179 $\cdot$ 5 and 4385 $\cdot$ 2, which are doubtless enhanced lines of iron at corresponding wave-lengths; these lines, how-

ever, are simply regarded as "characteristic solar lines" (p. 154), although as the true solar stage is approached they cease to be conspicuous.

Among many interesting results, it may be mentioned that a few stars have been found to have spectra resembling that of  $\alpha$  Cygni, which hitherto had been practically the only representative of its type. The detailed description of the spectrum of  $\gamma$  Velorum (Argûs), the brightest star of the Wolf-Rayet type, is also worthy of special mention.

The volume is enriched by three fine plates, one of which illustrates six typical spectra; another shows six examples of "peculiar" spectra, including  $\zeta$  Puppis and  $\gamma$  Argûs; while the third exhibits, by direct enlargements of portions of three spectra, the vast amount of fine detail portrayed by the prismatic camera.

Great praise is due to all who have taken part in this magnificent piece of work.

A. FOWLER.

#### FOREIGN INDUSTRIAL COMPETITION AND TECHNICAL EDUCATION.

ON the occasion of the prize distribution to the students of the Goldsmiths' Institute at New Cross, on December 12, Mr. Balfour made some remarks on technical education and its bearing upon foreign competition which are worthy of comment. With the optimism which characterises this statesman's utterances, he expressed the opinion that although

"unquestionably there was a time when we ignored the great need for a thorough scientific and artistic training in connection with our great industries," yet he was "not sure whether we are not now verging upon the opposite danger to that which we ran a few years ago," for there was a tendency, in some quarters at all events, to "talk as if the only thing which had to be done to restore British manufactures to their pristine condition in the world's industries was a manipulation of our methods of education."

Mr. Balfour then went on to say that he placed no faith whatever in the arguments which he constantly heard indicating the relative decay of British manufactures, and deprecated the tendency, which he characterised as a "dangerous fallacy," of supposing

"that every successful and prosperous manufacture started by any other nation but our own was a kind of robbery committed on British trade," for we ought to be satisfied with the reflection that, "broadly speaking, the prosperity of one nation conduces to the prosperity of all nations, and we are not poorer, but richer, because other nations are rich."

As was to be expected, these self-satisfying sentiments met with full approval; but the distinguished speaker proceeded to introduce a little rift into his lute when he said,

"I look with perfect serenity upon the general increase of the world's wealth as long as I can be assured that in this country we organise our labour in such a manner that the best workman gets the greatest remuneration; . . . that there is no lack of well-trained and skilled persons in all branches of manufacture; and last, but not least, that those who lead industry in this country, the capitalists, the manufacturers and the managers, show that flexibility, that power of adaptation to the ever-changing needs of the world which is, of course, an absolute necessity if we are to make the best of the great advantages by which we have been enabled to meet the demands of the world in the matter of manufacture."

Mr. Balfour is apparently already assured on these points, but can this attitude be accepted by those who view the future of their country from a higher standpoint than that of an armchair political economy? Are we to stand calmly by and see the supremacy in industry after industry transferred to foreign shores until at last, like the inhabitants of a Gilbertian island, we are re-

duced to living by taking in each other's washing? The economical laws which apply to nations are much the same as those which govern individuals, but we have yet to meet the man who takes pleasure in his competitors' wealth on the ground that it conduces to his own prosperity. What is to be gained by burying our heads in the sand and announcing that no danger is in sight? With nations as with individuals, progress must cease when self-complacency begins.

Considering first Mr. Balfour's last proposition—Do the leaders of industry in this country show that flexibility and power of adaptation to changing needs which is absolutely necessary for meeting the demands of the world in manufactures? If we are to credit the statements of experts in almost every branch of trade, and the facts which are patent to our eyes, we must conclude that they do not. In the chemical industries, where, before all others, adaptation to rapid changes and the immediate utilisation of new scientific discoveries are of paramount importance, we have not only lost the supremacy we once possessed, but we stand at present in great danger, in the organic-chemical manufactures at any rate, of falling out of the running altogether. The chemical trade of Germany, built up almost entirely during the last forty years, now amounts to an annual value of about 50,000,000*l.*, of which about 10,000,000*l.* represents the value of the production of colouring-matters, synthetic medicinal agents, perfumes, and other coal-tar products. If we examine in detail the statistics of this latter branch, we find that the six largest German manufacturers alone employ more than 18,000 workpeople, 500 chemists, 350 engineers and technologists, and 1360 business men, managers, travellers, clerks, &c. In England, the birth-place and cradle of this industry, there are certainly not more than 30 or 40 chemists and 1000 workpeople employed upon it, and whilst our imports of colouring-matters have slowly increased, our exports to the world of these products, which, fifteen years ago, amounted to about one-fourth of those of Germany, do not now amount to a tenth part. Even in the home market we are only able to supply about ten per cent. of the total quantity of dye-stuffs our textile industries require. In the manufacture of synthetic medicinal agents, artificial perfumes, sweetening materials, photographic developers, &c., which are all outgrowths of the coal-tar colour industry, the matter is even worse, for these manufactures are almost non-existent in this country. Even in the "heavy chemical" trade, which has always been regarded as one of our staple industries, we find ourselves seriously assailed, and most of the important developments of recent years have taken place upon the Continent. We further stand in imminent danger of losing nearly three millions annually by the destruction of our Indian indigo industry in competition with the synthetically prepared indigo of Germany, because the study of organic chemistry has been so much neglected in this country that we have neither attempted to improve (until quite recently) the crude and wasteful methods of obtaining the natural indigo, nor devoted ourselves to discovering methods for its artificial production. Is it conceivable that an English firm of chemical manufacturers would be willing to devote, as the Badische Company have done, nearly a million pounds to experimental plant, and scientific investigations extending over twenty years, in an enterprise of this character?

If, again, we turn to the engineering industries, in which a pre-eminence may fairly be considered our birth-right, we meet with a somewhat similar state of affairs. In electrical engineering it is universally recognised that we must now concede the palm to America. Also in tool-making machinery, printing machinery, type-writers, &c., the American manufacturers are able to turn out better and cheaper work than our own. In machinery for chemical processes Germany has established a speciality,

whilst in the building of motor-cars—a very large and profitable industry directly developed out of the cycle industry—France by her superior workmanship has been able to obtain a monopoly. We are also outstripped by France in all those industries in which the native artistic taste of the workman plays an important part.

Although it could not, of course, be expected that we should excel in every branch of manufacture, can we consider, with such facts as these before us, that our leaders of industry show the requisite adaptability to modern conditions to which Mr. Balfour refers? or, in other words, are they sufficiently alive to the importance of applying science to industry in every branch of manufacture? Further, are we justified in saying "that there is no lack of well-trained and skilled persons in all branches of manufacture"? Are our technical schools, as Mr. Balfour appears to believe, turning out the men who will reinstate our lost or declining industries? Much as we may appreciate the excellent work which these institutions are doing for the general education of the masses, we are forced to the sorrowful conclusion that this is not so, and that so far as higher scientific education is concerned the results are far out of proportion to the enormous sums which have been devoted to their establishment. The fault for this in no way lies with the technical schools themselves, but with the want of system and incompleteness of our national education. In place of putting a coping-stone of technical knowledge upon an already sound and thorough education, these institutions are more often called upon to cram the elements of a science, or, worse, the details of its industrial application, within a minimum of time into the minds of school-boys or lads engaged in technical pursuits, who, through absence of a satisfactory educational foundation, are quite unfitted for their reception. The result too often is the entire extinction of any natural originality which the lad might have possessed, and the conversion of his mind into a machine for the unthinking performance of routine operations. How is it possible, for instance, that a chemist who, after a very insufficient general education, has acquired his knowledge of the science by a two or three years' course of study at a technical school, should equal in capacity his German colleague, who, upon the basis of a sound school education, has received a five years' training at a German University or Polytechnicum, where he has not only acquired a thorough grasp of his own and cognate sciences, but by carrying out investigations has been stimulated in originality and encouraged to seek new knowledge for himself? Except in the rare instances, where native genius is bound to come to the fore, the former can have no possible chance in competition with the latter. It is even a matter of but little moment whether the education of the German has embraced any technical instruction, as with the sound knowledge he possesses of the principles of his science he will soon learn in actual practice their technical applications, and when learnt can usually carry them much further. That nearly all the best positions of the chemical profession in this country are at present filled by German chemists, or by English chemists educated in Germany, is the best proof of the inferiority of our educational methods.

What we undoubtedly require is what Mr. Balfour satirically calls "a manipulation of our methods of education." We require a "system" in the educational fabric of the country, which, together with a better appreciation of the value of science in every industry, would do much to enable our technical schools to fulfil their proper function and to carry out the work which the country expects of them. That such a reform of our educational methods may be long in coming we may, however, well believe, when we hear a distinguished statesman and leader of philosophical thought fail so entirely to appreciate the needs of the case, ARTHUR G. GREEN.