Most of the chemical work so far carried out has been done on the erythroaphins-*fb* and -*sl*, as these have been available in the largest quantity and they are the most stable members of their respective series. They are tenaciously held on alumina or calcium hydroxide chromatograms, and although some purification can be effected on talc columns, chromatography has not been generally employed. Solutions of these pigments show an intense fluorescence which is red in daylight and orange in ultra-violet light. They have no definite melting point but decompose with considerable charring above 300°, and they cannot be sublimed even in a high vacuum. They are readily soluble in pyridine, much less so in acetone, chloroform and carbon tetrachloride and very sparingly so in ethanol, ether and the other common organic solvents. Solutions in aqueous pyridine, sodium hydroxide and sodium carbonate are bright green and deposit green amorphous precipitates on standing. They contain neither nitrogen, halogens, sulphur nor methoxyl (Zeisel). Erythroaphin-*fb* contains acidic hydroxyls (0.84 per cent active hydrogen; Zerewitinoff) and several C—CH₃ groupings (12.4 per cent; Kuhn—Roth). Considerable difficulty has been encountered in obtaining consistent analytical values both for these substances and for the xantho- and chrysoaphins owing mainly to their tenacious retention of small amounts of solvent, but the results of a series of analyses suggest that the erythroaphins have an empirical formula C₁₅H₁₂O₄.

Low solubility in suitable solvents and tendency to decompose at higher temperatures have prevented accurate molecular weight determinations; the acyl derivatives, although more suitable for this purpose, still give variable results. In the case of erythroaphin-*fb*, X-ray analysis of the crystalline material indicates a molecular weight of either 260 or 519 ± 3 per cent according to whether the unit cell contains eight or four molecules. The higher value is in better accord with the results of cryoscopic determinations on the benzoyl derivative and would also be more in keeping with the intense fluorescence and extremely sharp absorption bands shown by the pigment, so that we have adopted provisionally a molecular formula C₃₀H₂₄O₈ for erythroaphin-*fb*.

Hydrogenation of the erythroaphins in presence of a platinum oxide catalyst or reduction with sodium hyposulphite yields orange fluorescent leuco-compounds which are rapidly re-oxidized in air, suggesting the presence of a quinonoid structure in these pigments. The exact nature of the nucleus as well as the nature of the changes involved in the series of conversions protoaphin → xanthoaphin → chrysoaphin → erythroaphin are still obscure.

It is of considerable interest that there is a very strong general resemblance between the properties of the erythroaphins (even to the difficulty of analysis and molecular weight determination) and those of hypericin, the photodynamic colouring matter of *St. John's wort*^{4,5}, which has been provisionally formulated as a polyhydroxy-mesonaphthodianthrone derivative, and it seems not unlikely that they are related in structure. Using *Paramecium* as test organism, Prof. D. Keilin has shown that erythroaphin-*sl* is strongly photodynamic. It is noteworthy that Dhéré⁶ has already remarked on the similarity between the ultra-violet and fluorescence spectra of hypericin, lanigerin (chrysoaphin-*ln*), strobilin (erythroaphin-*st*) and the mould pigment oxypenicilliosin⁷.

Full details of the investigation here outlined will be published elsewhere. We record with pleasure our gratitude to Mr. H. L. G. Stroyan for his invaluable assistance in locating and identifying the various Aphididae which we have examined, and to Dr. W. Cochran for the X-ray crystallographic examinations.

¹ Sorby, *Quart. J. Micro. Sci.*, (N.S.), **11**, 352 (1871).

² Buckton, "Monograph of British Aphids", **2**, 169 (London, 1879).

³ Blount, *J. Chem. Soc.*, 1034 (1936).

⁴ Brockmann, Pohl, Maier and Haschad, *Naturwiss.*, **27**, 550 (1939); *Ann.*, **553**, 1 (1942).

⁵ Pace and McKinney, *J. Amer. Chem. Soc.*, **63**, 2570 (1941).

⁶ Dhéré, *C.R. Soc. Biol.*, **131**, 672 (1939); *Boissiera*, **7**, 423 (1943).

⁷ Oxford and Raistrick, *Biochem. J.*, **34**, 790 (1940).

INSTRUMENTATION AND CONTROL IN INDUSTRY

SECTION A (Physics) of the British Association held a symposium on September 14 on "Instrumentation and Control, including Electronic Devices". The discussion was opened by Sir Ewart Smith, who spoke on "The Contribution of Instruments to Industrial Progress".

"The instrument field is already a vast one and it is extending rapidly as the result of advances in physical science on the one side, and the ever-growing demands of industry on the other. Industrial processes are becoming more complex in detail and the size of the unit is continually tending to increase; in addition, there is the demand for higher efficiency, for continuity in operation and for better control of finish and consistency, all of which call for a higher degree of instrumentation. Better instrumentation in turn leads to still wider possibilities of technical progress."

Sir Ewart summarized the main stages in the historical development of instrumentation, to indicate the lines future progress might be expected to follow, and stressed both the dependence of modern industry on instrumentation and the need for a new outlook with regard to it. When a large and complex industrial plant may depend entirely on instruments for its automatic control, it is clearly time to regard these instruments not as accessories but as an integral part of the plant. They are, in fact, the heart and brains around which the process should be designed. Industry is now recognizing this important fact, and is attempting to secure the full potential benefits of automatic control in this way.

Relation between Research and Industrial Application

Sir Ewart directed attention to the way in which an industrial instrument is frequently developed from a laboratory instrument which has been designed to meet a need in research, and stressed the important part played in the development of the instrument from one stage to another by the 'development' or 'design' engineer. He emphasized the vital need which had been pointed out at several previous meetings of other sections, and by Sir Henry Tizard in his presidential address to the Association, for ensuring that Great Britain possesses a sufficient number of properly trained applied scientists to take the knowledge made available by the research worker and to put it to effective use in industry.

The applied scientist has a very large part to play in revitalizing the national economy of Britain, for upon his ability must depend progress in applying the large amount of knowledge which has been discovered by the research worker. The applied scientist's function is to be the essential link combining together the potentialities of research, the requirements of the user and the possibilities of fabrication and construction in the industrial field. Sir Ewart defined 'development' as "the process of bringing knowledge derived from research to the state in which it can be applied directly to useful ends". The development engineer must therefore be an applied scientist in the true sense of the term, and it has been in the training of such men that Britain has not made the best use of its potentialities.

Sir Ewart recalled that at a previous meeting of the Association he had defined research as "the process of gaining knowledge in a systematic manner by the study of phenomena, or by the examination and correlation of existing data". Much attention has recently been directed to the importance of research work as defined by the first half of this definition; but Sir Ewart stressed very strongly that the time has now arrived when it is proper to emphasize the importance of work defined by the second half. As knowledge becomes more and more specialized, the need for co-ordination of the various specialized fields increases—for without it existing knowledge cannot be applied promptly to industrial problems. It is, therefore, necessary to give very serious thought to methods of correlation, indexing and dissemination of detailed knowledge in a form suitable for the applied scientist to use. At the same time, the student must be taught how to find such knowledge when it is required.

Sir Ewart said that in order to make effective progress, it is far more important that the applied scientist should have the right approach than that he should possess a vast fund of detailed knowledge. The universities and technical colleges should aim primarily at training men to understand basic principles, to be critical and to think for themselves. Educationists and industrialists alike should make it their duty to see that a proper proportion of the best brains coming forward should be trained in this manner to undertake the vitally important and supremely interesting work of development and design over the whole industrial field. If a sufficient number of applied scientists is assured, industrial progress will be accelerated and the fruits of research will be used to benefit the community much more promptly than is normally the case now.

Standardization of Technical Terms and Equipment

As a corollary to the need for correlation of information, so that it is easily accessible to the applied scientist, attention was directed to the equal need for standardization of units, definitions and general methods of presentation. It is in general agreed that such standardization would be extremely beneficial; but when attempts are made to obtain it, difficulties arise immediately. These difficulties are undoubtedly very real; but it is certainly worth while making individual sacrifices in order to overcome them.

Sir Ewart suggested that the whole subject of education of the applied scientist, and the correlation and indexing of information to make his work more efficient, is one worthy of discussion by the British Association, which provides a natural forum for the

general consideration of such matters. This suggestion was warmly welcomed by the president of Section A, Sir Lawrence Bragg, who suggested that a special session should be devoted to these matters at a future meeting of the Association.

From the standardization of units and nomenclature, it is a natural step to the standardization of material things. Sir Ewart advocated a very much greater degree of standardization of equipment and components in order to reduce production costs, and to assist interchangeability. It was made quite clear that it was not intended that this standardization should apply, for example, to complete instruments, but only to those dimensions or components of instruments which are commonly used. Far from hampering progress in design, such a measure of standardization would accelerate progress—as has been clearly demonstrated in other fields where standardization had been applied. Sir Ewart quoted the instance of the recent discussions between the United States, Canada and Great Britain on the standardization of screw threads. Here a major degree of tentative agreement has been reached, and it is hoped that all concerned will do whatever is possible to bring the discussions to a fruitful end. By putting off the problem to a future date the difficulties are only increased. They should be tackled now in a realistic and effective manner, instead of leaving them to increase in difficulty year by year.

In conclusion, Sir Ewart said that to obtain the most rapid progress in instrumentation, it is essential to adopt a progressive and critical outlook; to ensure that a large number of properly trained applied scientists are available to industry; to obtain acceptance of common standards of measurement and nomenclature; to index available knowledge to make it easily accessible; to increase the measure of standardization of some types of equipment, and to make sure that industrial processes are designed to give full scope to the potentialities of automatic control.

Use of Electronic Instruments in Iron and Steel Making

The need for good presentation of basic principles and good design was again stressed by Mr. S. S. Carlisle in his paper on "The Use of Electronic Instruments in Iron and Steel Making". The iron and steel-making industry is at present carrying through an extensive programme of modernization and development, and is thus finding wide use for the latest techniques of industrial measurement and control. There is, however, an understandable tendency to adopt techniques which are firmly established as reliable and suitable for continuous operation in the particularly rigorous conditions encountered. Those responsible for operating steel plant are keenly interested in electronic instruments; but sufficient confidence has not yet been inspired in electronics to create a great demand for them.

Mr. Carlisle believes there are three main reasons for this. In the first place, very exaggerated claims have been made for electronics as a solution to every problem. Secondly, the impression has not been dispelled that electronic equipment is fragile and inevitably extremely complicated. Thirdly, insufficient attention has been given, in general, to the design of electronic equipment to meet the requirements of the heavy engineering industry—which are robustness, continuous operation and immunity to large temperature variations, to dust, to fumes and to vibration.

A great wealth of information has been made available by research work; but design technique, it was suggested, has not progressed sufficiently rapidly to use this information to the best advantage for industry. The development of the operating principles and of the techniques of using the thermionic valve has progressed at such a pace during the war years that the establishment of sound design technique applicable to industrial use has been rather left behind. This may result from the ease with which thermionic valves can be used to construct measuring devices without the necessity of giving a great deal of attention to good engineering design. There has also been a tendency to instal such instruments on the plant before they have been sufficiently tested and developed.

Mr. Carlisle said that the greatest help to a proper application and use of electronics in industry would be rendered by the clear presentation of the basic principles used. The number of actual electronic components necessary to build up equipment for instrument needs is small, and a thorough understanding of the characteristics and limitations of these components and the circuits into which they are built would immediately remove much of the suspicion with which electronic equipment is regarded by those who run industrial plants. Mr. Carlisle proceeded to illustrate his general points by reference to particular types of installations, and then described in some detail the problems of temperature measurement in the steel industry and the methods used to overcome them. Unfortunately, there was insufficient time for Mr. Carlisle to give descriptions of several instruments which had been developed specially for the steel industry; but these, no doubt, will be published in the literature in due course.

In summing up his remarks, Mr. Carlisle suggested that electronic instruments will ultimately find preference over the established systems because of their greater flexibility, in design and application, their simplicity and their suitability for production in large numbers at low cost. There is clearly a strong argument for their use when so large a proportion of the measurements required are, or can be, made by primary measuring elements giving an electrical output. It was emphasized once again that the information and the components are available; it only remains to provide good application technique and sound design for the arduous operating conditions experienced in the heavy engineering industries.

Servo Mechanisms

No better example of what can be done in a specialized field to implement Sir Ewart Smith's plea for better training, more correlation of specialized knowledge and more standardization of terminology, etc., could be found than in the work described by Prof. K. A. Hayes in his paper on servo mechanisms.

The rapid development required for Service needs during the War led to production of a new fundamental theory and a new approach to design. It also led to a new technique for testing—which in itself is of very considerable scientific interest. The complexity of the equipment called for a new type of technician capable of dealing with the intricate circuits and mechanisms evolved; for example, in the No. 10 Predictor there are several servo mechanisms and numerous three-stage amplifiers connected in a very complicated manner. To maintain such equipment in the field, it was necessary to train

a large number of men who could think for themselves and use their initiative in carrying out repairs in the field. The ability to reason was called for in a high degree.

It fell to the lot of the Military College of Science to take a large part in working out a suitable training scheme and putting it into operation. The methods of teaching adopted should be of great interest to those in industry who have similar—although perhaps less complicated—problems to deal with. Although this training scheme was worked out for the maintenance man as opposed to the design engineer, it was initiated with the same intention as lies behind Sir Ewart Smith's suggestions. It was designed to inculcate ability to think rather than to amass a large amount of detailed knowledge—which in this instance would have proved useless in the field.

Prof. Hayes outlined the growth of servo mechanism technique, which had achieved rapid advances in the period 1925–38, and even more rapid advances since, during the Second World War. It was recognized by the Services at an early stage that the degree of accuracy required for gunnery, navigation, etc., could only be achieved by the use of automatic computing and controlling devices. Establishment of the underlying fundamental principles of the theory of position control followed quickly, and upon these principles the war-time success in the application of servo mechanisms was built up.

It is interesting to note the high order of performance demanded of the equipment required. For example, even a comparatively light gun weighs a matter of several tons, has a moment of inertia of order 10^6 lb./ft.² units, and yet may be required to move at rates up to 30° /sec. with an acceleration of as much as 10° /sec./sec. It must be trained to coincide continuously with the directing device with an accuracy of a few minutes of arc. The precision of the servo mechanisms was such that the limit to the accuracy of the whole system in this kind of application was normally set by that of the gears and bearings, and the rigidity of the frame and mounting, etc., of the heavy equipment to be moved.

A simplified example of position control was shown to illustrate the fundamental techniques employed. The importance of 'monitoring feed back' was stressed, and the difficulties introduced by the 'stiffness', natural period of oscillation, and lags in the system, were indicated. Time did not permit any detailed discussion of the correcting controls necessary to overcome them.

The amount of work proceeding in various Service establishments during the War on servo mechanisms was such that in order to spread the available information among all concerned and to stimulate discussion among them, the Ministry of Supply Servo Panel was suggested by Dr. A. K. Soloman and was formed under the chairmanship of Sir John Cockcroft, who was later succeeded by Prof. D. R. Hartree. The Servo Panel held regular meetings at which papers were read and discussed in the manner of a learned society, and special panels were set up to deal with particular aspects of the problem.

It is interesting to note how the Servo Panel performed many of the functions of correlation and codification of information, standardization of nomenclature and terminology, which Sir Ewart Smith had already stressed as being so vital to the applied scientist in the whole industrial field. Prof. Hayes reminded the meeting that the library of the Servo Panel, which contains one of the most comprehensive

ranges of books in existence on servo technique, is still available in the Ministry of Supply.

In conclusion, Prof. Hayes, commenting on the general nature of servo mechanism theory, said that the testing techniques evolved are being used to examine the nervous and muscular response of human beings, and that Prof. Tustin has suggested that the theory will predict the oscillations of an economic system.

The two papers which followed were more specialized. Dr. Uttley's paper directed attention to the great utility of servo mechanisms in the field of automatic spectrophotometry and, therefore, followed on very fittingly from the general discourse given by Prof. Hayes.

Dr. D. Gabor's paper, "Microscopy by Wave-Front Reconstruction" (see also *Nature*, 161, May 15, 1948), was not related directly with those which had preceded it. The new method of obtaining increased resolving power is expected to be of great importance in electron microscopy; and calculations show that it should be possible to obtain a resolving power of one Angstrom unit—which would make it possible to resolve the atomic structure of molecules which are not suitable for the usual methods of structure analysis. An interesting demonstration of the method, using an optical model, was given later in the day.

A. J. YOUNG

OBITUARIES

Prof. Johan Hjort, For.Mem.R.S.

THE scientific work of Prof. Johan Hjort, who died on October 7, shows three overlapping phases. As a young man, after his university training at Oslo and Munich, he spent some time at the Zoological Station in Naples (where he met MacBride and Boveri) investigating a problem of pure zoology, the development of the bud in the ascidian *Botryllus*, with special reference to the germ-layer theory, then in full vogue. His paper, published in 1896 (*Zool. Res. Norwegian North Atlantic Expedition*), is still regarded as outstanding by modern experts on the group. Until 1900 he was lecturer in zoology at the University of Oslo and seemed headed for an academic career. But even in this first phase his interests turned to the sea and its practical problems, for it was in 1897 that he made his first discoveries about the Norwegian prawn and its commercial possibilities.

His great period as a marine biologist and fishery expert began in 1900, when he was appointed director of fisheries in Norway, a post he held until 1916. He had at his disposal an excellent research vessel, the *Michael Sars*, and made extensive cruises in her, not only in Norwegian waters but also so far afield as Spitsbergen and Jan Mayen. Hjort was always happy in a ship. His investigations were not only scientific but also practical, for he had always the welfare of the fishermen at heart. By charting the distribution of the pelagic eggs of the cod, he was able to discover lucrative banks that had never been fished before, the high concentration of eggs indicating the presence of great spawning shoals; the results of this early work were published in "Fiskeri og Hvalfangst i det nordlige Norge" (Bergen, 1902). He advised the International Council to undertake a co-operative study of the spawning areas of the Gadoid fishes, and was largely responsible for organising the

research, which resulted in the publication in 1909 of the classical report of "Committee A" (*Rapp. Proc. Verb. Inter. Council*, 10).

Hjort's greatest achievement in this brilliant period was his elucidation of the problem of good and bad years in the herring and cod fisheries of Norway. With the help of able assistants—Dahl, Damas, Lea and Sund—Hjort made a vigorous attack upon the practical problem of why these fisheries showed such big variations from year to year. It happened, fortunately, that at the time when Hjort's work started, the technique of age-determination in fish by means of scales and otoliths was just being worked out. Under Hjort's direction this method was applied with great success to the study of the herring, particularly by Einar Lea, and it soon became established that the main cause of the fluctuations in the great spring herring fishery was the success or failure of the individual broods or year-classes composing the stock. Thus it was found that the 1904 year-class was remarkably abundant, and predominated in the catches for many years, while succeeding year-classes were very poor. Similar methods applied to the Norwegian cod, supplemented by extensive measurements, demonstrated the existence of specially prolific brood-years, as, for example, those of 1904 and 1912, while other years contributed little to the stock. Preliminary results for the herring were published by Hjort and Lea in 1911 (*Pub. de Circ.*, No. 61) and a full study of the question by Hjort in 1914, in an extensive paper on "Fluctuations in the Great Fisheries of Northern Europe" (*Rapp. Proc. Verb.*, 20). In 1914, at the request of the Canadian Government, he investigated on the spot the herring of the Gulf of St. Lawrence and adjacent waters, and found that their age-composition was similar to that of the Norwegian herring.

The study of fluctuations and their possible causes, initiated by Hjort, became a principal theme in all fishery and marine biological research for many years, and at Hjort's instigation it was frequently discussed at the International Council, particularly in the special scientific meetings which he introduced in 1926 (see, for example, *Rapp. Proc. Verb.*, 65 and 68; 1930). Hjort returned again and again to this problem, right up to the last.

Hjort was above all a great biologist, with a profound interest in, and understanding of, the relations between the organism and its environment. This is made particularly clear in the chapter on general biology which he contributed to that admirable book "The Depths of the Ocean" (1912), familiarly known as "Murray and Hjort". This book was the outcome of a four and a half months scientific expedition in the North Atlantic in 1910 in the *Michael Sars*, chartered for the purpose by the famous oceanographer Sir John Murray. The cruise gave Hjort a renewed interest in the general problems of marine ecology.

After his retirement from the post of director of fisheries in Norway, Hjort became a professor at the University of Oslo, and the third phase of his scientific odyssey began. Though he still retained his keen interest in fishery problems and continued to be a dominant figure in the International Council, his mind turned more towards general scientific and social questions. He gave much time to private study, including a period spent at Cambridge.

In 1921 he published a small book on general scientific method, "The Unity of Science", and in 1931 a larger volume called "The Emperor's New