matching field. H. G. Sperling (U.S. Naval Medical Research Laboratory, New London) examined the assumption of standard colour theory that the relative luminous efficiency function V_λ is a linear combination of the colour-mixture functions, measured for the same subjects. Using the flicker method for determining V_λ he found the assumption substantially true for wave-lengths greater than about 520 mμ. but below that wave-length discrepancies of the order of 15 per cent appeared.

N. T. Fedorov (Leningrad) reported rather similar discrepancies. While the practical repercussions of these blemishes on the ideal linear and additive system of colorimetry may be slight, their causes are of considerable interest in visual theory. For a large matching field, some of the observed small breakdown in additivity (high intensities) is attributable to the intrusion of rod vision. Such effects may be expected to increase if the matching field is centred not on the fovea but on an extra-foveal point. M. M. Bongard, M. S. Smirnov and L. Friedrich (Moscow), working on extra-foveal colour-matching, 10° out from the fovea, by the method of successive instead of juxtaposed presentation of stimuli, conclude that colour-vision there is essentially four-dimensional, not three-dimensional, the fourth fundamental spectral sensitivity being that of the rod mechanism. Matches made using four primaries were stable under variations of field intensity and adaptation while the approximate matches obtainable with three primaries were not.

The matching of colours produced by stimuli applied to different retinal areas, in the same or in opposite eyes, which are in different states of colour adaptation has been actively studied in recent years, the case when only foveal (rod-free) areas are used being of particular importance. New measurements by E. N. Yustova (Moscow) of the colour changes as the foveal retina adapts to the stimulus colour itself showed the very large effects produced. In an attempt to explain a large class of these phenomena, D. L. MacAdam (Eastman Kodak Research Laboratory) was led in 1955 to postulate the operation of up to six independent spectral sensitivities in foveal vision. A new analysis by R. W. G. Hunt (Kodak Research Laboratory) showed that three may still suffice if signals in the optic nerve are not linearly related to the photochemical absorptions in the end-organs and if the non-linearity depends in a suitable way on the colour-adaptation of the retinal area. In his contribution to this symposium, MacAdam adopted a point of view close to Hunt's and with the aid of some specific hypotheses, which seem to involve the transmission of the arithmetic differences of the responses (non-linear) of different receptors, he was able to explain his original results on colour-adaptation as well as some other psychophysical data.

Several contributors stressed the importance for colour perception of the time during which the retina is exposed to a particular pattern of stimulation (C. D. Farnsworth, U.S. Naval Medical Research Laboratory). The extreme situation is reached when, by suitable optical devices, the displacements of a retinal image produced by involuntary eye movements are nullified. R. W. Ditchburn (Reading), summarizing progress in this type of experiment, showed that a desaturation of hues—in some circumstances complete—may occur when stabilization of the retinal image is not sufficiently perfect to bring about complete loss of form vision.

Although only two papers dealt with questions of noise and quantum fluctuations in retinal response, the lively discussion provoked by the views and calculations of H. Barlow (Cambridge) on the intrinsic noise in cone mechanisms showed the continuing interest in this subject.

Brief commentaries on the essentials of all colour theories (Y. LeGrand, Paris) and on subjective colour measurement (W. D. Wright, Imperial College) provided a suitable introduction to the more detailed contributions reviewed above. The proceedings—papers and discussions—will be published shortly by H.M. Stationery Office. W. S. STILES

SAFETY IN THE CHEMICAL INDUSTRY

A SYMPOSIUM on "Safety in the Chemical Industry", arranged by the London Section of the Society of Chemical Industry, was held during October 14–15 at the Royal Institution. The chemical industry covers an enormously wide field of activity, and safety within it bears a direct relationship to manufacturing and handling, to safe transport and further handling by those who formulate and process the products of the primary producer.

In opening the symposium, Sir George Barnett, H.M. chief inspector of factories, dealt with the frequency rate of accidents in the chemical industry and mentioned that the figure for the chemical industry as a whole is 1·43 per 100,000 man-hours worked, as compared with 1·73 for the whole of industry. He also pointed out that a number of the larger chemical firms had frequency rates which were far better than the overall picture for the whole of the chemical industry.

He said that there were certain apparent dangers associated with the chemical industry, in the manufacture of poisonous substances, in the use of high-pressure vessels, in dealing with new reagents and intermediate substances and the instability of a large number of chemical substances, and in the continual exploration of the field in which new reagents and new catalysts are being used. Sir George laid particular emphasis on the importance of chemical design in relation to the health of the process worker and the maintenance worker and also stressed the point that technical knowledge and ability, foresight and imagination are necessary in planning and design. Within recent years, much chemical plant had, in his view wisely, been housed in the open air, and he pointed out the advantages of remote control in the operation of many chemical plants.

The discipline of safety in the chemical industry is perhaps at least as far developed as in any other industry in Great Britain, and this discipline is reflected in the frequency rates of accidents. Safety, *per se*, may be divorced from the actual day-to-day training of engineers, chemists and physicists within the chemical industry, but mention was made of a special course which is now being started at the Imperial College of Science, where the general principles of safety will be taught.

With the rapid expansion of the chemical industry since the War, the problems of plant design, erection and start-up have become of major importance. The significance of dealing with materials of high toxicity was stressed by Mr. K. M. Curwen in his talk on the

erection of a plant to produce new organo-phosphorus insecticides. He very properly emphasized the problems dealing with the flow sheet stage and mentioned, as did other speakers, the importance of considering flow sheets in relation to the more modern developments, and the erection of small-scale models so that all who are concerned with safety can study the processes as they concern the workers who eventually work on the plant, and the facilities which are given to them and to the maintenance staff during periods of overhaul and replacement.

Mr. T. Wardle and Mr. B. A. Weston, of the Ministry of Supply, talked of the precautions which are necessary in dealing with explosives and the significance of the Explosives Act in what might be termed 'good management'. Their paper described the effects of blast, flame, radiant heat, crater formation and the effect of flying missiles in relation to the behaviour of explosives. They mentioned the importance of design in the building and lay-out of factories in order to prevent the propagation of explosions, and stressed the importance of the plant manager or the head of the establishment in relation to safety. They pointed out that safety officers exercise a functional control in advising on necessary safety precautions.

They laid down certain definite safety principles with regard to the handling, cleanliness and care necessary with different classes of explosives—all related to the Explosives Act—and mentioned the need for the most careful investigation into the causes of accidents in the manufacture and use of explosive substances.

Safety in the use of electricity in the chemical industry was dealt with most adequately by Mr. S. J. Emerson, H.M. senior electrical inspector of factories. Mr. Emerson spoke of the statutory regulations and the dangers of electric shock, burns, fire and eye flash. He demonstrated many of the types of electrical equipment, including flame-proof equipment, and stressed the value of new plastics as insulators of electrical apparatus. He mentioned in particular the use of polyvinyl chloride and polythene as being, in the light of present knowledge, ideal insulators, even if metallic sheathing is used for cable covering.

He discussed the alternatives to flame-proof equipment and stressed the nature of intrinsically safe circuits and safe apparatus. He also dealt with the detection of static electricity, its prevention and the problems of circuit protection, and emphasized the importance of safe earthing in relation to safety in the chemical industry—particularly where explosives and solvents are manufactured or used.

The contemporary problems of the construction of chemical plant were dealt with by Mr. G. G. Lanham, who had been associated with the construction of such plant to the value of more than £45 million. It is well known that the hazards involved in construction are among the greatest in the country, and Mr. Lanham's lecture was illustrated by a series of slides showing that, in spite of the doubling of the contractors' employees, the frequency rate of accidents had been constantly reduced over a period of construction lasting 5 years.

Mr. Lanham emphasized the importance of design and of seeking the advice of all who are concerned from the design stage, including the safety officer and the construction engineer. The three main causes of accidents are falls of persons, falling objects and handling materials. Almost a third of the serious accidents which had happened in constructing plant happened in falls from heights. He illustrated the need for bigger and better cranes to erect bigger and better pieces of equipment and mentioned that on his particular site 14,000 tons of steel had been erected in 1956 with only one serious accident. He paid tribute to the Safety, Health and Welfare Regulations of 1948, which have done much to diminish the serious accidents in the erection of chemical plant.

Mr. Lanham also mentioned the use of scale-models in design and during the stages of construction, as the information which these can give is of the greatest value.

In the final analysis, safety in the chemical industry —as perhaps in every other industry—must depend on the positive and active support of top management, and this support should be reflected at all levels of supervision down to the key personnel who are responsible for plant operation. This was stressed most effectively by Mr. S. E. Chaloner, who defined the responsibility of the plant manager and the safety officer, the foreman and those responsible for dealing with the day-to-day hazards encountered in the chemical industry. He rightly emphasized the importance of entry into tanks and confined spaces, and of opening pipe lines—a hazard which is too often overlooked—and the necessity for providing adequate protective clothing for hands, faces, eyes and feet. In common with other speakers, he dealt with the problem of fire hazards and fire prevention, particularly in dealing with inflammable solvents.

The chemical industry cannot operate safely without a completely integrated team on each plant, and this was very rightly stressed by Mr. Chaloner in dealing with the question of plant operation and maintenance. He emphasized the significance of talks being given to new entrants into the chemical industry by all who are concerned with safety and mentioned the close liaison which is necessary between the production manager, the safety officer, the maintenance staff and, indeed, the universities who train graduates in science and who could do well to run even a brief course of training in the aspects of safety in relation to future careers.

During the discussion on this paper, the importance was stressed of colour coding for pipes, to ensure that everyone concerned was aware of what any pipeline was conveying.

Mr. D. A. Yonge dealt with the difficult problem of safety in plant operation and maintenance in the petroleum refining industry. He mentioned the basic factors of safe operation in design, in training and in inspection. The petroleum industry presents particular hazards both from the point of view of toxicity, and of fire risk and explosion. He emphasized the significance of taking adequate precautions in repair work, particularly when men have to enter confined spaces, and outlined the procedure for cleaning and freeing plant of gas, and bringing it into a suitable state for maintenance and repair. He outlined the 'permits to work' system, which must obviously be an important part of management in relation to work in the chemical industry. Apart from the necessity of permits to work, the problems of using flame-free tools was raised, and these are obviously of prime necessity in the petroleum industry.

Mr. A. Webster, of the Ministry of Supply, dealt with the problems of safety in the transport and storage of chemicals and mentioned the dangers which might be encountered in the handling of toxic

materials by inexperienced people. He stressed the importance of correct labelling, a matter which has received particular attention from the Association of British Chemical Manufacturers, and he brought out particularly the importance of drivers being instructed as to the method of dealing with any particular problem, when transporting materials by road.

Mr. Webster discussed the question of storage of chemicals in tanks and emphasized the need for generous tank space where possible and of having spare tanks available for the transfer of liquids. He was against the storage of liquids of a dangerous nature in overhead tanks, and felt that those who have to store dangerous materials would be well advised to discuss their problems with the local fire services, who might at any time be called in to deal with serious fire or explosion hazards.

Mr. J. Eyers gave a most illuminating history of engineering inspection since the 1850's. He mentioned the activities of various organizations covering the risks of explosion and break-down of engineering plant, together with the perils connected with transport and erection of plant and loss following break-down. Mr. Eyers illustrated this lecture with a large number of lantern slides and outlined the philosophy of engineering inspection during the last century. He pointed out the increasing use of pressure vessels designed to operate at high temperatures and mentioned the new materials which have come to play so great a part in the changing conditions of modern industry.

He devoted considerable time to the use of X-rays and gamma-rays, together with flaw detection equipment in plant examination, and analysed the problems of surveying nuclear reactor vessels.

As did other speakers, he stressed the importance of breakdowns and explosions which were due to simple faults in design and operation and pointed out that these could be avoided if more thought were given to the early stages of plant design.

Dr. A. J. Amor dealt with the medical aspects of safety in the chemical industry and the need for careful toxicological assessment of the nature of new substances to be manufactured. He emphasized that only by biological experiment could the toxicological properties of any chemical substance be determined, and that such experiments would in the main give some sound idea of the dangers which would be inherent in the manufacture so far as human beings were concerned. He stressed the significance of toxicological research, plant design and layout, education, discipline and training, and all methods of detection and analysis—particularly in view of the problems of environmental control upon which safety in the chemical industry really depended. Discipline in working in the chemical industry was very important.

He stated that, as the health of workers in the industry was of prime consideration, it was right and proper that the doctor in industry should have at his disposal all the special diagnostic facilities which enable him to maintain a constant control on the health of people engaged in the manufacturing processes. The plant manager and his staff, the safety officer and the doctor, all have their part to play in protecting the health of chemical workers.

Mr. R. J. Sherwood discussed the problem of manufacture and handling of radioactive substances and described their unique toxic properties. A comparison of the methods employed in the manufacture and use of radioactive substances could be made to the strict discipline of the operating theatre, where the nature of the biological hazards was similar to that of radiation hazards in being unseen but yet dangerous.

Mr. Sherwood mentioned the readiness with which sources from outside the body could be calculated and measured and the need for protection in terms of protective clothing, discipline in terms of laboratory and other work and the strict necessity for correct labelling and safe transport.

SCHOOL NATURAL HISTORY SOCIETIES EXHIBITION

A LARGE crowd of schoolchildren and their teachers gathered in the Lecture Hall at the British Museum (Natural History) on October 12 for the Ninth Annual Exhibition of the Association of School Natural History Societies. The main item on the programme, apart from the Exhibition itself, was a lecture on "Dinosaurs", given by Dr. W. E. Swinton. The younger members of the audience, for whom the term dinosaurs previously had little precise meaning, soon learned from the lucid explanations given by Dr. Swinton the variety of extinct reptiles of this type. His account of our present knowledge of the subject was followed by extracts from films in which, by animated models, the living appearance of the reptiles was realistically simulated. But the audience was reminded by Dr. Swinton's commentary that the scenes occasionally departed from modern ideas on the behaviour of the reptiles.

As in previous years, the Lecture Hall was well stocked with displays by member schools. There was on display a wide variety of common and not-so-common living animals and plants, locusts, liverworts, eyed lizards, lepidopteran larvæ and pupæ and pond life in profusion. There were also the careful and detailed accounts of ecological studies—a rookery survey by Bishop's Stortford College, a variety of bird records by Felsted School, an account of the distribution of *Pleurococcus* on tree-trunks by the William Grimshaw School, London, surveys of Hilbre Island (Buxton College), Alderney (Ackworth School), the Loughborough district (Limehurst Natural History Society, Garendon School) and Stoke Woods, Exeter (Hele's School, Exeter).

Foreign natural history, too, was well represented this year. The Hertfordshire and Essex High School for Girls, Bishop's Stortford, had a live praying mantis from Israel. Felsted School displayed Nigerian insects, and from Breeks Memorial School, Ootacamund, India, came an unsolved geological puzzle. In the beds of streams on the Nilgiri plateau are found pebbles of fossilized coral, yet there are no sedimentary rocks in the vicinity.

There was ample evidence of work in the laboratory as well as in the field. Lord Wandsworth College, Basingstoke, had compared wing area and body-weight of related species of flying and flightless water beetles. Bishop's Stortford College demonstrated an elegant apparatus for measuring the respiration-rate of cryptozoic fauna. Respired oxygen was replaced by electrolysis of a copper sulphate solution, the amount of oxygen absorbed by the animal being determined by daily weighings of the copper-plated cathode. Plant-breeding experiments on the inherit-