and to carry out scientific experiments with the view of improving the existing processes and methods, mechanical and chemical, in the manufacture of timber, and discovering new ways of utilizing timber. Apart from ad hoc researches, it is, of course, indispensable that fundamental investigations should also be carried out on the inner structure, chemical composition and physical properties of wood. The various investigations undertaken by the Wood Research Institute include problems raised by the scientific members of the Institute themselves, the solution of which is of interest to the industry, the further utilization and practical testing of new developments abroad, problems of general interest put to the Institute by the timber industry and, lastly, special development processes undertaken by special contract, for the sole benefit of individual timber manufacturers. The Institute is also an important centre of information and, in a suitable manner, puts at the disposal of the Austrian economy in general new knowledge and scientific results that have been obtained in the field of wood utilization at home and abroad. The work of the Institute is based on the closest collaboration of the various technical departments and their scientific staffs, and its lay-out has been considered with special regard to these matters. Only on the basis of such teamwork can each timber problem be dealt with from every relevant angle.

In order to eliminate overlapping with the work of other research organizations, the tasks of the Institute have been exactly defined. Research work starts the moment the timber leaves the forest and comprises all stages of treatment, manufacture and refinement until the finished product reaches the consumer. Indispensable collaboration with forest research is guaranteed by the fact that those concerned with forestry, especially the director of the Federal Station for Forest Research, Wien-Mariabrunn, are represented on the board of the Austrian Society for Wood Research, and are thus in a position to balance overlapping problems against each other.

With regard to its organization, the Wood Research Institute has been divided into a number of departments and sub-departments, each with its own director and scientific and technical staff. At present it consists of the following departments : microscopy and research on wood structure ; chemistry of wood and chemical technology ; chemistry of paper and cellulose ; pests and protection of wood ; physics of wood, including tests of strength ; mechanical technology of wood ; fibre boards and dowels ; and, lastly, wooden constructions, together with all the necessary laboratories, fittings and workshops. For reasons of expediency, the management of the Institute has been split into two and consists of a scientific director responsible for all the scientific problems and the organization of scientific research, and an economic director whose concern is the administration and the technical problems of the Institute. This solution has the great advantage that the scientific director is able to devote all his time to his true work and is never bothered by administrative and commercial questions.

After very careful planning, the Institute was opened on October 22 this year, although the erection of the buildings had only been begun during July 1952, and the importance of the occasion was emphasized by the fact that the opening was performed by the Federal Chancellor, Herr Julius Raab. The Austrian Institute of Wood Research is the first research institute in Austria to serve a whole big economic field. The opening celebrations included three lectures : the electron microscopy of wood, by Prof. A. Frey-Wyssling (Zurich) ; the future tasks of mechanico-technological wood research, by Prof. F. Kollmann (Reinbek, near Hamburg) ; and problems and the importance of lignin research, by Dr. K. Kratzl (Vienna). The scientific content of these lectures stressed the range of tasks of the Wood Research Institute, namely, the cultivation of general and fundamental research and of research in the important fields of mechanics and chemistry of wood utilization. The lectures had a double importance, however, for the fact that the speakers represented three different countries, namely, Switzerland, Germany and Austria, fully underlines the hope for a close collaboration in Middle Europe in the field of wood research.

SCIENCE AND APPLICATIONS OF PHOTOGRAPHY

CENTENARY OF THE ROYAL PHOTOGRAPHIC SOCIETY

IN celebration of its centenary, the Royal Photographic Society arranged an International Conference on the Science and Applications of Photography. The conference headquarters where nearly all the meetings were held was at the Institute of Education, University of London, and meetings lasted from September 19 until September 25. There were about five hundred members, of whom two hundred were from overseas ; 161 papers were read. The proceedings were grouped into five sections, namely, A, photographic science ; B, colour photography, kinematography, stereophotography, photogrammetry ; C, technique and applications of photography ; D, photomechanical processes ; and E, history, literature and training in photography, photocopying techniques.

In addition to an address by the president of each section, so arranged that all members of the Conference could attend, public lectures were given in the evenings by Mr. Harold White on "Fox Talbot and His Achievements", by Dr. G. B. Harrison on "Photography in the Service of Science", by Dr. C. E. K. Mees on "Fifty Years Work on the Theory of the Photographic Process" and by Dr. Ralph Evans on "Creative Directions in Colour Photography". At the Conference Dinner, on the last evening, the Astronomer Royal, Sir Harold Spencer Jones, proposed the toast of "Photography", replied to by Dr. C. E. K. Mees.

The amount of material presented was considerable, and it is quite impossible to summarize it all in a reasonable space. The topics mentioned here, therefore, come mainly from the section dealing with the science of photography, and have been selected from those available mainly because they can be included in a fairly coherent account. The full proceedings, amounting to nearly half a million words, will be published very shortly. For this prospect the Society is indebted to Dr. R. S. Schultze, honorary secretary of the Conference. References to the papers from which material for this account has been taken are given as superscript numbers. The material between any two such numbers has been taken from the paper given under the second number.

Significance of Adsorption by Silver Halide Grains

The most prominent general feature of the contributions dealing with the theory of photography was the importance attributed to adsorption phenomena at the surface of the silver halide grains. The grains are prepared by precipitation and subsequent treatment as dispersions in gelatin solutions, in consequence of which a layer of gelatin with a thickness of about 35 A. is bound tightly on them. In order to extend the colour sensitivity of emulsions beyond the limits to which silver halides are naturally sensitive, dyes are added. These dyes are adsorbed to the grains. If a dye is not too tightly held, the adsorption isotherm often displays a break, and the absorption spectra of the adsorbed dye above and below the break may be markedly different. This is taken to indicate a change, from a 'non-co-operative' state in which dye molecules on the grain are relatively isolated, to a 'co-operative' one in which they are closely packed and exerting strong lateral interactions. In the latter state the dye molecules, which for the most part are longer and broader than they are thick, are stacked in a monomolecular layer with the molecules face to face, and on edge at a steep angle to the grain surface. The more tightly adsorbed dyes usually give adsorption isotherms approximating to the Langmuir form, and are presumably always adsorbed in the latter state, whatever the concentration of dye in the surrounding medium.

Gelatin in the dye solution hinders adsorption by the grains, slowing down the rate of adsorption and reducing the amount of dye adsorbed in equilibrium with a given solution concentration, except when the concentration is high and the grains are almost completely covered by a monomolecular layer in any case. The effect is reversible : grains dyed in weak gelatin solution and transferred to stronger gelatin solution acquire the same surface conditions as if they were dyed in the stronger solution. For one particular merocyanine dye the heats of adsorption (calculated from the temperature coefficients of adsorption) varied from 3,000 cal./mole at 7 per cent gelatin, to about 8,000 cal./mole at $0 \cdot 16$–$0 \cdot 2$ per cent gelatin in the 'non-co-operative' state and about 9,500 cal./mole in the 'co-operative' state, and 12,200 cal./mole with no gelatin. On the assumption that adsorption of dye requires displacement of gelatin, the difference of 9,000 cal./mole between the highest and lowest values is presumably a measure of the heat of desorption of gelatin per dye molecule. Micro-Kjeldahl determinations of the nitrogen associated with dyed and undyed grains after centrifuging from 7 per cent gelatin solutions and washing gave direct indication of removal of gelatin on dyeing[1].

For a long time after the discovery of the colour-sensitizing action of certain dyes, those suitable for the purpose could only be selected by empirical trial. The same is still true to some extent : nevertheless, the general character which a dye must possess to be effective is becoming clear. Much the greater number of sensitizing dyes follow the general formula $A(— CH =)_n B$, where A and B represent heterocyclic nuclei, such as those of quinoline, benzothiazole, rhodanine, joined by a methine or polymethine bridge. Hydrogen atoms in the nuclei and bridge may be replaced by substituents. The nuclei themselves are planar or nearly planar in structure, and both experiment and theory suggest

that they will lie in the same plane, in the most stable configuration, when linked through a conjugated chain.

If it is assumed that a dye molecule is plane, a nearer approximation to its true shape than that given by its chemical formula can be reached by making a drawing using standard van der Waals radii of the units in the formula. When all possible geometrical adjustments in position have been made and two parts of the molecule still overlap, then the dye cannot be plane. Sensitizing dyes are known of all characters in which the shape is graded from 'loose', where there is more than adequate room for the dye to take a plane form, through 'compact' where the components of the molecule are so large that a plane form is just possible, to 'crowded', where the molecule must be seriously distorted from the plane form. As a general rule, it may be taken that a 'crowded' dye is a poorer sensitizer than a 'compact' one, and that it absorbs light less strongly, though maybe only slightly so. It seems that planar dyes can arrange themselves on the silver halide grains edge-on and tightly packed more readily than crowded dyes, and that this is the disposition which leads to most effective transfer of the energy they absorb to the silver halide.

The general indications are that 'compact' dyes aggregate more readily than 'loose' dyes, as might be expected since they cannot vary appreciably from the form which they must have in the aggregated state. Poor sensitization is not, however, necessarily attributable to overcrowding. Negative substituents such as nitro- and acetyl-, introduced where they cause no crowding, usually lead to depression of sensitization, and other groupings, not negative, also have similar effects. Moreover, a dye does not need to be planar to be a good sensitizer ; though the cases known suggest that the molecule must consist of a substantial planar part, groups not lying in the plane being twisted or rotated out of the plane[2].

The photoconductivity of the silver halide grains in commercial photographic materials can be measured if the strong electrolytic conductivity is balanced out. It is then found that the variations with wave-length of the light absorption, the photoconductivity and the photographic sensitivity are parallel. The energy absorbed by the dye, therefore, is made available to release electrons in the silver halide, after which point the processes leading to the creation of the latent image are identical, whether exposure is by light in the sensitizing or the non-sensitizing region of the spectrum. The absorption of sensitizing dyes in solutions frequently varies strongly with concentration, and at high concentrations many show a very strong narrow absorption band on the long wave-length side of the normal absorption. This 'J-band' is due to the formation of long aggregates like 'linear' crystals, in which 'exciton' propagation of energy occurs. Close packing of the dye molecules on the grains is favourable to 'exciton' propagation, but such propagation must not be too easy or the energy is likely to be lost in unwanted ways. Certain compounds (among which are dyes) known as supersensitizers confer added effectiveness in colour sensitization. It appears that these must be such as to fit well into the structure of the dye layer, and also to cause a local distortion of the structure at which transfer to the silver halide can occur. Other compounds act as desensitizers, so that the 'exciton' energy is

lost. When the silver halide grains are dye-sensitized there is some loss of their natural sensitivity. This may be due to loss of electrons, which have been excited into the conduction band, to the dye, where they lose their energy and cannot assist in the production of the latent image[3].

Gelatine has a strong influence on the rate of development. If silver halide grains are free of gelatine they are, with many developers, reduced to silver whether they have been exposed to light or not. In the ordinary way, differentiation between exposed and unexposed grains is extremely strong as, of course, it must be if development is to produce useful results. The rate of development is controlled substantially by two factors, namely, AT, a statistical factor, and an exponential factor, $\exp(- E/RT)$, E being an activation energy. The ratio of the rates of development of exposed and unexposed grains is then $(A'/A'') \exp(\Delta E/RT)$. The difference in activation energy ΔE estimated from the temperature coefficients of development is of the order of 6–12 kcal./mole, and is not likely to be much affected by the adsorption energies, which are probably nearly the same for exposed and unexposed grains. Developers can often exist in non-ionized and ionized forms, and the activation energy will vary with ionization. If the developing agent is ionized, the factor A will also be influenced by the charge on the silver halide grain. This is negative in ordinary photographic emulsions, and, judging from the zeta-potential, imposes a barrier of the order of 50 mV. Negatively charged ions are subjected to repulsion, and only a fraction of them will have sufficient energy to penetrate the barrier, the fraction decreasing by an order of magnitude as the ionic charge increases by one electron. The rate of development should therefore be increased if the charge barrier were eliminated. This expectation was borne out by tests in which photographic material was bathed in an active quaternary salt, which reduces and possibly eliminates the charge barrier. These considerations neglect adsorption, but it has been shown that developing agents do adsorb to silver halide, for some dyes, adsorbed to silver halide, are displaced by developing agents. This is not always so, for if the dye and developer are in ionic form and of opposite sign, the developer may be adsorbed and bind the dye still more tightly to the silver halide[4].

Surface-active cationic substances which reduce the charge barrier at the surface of silver bromide crystals in emulsion can also lead to increases in rate of fixation by thiosulphate. The accelerating effect decreases as the concentration of thiosulphate is increased, and displays a maximum in relation the concentration of surface-active agent[5].

The rate of development of metol when used alone is slow, and of hydroquinone, slower still. Together they develop rapidly. Two hypotheses have been put forward to account for this phenomenon of 'super-additivity'. One suggests that metol oxidized during the process of development is reduced to its original form by hydroquinone, the other that the low activity of hydroquinone arises because it is strongly ionized and cannot penetrate the charge barrier on the surface of the silver halide, but can do so if an intermediate product in the oxidation of metol is adsorbed to the silver halides. A new developer, 1-phenyl-3-pyrazolidone, behaves in a similar way to metol and in this case the formation of an intermediate when it is used alone is revealed

by its red colour. The presence of hydroquinone prevents the formation of the red colour. Thus, the regeneration hypothesis seems likely to be sound, and indeed, other evidence strongly favours it. Nevertheless, some of the experiments described also suggest that the charge barrier is reduced so that hydroquinone also may take part in development in the mixed developer[6],[7].

It has been shown that silver ions are adsorbed to silica or glass when hydroxyl ions are present, and that the material so produced is photosensitive. In silver bromide sols, silver ions are adsorbed from acid solution. If then the hydroxyl ion concentration is raised, the sol becomes more sensitive to light. This is probably due to the formation of a silver–hydroxyl complex on the surface of the silver halide. At high solution concentrations of hydroxyl ions, the number of hydroxyl ions adsorbed was found to be about one-fifth of the number of available ion-sites on the surface of the silver bromide. As this complex is photosensitive, it appears that two photolytic processes are possible, and may both occur in ordinary photographic materials : namely, transfer of an electron from the lattice of silver bromide to a surface silver ion, and transfer of an electron from the silver–hydroxyl complex. Silver bromide sols, with no gelatin, are further sensitized by allyl thiourea, when it is adsorbed without breakdown to the silver bromide crystals. The H. and D. curve then displays two parts : first a slow rise of opacity with increasing exposure, and then a very rapid rise. The first of these is attributed to the silver–hydroxyl complex, and the second to the silver halide crystal itself. Confirmation of this hypothesis is provided by the difference in colour sensitivity of the two regions of the curve[8],[9].

The importance of the conditions at the surface of silver bromide crystals has been underlined by experimental results on large thin crystals. Previous work showed that such crystals were sensitized by very thin deposits of silver, gold and metallic sulphides. In further experiments, crystals sensitized in the above ways were dipped in inert gelatin solution adjusted in silver ion and hydroxyl ion concentration, drained and dried. The gelatin improves the stability of the sensitizing layers, decreases the fog and adds to the sensitivity, the additional sensitivity being greater the higher the hydroxyl ion concentration, and somewhat greater the higher the silver ion concentration. A similar kind of result is obtained when the crystal has not been sensitized beforehand. The sensitization by gelatin is much greater if the crystal is digested in warm gelatin solution for periods up to half an hour. The gelatin film was found to be detachable by re-immersion in gelatin solution. When it settled back on the crystal so as to cover a part of the crystal not previously covered, the sensitization was transferred with the gelatin.

Sensitization was found to be accelerated by known sensitizers of the reducing types, gold salts, and thiosulphate and substituted thioureas. Products of the sensitizing process are formed in the gelatin adjacent to the crystal surface, and on the crystal surface itself, those on the latter probably consisting of aggregates of silver, gold, silver oxide or silver sulphide. Of the two, the products in the gelatin layer are the more effective as sensitizers.

It has always been difficult to account for the apparent lack of recombination of positive holes (roughly speaking, bromine atoms left by electrons

which have been raised to the conduction bands) and electrons in the Gurney–Mott theory of the latent image. The above experimental results lead to the suggestion that the function of the chemical sensitizer is to trap the positive holes created during exposure to light. The crystals formed during the preparation of photographic emulsions are supposed to consist of polyhedral blocks, slightly misaligned, the boundaries of which constitute severe local dislocations. These dislocations persist out to the surface, where they provide a region for localized separation of silver—the surface latent image. The internal dislocations can also provide sites for internal latent image[10].

The above description does not require the supposition that gelatin is occluded within the grains, which has been put forward to account for the existence of internal latent image. The supposition is unlikely to be true. If gelatin is completely removed from the surface of grains (by bathing in hypobromite solution), the internal gelatin, if any, can be released by dissolving the grains in thio-sulphate and brought to a higher concentration by foaming. A modified Zsigmondy gold number test then shows that the average gelatin content is certainly less than one gelatin molecule to six grains. Many more than one-sixth of the grains can carry internal latent image. Thus, occlusion of gelatin is unlikely, and in any event not a necessary condition for the production of internal latent image[11].

The general tenor of the work so far described, therefore, has been to emphasize the importance of the conditions at the surface of grains, and, in considering how the latent image is produced, to pay at least as much attention to the mode of disposal of the bromine (the positive hole in the crystal lattice) as to the production of development centres by aggregation of metallic silver. The theory of latent image has returned part way to the old hypothesis that silver bromide grains become developable as a result of formation of sub-halides by the escape of bromine[12].

Some Chemical Aspects

Bromine and chromic acid solutions applied to photographic materials will make them less sensitive or, if applied after exposure, reduce the latent image capable of being developed. It was suggested that desensitization of weak sensitivity centres (that is, those requiring heavy exposure to convert to latent image) is a consequence of adsorption of bromine or chromate ions. Sensitivity centres more easily converted to latent image behave more like weak latent image, while strong latent image is oxidized[13]. The results may be taken as suggesting that weak sensitivity centres are special locations where silver is formed as a result of exposure; stronger centres already contain some silver, and true latent image requires a certain minimum amount of silver. This would be consistent with results of tests of various kinds on the fog produced by heavy sensitizing treatment. When sensitized by reduction (with stannous chloride) the fog has the properties of metallic silver; but when sensitized by sulphur-containing gelatin, its properties are more nearly those of silver sulphide[14].

It has long been known that sharp-edged, and especially contrasty, details in photographs are affected by diffusion of the developer and its reaction products. In black-and-white photography this causes distortions of tone-reproduction and even

makes the photograph of a detail different in geometry from the original image. In modern processes of colour photography, which use three layers of emulsion, differently colour-sensitized and, in the final result, differently coloured, any one of the three layers may be affected by the development processes in the other two. The results seem to be fortunate : in most cases the colour quality is improved[15]. A yellow filter layer is necessary in colour films to eliminate blue light remaining after the top blue-sensitive layer has been exposed. This is usually of colloidal silver, the particles of which accelerate the reduction of silver salts produced during development. In this way a colour fog is produced. It was by a study of this phenomenon in a commercial colour process that a specially rapid process was worked out for the production of copies of documents. In this process the unexposed silver salts of a negative emulsion are made to produce a positive silver image in a second emulsion in contact with it[16].

Physics of the Developed Image

There is still much interest in the capacity of photographic materials for reproducing detail, which justifies leaving aside the main topic of surface phenomena and mentioning something about what is commonly called the physics of the developed image. The capacity of a photographic material to record fine detail is limited by the diffusion of light in the sensitive layer and the heterogeneity known as granularity or graininess. The best description of the light scattering is the light distribution in the neighbourhood of a vanishingly small, brightly illuminated spot. This is difficult to measure experimentally, and it is customary to throw a thin line of light on the sensitive layer and measure the light distribution thereby produced. The fall of intensity each side of the line is exponential. If an arbitrary function is assumed for the light distribution around a point, integrated to give the distribution for a line, and the integral equated to the exponential distribution observed, the nature of the arbitrary function may be completely determined, and it is then available for calculating the light distribution in other forms of image. Experimental tests are in as good agreement as can be expected, considering the difficulties of the measurements[17]. The amount of diffusion increases with thickness of the layer, but less so when the exposure is with light of short wave-length, owing to the stronger absorption.

In measurements of resolving power the aperture of the lens used to project the test image is important. If the aperture is low, the resolving power of the lens is limited ; if the aperture is considerable, some of the image is out of focus by reason of the thickness of the sensitive layer, and this limits the resolving power. Consequently, maximum resolving power is observed at a medium aperture[18]. In autoradiography the resolving power is largely dependent on the thickness of the emulsion layer, and also on the thickness of the specimen and intimacy of contact[19].

The measurement of resolving power in radiographs is somewhat difficult because the preparation of suitable test objects is difficult. It has been found, however, that a mercury physical developer, to intensify the silver image, is capable of giving a deposit of mercury, in a photographic test object of a customary pattern, sufficiently opaque to X-rays to make satisfactory test objects for the purpose[20]. An interesting point is that colour photographs often

appear sharper than black-and-white photographs with the same resolving power. Experiments were reported which indicate that the judgment of sharpness depends upon the saturation of the colours and the structure of the photograph[21].

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TOXIC HAZARDS OF PESTICIDES TO MAN

FROM the time of his first appearance on this earth, man has been engaged in mortal combat by insects and other types of vermin. Through all the centuries of recorded time men have been plagued by insects, and literally millions have died of insect-borne diseases or of starvation, often induced by loss of crops directly attributable to various types of pests. Insect-borne diseases rank high, if not foremost, among the great public-health hazards of the world. For centuries yellow fever, malaria, plague, typhoid and dysentery, to mention only a few well-known examples, have brought misery and death to millions of humans, determined the outcome of wars, and in no small way affected the course of history.

Likewise, in the agricultural sphere insects, plant diseases, weeds, rodents and other pests exact an almost unbelievably heavy toll on all agricultural production. Estimates of crop-losses due to these pests may vary from as low as 10 to as high as 50 per cent of all agricultural production. While there is a paucity of statistically sound data to support any such estimates, it seems safe to assume that the tribute demanded and taken by pests is at least a quarter to a third of the world's agricultural output.

In days gone by, as more and more food was needed to feed an ever-increasing population, nations one after another sought to colonize new lands and thereby expand food production ; but the door to this avenue of escape is practically closed. Now that there are no new lands to conquer, man shows signs of acquiring some sense with regard to developing a sound agricultural programme. Such a programme must abandon the age-old practice of exploiting—or as we say in the United States, 'mining' our fertile soils—and must provide for the adoption of sound scientific procedures, not the least of which is practical pest control.

Science has developed ways and means of combating most of the vectors of insect-borne diseases and many of the more important crop pests ; but, unfortunately, in most cases the actual control of these pests involves the use of one or more of the rather toxic chemicals which may be objectionable from certain points of view.

Any attempt to evaluate such hazards as may be inherent in the use of pesticides should be predicated upon a rather thorough understanding of a few of the more-or-less axiomatic principles involved : (1) Practically all pesticides have toxic properties and are toxic to warm-blooded animals, including man, as well as to insects. If they did not have these properties, they probably would not control pests and therefore would not be good pesticides. (2) The fact that most pesticides are toxic to man and animals does not necessarily mean that they cannot be used safely. If one develops a proper respect for the toxic properties of a substance, it may frequently be used with greater safety than a much less toxic substance which is apt to be handled carelessly. (3) A careful distinction must be drawn between the terms 'hazard' and 'toxicity'. Toxicity is the capacity of a substance to produce injury, and hazard is the probability that injury will result from the use of the substance in the quantity and in the manner proposed. To be at all reliable, any estimate of the hazard involved in the use of a substance must be based not only upon a knowledge of its inherent toxicity, but also upon the details of its proposed use, as well. (4) To avoid hopeless confusion, one must distinguish between use or operation hazards, and residue or food contamination hazards.

Most individuals interested in the hazards associated with pesticide usage have read some of the charges brought against pesticides, and at least some of the arguments advanced in their defence. Obviously, the problems encountered in the introduction of new chemicals are not unique. In common with many other advances in science and technology, pesticides must be regarded with mixed feeling, in that on one hand they possess highly desirable and at times almost miraculous properties for good and, on the other hand, definite objectionable or undesirable characteristics capable of producing harm. The problem is so to balance these attributes and so to control the use of these chemicals as to secure the maximum benefit and the minimum harm. In no case should public policy be totally regulated or guided by either the optimist who sees only the Utopian pesticidal properties, or by the pessimist who sees only the most dismal potentialities for wanton destruction.

We must strive for an objective point of view wherein good and bad, desirable and undesirable, potential benefits and harm, will be brought into proper perspective and balanced one against the other. In so doing, let us recall that fire is at one and the same time man's greatest servant and