

JOURNAL OF THE OIL AND COLOUR CHEMISTS' ASSOCIATION



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January 1972

An elastic factor determined from Monk micro-indentation measurements

R. Katz

Investigation of the water and ion permeation characteristics of certain polymers

J. Boxall, J. A. Von Fraunhofer and S. C. Werren

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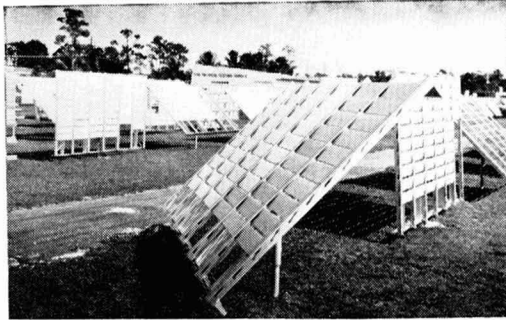
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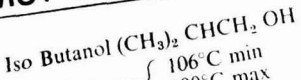
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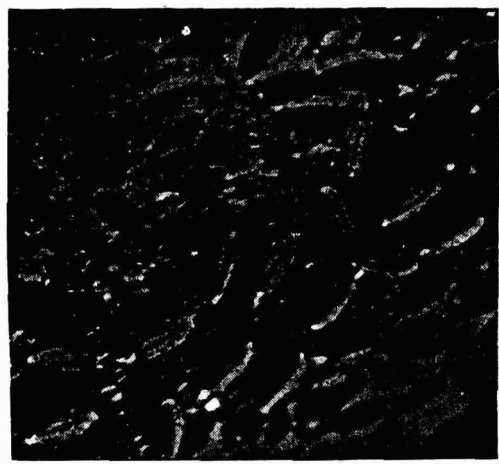
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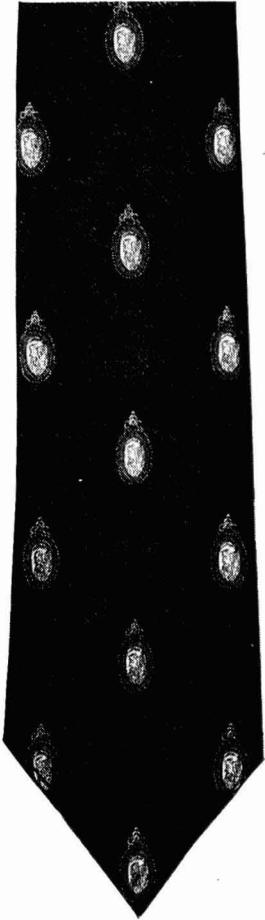
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INDEX TO ADVERTISERS

A			
Ashby, Morris, Ltd.	iv
B			
Banner, Samuel, & Co. Ltd.	i
BIP Chemicals Ltd.	ix
C			
Cory, Horace, & Co. Ltd. . . . .	..	..	viii
K			
Kunstsharsfabriek Synthese . . . . .	..	..	iii
M			
Metchim & Son Ltd. . . . .	..	..	Cover
S			
Shell UK Chemical Co. Ltd.	vi
Sub-Tropical Testing Inc.	Cover
Suter, A. F., & Co. Ltd.	i

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Contents **Vol. 55 No. 1** **January 1972**

Transactions and Communications

An elastic factor determined from Monk micro-indentation measurements	15
<i>R. Katz</i>	
Investigation of the water and ion permeation characteristics of certain polymers	24
<i>J. Boxall, J. A. Von Fraunhofer and S. C. Werren</i>	
Wood protection	35
<i>G. L. Holbrow, A. F. Sherwood, D. Dasgupta, D. Gardiner, M. C. Gibson, and M. J. Haines</i>	
<i>Editorial</i>	52
<i>Correspondence</i>	52
<i>Reviews</i>	53
<i>Student Review</i> Paint Technology Manual Part Seven	55
<i>Information Received</i>	72
<i>Section Proceedings</i>	75
<i>Notes and News</i>	81
<i>Register of Members</i>	87
<i>Forthcoming Events</i>	88

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Transactions and Communications

An elastic factor determined from Monk micro-indentation measurements

By R. Katz*

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Summary

The indentation measurements of coatings, as obtained from Monk (ICI) micro-indentation apparatus, show a behaviour following a modified Hertz type equation. Thus, an elastic factor is proposed which may be evaluated from indentations of coatings attached to a substrate.

Keywords

Properties, characteristics and conditions primarily associated with dried or cured films:

elastic modulus
tensile strength

Process and methods primarily associated with analysis, measurement and testing:

indentation test

Un facteur d'élasticité déterminé au moyens des mesures rendues par l'appareil de micro-indentation de Monk

Résumé

Les mesures de l'indentation des revêtements obtenues à partir de l'appareil de micro-indentation de Monk-I.C.I. démontrent un comportement en accord avec une équation du type Hertz modifiée.

Ainsi, on propose un facteur d'élasticité que l'on peut évaluer au moyens des indentations des revêtements appliqués à un support.

Ein mittels des Monk Mikro-Indentations-Messgerätes Bestimmbarer Elastizitätsfaktor

Zusammenfassung

Die Indentationsmessungen an Anstrichfilmen, welche mit dem Monk (ICI) Mikro-Indentations-Apparat erhalten werden, weisen ein einer modifizierten Gleichung vom Hertz Typ entsprechendes Verhalten auf.

Es wird ein Elastizitätsfaktor vorgeschlagen, welcher aus Indentationen in an einem Substrat haftenden Anstrich bestimmt wird.

Коэффициент упругости определяемый по измерению микро-углубления Монка

Резюме

Измерения индентации покрытий, получаемые на аппарате микроуглублений Монка ICI, обнаруживают поведение в соответствии с модифицированным типом уравнения Герца. На этой почве формулируется коэффициент упругости, который может быть оценен по индентации покрытий наложенных на субстрат.

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Introduction

The ageing properties of paint films are commonly estimated visually by noting the degree of checking, chalking, blistering, peeling, etc.

No measurable physical property of coatings has yet been shown to change significantly with ageing. Many correlations have been tested. The best appears to be that of Van Loo,¹ in which a relationship between the tensile strength and durability of stripped coatings was found. Nevertheless, the behaviour of attached and free films is known to differ. Thus, it is desirable that some physical property of a coating should be measured whilst attached to a substrate.

The Monk micro-indentometer² seemed to be a promising tool, as it measures the indentation of films adhering to the substrate. These measurements may be correlated with elastic properties such as tensile strength³ or Young's modulus,⁴ which vary with ageing.

In this study, the feasibility of evaluating an elastic factor by micro-indentation measurements was examined.

Experimental

The following formulations were prepared:

<i>Nitrocellulose</i>				<i>Alkyd</i>				
				<i>Pts by wt</i>				
Nitrocellulose	$\frac{1}{2}$ sec	..	..	100	Fatty acids	..	..	350
Diocetyl phosphate	..	..	..	33	Glycerol	..	..	38.8
Non-drying alkyd	..	..	..	100	Pentaerythritol	..	..	82.7
Butyl acetate	..	..	..	200	Phthalic anhydride	..	..	14.5
Butanol	..	..	..	100	Maleic anhydride	..	..	2
Ethyl alcohol	..	..	..	40	Xylene (azeotropic addition for cooking)	..	..	20
Toluol	..	..	..	400	White spirit	..	..	370
					Pb-naphthenate 24%	..	..	15
					Co-naphthenate 1%	..	..	18

<i>Epoxy/polyamide (2 : 1 by weight)</i>				<i>Polyamide</i>				
<i>Epoxy</i>				<i>Pts by wt</i>				
Epon 1001	50	Versamide 115	..	..	25
Methyl isobutyl ketone	25	Isopropyl alcohol	..	..	12.50
Xylene	25	Toluene	..	..	12.50

The epoxy/polyamide mixture was aged at room temperature for two hours before application. The mixtures were spread by the ICI spinner on mild steel panels.

The epoxy/polyamide coatings were applied to three different types of panel: mild steel, aluminium and tin-coated steel. (In the interests of brevity, the latter will be referred to as "tin".) The hardness of these metal substrates was measured with a Rockwell hardness tester equipped with a 15kg load and a ball indenter with a radius of $\frac{1}{16}$ in. Adhesion of the epoxy coatings to the substrates was tested by an adhesion knife (by cross hatching).

The films were dried for one week in the laboratory, and their thickness measured with an Elcometer thickness gauge. A further check on thickness was made by a micrometer measurement of the stripped film after testing. Discs of 3.45cm diameter were cut from the coated panels.

The indentation measurements were carried out with the Monk micro-indentation apparatus.² This instrument measures the indentation produced by a sapphire hemispherical needle under various loads. The disc sample was placed on a special stand which could be maintained at a constant temperature in the range of -20°C to 90°C . The discs were kept inside the glove box of the apparatus for 24 hours. The relative humidity in the box was maintained at 20 per cent. Measurements were performed at a room temperature of 27°C , as difficulties were encountered in trying to maintain the temperature steady for long periods of time.

The indentation depths were recorded on a recorder with a range of 0-15 psi, which corresponds to 0-6 microns indentation. The recorder was allowed to run without a load for a short time to ascertain that the surface was even. The load was then applied for 115 sec. After removal of the load, elastic recovery was recorded for a further 40sec.

The maximum indentation, obtained from the recorded curves with a high degree of accuracy, was used for calculations. The needles were so chosen that maximum indentation would vary between 0-6 microns when loads of 5-20g were supplied.

The correlation between load and indentation is summarised in Figs. 1 and 2. The intercepts of the curves as a function of indenting needle radius are shown in Fig. 3.

Results

The results are summarised in Tables 1-3.

Table 1
Epoxy/polyamide (2:1) coatings (see Fig. 1)

Substrate	Rockwell hardness	Film adhesion to metal (%)	Film thickness (microns)	Slope*
Steel	67-70	61	31-35 75 115	1.15 1.13 1.22
Aluminium	55-59	95	30-35 75	1.25 1.25
Tin	71-79	95	35 70	1.17 1.15

*The measurements were performed with a needle of $r = 0.0025\text{in}$ and with loads of 5-20g.

Table 2
Indentations by different needles (see Fig. 2)

Polymer	Radius of indenting needle (in)	Slope	Intercept
Alkyd	0.0025	1.28	2.0
	0.005	1.3	3.6
	0.008	1.8	4.95
Nitrocellulose	0.0025	1.28	1.18
	0.005	1.32	2.8
	0.008	1.32	5.0
Epoxy	0.0025	1.3	3.85
	0.005	1.37	8.75
	0.008	1.56	14.5

Table 3
Intercepts of curves as a function of needle radius (see Fig. 3)

Polymer	Slope	Intercept
Alkyd	0.75	1.0
Nitrocellulose	1.3	0.385
Epoxy	1.15	1.4

Discussion

A metal substrate may affect the total indentation⁵ by virtue of its own hardness or by the nature of coating's adhesion to it. This effect is greatly dependent on coating thickness.

Coatings of epoxy resin of 35μ thickness on mild steel and aluminium panels have the same indentation values, in spite of differences in metal hardness and coating adhesion. However, epoxy coatings on tin have lower indentations than on mild steel and aluminium substrates. Whilst tin has a higher hardness value than the other two substrates, its coating adhesion is equivalent to that of aluminium. No explanation of the differences in indentation values can be offered.

As the purpose of this study was not to investigate the effect of the nature of the substrate on indentation, but only to characterise it, no further experiments on this subject were undertaken. However, in order to eliminate possible errors due to this effect, coatings for comparative evaluations were applied to the same substrate.

Thickness effect

The effect of coating thickness on indentation values is understandable: the thicker the coating, the lower the indentation (see Fig. 1). Thus, a standard thickness of 35μ was adopted for further study.

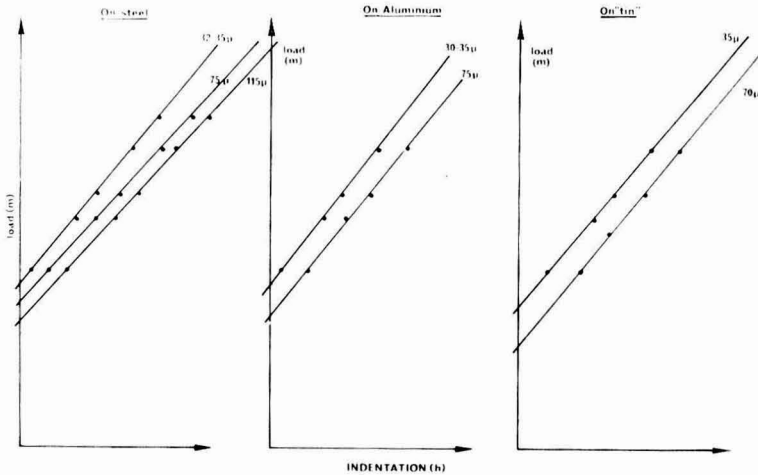


Fig. 1. Coatings of epoxy/versamide (2:1)

Variables

As substrate type and coating thickness were standardised, the only variable remaining was the composition of the coatings.

In the test procedure, ageing temperature and time elapsed between tests were kept constant; the variables were the loads applied and dimensions of the indenting needles.

A thorough, critical, assessment of precision measurement with the Monk micro-indentation instrument has been given by Fink-Jensen.⁵

Theoretical

A correlation of the measured variables (load, indentation and radius of indenting needle) with Young's modulus is given in the Hertz equation.⁴ The Hertz equation was derived from the situation of two compressed elastic spheres, a particular case being two elastic spheres compressed into a plane. The following equation is given:

$$\frac{E}{1 - \gamma^2} = \frac{3mg}{4r^2 h^3} \dots\dots\dots (1)$$

- E = Young's modulus
- γ = Poisson ratio
- m = load mass
- g = gravity constant
- r = radius of needle
- h = indentation

When the above equation was used to evaluate E from indentation measurements in this study, no reasonable values were obtained.

Consequently, this study was aimed at deriving an equation which would be in accordance with the experimental results.

The relationship between load and indentation: the curves in Fig. 1 are straight lines, possessing the same slope but different intercepts. Straight lines are

expressed by the equation $y = a + bx$. For the plots in Fig. 1, this equation will be:

$$\log m = a + b \log h \dots\dots\dots (2)$$

$$\text{or } m = Ch^b \dots\dots\dots (3)$$

As seen from Fig. 1, C is a function of thickness. For coatings of equal thicknesses, the C value will be given by the intercept on the $\log m$ axis.

The value of b is the slope of the curves.

The relationship between load and needle radius: Fig. 1 was plotted from results obtained with the same indenting needle. When needles are changed, C will be a function of r .

Figs. 2 and 3 were plotted in order to find the relationship between m and r .

The curves in Fig. 2, being of $\log h$ against $\log m$, are of the same type as that of Fig. 1, corresponding to equation (3).

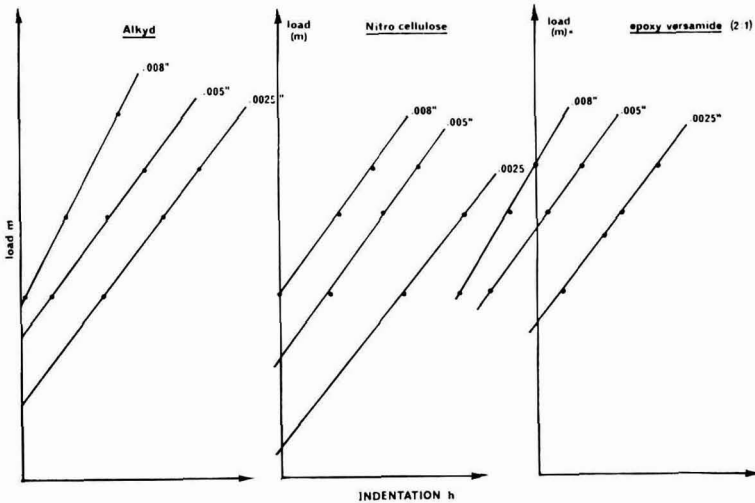


Fig. 2. Coating indentations by different needles

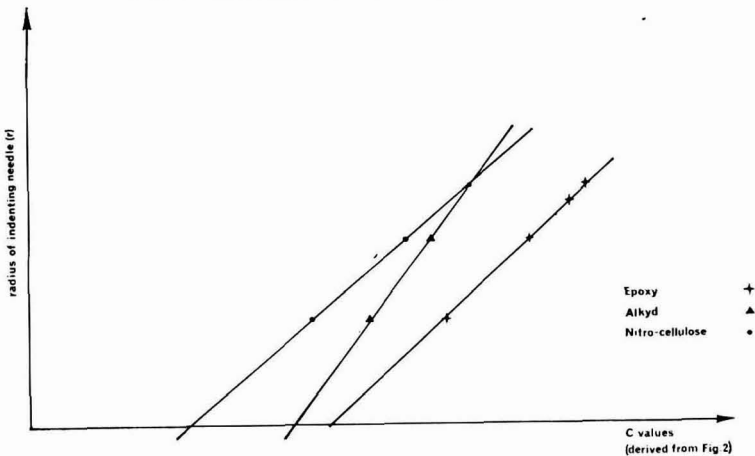


Fig. 3. Effect of radius of indenting needle

The thickness is constant, thus the curves differ only on account of the radii of the needles.

For a constant indentation $h = 1$, the C values (intercepts) will be related to r .

C values were, therefore, plotted in Fig. 3 as a function of r , again yielding straight lines. If D is the new intercept and c the slope, the expression will be:

$$B = Dr^c \dots\dots\dots (4)$$

Substituting this in equation (3) gives:

$$m = Dr^c h^b \dots\dots\dots (5)$$

$$\text{or } \frac{m}{r^c h^b} = D \dots\dots\dots (6)$$

Equation (6) may be compared with the Hertz equation in a rearranged form:

$$\frac{4}{3} \cdot \frac{1}{g} \left(\frac{E}{1 - \gamma^2} \right) = \frac{m}{r^{\frac{1}{2}} h^{\frac{3}{2}}} \dots\dots\dots (7)$$

The correspondence to equation (5) is obvious. Thus, data obtained from indentation measurements of coatings fit into a modified Hertz formula.

D—an elastic factor

D will have a value proportional to Young's modulus (Poisson's ratio is a function of temperature alone):

$$D = \text{constant } E \dots\dots\dots (8)$$

Stress/strain relationships of pure elastic materials are the basis of the Hertz formula. For viscoelastic materials, however, these relationships are time dependent.⁷

The evaluation of an elastic factor from time measurements—an evaluation which, it is proposed, will be used on a relative basis—may be based on the above dependence.

D , the elastic factor, is easily obtainable as an intercept. If the indenting needle is not changed during the test, D will be simply obtained from measurements at several loads, as was the case in Fig. 1. The intercept B is proportional to D and could be used instead. This elastic factor could be evaluated as a function of ageing.

It should be emphasised that relative comparisons of an elastic factor are proposed. Absolute values are of no interest when ageing correlations alone are studied.

The elastic factor could be derived also if test needles have to be changed during ageing; the procedure is slightly more complicated, since the factors shown in Fig. 2 ($\log m - \log h$), for different r 's, and in Fig. 3 ($\log B - \log r$) are both involved.

The power factors b and c

The factors b and c are found to have values different from the power factors of the Hertz equation.

The b value: As seen in Fig. 1, there is a good reproducibility of b values as calculated from the slope of tangent. Reproducible values are obtained when the proper needles are used.

In Fig. 2, b values deviate, the deviation being greater the more unsuitable the needle, indentation values being very low in comparison with the mean error.

The same b value, 1.28-1.30, was found for the three different polymers: nitrocellulose, epoxy, and alkyd.

For rubber⁸ a b value of 1.35 is obtained, which appears to be due to geometric considerations not related to material characteristics.

The c value: For the three polymers mentioned above the following c values were found:

nitrocellulose	..	..	..	..	..	1.3
epoxy	..	..	..	..	..	1.15
alkyd	..	..	..	..	..	0.75
rubber	..	..	..	..	..	0.65; 0.5 (Hertz ⁴)

Conclusions

It is proposed that an elastic factor for coatings may be evaluated by measuring the indentation of the coatings whilst attached to the substrate, by means of the Monk micro-indentometer.

The elastic factor may be calculated from the intercept of the $\log m - \log h$ curve if the same needle can be used at several ageing time intervals.

If needles have to be changed during the test series, an auxiliary curve must be plotted (\log intercept (of $\log m - \log h$, for different r 's) against $\log r$) in order to calculate the intercept D .

The elastic factor values as functions of ageing may then be compared and durability thus evaluated.

Acknowledgments

We would like to dedicate this paper to the memory of a good friend and co-worker, the late Robert Sharon.

We would like, also, to thank Mrs R. Wertman and Mrs J. Klopper for their conscientious work and co-operation; the Israel Research and Development Scientific Council for the grant; and Mr F. Munk, Head of the Paint Research Association, for helpful discussions and permission to publish this paper.

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Investigation of the water and ion permeation characteristics of certain polymers

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Summary

The water permeation and leach-rate characteristics of four typical polymers used in protective coatings are reported. The results of these tests indicate that corrosion in the salt-spray test may be correlated with water permeability, but is independent of water vapour permeability. These results are accounted for in terms of a proposed new mechanism for water permeation through polymers.

Keywords

Properties, characteristics and conditions primarily associated with dried or wet films

water resistance
water vapour permeability

Structures or surfaces being coated

corrosion

Processes and methods primarily associated with analysis, measurement or testing

infra-red spectroscopy

Une étude des caractéristiques de pénétration par l'eau ou par les ions de certains polymères

Résumé

On rend compte des caractéristiques de pénétration par l'eau et du taux de dissolution de quatre polymères, typiques de ceux qui sont utilisés en revêtements protecteurs. Les résultats de ces essais indiquent que la corrosion provoquée par brouillard salin peut être liée à la pénétration par l'eau, mais elle ne dépend pas de la perméabilité de la vapeur d'eau. On peut expliquer ces résultats sous termes d'un mécanisme nouveau que l'on propose à l'égard de la pénétration des polymères par l'eau.

Untersuchung der Wasser und Jonendurchlässigkeitscharakteristika Gewisser Polymerer

Zusammenfassung

Die Charakteristika der Wasserdurchlässigkeit und Auslaugeschwindigkeit von vier typischen für Schutzfarben benutzten Polymeren werden angeführt. Die Versuchsergebnisse weisen daraufhin, dass eine Korrelation zwischen Korrosion beim Salzsprühnebeltest und Wasserdurchlässigkeit besteht, nicht aber mit der Wasserdampfdurchlässigkeit.

Diese Resultate werden dazu benützt, um einen neuen Mechanismus für den Durchgang von Wasser durch Polymere vorzuschlagen.

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Анализ характеристики водной и ионной проницаемости некоторых полимеров

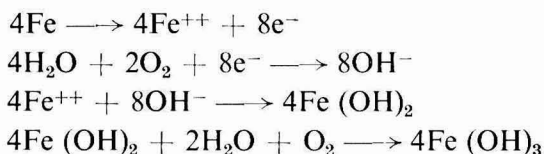
Резюме

Рассматриваются характеристики водопроницаемости и скорости выщелачивания четырех типичных полимеров, применяемых в защитных покрытиях. Результаты испытаний показывают, что коррозия в испытании соляного опрыскивания может быть связана с водопроницаемостью, но не зависит от проницаемости водяного пара. Эти результаты выражены посредством нового предложенного механизма для водопроницаемости в полимерах.

Introduction

The use of organic surface coating systems to protect structural steelwork, and metal-work in general, has now achieved pre-eminence as a method of protection against corrosion. The annual cost of corrosion runs into many millions of pounds, and this has led to a considerable research effort, particularly in the last decade. Attempts have been made to formulate new polymeric coatings and to classify the physico-chemical properties which any organic surface coating must possess to provide corrosion resistance for substrates.

One of the more important mechanisms of protection afforded by paints is the formation of a relatively impervious surface layer on the metal. The following mechanism for atmospheric corrosion has been proposed¹:



It is clear that the rate of permeation of oxygen and water through the polymer coating is of the utmost importance. Mayne² and Guruviah³ have demonstrated that this diffusion or permeation can occur at appreciable rates.

Guruviah³, in work on pigmented polymers, has shown that the low corrosion rates obtained could be explained if the rate of oxygen permeation through the coatings determined the corrosion rate.

Kooistra⁴ has suggested the presence of intermolecular, as well as intramolecular, pores in cured pigmented polyurethane and epoxide coatings. He has also suggested that water vapour permeability is affected by differences in the molecular structure of the materials such as functionality, chain length and pigment content.

Work by Yaseen and Ashton⁵, and the Pittsburgh Society of Paint Technology⁶, has related water absorption to exterior durability for a wider variety of unpigmented polymeric materials. Lower durability was observed with polymer films having greater water absorption characteristics.

Previous work on water and ion permeation by von Fraunhofer *et al.*⁷, on unpigmented polymeric materials, indicates that although the inherent resistance of polymers to ion solutions is high, their ability to protect substrate metals against corrosion is poor. Protection appears to be dependent both upon the polymer structure and the presence or absence of microporosity.

The mode of permeation of water and ions through certain unpigmented polymers is investigated in this work, and attempts are made to relate these transmission characteristics to molecular structure.

Experimental

For this investigation, polymers typical of those used in anti-corrosive paints were selected. These were:

an epoxy/polyamine system, based on a liquid epoxy resin modified with butyl glycidyl ether reacted with a fully saturated alicyclic amine based on isophorone diamine, the two components being mixed in the ratio 60 resin : 40 amine prior to use;

a tung oil phenolic varnish, of 6:1 oil length, prepared from a rosin modified diphenylol propane resin;

a vinyl chloride/vinyl acetate copolymer consisting of 87 per cent vinyl chloride and 13 per cent vinyl acetate; and

a medium viscosity grade of chlorinated rubber, externally plasticised with 5 per cent chlorinated diphenyl.

The free films of the polymers required for water absorption, permeability studies, and infra-red studies were prepared by coating glass panels with an ICI/Sheen spinner applicator. Dry film thicknesses of 40.0 ± 5.0 microns were prepared for each polymer. This thickness is close to that obtained with conventional paints in practice and was the greatest that could be achieved in one coat with three of the polymers studied. After coating, the panels were aged for 1 week in a horizontal position in a dust- and draught-free cabinet at 25°C . After removal of the polymer films, by flotation in water, the free films were blotted, and aged in a desiccator for 14 days.

Cold rolled mild steel panels, $15 \times 10\text{cm}$, used for the salt spray tests, were coated with the polymers by the ICI/Sheen Spinner Applicator to give dry film thicknesses of 40.0 ± 5.0 microns. The metal was prepared in accordance with BS 3900, Part A.3. The rear faces of the panels were coated with a standard resistant paint, and the edges protected by wax. Prior to coating, the metal panels were weighed. The polymer films were aged for 7 days prior to testing in a dust- and draught-free cabinet.

Water vapour permeability

Sections of the free polymer films were cut and mounted, using a two-pack pigmented epoxy adhesive, over 1.30cm diameter holes in the lids of 100ml capacity acrylic bottles. The lids, after ageing for 48 hours to cure the adhesive, were pressed on to the bottles which had been filled previously with 50ml of distilled water. A coating of petroleum jelly was applied between the lid and bottle to reduce vapour leakage.

Blank determinations, to check the vapour tightness of the apparatus, were prepared by using a lid with no hole in it. Preliminary studies had indicated that no liquid water or water vapour permeation through the two-pack epoxy adhesive was detectable and, therefore, the only possible leakage path from the test cell was via the screw cap and petroleum jelly seal.

The bottles were placed in a CaCl_2 desiccator and weighed periodically to determine vapour loss through the polymer. All determinations were performed in duplicate, at 15°C .

Water permeability

Test cells and blanks were prepared in an identical fashion to those used for the water vapour permeability experiments.

To determine the water permeability, the cells were filled with 10ml of distilled water, sealed as before, and inverted in a CaCl_2 desiccator.

The cells were weighed periodically to determine water loss. All determinations were performed in duplicate at 15°C .

Water absorption—leach rate characteristics

Weighed sections of the polymers, with an area of 80cm^2 , were totally immersed in distilled water. The samples were removed periodically, rapidly blotted free of surface moisture, and weighed to determine the change in weight. The polymers were then re-immersed in water to continue the test.

Salt spray testing

The test was performed in accordance with BS 3900, Part F4, over a period of 500 hours. After exposure, corrosion of the steel was assessed by visual inspection, and by weight change after removal of the polymer film and dissolution of the corrosion products in Clarke's Solution.

Infra-red studies

Two sections of each of the polymer films were taken, and infra-red spectra obtained, using a Perkin Elmer 337 Spectrometer. These samples of film were then totally immersed in distilled water for 350 and 700 hours respectively. After each period the films were removed, blotted free of surface water, and their spectra redetermined.

Results

Water absorption—leach rate characteristics

The results obtained from the weighings were used to plot a graph (Fig. 1) of percentage change in film weight against time.

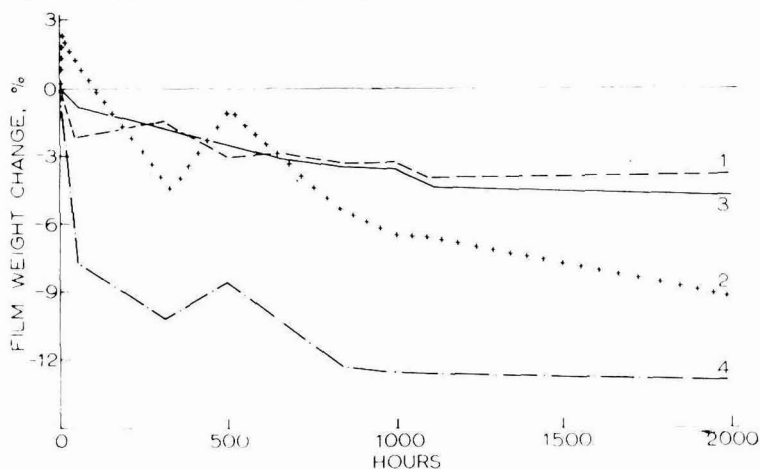


Fig. 1. Water absorption/leach rate characteristics (film surface area 80cm^2)

The results show that the epoxy/polyamine system (4) exhibited a rapid leach rate in its first 500 hours of immersion, then reached an equilibrium value after 1,000 hours. This polymer showed the highest film weight loss, 12.9 per cent after 2,000 hours.

The chlorinated rubber (1) and vinyl polymer (3) films exhibited similar behaviour upon immersion. Both slowly leached to give, after 2,000 hours' immersion film weight losses of 3.8 per cent and 4.8 per cent respectively.

The varnish film (2) after initial absorption of water, began to leach at a uniform but high rate. After 2,000 hours' immersion, a film weight loss of 9.0 per cent was found.

Salt spray test

After 500 hours in the test cabinet, the panels were removed and examined visually and for weight loss (see Table 1). The chlorinated rubber panel showed the most severe substrate attack: heavy pitting of the greater part of the metal

Table 1
Weight loss after 500 hours (Salt spray test)

Polymer	Weight loss of panel, % (in Clarke's Solution)	Metal loss (specimen) I-Metal loss (blank) %
Epoxy (4)	0.023	0.014
Chlorinated rubber (1) ..	0.068	0.059
Vinyl (3)	0.020	0.011
Varnish (2)	0.024	0.015
Blank metal	0.009	—

surface and pronounced film disruption by the corrosion products. This severe attack beneath the chlorinated rubber coating is reflected in the weight loss measurements. In contrast to this behaviour, the other three films appeared to retain their integrity and the panels showed correspondingly low weight losses. The epoxy-coated panel showed no apparent corrosion, apart from a small degree of blistering and rust formation at the edges, which was discounted in accordance with the specification instructions. With the varnish film, a few small isolated rust spots were observable on the metal substrate, although no film breakdown was evident. The vinyl coated panel, which showed the lowest weight loss, was uniformly covered with very small pits, but film integrity appeared to be maintained.

Water vapour permeability

Water vapour permeability, expressed as grams of water vapour lost against time, is shown in Fig. 2. It was found that duplicate results seldom deviated by more than 10 per cent, and the results were plotted using an arithmetical



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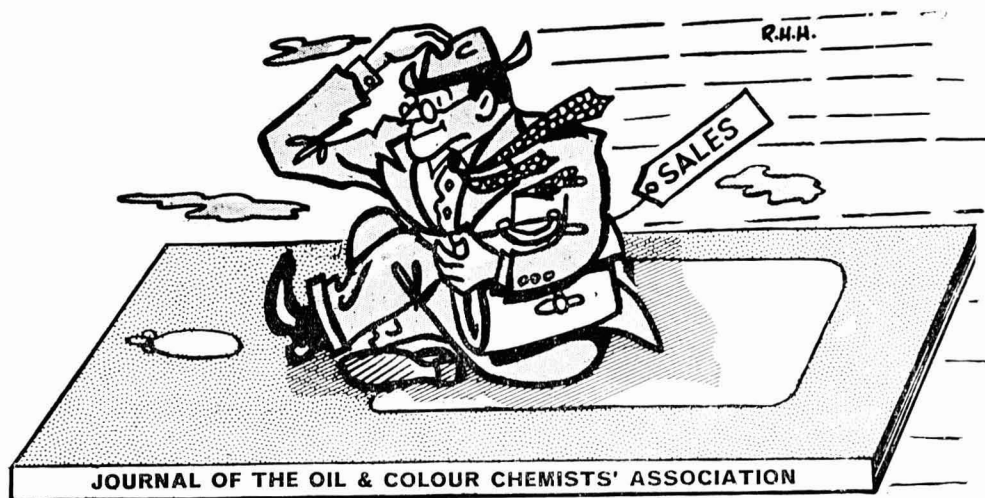
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mean. The mean of vapour loss through the blanks was subtracted from the mean of vapour loss through the polymer films.

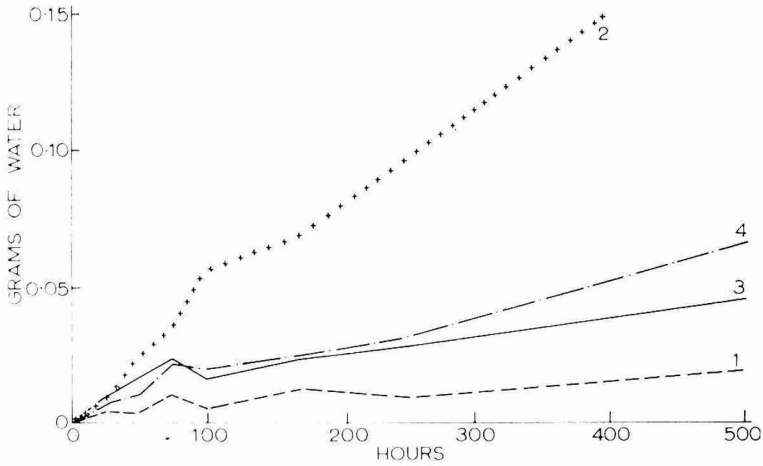


Fig. 2. Water vapour permeabilities

It can be seen that all of the polymers exhibit a general trend towards a linear increase in vapour permeability, the chlorinated rubber film being the least and the varnish film by far the most permeable.

Twenty-four hours after the test was started, it was noted that the varnish films were distended outward from their cells, having the appearance of large blisters. The effect was maintained throughout the test period; no film rupture occurred and none of the other polymers showed this effect.

Water permeability

Water permeability, expressed as grams of water lost against time, is shown in Fig. 3. It was again found that duplicate results seldom deviated by more

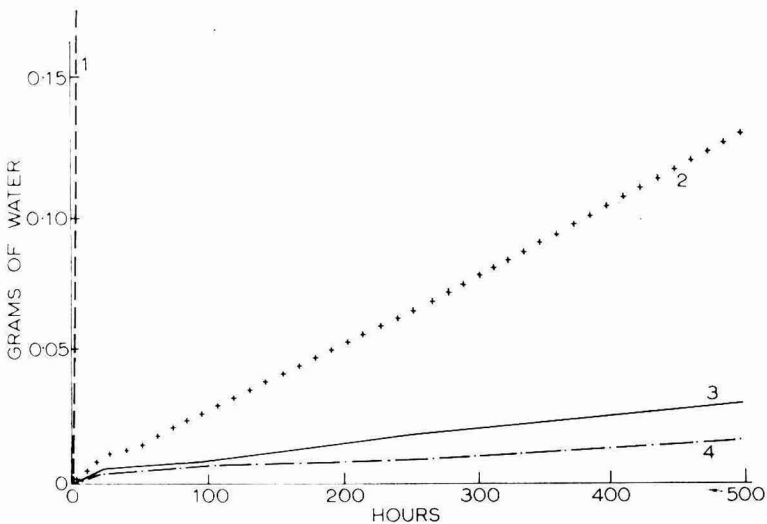


Fig. 3. Water permeabilities

than 10 per cent, and an arithmetical mean was therefore taken when plotting the results. The mean of water loss through the blanks was subtracted from the mean of water loss through the polymers.

It can be seen from the graphs that the chlorinated rubber allowed water to permeate at such a rate that, after 72 hours, all the water contained in the test cell had been lost. The permeability was initially linear, but this linearity was lost as water pressure on the film decreased. See Fig. 4.

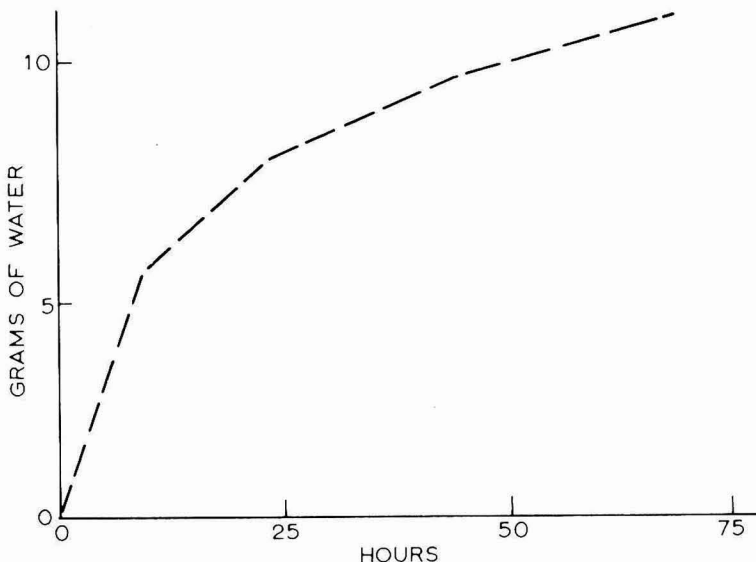


Fig. 4. Water permeability of chlorinated rubber

The epoxy and vinyl polymers both exhibited very low permeability rates, whilst the varnish had a somewhat higher rate; all the losses were linear with time.

During the test, it was noted that both the chlorinated rubber and varnish polymers exhibited swelling, with one of the chlorinated rubber films rupturing under the pressure. These were the only polymers which showed this effect.

Infra-red studies

Prior to immersion, the main absorption bands in the spectrum of each polymer were characterised and assigned to the component active groupings. The spectra taken after the samples had been immersed for 350 and 700 hours indicated that all of the main bands were unaltered in position, although the epoxy-polyamine showed an increase in the level of general infra-red transmission. All of the spectra of the polymers after immersion exhibited several minor changes, the significance of which has not yet been definitely established.

It was noted that, after immersion, none of the polymers showed an increase in the intensity of absorption due to hydroxyl groups, although inadequate removal of surface water lead to "masking" of the spectra, particularly in the higher wavelength regions.

Discussion

The results presented above indicate that the effects of water on the molecular structure of polymers varies, and that water absorption and transmission appear to occur by similar mechanisms in the different polymers.

In the infra-red spectra recorded after water immersion, no appreciable shift in position or intensity of bands due to the major groupings occurred in either vinyl acetate/chloride copolymer, the chlorinated rubber or the tung oil/phenolic varnish films. However, the epoxy/polyamine showed a general, progressive, increase in percentage infra-red transmission during the 700 hour immersion period. This is in accord with the water absorption/leach rate results (Fig. 1), which show that this polymer lost 10 per cent of its film weight over this period. The other three polymers, after 700 hours, had all lost approximately 3 per cent of their film weight. The effect of this low leach rate on the infra-red transmission characteristics might be insufficient to show in the spectra of the polymers.

All the infra-red spectra showed minor variations after water immersion which, although they could not be characterised, might represent the loss of low molecular weight entities or scission products from the polymer.

It was found that none of the spectra of the polymers after immersion exhibited any increase in intensity at wavelengths of 2.66, 2.74 or 6.27 microns. Absorption at these wavelengths is indicative of water in the gaseous state; therefore it would appear that the polymers did not retain in their structure any water vapour which could have been attributed to immersion in water.

In support of this, samples of the tung oil/phenolic varnish, theoretically the most water absorptive polymer studied in this work, were immersed in water, exposed to saturated water vapour and desiccated over CaCl_2 . After 168 hours under these conditions, the infra-red spectra of the three specimens

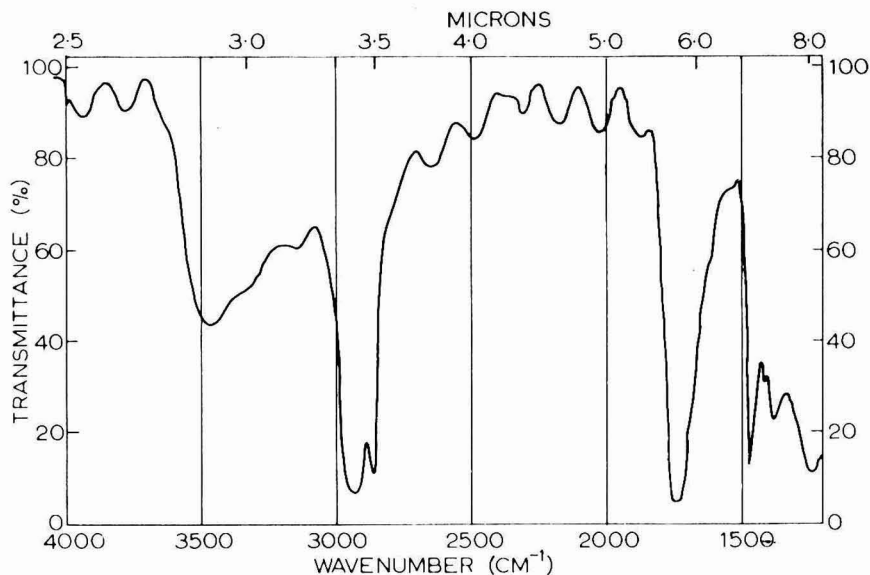


Fig. 5. Infra-red spectrum of varnish after immersion in distilled water

were recorded, see Figs. 5, 6, and 7. It can be seen that no increase in transmission occurred at the hydroxyl band wavelengths.

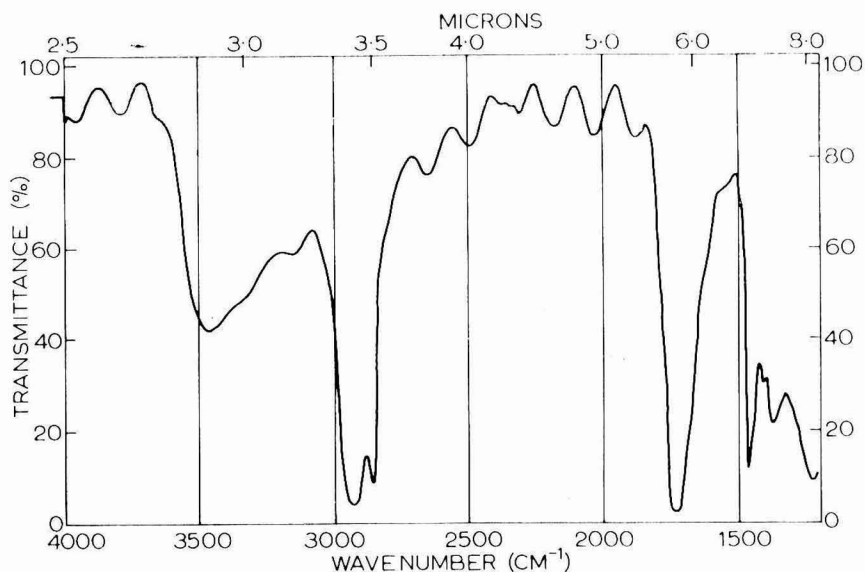


Fig. 6. Infra-red spectrum of varnish after exposure to saturated water vapour

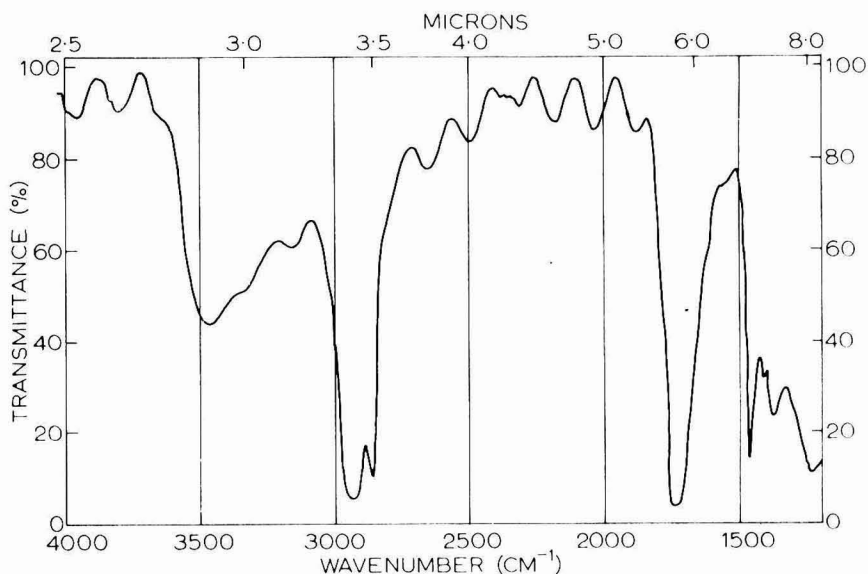


Fig. 7. Infra-red spectrum of varnish after exposure to water and desiccation over CaCl₂

A grouping effect of the polymers is apparent in the water absorption/leach rate results (Fig. 1). The chlorinated rubber and vinyl films, both of which are non-convertible coatings, exhibit a low but steady weight loss. The convertible epoxy and varnish films, however, exhibit high but rapid weight losses. It would

appear that it is the class of coating, i.e. whether convertible or non-convertible, that determines leaching characteristics of polymer films.

In the case of the varnish, vinyl, and epoxy films, it is probable that low molecular weight entities are leached from the polymer. The proportion of low molecular weight compounds in the varnish and vinyl may be low and therefore little change in the infra-red spectra is to be expected. A higher proportion of low molecular weight compounds is possibly present in the epoxy and so a more distinct change in the spectrum should be apparent. Loss of plasticiser is a probable result of immersion of chlorinated rubber in water, and again little change in the spectrum would be anticipated.

The water vapour and water permeability characteristics do not appear to be determined by the class of polymer (Figs. 2 and 3). Furthermore, the permeability characteristics are not influenced by the water absorption/leach rate behaviour of the polymers. Comparison of the water vapour permeability (Fig. 2) with the water permeability (Fig. 3) shows that the epoxy, vinyl and varnish polymers are more permeable to water vapour than they are to water in the liquid state, but both are transmitted. It is suggested that transmission through these polymers occurs via capillaries which exist within the cross-linked molecular structure. These capillaries probably have a range of diameters, so that molecules of water vapour permeate more readily than liquid water, the molecules of which are aggregated into large groups through hydrogen bonding and other secondary valence forces. It is also possible, in the case of water permeation, that there may be secondary effects such as surface tension and micelle formation within the film. Either effect, if present, would tend to reduce the permeation rate of water.

The chlorinated rubber polymer exhibited extremely rapid water permeation characteristics and poor salt spray resistance, but possessed a very low water vapour permeability. The greater rate of liquid water permeation of this polymer may be ascribed to capillary phenomena. The liquid water may be adsorbed on to the capillary walls or adsorbed within the polymer structure. This adsorption could result in dilation of the capillaries or some other form of swelling within the polymer. The attendant enlargement of internal pathways within the polymer film would permit massive permeation of the test solution. No such adsorption-dilation/swelling phenomena would be possible with water vapour, owing to the absence of a condensed liquid phase on the polymer surface. It is possible, however, that the flexibility of the polymer film has some effect on water permeation, especially as the polymer studied here had a lower plasticiser content. It has been demonstrated⁸ that plasticiser type and content markedly affects the permeability characteristics of chlorinated rubber.

Although there is no direct experimental proof of the existence of capillaries within polymer films, the "wick" effect previously reported⁷ lends support to this theory.

It is difficult to propose an alternative mechanism which could account for the differences in water and water vapour permeabilities in this study. The infra-red spectra also gave no indication of entrapment of water within the polymer or of any combination of water with the polymer. The former would be expected from the very small size of the hypothesised capillaries.

It is interesting to note that there is a correlation between substrate corrosion in the salt spray test (Table 1) and the water permeabilities (Fig. 3). Clearly, water permeability tests are of more fundamental and practical importance in polymer film evaluation than are water vapour permeability studies.

Conclusions

It has been demonstrated that the water permeability of certain polymer films is closely related to its protective action. Furthermore, there are differences in the water and water vapour permeability characteristics of such films and this may have important ramifications in corrosion protection. The incorporation of a leachable corrosion inhibiting pigment is clearly essential for a highly water permeable film but is less important for relatively impermeable ones.

Further work in this programme of investigations will be devoted to the interrelationship of corrosion rate and humidity (i.e. water vapour permeability), electrochemical characteristics and the effects of pigmentation.

Acknowledgments

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Wood protection*

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Summary

Wood, with its porous cellular structure, can absorb large amounts of water and suffer non-uniform dimensional changes. Rotting, by fungal attack, can occur when the water content exceeds 20 per cent of the wood weight. The aim of this work is to develop integrated systems involving preservative treatment and paint to protect joinery timber.

Permeability measurements on detached paint films have been related to the performance of painted wood. A spray cabinet, which automatically cycles wet and dry periods, was developed, and this provided a rapid assessment of preservative/paint systems. A more practical, but slower, test employed small glazed window frames.

Many preservative/painting difficulties can be associated with wood of unusually high porosity, being caused by bacterial attack. Two rapid, non-destructive methods for the detection of this type of wood have been developed, based on an isopropanol absorption test and on an air-leakage instrument.

Keywords

Types and classes of surfaces

softwood
timber

Types and classes of coating

wood finish
wood preservative

Properties characteristics and conditions primarily associated with: materials in general

moisture adsorption

dried or cured films

permeability

La protection de Bois

Résumé

A cause de sa structure poreuse et cellulaire, le bois peut absorber des quantités importantes d'eau, et par conséquent subir des changements de dimensions anisotropiques. Le pourrisage en raison d'une attaque par végétation mycélienne peut se produire dans le cas où la teneur en eau dépasse 20% de la masse du bois. Le but de cette étude est de perfectionner des systèmes intégraux, comprenant le traitement préservatif et la peinture, destinés à la protection de la menuiserie.

On a fait un rapport entre les mesures de la perméabilité des feuillets de peintures détachés du support et le comportement du bois peint. Afin d'assurer une appréciation rapide des systèmes préservatif/peinture, on a perfectionné un appareil à brouillard où il s'agit des périodes humides et seches automatiquement alternées. Un essai plus pratique mais plus prolongé se sert de petits châssis vitrés.

On peut lier beaucoup des difficultés préservatif/peinture à l'utilisation du bois d'une porosité exceptionnellement élevée à cause d'une attaque bactérienne. On a perfectionné deux méthodes rapides et non destructives, pour déceler ce genre de bois, basées respectivement sur un essai d'absorption d'isopropanol et sur un appareil pour doser les fuites d'air.

*This paper presents some results of an extensive research programme now in progress at the Paint Research Association and is based on a lecture given to Midlands Section by G. L. Holbrow and A. F. Sherwood on 25 September 1970. It is hoped to publish a final report on the work in about two years' time.

Holzschutz

Zusammenfassung

Holz kann zufolge seiner porösen Zellenstruktur grosse Mengen Wasser absorbieren und ungleichmässige Dimensionsänderungen erleiden. Sofern sein Wassergehalt 20% übersteigt, kann Verrottung als Folge von Pilzangriff vorkommen. Das Ziel dieser Arbeit war, integrierte Systeme zu entwickeln, welche Bauhölzer durch Behandlung mit Konservierungsmitteln und geeigneten Anstrichmaterialien schützen.

Durchlässigkeitsmessungen an abgelösten Anstrichfilmen wurden in Beziehung zum Verhalten von gestrichenem Holz gebracht. Es wurde ein Spritzgehäuse entwickelt, in welchem nasse und trockene Perioden automatisch abwechseln. Dieses ermöglichte eine schnelle Bewertung von Holzschutzmittel/Anstrichfarben Systemen. In einem praktischeren, aber mehr Zeit konsumierenden Test werden kleine, verglaste Fensterrahmen verwendet.

Viele Schwierigkeiten beim Auftragen von Schutzmittel/Anstrichmittel können in Verbindung mit der Beschaffenheit vom Holz-meist hoher Porosität- stehen, welche letztere durch Bakterienangriff verursacht wurde. Zur Entdeckung dieser Art Hölzer wurden zwei zerstörungsfreie Methoden entwickelt, welche auf einem Isopropylalkohol-Absorbiergestest und einem Luftleckageinstrument basieren.

Предохранение дерева

Резюме

Дерево, обладая пористой и ячеистой структурой, может поглощать большое количество воды и подвергаться неоднородным пространственным изменениям. Гниение, под разрушающим действием плесени, может иметь место когда содержание воды превышает 20% веса дерева. Целью настоящей статьи является разработка интегрированной системы, включающей обработку консервации и красок для защиты столярного дерева. Измерения проницаемости отделенных красочных пленок отнесены к характеристикам крашеного дерева. Разработана распылительная камера с автоматическими мокрыми и сухими периодическими циклами и это дало возможность быстрой оценки консервирующих и красочных систем. Более практичное, но более медленное испытание, применяло маленькие стеклянные оконные рамки.

Многие трудности в применении красочных и консервирующих средств связаны с деревом необыкновенно высокой пористости и причиняются коррозией бактериями. Разработано два быстрых неразрушающих метода для выявления этого типа дерева, которые основаны на испытании изопропанольного поглощения и на приборе измеряющем утечку воздуха.

Introduction

Wood is a natural material having a porous cellular structure. It is extremely variable; probably more so than any other natural product. Its porous nature is due to long narrow cells (called tracheids). In general, the cells of summer wood are smaller than those of spring wood. Paint, solvents, and water can enter through these cells, the ease with which this can occur depending on the way in which the pores are exposed, for example, as a result of radial or tangential cutting. Thus, softwoods, much used for joinery, have areas of varying porosity and permeability, depending upon the amount of spring, summer and heartwood present and the direction of cut.

To complicate matters further, sapwood (spring and summerwood), the most porous wood, is prone to bacterial attack of the cell walls if kept wet for some time, as can occur during transport or storage of the logs, resulting in even higher porosity. Such timber, known as "ponded" sapwood, is visually indistinguishable from normal wood and has similar mechanical properties.

This ponding effect may even occur as the result of storing timber in stacks under very wet conditions in, for example, a timber yard.

Over the last twenty years there has been a substantial change in the type of wood used in joinery timber. A great deal more sapwood is now used for reasons of economy. Also, as the result of intensive cultivation and selection of trees of fast growing habit and the practice of cropping relatively young trees, a high proportion of sapwood is being produced. Such wood readily absorbs water and, if its water content remains above about 20-25 per cent for long periods, fungal attack can occur.

Water is absorbed both in the liquid and vapour state, entering about ten times as fast at the end grain, where the pores are open, as at the face. From the dry state, water is first adsorbed on to the cell walls until the fibre saturation point, about 22-30 per cent water content, is reached. At around this point the hollow spaces between the cells begin to be filled with water until a water-logged condition is reached at 100 per cent water content of the wood weight or more. The cell walls swell as they absorb water, resulting in an increase in dimension, mostly in a radial direction, i.e. across the grain. This occurs up to the fibre saturation point; filling the voids with water does not result in any dimensional increase. The swelling and shrinking of the wood due to changes in water content below the fibre saturation point leads to splitting and, where frame structures are concerned, opening of joints.

Against these disadvantages of rotting and dimensional instability must be set the following advantages for the use of wood in buildings. It is still a relatively inexpensive raw material. Its ready adaptability allows easy prefabrication and its use in industrialised building techniques permits changes in architectural fashion to be accommodated by relatively inexpensive modifications of the production line. On site, it is readily adjusted and units can be constructed to suit specific purposes.

Some form of surface finish must be applied to protect wood from deterioration. Normally, this is a paint system which needs renewing at fairly frequent intervals. The Department of the Environment estimates that some £300m a year may be spent on repainting buildings. A substantial proportion of this is concerned with wood. The labour costs of painting joinery timber are at least five times that of the paint and therefore economies are being sought in reducing maintenance by devising an optimum partnership of preservative and paint to provide the longest effective lifetime.

Preservation

The preservation of timber by fungicides has been practised for very many years using such materials as creosote, copper naphthenate and water-borne copper/chrome/arsenic compositions. More recently, organic solvent type preservatives containing pentachlorophenol (PCP) or tributyltin oxide (TBTO) have been developed. An early treatment of this type, known as the Madison formula (developed by the Forest Products Laboratory, Madison, USA), is a complete treatment for exterior timber and not intended for painting, since it contains a substantial amount of paraffin wax as water-repellent, and often some pigment. For continued protection a fairly frequent reapplication of the composition is necessary. From this original formula, preservative pretreatments

for timber intended to be painted have been developed. In general, these are pigment-free and, if they contain a water repellent, seldom more than 0.5 per cent of paraffin wax is added, although other water repellents may be used.

For joinery timber intended to be painted the following methods of applying preservative are recognised:

- water-borne, copper/chrome/arsenic type to BS 4072 applied by vacuum/pressure impregnation,
- water-borne boron compounds applied by a diffusion process,
- organic solvent type applied by vacuum impregnation,
- organic solvent type applied by immersion (3 minute dip).

Impregnation or diffusion ensures penetration of preservative in depth. Penetration achieved by the immersion or dip treatment is less certain; with normal redwood sapwood penetration is 40 to 80mm along the grain, with an average penetration of 2.5mm in the tangential direction and up to 11.5mm in the radial direction. Since this method of treatment is simple and attractive economically it is the most favoured for joinery unit construction. Because of low penetration in the tangential and radial directions it is most important that the treatment is carried out after machining. Where cutting or planing cannot be avoided after treatment, the only way of re-protecting the cut edges is by liberal brush application of preservative. It must be emphasised that brushing is no alternative to dipping. Minimum preservative requirements are laid down in the Forest Products Research Laboratory Technical Note 24¹ as 1.0 per cent TBTO or 5 per cent PCP or their equivalent. Methods for the assessment of fungicidal activity and the measurement of penetration are given in this Note.

Water movement in wood

The absorption of water by wood, as has been shown above, can lead to dimensional change and rotting of the wood, resulting in premature failure of an applied paint film. The seriousness of these effects in practice has been demonstrated in a survey carried out by Tack² on window joinery on 11 housing estates. Over 1,000 readings on 137 windows, which had been in service for 1—14 years, were made. Two-thirds contained parts where the moisture content was high enough to sustain decay although there were only a few cases where actual decay was present. There was evidence that internal condensation played an important part in the wetting of window joinery.

The loss of water from painted joinery has been studied by Nash-Wortham and Savory³, who measured the moisture contents of painted blocks over more than one year. They found that, irrespective of primer type (acrylic emulsion, lead or aluminium) when employed in a three-coat paint system, the wood blocks dried out only very slowly. The paints proved to be excellent water barriers, both as a means of excluding water and in retaining water already present.

In practice, a painted window frame has the outside exposed to the weather and low temperatures in the winter, and the inside to higher temperatures, and in certain situations, e.g. in kitchens and bathrooms, to high humidity. The painted wood is thus subjected to water, both vapour and liquid under temperature and humidity gradients.

Experiments at the Paint Research Association have been carried out to study some of the factors involved in the movement of water through paint films into a wood substrate. Firstly, it is necessary to know the factors affecting the gain or loss of water from unpainted pieces of wood. By immersing an unpainted wood block in water and exposing a similar piece to 100 per cent RH, it was shown that water is absorbed about 1,000 times faster in the liquid phase than from the vapour phase; furthermore, water uptake from the vapour state stops at the fibre saturation point (22-30 per cent) whilst from the liquid state absorption continues to the fully waterlogged condition. Next, wood blocks were exposed consecutively to various conditions of temperature and relative humidity and the weight changes recorded. The results showed that over the temperature range examined (18°-35°) water content of the wood was dependent only upon the relative humidity of the surroundings.

Water movement through paint films

The Payne permeability cup⁴ method offers a convenient and rapid means of studying the permeability characteristics of detached paint films. In the experiments described below, water was placed in the cup, which was then sealed with a paint film. The whole assembly was then stored in a desiccator over phosphorus pentoxide, so that the humidity gradient across the film could be taken as being 0-100 per cent vapour. Parallel experiments were carried out in which the cup was inverted so that liquid water rested on the paint film; the conditions then were described at 0-100 per cent liquid water. The cups were weighed daily and specific permeability was calculated as mg water passing through 1 cm² of film of thickness 1mm per day. The values have no precise fundamental significance, but express simply the quantity of water passing through a paint film in a given time. The results are, therefore, relative but have considerable practical value where the amount of water passing through the paint film is the significant factor.

A number of solvent based and emulsion primers were selected to determine the differences in their permeability to vapour and liquid water; results are given in Table 1.

Table 1
Specific permeability of paint films at 25°C—vapour and liquid water (0-100% RH)*

Paint	Vapour	Liquid
Lead Primer to BS 2521 ..	0.27	0.22
Alkyd (20% PVC) ..	0.22	0.23
Alkyd (40% PVC) ..	0.17	0.16
Acrylic Emulsion A ..	3.7	10.4
Acrylic Emulsion B ..	4.2	20.5
Acrylic Emulsion C ..	2.6	4.3
Acrylic Emulsion D ..	6.6	19.5

*mg water/cm²/mm thickness/day

The effect on vapour permeability of the oil type primers after exposure to artificial weathering (BS 3900:F3) was examined and results are given in Table 2.

Table 2

Specific permeability of paint films at 25°C after artificial weathering—vapour (0-100% RH)*

Paint	Artificial Weathering			
	0h	200h	500h	1,000h
Lead primer to BS 2521	0.27	0.16	—	—
Alkyd (20% PVC)	0.24	0.18	0.18	0.18
Alkyd (40% PVC)	0.15	0.14	0.14	—

*mg water/cm²/mm thickness/day

All the above experiments were carried out at 25°C, but in practice painted wood is exposed at much lower temperatures. Therefore, permeabilities were measured at temperatures between 2.5°C and 25°C. Results are given in Table 3.

Table 3

Specific permeability of paint film at different temperatures—vapour (0-100% RH)*

Paint	2.5°C	10°C	15°C	20°C	25°C
Lead primer to BS 2521	0.02	0.05	0.07	0.12	0.22
Alkyd (20% PVC)	0.01	0.03	0.08	0.10	0.22
Acrylic Emulsion C	0.80	0.86	1.18	1.82	2.65

*mg water/cm²/mm thickness/day

The permeability of solvent based paints was the same with vapour as with liquid water (Table 1). This is presumably because the method of transfer of water through a paint film is the same for the two states and is probably by a solution mechanism. It is in sharp contrast to the absorption properties of wood where liquid water is taken up very much faster than water vapour. Many other solvent based paints have been examined, using a variety of extenders and a range of pigmentations, but none have been found to differ substantially in their vapour and liquid permeabilities.

The emulsion paints, both laboratory prepared and commercial products all had much higher permeabilities than the solvent based paints and their liquid water permeabilities were substantially higher than their vapour permeabilities. This implies that, when applied to wood, water as liquid could pass more readily through such a primer into the wood than it could pass out again as water vapour. Timber primed with these emulsion primers and stored or a building site without the protection of an oil based undercoat and finish could therefore gain more water as the result of rain than could be lost during dry periods.

In Table 2 it is shown that water permeability was little affected by the artificial weathering. The main feature of weathering was to embrittle the film, indeed some measurements could not be made because the films had become too brittle to handle as detached films. The reason for increased water pick-up of weathered painted wood is therefore not due to an increase in permeability of the paint film, but to its embrittlement producing microcracks through which liquid water is able to pass freely into the wood.

In Table 3 specific permeability is shown to be strongly dependent upon temperature. This is due to low partial pressure of water vapour at low temperatures; saturated air contains very little water to be transferred through the paint film. The practical significance is that if, for example, a window frame was painted with the same thickness of alkyd paint inside and out, the temperature inside being 25°C and the outside 2.5°C, both at the same R.H, then twenty-two times as much water would enter the frame from the inside as could escape through the outside paint film. This effect could be mitigated by using paint films more permeable to vapour than to liquid water. In this work so far no films of this sort have been found. An alternative solution would be to use a greater number of paint coats on the inside than on the outside, as advocated by Dooper⁵.

Water movement in painted wood

At the PRA many laboratory experiments have been carried out in which small painted blocks of wood (5cm × 5cm × 2.5cm), treated or untreated with preservative and painted, were immersed in water and the rate of water uptake measured. To obtain reproducible and consistent results, very great care had to be taken in the selection of wood free from knots and shakes and of closely matching porosity.

When single coats of paint were used, far more water was taken up than could be accounted for by permeability measurements on detached paint films. This was due to water being transmitted not so much through the paint film but via raised fibres which penetrated the film and acted as wicks. With some experimental emulsion paint, so many fibres were raised that the film had scarcely any effect as a water barrier. Only when three or more coats were used was a reasonable correlation with permeability measurements obtained.

As a barrier to water, a second coat of oil-based paint was extremely effective, the type of paint (aluminium, lead or lead-free) being of lesser importance. These experiments emphasise the need to apply at least two coats of paint to joinery that is to be stored on site for any length of time.

The use of a preservative pretreatment before painting with single coats of primer reduced the water uptake, except with a lead primer—then water uptake was increased. Single coats of a lead primer gave the lowest water uptakes but by using a water repellent pretreatment with an alkyd based primer it was possible to reduce water uptake to the level of that of the lead primer. It was concluded that the oil component of the lead primer was particularly effective in sealing wood, especially the end grain, thus reducing water uptake. The preservative treatments used also provided some sealing action, but were less effective than the oil component of the lead primer.

In practice, primed joinery timber may be stored on a building site exposed to the weather for up to six months. Laboratory tests were therefore made in

which the water uptake properties of primed panels were measured before and after 500h artificial, or six months natural, weathering. Where the primer film was in good condition, water uptake was little affected by the weathering treatment but where the film had chalked or cracked, water uptake increased on weathering. Where a pretreatment had been used (with or without a water repellent) the increase in water uptake was less, even where the paint film had chalked. The extent of this reduction and the effectiveness of the pretreatment under practical exposure conditions has yet to be established by exposure trials.

It is worth noting the efficiency of various treatments in their ability to reduce water uptake of a piece of wood. As a rough guide, taking the rate of water uptake by bare wood as 1,000, wood dipped for 3 minutes in a water repellent preservative is 400, with one coat of paint 100, and with a full coat paint system 7.

Cyclic water movement

In practice, painted timber is exposed to liquid water in the form of rain interspersed with periods of drying. Thus water is constantly moving in and out of the wood, the paint film reducing this movement. Ideally, the paint should restrain the water movement to an extent where there is little dimensional change, so as to keep the water content below 20-25 per cent, the critical level at which fungal attack occurs.

To study the restraining influence of paint films, a test cabinet was constructed which subjected painted panels to a water spray and drying cycle (see Fig. 1).

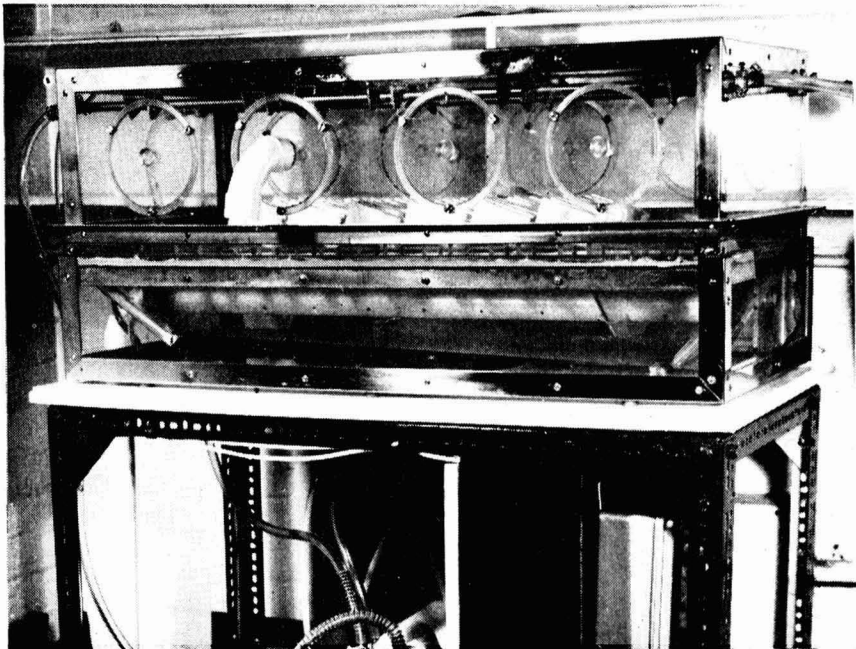


Fig. 1. Cyclic water movement test cabinet

Panels are supported on a Perspex grid. Water or air is dry passed through the perforated pipes placed in the roof of the cabinet

Painted wood blocks (8cm × 5cm × 1.5cm) are supported on a wide mesh grid in the centre of a Perspex cabinet. Spray jets are fitted to the roof of the cabinet and beneath the grid a tube is fitted with perforations facing downwards, through which air of controlled humidity (20 per cent) can be passed. The cabinet is maintained at 20°C and the following cycle conditions are used:

- (a) water spray for two hours,
- (b) transition period—air passed in at 20 per cent RH for five hours to bring the atmosphere in the cabinet to 60 per cent RH,
- (c) drying period—air at 60 per cent RH for 17 hours.

The water content of the panels is measured by weighing them one hour after the commencement of period (b) and at the end of period (c).

Preliminary studies showed that under these conditions the weights of panels at (b) and (c) increased at first but after a number of cycles reached constant values. The number of cycles to reach this steady state and the water maximum and minimum contents at this stage were recorded.

The apparatus has been used for the assessment of many types of primers used as single coats and multicoat systems.

Results of panels coated with one coat of primer are given in Table 4 and the typical curves are illustrated in Fig. 2.

Table 4
Behaviour of primer systems in spray cycle test

Primer	Cycle 1 water content (%)		Number of cycles for steady state	Steady state water contents (%)	
	Max.	Min.		Max.	Min.
Acrylic Emulsion 1	40	18	6	45	20
Acrylic Emulsion 2	32	20	5	42	26
Alkyd 1	19	15	7	37	22
Alkyd 2	19	17	13	30	27
Lead to BS 2521 1	15	14	13	29	27
Lead to BS 2521 2	15	12	8	22	20

A large difference in water content between maximum and minimum at the steady state will result in considerable dimensional cycling and, in the case of window frames, door frames, etc., could lead to the opening of joints. With the primers illustrated in Fig. 2, the best performance was given by the lead primers which not only “damped down” water movement at the steady state, but also, in the case of one lead primer, kept it below the critical level at which fungal attack could take place.

Natural exposure tests at Teddington were made on the same primers as used in the cycling test, applied to panels mounted horizontally. These panels had a central groove cut in the top face in which rain could collect. Breakdown of some primers occurred within six months by cracking and flaking from sharp edges of the panel. The same primers in the cycling test showed a large fluctuation between maximum and minimum water contents. From this

experience it was concluded that the cycling test could be used as a rapid laboratory sorting test, giving in seven to fourteen days useful results similar to those obtained in six months natural exposure at Teddington.

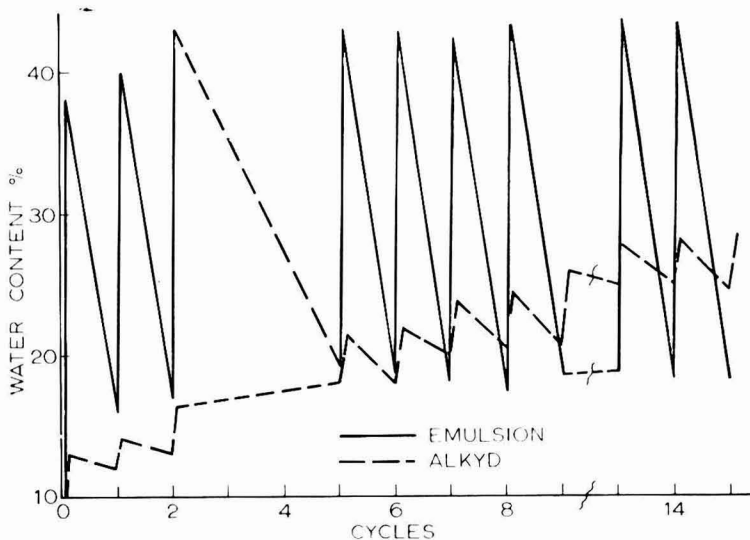


Fig. 2. Water content of wood during cycling

Highly porous wood

The presence of zones of high porosity in some wood has been mentioned earlier. Such wood absorbs a large amount of preservative solution, which can lead to serious over-painting problems in terms of poor drying, loss of gloss and staining of the top coat.

High porosity wood in joinery is clearly undesirable and wherever possible its use should be avoided for exterior use. It is generally accepted that high porosity wood constitutes only a very small proportion of all wood used in joinery; estimates of 3 to 5 per cent have been made. Experience at the PRA when buying wood for laboratory experiments is that particular deliveries may contain as much as 40 per cent which is highly porous while others contain none at all.

For laboratory experiments it is most important to use panels selected to a known porosity level. Two methods of test have been used for their selection:

Isopropanol absorption test (IPA test)

One drop (approx. 0.02ml) of isopropanol is spotted on to the surface (side grain) of a panel and the rate of absorption and spread of the drop is noted. On Scots pine (redwood) high porosity wood, absorption is complete in 1-2 seconds with only a small spread of the alcohol over the wood surface. On normal porosity wood, the absorption takes about 1 minute with a considerable surface spread.

For selecting panels for laboratory tests, six spots are placed on a panel 15 × 10cm. Some variation of porosity is observed over most panels and where

“average porosity” is required absorption in 40-70 seconds is accepted. If any areas are outside these limits the panel is rejected.

Porosity instrument

A second and very successful laboratory method for timber selection, which may have applications in the joinery industry, is based on a roughness meter (see Fig. 3), originally designed for assessing the profile of blast cleaned steel



Fig. 3. PRA/CIRIA roughness meter used as a wood porosity instrument

With an up-stream pressure of 50in water the down-stream pressure is 12in water when used over highly porous wood; for normal porosity wood the down-stream pressure will be about 40in water

and previously described in *JOCCA*⁶. The instrument works on an air leakage principle, so that when the sensing head is placed on a planed wood surface air escapes through the pores of the wood and the loss of air pressure is measured. The incoming air stream pressure (up stream) is set at an arbitrary 50in of water. The down stream pressure, i.e. pressure at the head, is read off from a second dial. The difference in upstream and downstream pressures, i.e. pressure drop, is recorded and in these experiments has been termed “Porosity Index.” For laboratory tests, 10 readings are taken over the face of a 10 × 10cm panel and from the results the distribution of porous areas can be detected.

A series of panels were selected by the two methods and, after equilibrating to 60 per cent RH, were dipped for three minutes in a commercial water repellent preservative. Table 5 gives the weight of preservative absorbed, the average time for absorption by the IPA test and the “Porosity Index” both expressed as an average and the range recorded for the ten readings.

Table 5
Porosity of wood and preservative uptake

Preservative mg ml ⁻¹	IPA absorption test (Sec.)	"Porosity Index"	
		Average	Range
470	1	34.2	32-36
447	1	33.5	28-36
368	1	31.3	29-33
348	1	31.8	31-33
244	1	23.5	7-36
220	10	18.2	2-30
195	3	21.7	13-28
136	5	19.4	12-30
84	5	9.5	3-21
68	50	5.9	1-21
63	7	10.2	6-15
39	10	5.7	1-15
22	50	2.1	1-4
16	30	1.5	1-2
7	50	1.7	1-3

In the intermediate porosity region, as judged by average porosity index readings or preservative uptake, the panels contained small areas of high and low porosity. It is possible that the wood comprised either high or normal porosity material and there was very little wood of an intermediate porosity.

The effect of porosity on preservative uptake was very marked, and for the extreme examples given in Table 5 a variation of nearly 65 times in preservative uptake was observed. In selecting Scots pine planks for laboratory experiments, a variation in preservative uptake of 30 times between normal and high porosity wood has frequently been experienced. In terms of cost under practical conditions it has been calculated that for a small 12 × 24 inch window frame the preservative taken up by a 3 minute dip would cost $\frac{1}{2}$ p for normal porosity wood and 15p for high porosity wood.

The effect of the preservative loading was investigated by selecting sets of panels to cover the range of loadings given in Table 5 and, after 24 hours drying, painted with systems as shown below.

Acrylic emulsion primer only. Drying was affected at preservative loadings in excess of about 15mg ml⁻¹; at 220mg ml⁻¹ the effect was so severe that the film remained soft even after four weeks. Adhesion was affected at a loading of about 75mg ml⁻¹. Discoloration was observed at loadings above 150mg ml⁻¹.

Emulsion primer, alkyd undercoat and alkyd finish (applied at 24 hour intervals). Undercoat drying was affected with some discoloration at loadings above 60mg ml⁻¹, whilst cissing of the top coat occurred with loadings above 220mg ml⁻¹. Adhesion failures in some form occurred at loadings above 50mg ml⁻¹.

Alkyd primer, undercoat and finish (applied at 24 hour intervals). Slow drying of the alkyd primer and undercoat and loss of gloss of the top coat

were observed at loadings above 150mg ml^{-1} . Staining developed after four weeks on all panels with loadings in excess of 75mg ml^{-1} . There were adhesion failures at loadings above 220mg ml^{-1} .

Other sets of panels were allowed eight days' or six weeks' drying before painting. After eight days, those panels with loadings greater than 150mg ml^{-1} showed drying and staining defects. Adhesion of the emulsion primer was poor, but adhesion of the alkyd primer was satisfactory. After six weeks, drying of the paints was satisfactory and there were no staining difficulties, at least immediately after painting, but adhesion of the emulsion primer was not entirely satisfactory at loadings greater than 150mg ml^{-1} .

It is clear from the above experiments that porous wood can lead to undesirably high loadings of preservative, which have adverse effects on paints. So far only the immediate effects on drying, adhesion and staining have been examined. It still remains to be determined what effects there are on long term weathering. The evidence of these experiments suggests that, at least with the particular commercial water repellent preservative used, loadings of about 40mg ml^{-1} should not be exceeded when painting is to follow within 24 hours. If a drying period of at least a week is allowed before painting, the safe preservative loading may be at least doubled. The best solution would be to reject highly porous wood for use in exterior joinery.

Window frame tests

It was realised at the commencement of the work that a practical evaluation using window frames which involved glazing, putty and joints would be essential to evaluate fully selected systems of preservative and paint. However, because of the space required tests would have to be restricted to about 100 frames. This meant that laboratory testing, which was rapid, would be used for screening something like 26,000 combinations of preservative and paint from which a hundred of the best would be evaluated by a window frame test.

A test cabinet was constructed, consisting essentially of a large box with openings in the front panel to which fully glazed window frame units were attached and so sealed the box, see Fig. 4. The cabinet was mounted out of doors with the window frames facing south. The interior of the cabinet was held at a minimum of 15°C by means of an electric fan heater and 75 per cent RH with trays of salt solution. With the daily variations in temperature, condensation occurred on the inside of the frames thus simulating the severe conditions experienced in a kitchen or bathroom. The frames consisted of standard opening lights ($1 \times 2\text{ft}$) into which stainless screws were inserted at the corners and the top, bottom and side rails. Water content of the wood at these points was determined by a conductivity measurement.

Water movement in the frames as affected by different primers was studied using the following primers: acrylic emulsion, lead to BS 2521, an industrial lead-free, and a lead-free based upon a tung/phenolic varnish. The same alkyd undercoat and finish were applied to all frames. The frames started at an initial 14 per cent water content; the results after 13 weeks' exposure are given in Table 6.

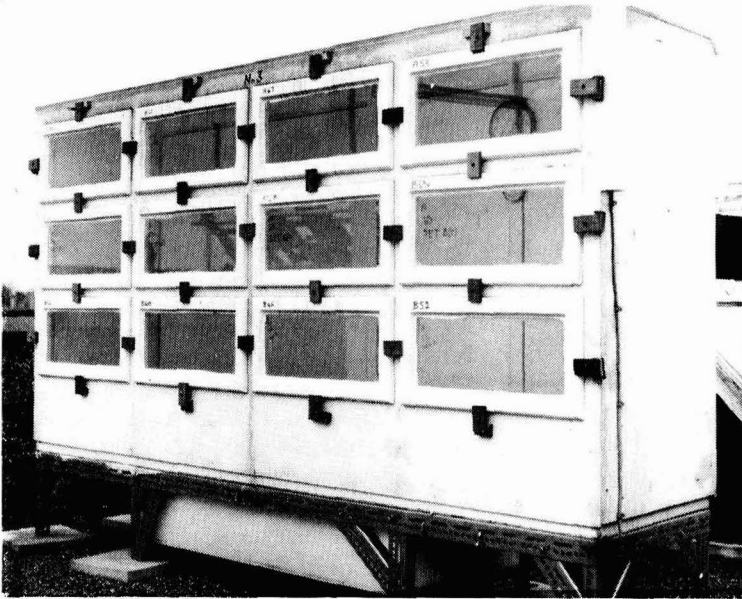


Fig. 4. Window frame test cabinet

Glazed window frames are clamped on to a cabinet, the inside of which is maintained at 75% RH at a minimum of 15°C

Table 6

Water contents on outer and inner surfaces of window frames after 13 weeks' exposure (%)

Primer	Surface	Water content (%)							
		Close to glass edge				Close to outer edge			
		Top	Right	Bottom	Left	Top	Right	Bottom	Left
Acrylic emulsion	Outside	15	18.5	20	22	14.5	21.5	21	25
	Inside	9	10	10	12	9	9.5	9.5	10.5
Industrial	Outside	14	30 †	13	18	16	27	15	25
Lead-free	Inside	11	16.5	10	11.5	10	14	10	12
Lead	Outside	14.5	14.5	16.5	15.5	15.5	16	16.5	17
	Inside	9	13	9.5	12.5	11	12	11.5	12.5
Tung/phenolic Medium	Outside	13	30 †	30 †	19	14	30 †	30 †	16
	Inside	10	16	13.5	13	11	16.5	12	12

There was a water gradient across all the frame members with the highest concentration at the outer surface. Water contents high enough to support fungal attack were found in all but the lead primed frames. Apparent bias was observed in the results. The right-hand (vertical) rails generally had a higher water content than the left hand rails; the reason for this is uncertain but is probably due to the prevailing wind direction.

The conditions of the frames and paint film at 13 weeks were found to be as shown below.

Acrylic emulsion primer	All joints showed movement on inside surface with some lifting of the paint around joints. On the outside, all joints showed considerable movement. Cracking of the paint occurred over exposed end grain.
Industrial lead-free primer	Severe movement of the joints on inner and outer sides. Cracking of the paint occurred on the lower ends of inside side rails. On the outside this was severe and some flaking had occurred.
Lead primer	No joint movement—paint film good.
Tung phenolic medium primer	All joints showing movement on the inside surface with the paint peeling slightly at some joints. On the outside the joint movement was mostly at the lower joints. Some cracking of the paint occurred over exposed end grain.

The lead based systems gave the best overall performance. Emulsion and industrial lead-free primers allowed severe joint movement in the test frames. The latter primer appeared to be too brittle, causing the complete paint system to crack and peel.

More than a year's experience with this form of window frame test shows that the results give a good indication of the performance of a preservative/paint system under practical conditions with some measure of acceleration, possibly by a factor of two.

Conclusions

The permeability of oil type wood primer films was the same to vapour and liquid water; for emulsion primers permeability to liquid was greater than to vapour. Artificial weathering of detached films, for up to 1,000 hours had little effect on permeability. Specific permeability, or the rate of passage of water through the film, was much lower at low temperatures (2.5°C) than at normal temperatures (25°C).

One coat of paint was a less effective water barrier than the permeability measurements suggested, because of sinkage into the wood surface and fibres penetrating the paint film. Three coats of oil-based paint provided a very effective water barrier. However, even one coat of paint was more effective in reducing water uptake than a water repellent preservative dip treatment.

Painting problems such as slow drying, poor adhesion and staining were associated with high loadings of preservative taken up by highly porous timber. Non-destructive methods for detecting highly porous timber were developed.

Test methods for the evaluation of preservative treatment/paint systems included a laboratory spray cabinet test and natural weathering of grooved panels mounted horizontally, allowed the best systems to be selected for a final assessment in a window frame cabinet.

Future work

A sequential scheme of tests is now being applied to a planned series of preservative treatment and primer systems. A fully integrated paint system will be achieved when there is an ideal relationship between wood, pretreatment, primer and subsequent paint coats. It is expected that the work will yield more than one integrated system and will indicate those most tolerant of poor practice such as:

- shop primed timber remaining on site for more than six months before painting,
- over-thick coats of primer resulting from poor dip-painting practice or too thin coats applied by spray, or even
- omission of a paint coat.

Acknowledgments

The authors are grateful to the Director and Council of the Paint Research Association for permission to publish this paper, and to the Department of the Environment under whose sponsorship part of the work was carried out.

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Discussion at the Midlands Section

MR H. J. GRIFFITHS (CHAIRMAN) asked for advice on sealing oak stills.

MR A. F. SHERWOOD said that it was difficult to improve on calcium plumbate primers or lead primers to BS 2521 to seal open textured wood. He commented that many new filler compositions showed a marked tendency to fall out.

MR C. HEPTINSTALL commented that the work as described would be unlikely to offer a solution to more than isolated problems, as wood was so variable, and selection was uneconomical.

MR SHERWOOD emphasised that selection of sample substrates was made to ensure an adequate range of wood qualities including timber with high sapwood content. There had been some difficulty in obtaining the very porous wood.

MR G. L. HOLBROW added that the aim was a painting system tolerant to wood variation. It was envisaged that this would involve an integrated system of preservation and paint. Where highly porous timber was used, then the preservative pretreatment would most likely require to be combined with a sealing treatment.

MR P. F. M. COVERDALE asked if any material of a cellulose or urea nature was used by timber suppliers to seal wood.

MR HOLBROW replied that he was not aware of any such treatment.

MR R. F. HILL asked if rot was arrested if over-painted.

MR HOLBROW said that if the wood was dried to less than 20 per cent water content before painting it was likely that rot would be arrested, at least temporarily.

MR J. DAVIS wanted to know how long preservatives remained effective when suitably over-painted.

MR HOLBROW answered that he had no data other than that PCP and TBTO were believed to remain effective for several years. It was intended to check this when repainting trials were started in about three years' time.

MR GRIFFITHS wondered if there were any noticeable trends in the quality of timber.

MR HOLBROW replied that the amount of sapwood was on the increase. One reason was that fast growing varieties of pine were being planted and harvested while quite young. This meant the tree was mainly composed of sapwood with only a small amount of heartwood in the centre.

MR HEPTINSTALL informed the meeting that thousands of square miles of virgin forest remained in Russia and Canada.

MR A. COVERDALE asked if preservatives had any effect in preventing joints from opening in frames.

MR HOLBROW said that water repellents and other resinous binders present in a preservative hindered water ingress particularly through the end grain, therefore some dimensional stabilisation was achieved. However, the paint system provided the main sealing action. If sawing took place after dipping in the preserving solution, the exposed surface should be liberally treated by brushing with fresh preservative.

MR SHERWOOD contributed some thoughts on painting over preservative treatments. Water repellents used in excessive quantities would always give trouble; solvents would leach resin from knots and leave stains; and wood of excessive porosity would absorb so much solution that solvent evaporation could seriously soften paint films. It was common for porous wood to take up 20 times more preservative than normal, in itself a significant addition to joinery costs.

Next month's issue

The Honorary Editor has accepted the following papers for publication, and they are expected to appear in the February issue of the *Journal*.

"The glycerolysis step in the production of oil modified alkyd resins Part V Glycerolysis of castor oil and dehydrated castor oil," by N. A. Ghanem, M. A. El-Azmirly and Z. H. Abdul El Latyl.

"A mathematical review and comparison of ink transfer equations," by M. Cropper.

"Weathering of paint IV Influence of the radiation intensity on chalking of paint films," by E. Hoffmann and A. Saracz.

"An investigation of some factors affecting the performance of primers for galvanised steel," by W. H. Newell.

Editorial

SI Units

At the meeting of the Publications Committee held on 22 November 1971, it was decided that, in the *Journal*, SI Units would be used exclusively as from January 1975. As explained in the April 1971 issue, SI Units have become recommended units in the *Journal*, but it was not felt appropriate to insist upon their use at that stage. As these units are being increasingly accepted, it is felt that by 1975 there will be little difficulty in taking this step, and authors are recommended to use SI Units where possible in all papers during the coming three-year period, so that a gradual phasing-in of the system can take place.

Correspondence

Surface coatings

SIR—As one of Mr Fisk's earlier converts, for many years I supported him in his losing battle against the alleged tautology (*JOCCA*, 1971, 54, 1081). Let him be assured that I fought long and hard on his side when the designation of our professional grade was under consideration.

Now, however, I am gravely concerned for his digestion, and venture to pass on to him, and others similarly misguided (if not, perhaps, so rash), the enlightenment I received from Dr S. H. Bell.

The Concise Oxford Dictionary has, "Coating. Layer of paint etc; material for coats."

Webster's New World Dictionary is even clearer:

- "Coating 1. Something covering or spread over a surface.
2. Cloth for making coats."

Neither is the reference quoted by Dr Bell, but both make the point. The adjective in *Surface Coating* is not tautological; it is necessarily qualifying as all good adjectives should be. In any case, would not Mr Fisk prefer an element of tautology to one of ambiguity?

I know nothing about cloth for making coats, so am happy to remain.

Yours faithfully,

A. R. H. Tawn, FTSC

34 Crest View Drive,
Petts Wood, Kent, BR5 1BY
12 November 1971

Reviews

TEXTBOOK OF POLYMER SCIENCE

By F. W. BILLMEYER JR. Second Edition. New York: Wiley-Interscience, 1971, pp. xiv + 598. Price: £7.50

This expanded and up-dated edition still shows its ancestry in the author's Textbook of Polymer Chemistry published in 1957—and is none the worse for it. The layout is substantially the same as that of the first edition and, in this reviewer's opinion, Professor Billmeyer's conciseness and accuracy in presenting the subject in breadth have yet to be surpassed.

Those parts of the work dealing with well established principles are little changed but the treatment of developing areas of polymer science has been extensively revised and expanded at the expense of redundant material. It is a measure of the author's stature that he is prepared to chop what he must at one time have cherished. That much-worshipped god, the Alfrey-Price equation is revealed as a graven image, "not entirely sound from the theoretical standpoint and—best regarded as semi-empirical." New material includes much on polymer solutions, structure and bulk properties, on ionic and co-ordination polymerisation, and on the newer types of polymers such as the heterocyclics and ladders.

The book is addressed to those with no previous knowledge of polymer science, but it assumes something near degree level in organic and physical chemistry, with more than a smattering of physics and elementary maths. For such it is an invaluable introduction, provided they realise that it is so concise as to be almost a study guide, necessitating extensive further reading. For the experienced specialist, it provides a useful broad view of the present state of the art, whilst all classes of reader will be helped by the excellent subject index.

Writing for this *Journal*, the reviewer must criticise Billmeyer's neglect of surface coatings as the fourth polymer-based industry alongside plastics, rubbers and fibres. Even allowing his conciseness, half a page on alkyds seems barely adequate.

A. R. H. TAWN

INDUSTRIAL PAINT APPLICATION (SECOND EDITION)

By W. H. TATTON AND E. W. DREW. London: Newnes-Butterworth, 1971, pp. 266. Price £3.50

This second edition of *Industrial Paint Application* embodies all the important advances which have been made in this field since the original edition was published in 1964. It is a well presented book covering all the well established methods of application including brushing, dipping, barrelling, flow roller and curtain coating. Spraying is discussed in all its forms, which include conventional, hot, airless and electrostatic techniques including automatic systems and equipment for the application of two-component materials.

The newer application processes are very well covered, and plenty of space is given to electrodeposition and powder coating. The principles and mechanisms of these processes are well defined. Other specialised techniques discussed include vacuum impregnation, vacuum deposition, ultra-violet and electron beam curing.

The all-important subjects of metal cleaning and metal pretreatment are dealt with and the chapter on stoving ovens gives good advice on possible causes and remedies for such common defects as gas checking, solvent wash and solvent boil.

The final chapter is on the Principles of Paint Technology, and is just sufficient to whet the appetite of the application technician without frightening him with too much basic science.

A book written primarily for the guidance of the paint technologist and technical sales representative has achieved its object. It is suitably illustrated with plates and diagrams, and commercial trade names of apparatus discussed are used throughout. The book is well indexed.

H. J. CLARKE

Paint Technology Manuals

Part Seven : Works practice

Foreword

This work was originally intended to become the final volume of the series of Paint Technology Manuals written by a team of specialists commissioned by the Oil and Colour Chemists' Association. However, for a variety of reasons, it has been decided not to publish this, the seventh part, in the same form as the earlier six volumes. Since one of the original reasons for the publication of the Manuals was to be of help to students and younger personnel studying for the City and Guilds of London Institute examinations in paint technology, the Council of the Association decided that appropriate extracts would be taken from the original manuscript by the Honorary Editor, Mr S. R. Finn, BSc, FRIC, FTSC, and printed in the Association's *Journal* each month throughout 1972 in the form of Student Reviews. Additional run-on reprints of each Student Review will be made as the *Journal* is printed, and these will be collated and bound at the end of the year. Thus a limited number of bound copies of Part Seven will be available for sale. Members of the Association will be given priority in the sale of the bound version, and registered Students of the Association will be allowed to purchase one copy each at a considerably reduced rate.

To readers of the *Journal*, it should be explained that, in order that no extraneous material shall appear in the bound version, it may be necessary on occasion to leave a blank page at the end of a Student Review, or otherwise alter the format of this particular section from that usual in the *Journal*. The Council hopes that readers will accept this slight inconvenience in the cause of education of younger personnel in the paint industry.

It will be noticed that there is additional material in the running headings to this section in order that the pagination of the reprint shall run consecutively for ease of reference and indexing. Similarly, figures and tables in this section will be numbered consecutively throughout the year, and not numbered separately in each issue.

Preface to Part Seven

This volume is concerned with the practical aspects of making paints. In view of the fact that there has been little published material on this topic, a fairly broad coverage is attempted, including factory layout and organisation, paint and media manufacturing processes, legal aspects and safety precautions. A breakdown of the content of the volume, by instalments, is given below:

Chapter 1—The factory. Siting and layout

Chapter 2—Raw materials. Storage and handling

Chapter 3—Varnish and media manufacture:

- (a) Cold processes
- (b) Manufacture in open vessels
- (c) Manufacture in closed vessels

Chapter 4—Paint manufacture:

- (a) General
- (b) Processes involving premixing
- (c) Processes without premixing
- (d) Layouts, maintenance, filling and warehouse

Chapter 5—Factory organisation and personnel

Chapter 6—Legal requirements and regulations

Chapter 7—Factory hazards and safety precautions

References are made throughout Part Seven both to papers in the Journal of the Oil and Colour Chemists' Association and to the six volumes of the Association's Paint Technology Manuals published by Chapman & Hall Ltd. Of the latter, Part 1, Non-convertible coatings available in second edition; a third edition of Part 2, solvents, oils, resins and driers, is under discussion Part 3, Convertible coatings, Part 4, Application of surface coatings, and Part 5, The testing of paints, should all be available in second edition around the end of 1972; and Part 6, Pigments, dyestuffs and lakes, the last to be published, is available in first edition. It is hoped that these references will augment the extracts in this volume into a comprehensive treatise on the subject of works practice, and thus form the seven volumes into a complete textbook on all aspects of paint.

January 1972

S. R. FINN

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Paint Technology Manuals. Part Seven: Works practice

Chapter I. The factory: siting and layout

Layout

The opportunity seldom arises, at least in the United Kingdom, to design a completely new paint factory on a vacant site. Modification or extension of an existing factory or the installation of new equipment into an existing building are much more usual, and here the principles which would be used on a new site should be followed as closely as practicable.

The following fundamental principles should be kept in mind by the designer:

- (a) a successful production unit is bound to grow;
- (b) materials must be moved as little as possible and should be moved in straight lines, as far as practicable, during their manufacture;
- (c) liquids can be moved much more easily than solids;
- (d) when moving liquids, it is advisable to use gravity as much as possible;
- (e) processes using heat and organic materials usually involve a high fire risk and, therefore, should be kept separate from other process areas.

An example of a typical flow scheme is shown in Fig. 1.

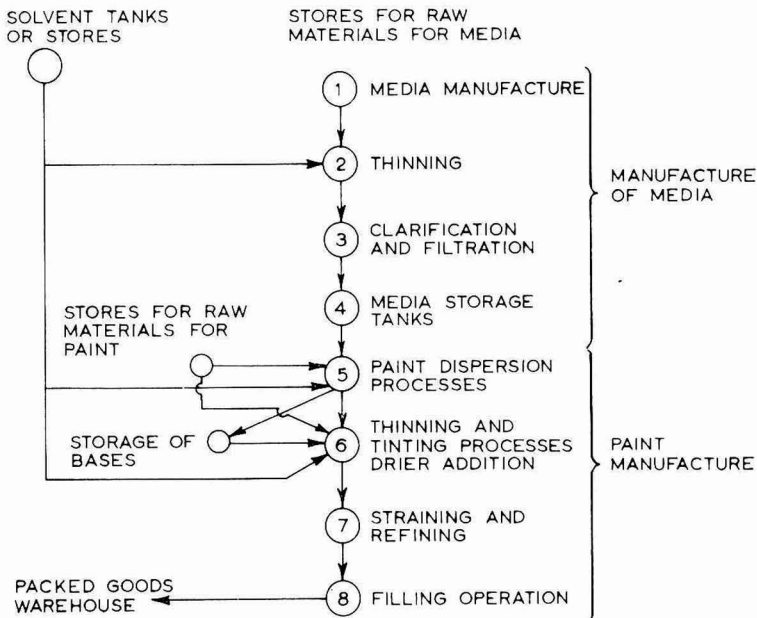


Fig. 1. Typical flow diagram for paint manufacture

Operations 1, 2 and 3 involve the main fire risks and so must be separately housed.

The site

Where an established site does not have to be used, choice of a site may be affected by a desire to establish the works in a particular locality; this will apply to firms whose sales interests are localised, in order to keep the distribution costs as low as possible but, in general, the choice of a particular site should be analysed carefully in the light of the factors to be discussed.

Consideration should also be given to any statutory requirements of regulations such as the Factories Act, Town and Country Planning Act, Distribution of Industries Act, Local Bye-Laws and the need in many areas to obtain building permission from Local Planning Authorities. Ideally, an existing site should be cleared completely, but where replanning and rebuilding has to be done without interfering with current production, it may present complex problems to all concerned.

Economics

One of the major factors to be considered will be the cost, by purchase or otherwise, of the land upon which the factory will stand. The actual area necessary can be controlled by the type of building erected, and the fullest discussions should take place with the architect, reviewing the comparative initial costs of single or multi-storey buildings. If the intention is to rent the premises, then a similar comparison, based on an equal square footage of area occupied, may prove illuminating. In either case, these estimates should be closely allied to calculation of the probable cost of running the building(s), which will call for estimates of such factors as heating, rates (local government charges), lighting and maintenance. Experience has shown that, although a multi-storey building may cost more initially, it can eventually prove to be cheaper to run efficiently.

Practicability

The important questions to consider under this heading are set out below.

Is the ground suitable for sinking underground storage tanks and for bearing heavy loads?

Is there any likelihood of flooding from local rivers or isolation of the site by freeze-ups of main trunk roads over high ground during the winter period, which can have the effect of limiting the supplies of essential raw materials received, as well as preventing the despatch of finished goods?

What other types of manufacture occur or are likely to occur within the immediate vicinity? (Processes resulting in the evolution of sulphur compounds could cause havoc in paint factory handling white lead.)

If the site is within an urban area, what restrictions are imposed upon noise, discharge of waste steam, discharge of odours, and so on?

Essential services

Detailed enquiries should be made to find out whether adequate supplies and reserves are available of (a) power for driving machinery, (b) power in the form of heat (for varnish, synthetic resin, emulsion manufacture, etc.), if fuel

oil, coke, coal or some other form of transported fuel is to be employed, as opposed to gas which would be piped into the site (see the following paragraph on accessibility); (c) water for process work, for cooling, for boiler or other purpose requiring any large quantity of this increasingly valuable commodity; and also whether there is sufficient water available for fire fighting.

Accessibility

The site must be readily accessible by road and/or rail, and even by water, so that raw materials and finished goods can move rapidly to and from the factory. Adequate accessibility is the keynote: the largest form of vehicle likely to arrive on the site (excluding, of course, special occasions when large, heavy plant is involved) must be able to deliver or collect with the minimum of difficulty and delay; entrance or exit gates should be wide enough to accommodate road vehicles of the largest road tanker size; and the external roadways beyond the site should also be amply adequate to permit easy access.

Another point worthy of consideration concerns the scattered site with internal roads, which should be as wide as possible, to permit unrestricted movement by transport; preferably they should be planned with a ring road, so that an exceptionally large vehicle which was unable to turn round inside could dispose of its load and then proceed across a link in order to leave the site.

Personnel

A sufficient labour force (both administrative and productive) for the complete manning of the factory should be available locally. The availability of labour may be affected by the presence of other factories in the locality; many companies starting factories in development areas have found that neighbouring employers force up wage levels in order to attract labour. If such conditions are likely to occur, production might become economically unsound, and a site in a locality with an easier labour supply should be sought.

The type of labour likely to be available warrants some thought. An area undergoing redevelopment can offer staff which may be loosely described as "rural". Such labour will usually become first class industrial material, but its development takes time.

Consideration must be given to the frequency of public transport to and from the factory, particularly very early and very late in the day—in the event of shift work being operated the easy transportation of workers at unusual times is vital. Absence of public transport facilities can be overcome by having the works' own bus; this in itself will introduce several additional problems—driver, maintenance, insurance, routing, etc. Generally, in opening a new factory, key personnel are imported from outside the area (probably from a parent company) and the complication of suitable living accommodation for such people has to be resolved.

General layout

Once the site has been chosen, the outline layout becomes the next task. There are, of course, few hard and fast rules governing layout, and the manner in

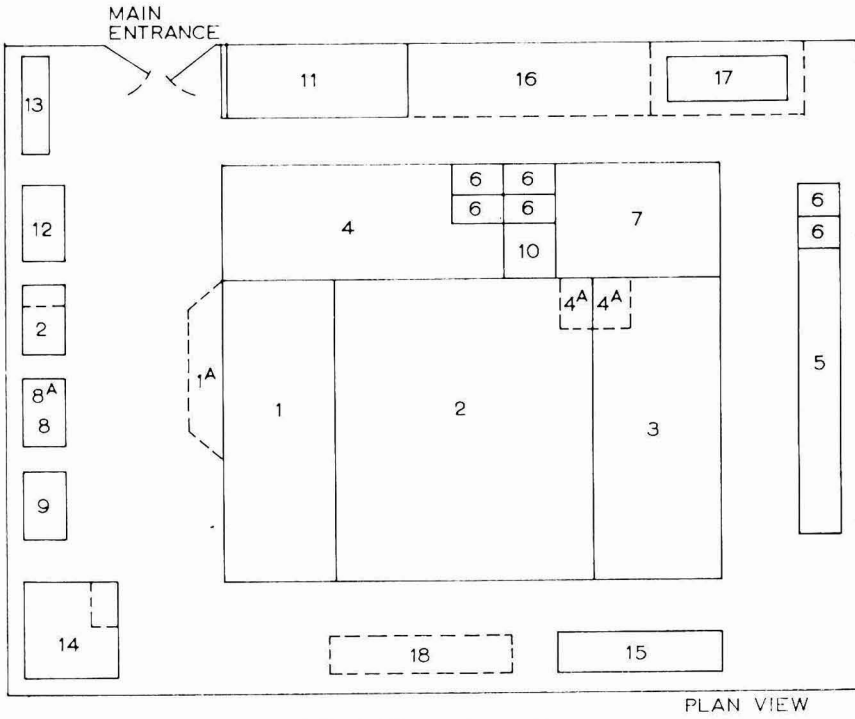


Fig. 2. Single-storey site

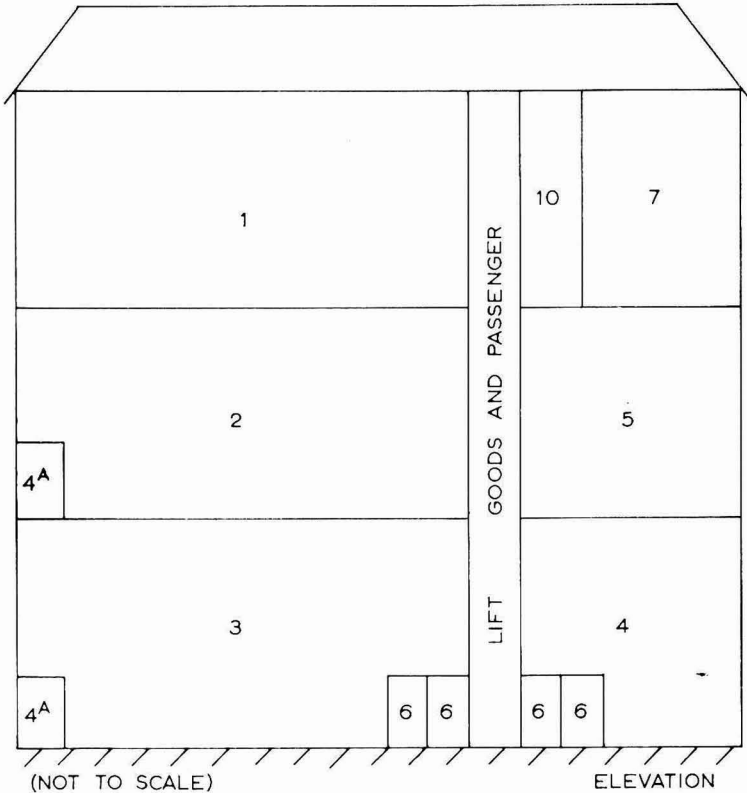


Fig. 3. Multi-storey main building

Table 1
Key to the numbers shown in Figures 2 and 3

Number	Meaning
1, 1a ..	Raw material storage, including drummed goods
2 ..	Manufacturing zone
3 ..	Labelling, packing and despatch zone
4 ..	Administrative offices—Managerial, buying, secretariat, sales, home/export, general, accounts, costing, telephone, wages, reception, purchases; payment, personnel
4a ..	Works offices—Works manager, despatch and transport, departmental foreman
5 ..	Laboratories—Works, including testing, research and development, chemical and physical, darkroom and balance room. Customer service, including application, apparatus. Library and office
6 ..	Toilets—Managerial/office/works, male and female, with a rest room for latter
6a ..	Clothes locker space or room—Separate for male and female in works. Essential in GB under Factories Act
7 ..	Canteen—Kitchen, dining rooms, refrigerated store, hot and cold water for washing up. This section <i>may</i> also be used as a social club out of working hours
8 ..	Boiler house—Providing heat for buildings or plant. If modern oil-fired high-efficiency boiler, small laboratory for water testing may be necessary. May house compressor for compressed air
8a ..	Fuel storage-tanks or dump
9 ..	Maintenance shops—May include pipefitters, electricians, general engineers, builders, carpenters, etc.
10 ..	First Aid room or point—Permanent telephone contact with outside world (usually a direct line)
11 ..	Garage for transport, directors' cars—May include workshop for vehicle maintenance
12 ..	Main fire point—May house mobile fire-fighting engine, rescue devices, breathing apparatus. If sprinkler system installed in factory, will house cut-off valves. There <i>must</i> be other fire-fighting appliances sited throughout the factory
13 ..	Gate house—May control weighbridge. Main clocking-in point, facilities for night watchman, permanent telephone contact with outside world. Fire alarm on/off switching for whole site
14 ..	Tank farm—Includes pump house for distributing solvents to departments using them; could include intermediate vehicle store (covered in)
15 ..	Drum cleaning department—In addition to hot and cold water, steam, etc., may require chemical neutralising plant before effluent is discharged into sewers
16 ..	Car park—This must be adequate
17 ..	Bicycle racks
18 ..	Empty drum storage—May be covered or uncovered

which the various sections or departments of a factory are placed on the site will be controlled by the particular function of that factory. The sketches which follow are intended as basic suggestions which aim at: (a) easy throughput from raw material to finished product, (b) easy accessibility, (c) a minimisation of fire risk by siting those departments with the highest fire potential on the perimeter, and (d) some degree of self-containment. Allocation of space to the various sections will be largely dependent upon: (i) the overall space available, and (ii) the production needs of the units, since this will obviously be controlled by the size, frequency of any particular type of plant, and so on. These matters need careful co-operation between the company and the architect in the earliest stages of the planning, and certainly warrant detailed planning.

The numbering system employed in the figures is explained in Table 1.

A single- or multi-storey factory?

The choice between a multi-storey building and a single-storey layout is an important decision. In both, the varnish manufacturing unit is separate from the paint unit on account of the fire risk.

In the vertical layout, the handling of material is easy and economical of labour. Once the materials have reached the top floor by lift or pump, they move largely by gravity to the filling area and major mechanical movement is required only from the filling area space to the warehouse. In addition, the actual area of land occupied and consequently its purchase price are minimised. There are, however, disadvantages such as increased fire risk to materials, plant and personnel, and the high cost of erection of a building in which heavy machinery must be accommodated on the higher storeys, as in the case of the paint unit shown in Fig. 3.

To overcome the high cost of the vertical structure, a horizontal layout can be used. This method reduces both the fire risk and the very high cost of erection, since all the heavy moving loads are supported at ground level. On the other hand, it increases the area covered by the building and cost of the land, and complicates the handling of materials and requires a large number of minor lifting operations. Difficulties associated with lifting gear have been reduced in recent years by the use of fork lift trucks, which, owing to their mobility, can be used for a large number of small lifting operations.

The decision whether or not to erect a single- or multi-storey factory may well be controlled by quite independent factors—either safety or legal. If the unit is to handle materials classified as highly inflammable, the safety factor will operate in favour of a single-storey unit.

A compromise frequently reached is to limit the building to two storeys, or alternatively to utilise upper air space to a maximum. This is achieved by a floor level installation of the usual plant with a metal grille staging at feed level coupled with a dry non-inflammable raw material store at the same level. Fig. 4 indicates how this could be done.

Once again, it becomes a question of assessing needs against costs.

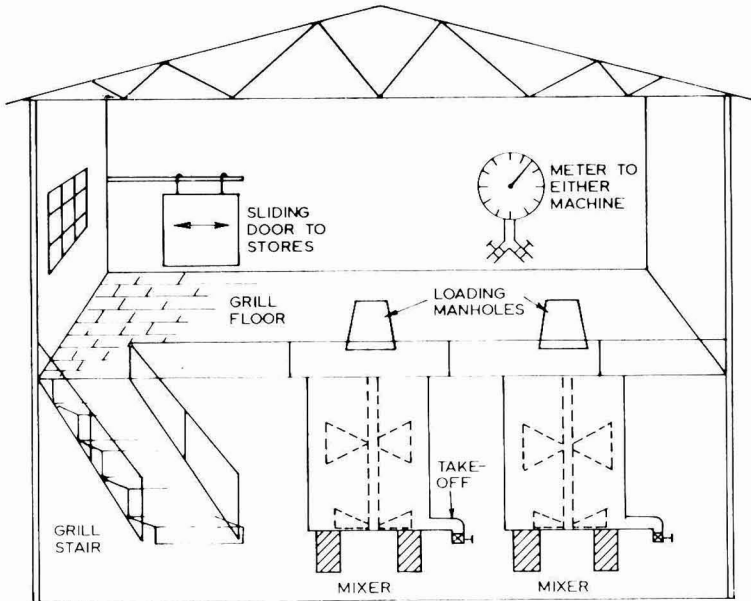


Fig. 4. Utilisation of upper air space

The comments made so far have assumed a factory layout employing only one store. Many paint factories, however, use a system of grouped machines fed from independent sub-stores. Experience has shown that their basic needs are the same as those already discussed, and the advantages and disadvantages of the two methods will be discussed in Chapter Two.

General points

Other requirements which should be borne in mind when considering the layout are shown below.

- (1) Easy access to the supply lines (pipes, wires, conduits) of the main services already mentioned at all positions. A similar comment would apply to any intermediate supply lines, e.g. those conveying the medium to the paint mill.
- (2) Adequate (at least 14ft) overhead clearance on internal roadways for these lines allowing easy passage of transport, e.g. vehicles delivering empty containers are frequently very high.
- (3) Adequate clearance between machines (when considering where these will be situated), e.g. a secondary driving shaft might have to be withdrawn at some future time for attention and necessitate sideways removal.
- (4) Flexibility of building layout wherever possible; some planners start off on a new site by working to one side, equipping the buildings with easily removable curtain walls facing inwards and thereby facilitating future expansion. Inside any buildings the supporting columns should be spaced at the absolute maximum distance apart; a single span structure is preferable since it leaves the inside flooring, etc. absolutely clear for plant installation.

(5) The correct type of floor for the department concerned, with good facilities for keeping it clean. Some bituminous floorings floated over base concrete look excellent when first laid but give rise to considerable trouble, since they are easily softened by many of the solvents likely to be spilt on them.

(6) Doorways that can be opened widely enough (and are initially high enough) to allow the passage through them of the largest materials handling equipment expected to be used. There must be a sufficient number of doorways to satisfy any legal requirements, e.g. as fire exits; generally fire exit doors must open outwards. Rubber doors which can be pushed open from either direction by a fork lift truck save both time and mechanical damage.

(7) Adequate and proper ventilation and heating apparatus in each department.

(8) In cases where poisonous substances (as defined by legislation) will be handled, proper storage facilities for such substances, proper storage facilities for workers' outdoor clothing and proper washing or bathing facilities with sufficient hot and cold water, must be provided (*cf.* the Lead Regulations in GB). The point here, of course, is to ensure at the planning stage that areas No. 6 in Figs. 2 and 3 are really adequate and capable of being extended easily should the need arise.

The foregoing will have given some idea of the scope covered in planning a new factory; obviously detailed collaboration is required between all those concerned in the construction and future operation of the factory.

In view of the fact that some of the sections or departments will not be included in the treatment of plant layout, comments on these are included at this point to help the student obtain the fullest possible overall picture of the factory.

Boiler house

It is an essential need in factories to provide pleasant working conditions, and adequate working temperatures inside all departments is part of this need. Statutory requirements, where applicable, lay down minimum temperatures, and, in many paint factories, there are also technical requirements as far as temperatures are concerned; e.g. emulsions, varnishes and lacquers must be stored at reasonable temperatures. These two factors raise the question of what type of factory heating should be installed, and the answer will usually be found by applying two simple yardsticks—is the proposed system (i) safe, and (ii) economic?

The great popularity of hot water or low pressure steam for factory heating may be attributed to its satisfactory performance in these respects. Provision must therefore be made for a boiler and boiler house of a size adequate to produce the amount of heat required. In addition, careful thought will have to be given to the placing and routing of pipework, ensuring that it does not obstruct roadways, gangways, doorways, machinery, etc. Maintaining and running a boiler will become another consideration, since if, for example, solid fuel is used, then the fire will need feeding, de-clinking, and possibly lighting up each Monday morning. Electrically operated automatic oil firing eliminates these jobs, but general maintenance of the system and supervision during excessively cold weather to prevent freezing up require attention which-

ever method is used. Hot air circulation from oil-fired heat exchange units is another way of obtaining reasonable working temperatures and, in some instances, this may be achieved by means of a master unit with ducting carrying hot air to various departments or, in cases where buildings are spread out, by individual units for each department or part thereof. In the paint industry, the latter system usually necessitates an outer building to house the unit (so that there is no naked flame inside the department handling paint) with hot air ducting led through the wall into the department. In passing, it is interesting to note that some operators (especially female) have said that they find such heating unpleasant because it affects their throats, fuzzes up their hair or makes them prone to catching colds. Such comments seem to be prejudicial rather than factual.

Some factories will require steam heating for actual production work and this generally means that the boiler becomes a larger unit working at higher pressures. Firing problems may be similar to those already described (although automatic solid fuel firing eases the situation) and, in addition, water softening may be necessary, with possible laboratory control as well as legal conformity with safety requirements necessitated by the higher pressures. Factory heating can be "bled-off", but the radiators, pipework, etc., will have to be different from those described earlier and boiler tubes will need regular cleaning.

Compressor room

Where compressed air is required, the compressor and air receiving vessel will require siting. Occasionally this will be in the boiler house, but generally it will be in a separate brick-built section isolated from its immediate neighbours. The size of the unit will depend on the amount of air required, and it will comprise an electric motor (or other driving member) to operate the compressor and a receiving tank for the air, with ancillary pipework to take the air wherever it is required. Apart from ensuring conformity with legal requirements, the compressor will need regular lubrication and servicing (checking of air filters, valves, pistons, etc.), filling of the oil sump, and regular blowing down of the tank to remove condensed water; this latter requires a pipe to an outside drain, so that the water does not enter the compressor room. Adequate lighting is essential in this section and for large compressors water cooling will also be needed.

First aid room

If the factory is large enough to need a first aid room (permanently staffed or not), then this should be sited as carefully as possible. Close proximity to areas of greatest personal risk and easy egress for stretcher cases should the need arise are points to be borne in mind. The room should not be noisy, or overshadowed by adjoining high structures, and it should be away from fumes, exhausts, etc.; adequate lighting, heating and hot and cold water should *always* be available, as should direct communication with the gate house. The whole place needs to be bright and cheerful and arrangements must be made to keep it clean—e.g. floor washing when unoccupied, walls and ceilings cleaned, etc.

Gate house

The design and size of this important section will depend on its functions, e.g. there may be a weighbridge sited outside for which the gatekeeper has to accept responsibility. It needs to be large enough and comfortable enough to do its job properly, with adequate window areas to allow all-round visibility of outside roads, internal roads, car park, and adequate lighting for night-time. It should be self-supporting for heating (so as to be warm when the factory heating is off), and usually needs simple facilities for making tea, etc. In addition, direct telephone lines should be installed, and a keyboard for all departmental keys is another useful adjunct. A clocking-in clock with card rack may also be sited here.

Cleaning section

Mixers and similar machinery can be cleaned in position by use of a suitable solvent or caustic soda solution. However, it is generally preferable to install a separate plant for cleaning of portable mixers, pans, drums, etc. This section will require particular attention as far as both siting and installation are concerned. Solvent cleaning presents high fire risks; efficient fume extraction is essential, and settling tanks for effluent collection are needed. In general, this method is more expensive than alkali cleaning, and it can prove time consuming and difficult with some finishes.

A typical alkali cleaning plant consists of a large tank about 6ft deep, sunk to 3ft below floor level. Heating is generally by steam coils fitted around the sides of the tank, since bottom heating becomes less efficient as sludge forms. A circulation system for the alkali is provided, and the pans etc. are suspended by some suitable means, e.g. a travelling crane. It is normal to use an aqueous caustic soda solution of about 5-7 per cent, at a temperature of 60-78°C, and as well as ensuring that all materials used can withstand these conditions, the sides of the tank should be insulated both above and below floor level, both for economy and operator safety.

The building housing the plant must have an ample water supply and an efficient extraction system to remove the high concentration of steam and water vapour which builds up. For safety reasons, good lighting is necessary, and the flooring should be of a non-slip formulation. Operators must be provided with full protective clothing, paying particular attention to the protection of the eyes, and a first aid box should be provided, even if the plant is near a first aid room.

The alkali process requires careful washing of the articles after cleaning, and ample floor space should be allowed. A central drain should be fitted, running into a series of settling pits or tanks fitted with weirs, incorporating arrangements for neutralising the final effluent, either by automatic pH control, or by acid drip feed with control by frequent pH tests.

General maintenance of this section must be given high priority. Brickwork and all metal work should be protected from the corrosive atmosphere by coating with resistant systems such as high build chlorinated rubber or epoxides, and frequent cleaning and repainting will be necessary.

Automatic cleaning apparatus is available, but, in general, this cannot be used for containers of varying sizes and shapes. The considerations relating to the siting and erection of such a plant are similar to those outlined above.

Canteen

Depending on the size of staff and type of catering undertaken, this department can vary from a simple "cafe" serving light refreshments to a full restaurant service. The area allocated and its breakdown into kitchens, stores, dining rooms, etc. will need attention in the first stages of planning. The running of the department will probably be in the hands of a manager or manageress, so that the works manager is relieved of any direct day-to-day responsibility. On the other hand, he will be directly involved in maintenance and the positioning of services. Lighting, decoration, floors and walls should also be considered; certainly the problems encountered from workers' dirty clothing and boots need attention.

Car and cycle parks

These need to be adequate, with some room for expansion, and should be sited as near to the main gate as possible. This will eliminate (a) any risks to pedestrians on internal roads from moving cars, motor-cycles or bicycles; (b) undue risk of pilferage of either factory products or factory materials, since the area in question can be kept under constant supervision by the gate house. Proper lighting and road surfacing are essential, and it is also advisable to have a proper surrounding wall or fence which will prevent unauthorised persons from entering the premises or parks. Pedestrian exit gates are a useful extra, especially if these lead straight into the site.

Other sections

Maintenance workshops vary in size and equipment from factory to factory, and their set-up depends entirely on their function. The earlier comments on heating, cleanliness, and lighting apply equally to such workshops, and if lathes, drills etc. are installed, it is advisable to regard the workshop as a miniature engineering works with close attention to layout and legal requirements. If a works engineer is in charge, then an office for his records will be needed, and this may also have to house a drawing board, test equipment and so on.

Rest rooms are legally required under some circumstances, and must be separate for male and female staff. Their furnishing and decoration, as well as their siting, require thought, but generally rest rooms should be warm, well-lit and comfortable, with a minimum of extraneous noise.

Factory lighting

The importance of lighting in paint and allied factories is paramount and it should be first class in both effect and safety.

The positioning and spacing of lighting units in different departments or areas should be planned carefully, and in working areas bad shadowing should be avoided assiduously. In those departments where colour matching has to

be done in the works, the ideal is natural north lighting but, in the event that artificial lighting has to be used for limited periods, then this warrants a properly illuminated area reserved for this operation only.

All light switches should be fitted in clearly visible positions (and should be *kept* clean and visible) and operators should be trained to switch lights off as well as on; early morning shift workers or night workers will need factory lighting, but as the day advances this lighting is frequently unnecessary—a fact often overlooked, with a resultant waste of electricity. It is equally important that adequate lighting of the correct type is provided for exterior roadways, uncovered stores, and, in fact, any area through which people have to pass. Similar comments apply to the switching for these areas. Sufficient and proper lighting for security guards is another important thing to remember when considering factory lighting.

No text has been printed on this page in order that reprints of the extracts from Part Seven of the Paint Technology Manuals may be run-on at the time of printing this issue of the Journal. It is intended at the end of the year to collate and bind these extracts and to offer them for sale. Registered students of the Association will be able to purchase one copy each at a considerably reduced rate.

Thames Valley Section

Metal pretreatment

The first meeting of the Thames Valley Section, Student Group, was held at Slough College on 5 October 1971. A lecture entitled "Metal pretreatment" was given by Mr P. Burden of Pyrene Ltd., Metal Finishing Division.

Mr Burden commenced the talk by outlining the processes involved in chemical treatment. Pretreatment of metal involved five stages. The first was the use of cleaners to remove dirt, grease, etc. Trichlorethylene was only used to a limited extent, because of its cost and inability to remove particulate soils. Emulsifiable cleaners such as paraffin were reasonably popular, but by far the best and most widely used processes were alkali treatments, using either spray or dip techniques. This stage was followed by a simple cold or warm rinse.

Next came the conversion coating, which differed for individual substrates. For steel, a crystalline zinc phosphate, $Zn_3(PO_4)_2 \cdot 4H_2O$, or iron phosphate, $Fe_3(PO_4)_2$ was best. For hot dip galvanized components, phosphate and chromate treatments were recommended. For aluminium, chromate treatments gave optimum results.

The rinsing operation which followed conversion was critical, as chemical residues could cause blistering of subsequent paint films. A final rinse with chromate solution had been found to enhance corrosion protection. The final process was that of drying the coating.

Mr Burden continued by giving a brief outline of the steps involved in coil coating and high speed sheet coating systems. After this a film was shown, illustrating the points in the lecture.

Mr M. Moore proposed a vote of thanks on behalf of the 32 members and guests, which was warmly acclaimed by all those present.

P. MCM.

Information Received

(In case of difficulty regarding addresses, members and subscribers to the JOURNAL, should apply for details to the Director & Secretary of the Association at the address shown on the front cover.)

It has recently been announced that, as from December 1971, the **Resinous Chemicals Division of British Paints and Chemicals** has taken over responsibility for the manufacture and sale of hard resins previously manufactured by **ICI Ltd.** This range consists of the products *Bedesol 66*, *Bedesol 72*, *Bedesol 76* and *Paralac 385*. This move has been made, says ICI, to facilitate expansion in other surface coating areas.

P. W. Allen & Company has introduced a new system for safe visual inspection of cans and drums containing Group 2C gases. The system comprises a straight light probe and a cranked viewer, both of which incorporate lamps powered by U2 batteries. The use of the instruments in Group 2C explosive atmospheres is covered by IS Certificate No. 87.

Beckurane 2-225, a new polyurethane resin designed to improve the corrosion resistance of metal protection systems in industrial environments, is now available in the UK from **Synthetic Resins Ltd.** Developed by **Spencer Kellogg** in the USA, *Beckurane 2-225* is based on an aliphatic isocyanate, and is intended for use in two-pack systems with alkyds or polyesters. Formulations based on the resin are claimed to have survived 250 hours' exposure to continuous salt spray and humidity according to DEF 1053 methods 24 and 25 respectively; no blistering or rust creep was noted.

Kronos Titanium Pigments Ltd. has been appointed distributors of two new flame retardant pigments developed by the Pigments and Chemicals Division of **NL Industries Inc.**, Kronos's American parent company. The two pigments, *Oncor 75 RA* and *Oncor 23A* are intended for use in halogenated paints and plastics.

A complete system for the automatic injection of chemical solutions into a main process stream is announced by **Metering Pumps Ltd.** The *Metriflow* system is operated by a water or compressed air supply; no other power is required. It consists basically of one or more injection pumps operated by the motive water or air supply, a meter actuated by the main flow, and a pilot valve rotated by the meter, which controls the stroking rate of the pump, thus ensuring that the rate of injection is directly proportional to that of the main flow.

For flows of liquid under 1,500 gallons per hour and 2,800 gallons per hour, 1½in and 2in meters respectively can be fitted directly in the main itself. For greater flows, the meter is fitted in a by-pass round an orifice plate or venturi tube designed to give a differential head not exceeding 9ft at maximum flow.

Full details of the pump, including fitting and consultancy services, are available from Metering Pumps.

It has been announced that **Carson Paripan Ltd.** and **Hadfields (Merton) Ltd.**, the paint manufacturing division of the **Bestobell** group, have signed a licensing agreement with the **Nile Paintworks Company Ltd.**, of Omdurman, for the production of Carson/Hadfields decorative and industrial paints in the Sudan. Under the agreement, Carson/Hadfields will provide technical, manufacturing and marketing advice.

This follows a number of similar licensing arrangements between the company and other Middle East companies; the policy results from the general developments of tariff barriers against direct export from the UK, say Carson/Hadfields.

The Industrial Paints Division of Hadfields has also announced a new range of fire retardant electrical varnishes. Claimed to be the first varnishes of this type specifically formulated to be flame retardant, the new products pass the Ministry of Defence fire risk test (DEF 5011, para 7) and are self extinguishing after 15 seconds exposure to a naked flame. The range comprises three formulations: a standard Class B finishing varnish, a high-build Class B finishing varnish, and a Class F enveloping varnish.

The new *V/I* 1in insertion meter from **Electronic Flo-Meters Ltd.** will accurately measure fluid flow in pipelines as small as 1in in diameter, it is claimed. The *V/I* meter is based on a free spinning helical multi-bladed rotor rotating through the field of a magnetic pick up coil, which registers a pulse each time the magnetic flux is disturbed by one of the rotor blades. The meter is claimed to provide no resistance to fluid flow in gases and liquids at pressures up to 3,000 psi, and to have a linear flow characteristic.

Postans Ltd. was the subject of a four-page supplement published in the Birmingham Post for 21 October 1971. The supplement contained articles giving the history of Postans, and details of its technical and marketing operations. All articles in the supplement were written by Postans' staff, including several Members of the Association.

A brief guide to the latest analytical instruments produced by **Electronic Instruments Ltd.** for the chemical and power industries is given in a recently published leaflet. Copies are available from EIL on request.

AIN Chemicals Ltd. has extended its plant for the manufacture of fine organic chemicals, it has recently been announced. Quantities of a range of materials up to one ton can now be supplied, and capacity is available for manufacture on contract.

The latest addition to the range of industrial cleaning equipment manufactured by **Kina Engineering Ltd.** is a wet sand blaster. Fast, effective and efficient cleaning, particularly of plant and equipment previously inaccessible to conventional cleaning equipment, is claimed, without any atmospheric pollution occurring.

A scientifically controlled programme on corrosion prevention in the marine industries has recently been completed by **Yarsley Research Laboratories Ltd.** Commercially prepared steel specimens corresponding to various areas of a ship were taken, and coated with a variety of modern surface coatings under conditions strictly according to the manufacturer's recommendations. The specimens were then immersed in some 200 liquids, representing typical ship's cargoes, for prolonged periods. The specimens finally underwent rigorous physical testing, and IR and UV spectroscopy of the coatings, in an attempt to obtain a wide comparison of the various systems' performance. The results of the project have been made available for sponsoring organisations and further details are available from Yarsley.

It has recently been announced that **Stella-Meta Filters** has become a division of **The Permutit Company Ltd.** as from 1 January 1972. The transfer of the filtration division from **Vacuumatic Limited**, its previous parent company, to Permutit is the latest step in the rationalisation of the liquid treatment and engineering activities of the **Portals Group**. Following the transfer, Stella-Meta Filters will progressively move to Permutit's London headquarters.

The *Flameguard* is a new flammable liquid safety container introduced by **A. Gilby and Sons Limited**. The container, of one gallon capacity, is intended for use where a fire hazard exists and flammable solvents are required for cleaning purposes.

Three new models have been added to the **Perkin-Elmer Limited** range of infra-red spectrophotometers. These are: the *Model 720*, a low price model incorporating two scan speeds and two slit programmes, with push button operation; the *Model 157G*, similar to the earlier *157* but fitted with a diffraction grating and incorporating seven slit programmes—the resolution in this model (1.5cm^{-1} at $1,000\text{cm}^{-1}$) is claimed to be the highest available on an instrument of comparable price; and the *Model 357*, scanning from $4,000\text{cm}^{-1}$ to 400cm^{-1} with two diffraction gratings, and incorporating abscissa scale expansion of $\times 2.5$ and $\times 10$.

Mastermix Engineering Limited has published a technical bulletin giving full details of the *Batch Mastermill*, first introduced at OCCA 23. This machine is designed for rapid grinding and dispersion of pigments in one operation, with quick discharge and easy cleaning facilities.

A range of intermediate bulk liquid containers has been introduced by **PRM Container Systems Ltd**. Similar to the company's solids containers, the new *Bulkbins* are rotationally moulded from high density polythene, with a steel framework for support. Loading is via an 18in diameter manhole, which is closed by a plastic cover and neoprene rubber gasket and secured with a heavy duty cam action clamp band, and discharge by a valve in the centre of the base; a variety of valves are offered. Many extras can also be obtained, such as a level indicator for the *Bulkbins* or batch card holders or fork-lift truck retainer bars for the frame. Four sizes are available, 1250, 1500, 2000 and 2750 litres in capacity, tare weights being 210, 239, 260 and 323kg respectively.

Section Proceedings

Irish

Factors which affect efficiency of ball milling

On Friday 15 October, Dr W. Carr of CIBA-GEIGY (UK) Ltd gave a talk to the Irish Section on the subject "Factors which affect the efficiency of ball milling."

There were 28 members and eight visitors present for this very interesting talk which was followed by a lively question and answer period. This paper has been accepted for publication in the Journal, and therefore will not be reported here.

The vote of thanks was given by Mr J. Corrigan.

A.R.

London

Cost effectiveness and profitability in the paint industry

The first meeting of the 1971-72 Session was held on 13 October 1971, at the Polytechnic of the South Bank, London SE1. The Chairman, Mr D. E. Eddowes introduced a forum on "Cost effectiveness and profitability in the paint industry."

Introducing the forum, Mr Eddowes referred to the importance of value analysis in the planning of technical developments; this had been the theme of some of the exhibitors at the last OCCA Exhibition.

The first speaker was *Mr F. Brocklehurst*, of BJB Group Supplies Ltd. Mr Brocklehurst referred to the importance of cost-effectiveness, rather than cost reduction. A benefit was associated with each cost; some costs were good, if they were incurred in order to make money. Other costs, i.e. activities, did not produce a profit; this raised the question of whether they were worth while. For example, it was usual to allocate costs over a whole range of colours, while in practice it might be that producing two or three special colours was one of the main cost factors. Mr Brocklehurst described the setting up of a purchase research technical department, whose task it was to apply a discipline to formulation against a technical background, and to attempt to reduce the number of different products which were bought. There was only a marginal technical advantage in some products, and there was a danger of formulating "plus properties" into the product which did not contribute to profits.

Advantages came from the ability to buy and store in bulk, and to cut down the handling of products in the factory. Simplifying activities was a way of saving money, but this should not be allowed to inhibit the desire to invent and innovate. The better use of fixed assets was another example; the more standardised the production, the less was the stand-down time on the plant.

The next speaker was *Mr D. Addenbrook*, of CIBA-GEIGY (UK) Ltd., Pigments Division. He also developed the theme of techno-commercial unity. One of the most fundamental topics concerned with organic pigments was dispersion, which was a function of both the pigment and the vehicle. The dispersion process involved a lot of energy, but the degree of dispersion controlled strength, flow, opacity and gloss. Mr Addenbrook referred to the development of easily dispersible pigments, and to Dr Carr's recent work on the development of full colour strength from pigments by prolonged milling.

He also criticised poor buying techniques in the paint industry; it was very desirable that the pigment maker should be able to get a premium for easily dispersible pigments.

In selecting a pigment, for example a yellow 10 G, the value of the product should be adequately realised in its selling price, in terms of colour strength. However, lightfastness fell as strength was increased; should one use a strong but less lightfast pigment, or should one go to a more expensive, more lightfast pigment? It was clear that highly technical commercial decisions had to be made in selecting pigments.

Dr B. E. Lowe, of Shell Chemicals (UK) Ltd., said that the task of a speciality raw material supplier was to provide a service to the paint industry. The raw material supplier had a keen interest in the effective use of the technical skills of the paint industry. He considered that it would be desirable for both the raw material suppliers and the paint industry to concentrate their R & D effort in selected areas. Both the customer and the supplier could become specialists. There were three general categories of technical service, (a) literature (b) technical representatives, (c) the laboratory specialist. The latter was very expensive, and his efforts should be concentrated in areas where he could be of greatest benefit.

Mr R. R. Blakey, of Tioxide International Ltd., said that efficient utilisation of titanium dioxide was concerned with dispersibility and the state of dispersion of the pigment in the final paint film; the latter was really the more important. The paint maker wished to produce the maximum throughput in the minimum time and with the minimum energy requirement. Dispersibility was not necessarily related to high opacity, but other properties were dependent upon the degree of dispersion, so that one had to try to achieve the best compromise in terms of the optimisation of several properties in one paint.

Mr Blakey referred to recent work at the Paint Research Association on the efficiency of utilisation of titanium dioxide in terms of opacity; Tioxide International had also made a study of the question of efficient pigment utilisation. For example, film thickness could be increased to improve opacity, as in thixotropic paints. On the subject of proprietary additives, Mr Blakey said that only in very few cases had it been possible to use such additives to increase opacity. Optical brighteners were also of no use in paints, as they could not function in the presence of large concentrations of TiO_2 , which absorbed the UV radiation.

Mr K. Safe, of Vinyl Products Ltd., referred to the formulation of emulsion paints. There could be a need to produce a better and/or cheaper paint. It was necessary to specify in detail the qualities which were desired. There were two approaches to reformulation; one could try to use one's existing materials more efficiently, or one could take a wider look at other raw materials, even including more expensive polymers, which could produce a better or cheaper product. Mr Safe gave an example of producing a high quality paint for interior use. He specified opacity, level of scrub-resistance, and the level of non-volatile volume in the paint. Using one pigment, one extender, and similar types of protective colloid systems, he showed the results obtained using a number of different types of polymer latices.

Mr L. H. Silver, of the Silver Paint and Lacquer Co., said that the basic raw material in the industry was people. Profitability was very much a question of how to use people most efficiently. The paint industry made a profit of about 5 per cent on its turnover. Therefore every employee spent 95 per cent of his time just to break even, and only the last 5 per cent was profit producing. If it were possible to get an extra 5 per cent out of people, profitability could increase by something like 50 per cent. It was necessary to get people to care about what they were doing. Referring to large organisations, Mr Silver spoke of the frustration which some people felt. To overcome this, it was necessary to see that everyone was adequately rewarded, to have basically good working conditions, and to show that one treated people as individuals. He considered that the actual size of unit concerned had no bearing on efficiency.

After a break for tea, the meeting was opened for an extensive general discussion. This included questions on the differing patterns of use of titanium dioxide in the

UK, Europe and the USA. It was stated that the use of TiO_2 in latex paints in the USA was lower than in the UK. On the continent, TiO_2 usage varied considerably. Another point made was that in some European countries paint was still sold by weight, so that lithopone and barytes were used. Another speaker asked whether it would be possible to increase the standardisation of raw materials, e.g. organic pigments. It was pointed out that even within the one colour index reference, the performance of competitive products could vary enormously. Many other points were raised and answered in the discussion, which lasted for over an hour.

V.T.C.

Manchester

A review of printing inks and printing processes

Some 60 members and guests attended a student meeting of the Manchester Section at the Manchester Literary and Philosophical Society on Wednesday 13 October 1971.

Mr Redman was in the chair, and introduced Mr F. Lewis, of WPM Colour and Adhesives Ltd., who proceeded to give "A review of printing inks and printing processes".

Mr Lewis commenced by outlining the main types of printing and defining the meaning of the various terms used such as, flexographic, letterpress, gravure, lithographic and screen printing.

He then proceeded to describe typical printing inks for the various methods, going into great detail regarding resins, pigments, solvent and including a good account of methods of manufacture.

The lecture was well illustrated with examples of commercial printed articles of all types.

A lively question time followed during which Mr Lewis was assisted by his colleagues Mr Duffy and Mr Taylor.

A. MCW.

Midlands

Trent Valley Branch

Corrosion and the automobile

The first meeting of the new session was held at the British Rail School of Transport, Derby, on 14 October under the chairmanship of Mr E. Hare.

This was a joint meeting with the East Midlands Branch of the Institute of Metal Finishing, and there were 40 OCCA Members and guests to hear Mr H. L. Quick, of Chrysler (UK) Ltd., give his paper on the above topic.

The average cost of auto corrosion in this country was just over £1 million per annum. A lot of investigation had and was taking place to assess what factors affected the rate of corrosion and what can be done to arrest it.

Steady and significant progress has been made in the industry and it was felt that the internal environment was now more or less under control. In this particular sphere exhaust valves and valve seats were subjected to extreme heat and mechanical stresses, lubricating oils liable to deteriorate and break down and cooling systems were always prone to corrosive activity. In the case of valves, the type of steel being used at present was capable of withstanding high temperature and working stresses while lubricating oils, as a result of endless research, were now highly efficient. As for cooling systems, the inclusion of an inhibitor was vitally necessary. There were three basic types in use in the UK at present all of which met the recommended BS standards.

Mr Quick then dealt at some length with the external environment—exhaust systems, brightwork, bodywork, etc. The corrosion problems in this field were all too obvious. The presence of an electrolyte was necessary for corrosive activity to start up and as a car spent the majority of its life in the open their presence was assured. Exhaust systems were very prone to corrosion, particularly with short journeys, but a lot of work had been done by introducing the use of chromed steel, aluminised steel, etc., and in general the life of the system had been prolonged.

Probably the greatest contributory factor towards body corrosion generally was the use of rock salt on the roads during the winter months. During 1969, for instance, a total of 1,600,000 tons of neat rock salt were used on motorways in the UK. A lot of research work had already been carried out in the USA, Canada, Germany and by the UK Road Research Laboratories to assess the possibility of including an inhibitor of some type (chromates, for instance). However, it was found that this put the cost up by a relatively high margin, and therefore it had been reluctantly decided that the cost of inhibited road salt was prohibitive and not practical at present.

Mr Quick then dealt briefly with the problems in earlier years associated with the preparation of the body metal prior to painting. The ordinary spray phosphate methods were not too thorough (many parts of the body were missed) but latterly the spray/dip treatment had been adopted. The top area was sprayed while the bottom area was immersed and, therefore, all surfaces and crevices were treated. For the primer and finishing coats, electropainting was now widely used and most world car manufacturers had adopted this process. Acrylic top finishes were now used by most makers. The possibility of using zinc coated steel sheet for car bodies had been investigated in the USA. However, the conclusions reached are that this could only be used for certain areas as the zinc coating could be penetrated and then break down.

As for brightwork on automobiles, a number of different products had been used with various degrees of success including bright nickel plating, chromium (micro-cracked chrome was very durable) and latterly stainless steel and anodised aluminium. This last mentioned product was now being used very widely as it was durable and cheap. Stainless steel is still an expensive commodity, but was finding increasing use for low down brightwork, i.e. hub caps, etc., where good strength plus corrosion resistance was needed.

Mr Quick's lecture was illustrated throughout with a series of slides and the final question period was, as would be expected, a lively one.

A vote of thanks for a very informative and entertaining paper was given by Mr H. F. Clay and this was heartily endorsed by the remainder of the audience.

D.F.G.

Newcastle

The fibre optics colorimeter and its applications for industrial colour control

The first meeting of the current session was held in the Royal Turks Head Hotel, Newcastle, on Thursday 7 October 1971, when Mr D. Irish of the Paint Research Association presented a paper entitled "The fibre optics colorimeter and its applications for industrial colour control." This paper has been published in the *Journal* in February 1971 and, therefore, only a brief outline of the paper is given here.

Mr Irish first described the fibre optics colorimeter, and discussed the sensitivity and reproducibility of the instrument. It was shown that the fibre optics colorimeter was extremely sensitive to small colour differences.

Mr Irish then went on to discuss colour matching of paint and the work which had been done in colour control of paint in batch production. He finally mentioned other

possible industrial applications such as in anodising, strip coating, and paper, food and plastics processing.

A lengthy question and discussion period followed the paper in which Messrs Baxter, James, Dowling, Hall, Caddell, Whitfield, Blackey and Hulme took part. The Section Chairman, Mr A. A. Duell closed the meeting by thanking Mr Irish for a most interesting paper.

A.L.

Thames Valley

The Consumers' Association—aims and achievements

Mrs Williams of the Consumers' Association spoke to a meeting of the Thames Valley Section at the Beech Tree Hotel on Thursday 23 September. Her talk was delivered competently with wit and wisdom and it covered some important aspects of the consumer revolution as seen through the eyes of the Consumers' Association. She began by tracing some of the key events leading up to the present day state of consumer awareness, which she felt was still at an unsatisfactory level. Though the Consumers' Union started in America in 1937, World War II and the subsequent Korean war impeded progress in Britain and it was not until 1957 that any polarisation toward unbiased product information occurred. On looking back, it would seem that the event was largely triggered off by the birth of the Independent Television Authority. At this one stroke it became obvious that the consumer would need to be much better informed about the multiplicity of products and brands of products constantly being promoted by manufacturers, and more especially, that he would need some form of protection from this growing bombardment.

Thus it came about that the first issue of *Which?* was published by the Consumers' Association in 1957 with a starting circulation of some thousands of copies. One of its primary aims was to make the public better informed, and in so doing to help them sort out the mass confusion as a result of the rapid growth of new and unfamiliar products, not always attended by adequate instructions and care in labelling.

With its gathering strength the Consumers' Association had sought to increase its range of usefulness to the public, and had therefore surveyed some service industries about whose activities the general public was very ill-informed. For example, more was now understood about the method of allocating bank charges, and funeral costs, estate agents, insurance, had all come under scrutiny. The information had either been made available in the ordinary editions of *Which?* or in the more specialist editions such as *Money Which?* or *Motoring Which?* if the matter required to have been treated in depth.

Mrs Williams went on to describe how CA worked in practical terms. There was a team of around 40 trained and selected shoppers who bore no special CA identification at the time they purchased. In the past six months, new laboratory facilities had been opened at Harpenden, supplementing the work of the existing car-test unit at Gosfield. Research work was in the hands of qualified graduate project officers, who often opted for a three year contract. In addition to the activities described above connected with comparative testing, CA had acquired other duties. The government sponsored Consumer Council was wound up by the Government in March. This meant that, in particular, CA was increasing its representation in the various Government and other committees that abounded.

During the development of its more sophisticated evaluation techniques, *Which?* had, of course, made mistakes but there was constant revision and refinement. However, *Which?* had one basic defect that had to be recognised. Its financial support derived largely from individual subscribers. It might therefore be accused of having

a "cheque book" image, which would imply that its income was being spent largely on providing information for the middle classes. However this was not strictly true and as working class earnings advanced this "taint" might be largely removed. Undoubtedly *Which?* hoped ultimately to reach a much wider public than was available through the subscription scheme and public libraries. A step in this direction had recently been made in the setting up of the *Which?* advice centre in Kentish Town, London, where immediate personal help was available.

The question period gave Mrs Williams the opportunity to reveal additional information. An exchange of personnel had been arranged with the American Nader team. She reassured members who were uneasy that the basic versions of *Which?* might suffer in content and depth because of the launching of the new *Handyman Which?* this Autumn. There was also some further discussion of the basic *Which?* dilemma of how to widen its mass appeal without incurring the extra costs inherent in any educational project.

The vote of thanks was given by Committee Member Mr Jarvis and was warmly endorsed by the audience, comprising 22 members and 7 visitors.

R.E.G.

West Riding

Pigmentation of plastics

A meeting of the West Riding Section was held on Tuesday 12 October, 1971, at which a talk entitled "Pigmentation of plastics" was given by Mr J. E. Todd, of CIBA-GEIGY (UK) Ltd.

Mr Todd discussed the problems encountered with the pigmentation of plastics, notably thermoplastics. Any pigment used had to show good dispersion and also to be able to withstand the processing conditions, notably high temperature. There was also the possibility of chemical attack at these high temperatures from additives or polymer breakdown.

Mr Todd went on to outline the need for good compatibility and describe the effects to which incompatibility of the pigment can lead, for example bronzing or chalking. A further requirement was for good light or weather stability, and several factors influenced this. For example, the introduction of white pigment often reduced the apparent light stability of the pigmented plastic. Higher pigment concentrations normally provided better stability, and exposure conditions could also influence this property.

Mr Todd then proceeded to discuss the problems involved in incorporating pigment into a solid and the methods used in achieving the desired result and obtaining optimum dispersion. Various methods could be used to improve the dispersion characteristics of the pigment. A common process was to give it a resin treatment to minimise the formation of aggregates or agglomerates.

Following a lively question-time the vote of thanks was proposed by Mr J. N. McKean.

R.C.

Optional Professional Grade for Ordinary Members

The Professional Grade Committee has issued the first list of 103 Ordinary Members admitted to the Professional Grade and, where these members are Past Presidents or are currently serving on Council or Committees, the relevant designatory letters are shown after their names on pages 1-14 of this issue of the Journal. The full list showing the Sections to which the members are attached is given below.

Fellow in the Technology of Surface Coatings (FTSC)

Name

Anderson, George (*Scottish*)
Arnold, James Eric (*London*)
Arnold, Michael Henry Miller (*London*)
Atherton, Donald (*Scottish*)
Austin, Denis Leonard (*Bristol*)
Banfield, Thomas Arthur (*Newcastle*)
Bell, Sydney Hector (*London*)
Bennett, Norman Arthur (*General Overseas*)
Bews, Ian Charles Randall (*London*)
Blenkinsop, Arthur Willis (*Newcastle*)
Bohringer, Eberhard (*London*)
Butler, Cecil (*West Riding*)
Campbell, George Alexander (*Manchester*)
Ceresa, Raymond John (*London*)
Chatfield, Herbert Walter (*London*)
Clarke, Harry James (*Midlands*)
Colborn, Douglas Charles (*Thames Valley*)
Collings, Arthur Geoffrey (*London*)
Coupe, Raymond Richard (*London*)
Crowl, Victor Terrell (*London*)
Day, Keith Julian (*London*)
Dunkley, Frederick George (*Midlands-Trent Valley*)
Ellinger, Marianne Livia (*London*)
Finn, Stanley Russell (*Hull*)
Gay, Philip James (*Hull*)

Gellman, Alexander (*London*)
Gosling, Harry (*Manchester*)
Gray, Denis Roy (*West Riding*)
Hampton, Horace Arthur (*Manchester*)
Hess, Manfred (*London*)
Hill, Roger Frederick (*Midlands*)
Holbrow, Gordon Leonard (*London*)
Holt, Alfred Gordon (*Thames Valley*)
Jacob, Basil (*Thames Valley*)
Keenan, Henry Wilfrid (*London*)
Kekwick, Leslie Oliver (*London*)
Landmann, Axel Wolfgang (*London*)
Lasser, Howard Gilbert (*General Overseas*)
Lewin, John Buckingham Grey (*London*)
McLean, Angus (*Scottish*)
Mell, Cedric Charles (*Hull*)
Mitchell, John Edmund (*Manchester*)
Moon, William Robert (*Manchester*)
Morgans, Wilfred Morley (*London*)
Parfitt, Geoffrey Derek (*Newcastle*)
Penfold, Arthur de Ramon (*General Overseas*)
Rudram, Arthur Thomas Stephen (*London*)
Seymour, Norman Henry (*Manchester*)
Smethurst, Jack (*Manchester*)
Smith, Francis Mark (*Manchester*)
Sowerbutts, Frank (*London*)
Tatton, William Henry (*Thames Valley*)
Tawn, Alec Richard Hornsey (*London*)
Taylor, Cyril James Allan (*Midlands*)
Touchin, Herbert Roy (*Manchester*)
Wall, Dennis Charles (*Manchester*)
Westwood, George Ernest (*London*)

Associate in the Technology of Surface Coatings (ATSC)

Name

Adams, John Charles (*Midlands*)
Beere, André Jaime (*Thames Valley*)
Bird, George Donald Chaplyn (*Midlands*)
Blackledge, Amos (*Manchester*)

Chellingsworth, Horace Thomas
(*Midlands*)
 Cole, Francis William (*Midlands*)
 Constantinides, Erricos (*London*)
 Dalton, Frank (*Manchester*)
 Davies, Frank Watkin (*London*)
 Donkersley, Brian (*Newcastle*)
 Fairless, Joseph (*General Overseas*)
 Fell, Alan William (*Manchester*)
 Gay, Alan Stanley (*Midlands*)
 Greenfield, Eric (*Midlands*)
 Harrison, Cyril Geoffrey (*Hull*)
 Heald, Desmond (*Manchester*)
 Hill, Gilbert Victor Geoffrey
(*Thames Valley*)
 Holmes, David James (*Midlands*)
(*Trent Valley Branch*)
 Howells, Barry John (*Hull*)
 Kitchen, John Robert
(*Midlands-Trent Valley*)
 Lang, Robert (*Scottish*)
 Lewis, John David (*Thames Valley*)
 Mikucki, Wiktor (*London*)
 Miller, James (*Scottish*)
 Mitchell, Seward John (*Midlands*)
 Moore, Frank Roden (*West Riding*)
 Moore, James (*Midlands*)
 Morpeth, Frederick Johnson
(*Manchester*)
 Morris, David (*West Riding*)
 Murray, Robert Frederick (*London*)
 O'Connor, Eugene Daniel (*Manchester*)
 Pace, Graham (*Midlands*)
 Rout, Peter George (*West Riding*)
 Routley, Alan Francis (*London*)
(*Southern Branch*)
 Scott, Neville (*Manchester*)
 Silsby, Denys John (*Midlands*)
 Springett, Robert Arthur Edward
(*London*)
 Suthers, Peter (*Manchester*)
 Thomas, Hugh Sydney (*Manchester*)
 Trevitt, Edwin William (*London*)
 Triggs, Francis Cyril (*London*)

Westbrook, Ernest Louis Edward
(*London*)
 Whetstone, Peter John (*London*)
 Zissell, Martin John (*London*)

Licentiate in the Technology of Surface Coatings (LTSC)

Name

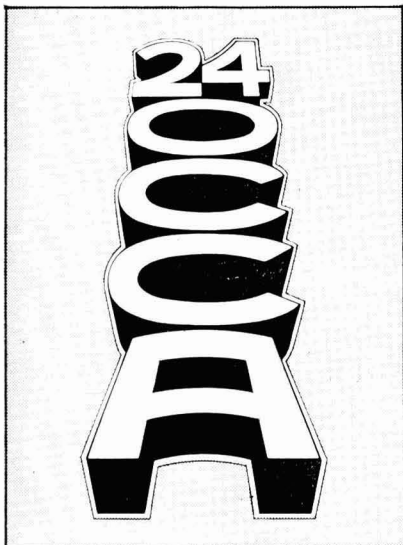
Cox, Garth Anthony (*West Riding*)
 Schierbaum, James Helmut (*Midlands*)

The full current regulations were set out on pages 919 to 921 of the September 1971 issue of this *Journal* and reprints, together with copies of the application form, are available from the Association's offices.

Details of the pattern suggested for dissertations for the Licentiate Grade were given in the December 1971 issue of the *Journal* (p. 1189). A further list of those admitted to the various grades will be published in due course and, in the meantime, members are reminded that sponsors will not be required for the first year of the scheme i.e. until after October 1972.

Council has been much encouraged by the enthusiasm and goodwill with which the scheme has been welcomed on all sides and it particularly requests senior members of the Association to encourage younger personnel to take the necessary steps towards admission to the Licentiate or Associate grades.

Certain members who have retired from active business have intimated that they would like to be associated with this scheme and the Professional Grade Committee wishes it to be known that in these cases, for the purposes of the regulations, it will take into consideration the position held on retirement.



Technical Exhibition

17-21 April 1972

Further applications received for 24-OCCEA

Since the list of exhibitors was published in the December issue of the *Journal*, the following companies have applied for space at the Association's Twenty-Fourth Technical Exhibition:

D. H. Industries Ltd.
 Mastermix Engineering Co. Ltd.
 Molteni Off. Mecc. of Milan
 Torrance & Sons Ltd.

It is planned that copies of the *Official Guide* will be available next month and each member of the Association, wherever resident, will receive a personal copy on publication. Any person wishing to receive a copy, which will be sent free of charge, should apply to the Association's offices.

Association Conference 1973

Preliminary notice

Council announces that arrangements are being made for the next Association Conference to be held at Eastbourne from 19-23 June 1973 with headquarters at the Grand Hotel, and full details will appear from time to time in this *Journal*.

Descriptive leaflets, giving the arrangements of the lectures together with an application form, will be sent to all members of the Association at the end of this year and any non-member wishing to receive a copy of the leaflet should apply to the Association's office.

It is hoped that the theme of the Conference will be agreed at the Council

Meeting later this month, in which case this information will be published in the March issue of the *Journal*, together with an invitation to any person, whether or not a member of the Association, who feels that a report of his work in the relevant field may be suitable to be one of the technical papers, to submit a synopsis (of approximately 250-500 words) to the Hon. Research & Development Officer of the Association (Mr A. R. H. Tawn, 34 Crest View Drive, Petts Wood, Kent BR5 1BY).

It will be recalled that it is the custom at the Association's Conferences for the authors merely to outline their papers, highlighting points of interest, and for a

general discussion of the paper to follow. The author will not be expected to deliver the paper in toto, since pre-prints are

circulated a month in advance so that delegates may read these thoroughly before the Conference.

Association Dinner and Dance 1972

At the end of December, Members attached to the United Kingdom, Irish and General Overseas Sections will have received the application form for the Association's Biennial Dinner and Dance, to be held on Friday 12 May 1972 at the Savoy Hotel, London, WC2.

The Reception will take place at 7.00 p.m. for Dinner at 7.30 and, on this occasion, there will be two short speeches only—a Welcome by the President and a Reply on behalf of the guests—so that dancing, to The Jerome Orchestra,

can commence as soon as possible and continue until 1 a.m. There will be an interval at 11.30 p.m. for tea and cakes.

The price of single tickets is £5.00 each and applications should be made by Members as soon as possible after receipt of the form. Tables will be arranged to accommodate 12 or 10 persons each, although it may be possible to arrange a few tables for eight persons.

Non-members wishing to receive forms should contact the Association's offices.

Jordan Award

This award was instituted by the late Mrs M. R. Jordan in memory of her husband Dr L. A. Jordan, who was President of the Association 1947-49 and an Honorary Member, and who died in December 1964.

The Committee invites applications for the third award of **£100**.

The rules of the Award are:

1. The Award will be made for the best contribution to the science or technology of surface coating by a member of any nationality working in either the academic or industrial field who is under the age of 35 at the date of application.

2. The final date for submission of applications will on this occasion be **29 December 1972** and it is hoped to present the award at the Eastbourne Conference in the following June.

3. The selection of the recipient of the Award will be made by a Committee under the chairmanship of the Associa-

tion's Hon. Research and Development Officer.

4. There will be two methods of application. First, by the submission of a paper describing original work by the candidate which is offered for publication in the *Journal* or has been so published during the two years prior to the closing date for application. The alternative method will be by recommendation by a superior for work which for reasons of commercial secrecy cannot be published; in this case the candidate will be expected to submit a dissertation on a topic relating to his work and demonstrating his superior knowledge of the principles thereof. The Award is for *individual* merit and clear evidence of the candidate's own contribution will be required if a paper is offered under joint authorship.

5. Applications should be addressed to the Director & Secretary at the Association's offices.

Manchester Section



Seen at the Manchester Section Dinner Dance (right to left) The President (Mr A. W. Blenkinsop), Mrs Blenkinsop, Mr R. Chester (Guest of Honour), Mrs Chester, Dr F. M. Smith (Chairman, Manchester) and Mrs Smith

Annual Dinner and Dance

An all time record of 446 members and guests attended the Section's Annual Dinner Dance at the Piccadilly Hotel, Manchester on Friday 22 October.

After proposing the loyal toast in true Lancastrian fashion, the Chairman, Dr F. M. Smith, proposed the toast to the guests, in particular Mr and Mrs R. Chester, Chairman and Managing Director, Donald McPherson Group Ltd, the President, Mr A. W. Blenkinsop and his wife, Mr R. H. Hamblin (Director & Secretary) and Chairman of Sections and their partners as follows: Mr F. D. H. Sharpe (Irish), Mr H. J. Griffiths (Midlands), Mrs K. Driver (West Riding) Mr D. S. Eddowes (London).

Replying for the guests, Mr Chester showed a remarkable knowledge of the early history of OCCA and pointed out the long association of his company with the Manchester Section.

The final part of the proceedings was rounded off by Mr S. Duckworth presenting a small memento to the Chairman's Lady, Mrs F. M. Smith, on behalf of the Section.

Dancing then commenced to Stan Westley and his band with occasional interspersions of a disco session with a disc jockey, which proved a very successful innovation and after a most enjoyable evening the dance finished at 2 a.m.

A.MCW

News of Members

Mr M. Strange, an Associate Member attached to the Manchester Section, has recently joined AIN Chemicals Ltd. as director with responsibility for the marketing of the company's products. Mr Strange was formerly with Vinyl Products Ltd. and Industrial Latex Compounds Ltd.

Dr B. S. Gidvani, an Ordinary Member attached to the London Section, was recently re-elected as President of the Paint Manufacturers and Allied Trades Association Ltd. for the period 1971-72.

Dr E. Bohringer, an Ordinary Member attached to the London Section and a Fellow in the Professional Grade, was re-elected as Vice-President of the PMATA for the same period.

At the AGM of the British Colour Makers' Association on 3 November 1971, the officers elected included many OCCA Members. These are shown below, with the Member's grade and the Section to which he is attached.

Chairman: Mr W. B. Cork (Ordinary, Hull)

Vice-Chairman: Mr P. Perkin (Ordinary, Manchester)

Hon. Treasurer: Mr F. B. Mortimer-Ford (Ordinary, London)

Council:

Mr J. Bradley (Ordinary, Manchester)

Mr A. S. Callaghan (Ordinary, Manchester)

Mr H. G. Clayton (Associate, Manchester)

Mr V. Watson (Ordinary, Manchester)

City and Guilds of London Institute examination results

Congratulations are extended to the following Members and Students of the Association upon their success in the recent City and Guilds of London Institute examinations. The candidates' Sections and classes of Membership are shown in italics.

Paint Technicians Certificate Part I

L. G. Cole (*Student, Manchester*)

A. D. Higgins (*Student, Manchester*)

J. T. Howarth (*Student, Newcastle*)

T. Jackson (*Associate, Manchester*)

D. M. McRobbie (*Student, Manchester*)

S. W. H. Naqui (*Associate, Thames Valley*)

A. Sheath (*Student, Manchester*)

R. L. Taylor (*Associate, Manchester*)

Paint Technicians Certificate Part II

J. Barrie (*Ordinary, Manchester*)

R. A. Bulbeck (*Ordinary, Thames Valley*)

T. B. Caplen (*Student, Thames Valley*)

S. A. Hamdulay (*Ordinary, London*)

N. Harding (*Student, Manchester*)

J. J. Hookway (*Student, Thames Valley*)

P. F. Le Maistre (*Student, Midlands*)

A. Sarkissian (*Ordinary, Thames Valley*)

A. J. Waterer (*Student, Thames Valley*)

A. Whattling (*Student, Manchester*)

New FSPT President

Mr J. P. Teas became the 50th President of the Federation of Societies for Paint Technology on 29 October 1971 during the FSPT 49th Annual Meeting at Detroit. Before he became President-Elect in 1970, Mr Teas was Hon. Treasurer of the Federation.

The new President-Elect is Mr A. G. Rook, who was FSPT Treasurer 1970-71.

FSPT Golden Anniversary

The 50th Annual Meeting and 37th Paint Industries' Show of the FSPT, which will mark the Federation's Golden Anniversary, is to be held in Atlantic City from 24-28 October 1972. The Annual Meeting will take place in the Chalfonte-Hadden Hall, which will also house the Paint Show.

Interfinish 72

Programmes for the 8th international Interfinish congress, to be held in Basle, Switzerland, from 5-9 September 1972 in conjunction with the Surface 72 exhibition, have now been issued, and are available from the congress secretary, Dr E. M. Bammatter, CH-400 Basle 21/Schweiz.

GDCh Paint and Pigments Group

The annual congress of the German Chemical Society "Paints and Pigments" Group (Gesellschaft Deutsche Chemiker Fachgruppe Anstrichstoffe und Pigment") is to be held in Bad Pyrmont, Germany, from 26-30 September 1972. The programme will be available in the spring of 1972; those interested should contact Dr H. Rechmann, c/o Titangesellschaft mbH, 509 Leverkusen, Postfach 80/90, Germany.

Register of Members

The following elections to Membership have been approved by Council. The Section to which new Members are attached is given in italics.

Ordinary Members

- BATESON, GRAHAM ALAN, BTech, CIBA-GEIGY (UK) Ltd., Hawkhead Road, Paisley, Renfrewshire, Scotland. (*Scottish*)
- BROWN, LAURENCE SIDNEY, 86 Fourth Avenue, Rush Green, Romford, Essex. (*London*)
- CARRUTHERS, MAURICE MUNRO, 8 Campbell Street, Johnstone, Renfrewshire, Scotland. (*Scottish*)
- FERGUS, MICHAEL DAVID, LRIC, Berger Paints, Freshwater Road, Dagenham, Essex. (*London*)
- GREEN, BASIL R., 25 Albany Road, Manor Park, London, E12. (*London*)
- L'ESTEVE, DEREK CECIL, 44 Victoria Road, Frome, Somerset. (*Bristol*)
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Forthcoming Events

Details are given of meetings in the United Kingdom up to the end of the month following publication, and South Africa and the Commonwealth up to the end of the second month.

Monday 3 January

Hull Section: "Current thinking on flame retardant paints" by Mr A. G. Walker of Associated Lead Manufacturers Ltd., to be held at the Queens Hotel, George Street, Hull, at 7.00 p.m.

Thursday 6 January

Newcastle Section: "The use of zinc oxide in photocopying techniques" by Mr P. J. Robinson of Durham Chemicals Ltd., to be held at the Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne, at 6.30 p.m.

Tuesday 11 January

Scottish Section—Eastern Branch: Joint meeting with BPBMA. "Developments in ink technology" by Mr G. H. Hutchinson of A. B. Fleming & Co. Ltd., to be held at the Carlton Hotel, North Bridge, Edinburgh, at 6.45 p.m.

Thames Valley Section—Student Group: "Colour" by Mr R. Jeffs of ICI Ltd., Pigments Division, to be held in the main Lecture Theatre, Slough College, at 4.00 p.m.

West Riding Section: "The functions of the Factory Inspectorate" by Mr P. F. J. Buchanan (HM Inspector of Factories, Leeds West District), to be held at the Griffin Hotel, Boar Lane, Leeds, at 7.30 p.m.

Wednesday 12 January

London Section: "The effects of lithographic ink ingredients" by Mr J. R. Groom and Mr K. Atkinson of Sandoz Products Ltd., to be held at the South Bank Polytechnic, Borough Road, SE1, at 7.00 p.m.

Manchester Section—Student Group: "Chlorinated rubber in inks and

surface coatings" by Dr D. R. Sayers of ICI Ltd., Mond Division, to be held at the Manchester Literary and Philosophical Society at 4.30 p.m.

Newcastle Section—Student Group: "Marine paints" by Mr W. Hall of British Paints & Chemicals, to be held at the Newcastle Polytechnic, Ellison Place, Newcastle upon Tyne, at 3.00 p.m.

Friday 14 January

Manchester Section: "Pyrolysis gas chromatography" by Mr C. E. Roland Jones of Vinyl Products Ltd., to be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester 1, at 6.30 p.m.

Scottish Section: Annual Dinner Dance, to be held at the Kintyre Suite, Central Hotel, Glasgow, at 6.30 for 7.00 p.m.

Thursday 20 January

London Section—Southern Branch: Joint meeting with the Institute of Metal Finishing. "Electrodeposition" by Mr McKay of Berger Paints Ltd., to be held at the Lecture Theatre, Chemistry Department, Portsmouth Polytechnic, Burnaby Road, Portsmouth, at 7.30 p.m.

Scottish Section: "Modern trends in printing inks" by Mr G. H. Hutchinson of A. B. Fleming & Co. Ltd., to be held at the St. Enoch Hotel, Glasgow, at 6.00 p.m.

Thames Valley Section: "Painting and printing on plastics" by Mr J. R. Taylor of BP Chemicals International Ltd., and Mr R. G. Kinsman of Winstones Ltd., to be held at the Beech Tree Hotel, Maxwell Road, Beaconsfield, Buckinghamshire, at 7.00 p.m.

Friday 21 January

Irish Section: "Magazine production by the web offset process" by Mr G. F. Jones of Irish Printing Inks Ltd., to be held at the Clarence Hotel, Wellington Quay, Dublin, at 8.00 p.m.

Midlands Section: Annual Dinner Lecture: "Coil coating in the seventies" by Mr P. D. Winchcombe of British Steel Corporation, to be held at the Chamber of Commerce and Industry, 75 Harborne Road, Birmingham, at 6.30 p.m.

Saturday 22 January

Scottish Section—Student Group: "The future of plastics" by Dr N. Grassie of the University of Glasgow, to be held at the St. Enoch Hotel, Glasgow, at 10.00 a.m.

Wednesday 26 January

London Section: "Building paints"—No. 2 in a series on "Surface coatings—their use and abuse", to be held at the South Bank Polytechnic from 2.15 p.m. to 5.30 p.m.

Scottish Section—Eastern Branch: "Aerosols, past, present—future" by Mr D. Lake of DH Industries Ltd., to be held at the Carlton Hotel, North Bridge, Edinburgh, at 7.30 p.m.

Friday 28 January

Bristol Section: Joint meeting with the South Western Branch of the Institute of Printing. "Practical pigment dispersion" by Mr J. Groom and Mr H. Baker of Sandoz Products Ltd., to be held at the Royal Hotel, Bristol, at 7.15 p.m.

Thursday 3 February

Newcastle Section: "Alpha-olefins, new monomers for surface coatings" by Mr K. B. Gilkes and Mr A. Laws of Resinous Chemicals Ltd., to be held at the Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne, at 6.30 p.m.

Friday 4 February

Thames Valley Section: Buffet Dance, to be held at "Great Fosters", Egham.

Monday 7 February

Hull Section: "Powder coatings" by a member of staff of Shell Research Ltd., to be held at the Haven Inn, Barrow Haven, Lincolnshire, at 7.00 p.m.

Please note new venue.

Tuesday 8 February

Thames Valley—Student Group: Works Visit to a furniture factory, starting from Slough College Car Park at 1.00 p.m.

West Riding Section: "Industrial surface coatings, and the paint industry" by Mr F. Armitage, to be held at the Griffin Hotel, Boar Lane, Leeds, at 7.30 p.m.

Wednesday 9 February

London Section: "A new approach to the preparation of alkyds based on the glycidyl ester of a branched chain acid" by Mr G. Rossa of Shell Research Ltd., to be held at the South Bank Polytechnic, Borough Road, SE1, at 7.00 p.m.

Newcastle Section—Student Group: "Modern paint production" by Mr J. L. Baxter of Dufay Paints Ltd., to be held at the Newcastle Polytechnic, Ellison Place, Newcastle upon Tyne, at 3.00 p.m.

Thursday 10 February

Midlands Section—Trent Valley Branch: "Micronised pigments and future developments" by a speaker from Bayer Ltd., to be held at the British Rail School of Transport, London Road, Derby, at 7.00 p.m.

Scottish Section: "The effect of recent changes in shipbuilding processes on ship painting" by Dr D. Atherton of Craig Hubback Ltd., to be held at the St. Enoch Hotel, Glasgow, at 6.00 p.m.

Friday 11 February

Manchester Section: "Chrome pigments up to date" by Dr D. A. Plant of ICI Ltd., Dyestuffs Division, to be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester 1, at 6.30 p.m.

Saturday 12 February

Scottish Section—Student Group: Works visit to Outram Press.

Tuesday 15 February

London Section—Southern Branch: "Reflections on an industry" by Mr D. E. Eddowes of Polymer, Paint & Colour Journal, to be held at the Pendragon Hotel, Southsea, at 7.00 p.m.

Wednesday 16 February

Scottish Section—Eastern Branch: "Some problems of ink and paper performance in printing" by Mr E. W. Peacock of PIRA, to be held at the Carlton Hotel, North Bridge, Edinburgh, at 7.30 p.m.

Friday 18 February

Irish Section: "The treatment of timber" by Mr P. J. Coyle of Protim (Ireland) Ltd., to be held at the Clarence Hotel, Wellington Quay, Dublin, at 8.00 p.m.

Midlands Section: "The changing structure of the paint industry" by Mr D. E. Eddowes of Polymer, Paint & Colour Journal, to be held at the Chamber of Commerce, 75 Harborne Road, Birmingham, at 6.30 p.m.

Newcastle Section: Ladies Night, to be held at the Five Bridges Hotel, Gateshead.

Midlands Section—Trent Valley Branch: Lager tasting evening at the Yew Lodge, Kegworth.

Thursday 24 February

Thames Valley Section: "Training for the paint and printing ink industries" by Mr A. R. H. Tawn of Cray Valley Products Ltd., to be held at the Beech Tree Hotel, Maxwell Road, Beaconsfield, Buckinghamshire, at 7.00 p.m.

Friday 25 February

Bristol Section: A lecture by Professor E. M. Evans of BP Chemicals International Ltd., to be held at the Angel Hotel, Cardiff, at 7.15 p.m.

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