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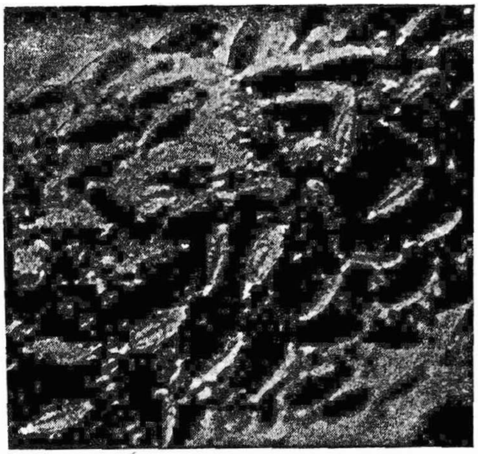

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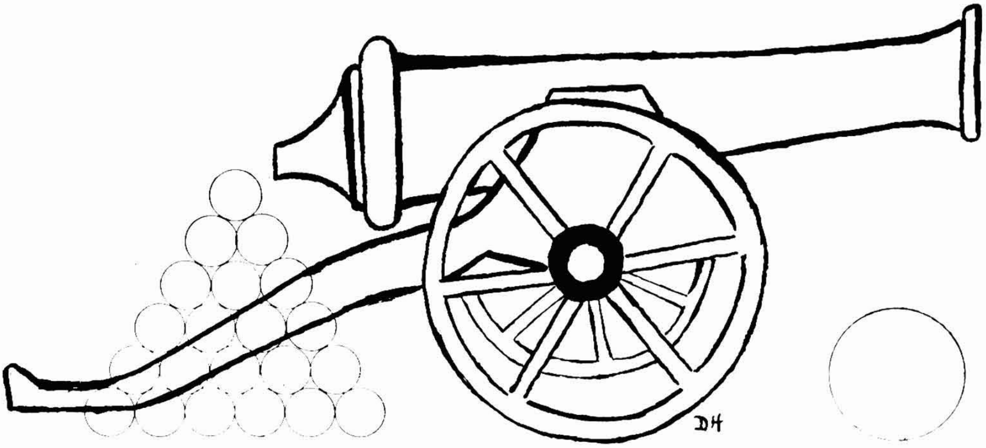
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Transactions and Communications

Weathering of paint films V: Chalking in emulsion paint films caused by silicone-coated anatase titanium dioxide and zinc oxide at varying humidities

By E. Hoffmann and A. Saracz

Division of Building Research, Commonwealth Scientific and Industrial Research Organisation, Melbourne, Australia

Summary

Chalking of paint films formulated with anatase titanium dioxide or zinc oxide coated with silicone, under different conditions of humidity, was investigated in a xenon arc weatherometer. Chalking is entirely suppressed at 70 per cent relative humidity, but is the same as for paints compounded with untreated pigments at 100 per cent relative humidity.

During the weathering process, the pigment volume concentration of the film changes. It has been shown how this can be calculated by weighing the paint film before and after the chalk is removed, and it is suggested that the change in mechanical properties of the weathered paint film could be estimated from the change in the PVC.

Keywords

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

Equipment primarily associated with analysis, measurement and testing
weatherometer

Properties, characteristics and conditions primarily associated with raw materials for coatings
pigment surface treatment

Surface active and rheological agents
silicone

Vieillissement de feuils de peintures Vème. Partie: Le farinage de peintures-émulsion à diverses humidités provoqué par le dioxyde de titane du type anatase et par l'oxyde de zinc traités par silicone

Résumé

Le farinage des feuils de peintures à base du dioxyde de titane du type anatase ou de l'oxyde de zinc traités par silicone a été dosé à diverses taux d'humidité au moyens d'un weatheromètre à l'arc de xénon. A l'humidité relative de 70% le farinage est complètement supprimé, mais à 100% il est du même ordre que celui des peintures à base des pigments sans traitement.

Au cours du processus de vieillissement, la concentration pigmentaire par volume du feuil se change. On a démontré comment on saurait doser ce changement par notant le poids du feuil avant et après l'enlèvement de la farine, et l'on suggère que l'altération des caractéristiques mécaniques du feuil vieilli de peinture pourrait être apprécié à partir du changement de la CPV.

Bewitterung von Anstrichfilmen
V: Abkreiden von Dispersionsfarbfilmen, Verursacht durch mit Silicone Beschichtetes Anatas Titandioxid und Zinkweiss bei Verschiedenen Luftfeuchtigkeiten

Zusammenfassung

Das Abkreiden von unter verschiedenen Feuchtigkeitsverhältnissen mit Silicone überzogenen Anatas Titandioxiden oder Zinkweiss enthaltenden Anstrichmittelfilmen wurde in einem Xenonbogen Weatherometer untersucht. Abkreiden wird bei 70% relativer Luftfeuchtigkeit völlig unterdrückt, entspricht aber dem von unbehandelte Pigmente enthaltenden Anstrichfarben bei 100% relativer Luftfeuchtigkeit.

Die Pigmentvolumenkonzentration des Films verändert sich während der Bewitterung. Gezeigt wird, wie dies durch Wägen des Anstrichfilms vor und nach Entfernung der Kreidung berechnet werden kann. Es wird postuliert, dass die Veränderung der mechanischen Eigenschaften des bewitterten Anstrichfilms von der Veränderung des PVKs berechnet werden kann.

Выветривание красочных пленок. V. Известкование в эмульсионных красочных пленках, вызванное силикон-порытыми анатазом двуокиси титана и окисью цинка при разных влажностях

Резюме

Анализируется известкование красочных пленок формулированных анатазом двуокиси титана или окисью цинка, покрытых силиконом при разных условиях влажности - на везерометре ксеновой дуги. Известкование полностью подавляется при 70-ти процентной относительной влажности, но одинаково как и для красок смешанных с необработанными пигментами, при 100 процентной относительной влажности.

В течение процесса выветривания, объемная пигментная концентрация пленки меняется. Показано каким образом это может быть расчитано, путем взвешивания красочной пленки до и после удаления мела и предполагается что изменение в механических свойствах выветренной красочной пленки, может быть оценено на основе изменения в объемной пигментной концентрации.

Introduction

It has already been pointed out in some detail[1] that, for the development of an accelerated test method, it is necessary to know a great deal about the mechanism of the changes which take place or, at least, to know what variables influence these changes and the degree to which they do so.

The weathering of paint films will presumably be influenced by humidity,[1, 2] wavelength of the incident radiation[3], temperature of the paint film,[3] and intensity of the radiation.[4] The effect of the radiation seems to be greatest when the paint film is saturated with water, that is, when condensation occurs on it and it is irradiated at the same time. It is not surprising that the paint film in this condition is so liable to damage when the increased water uptake of the film at different relative humidities is considered. A characteristic curve (Fig. 1) shows that very little water is absorbed up to 95 per cent relative humidity but that absorption rises rapidly thereafter.

This paper records investigations of the chalking rate of paints formulated with silicone-treated anatase titanium dioxide and zinc oxide at 70 and 100 per cent relative humidity (when condensation actually occurs). Paints compounded with untreated anatase titanium dioxide or zinc oxide show strong

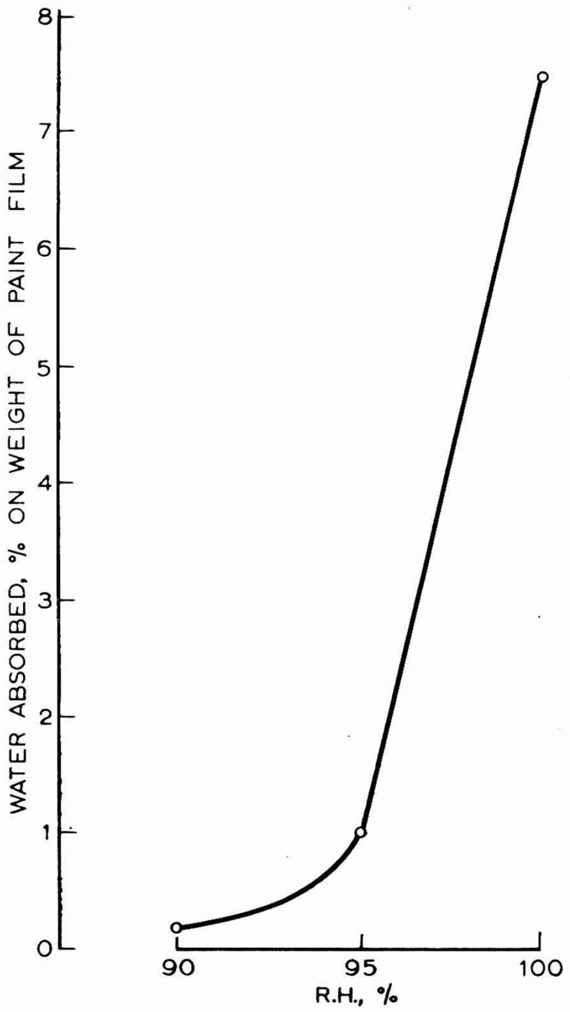

Fig. 1. Water absorption of paint film formulated with zinc oxide and a vinyl acetate/acrylate copolymer

chalking under these conditions. The availability of a type of non-chalking zinc oxide would be of great practical interest, because of its possible use for fungus-resistant paints, provided, of course, that its fungistatic properties remained unchanged, which is by no means certain.

Preparation of coated pigments

From 30 to 40g of pigment was dispersed in 200 ml water with a sufficient amount of water-soluble sodium methylsiliconate solution to give a concentration of 5 or 10 per cent siliconate solids on the weight of the pigment. The suspension of anatase titanium dioxide was acidified to pH 1 and the zinc oxide suspension to pH 7. Stirring was continued for some time and the suspension was centrifuged, washed free of acids, and the sodium salt formed. The pigment was then used for the preparation of the paint.

The supernatant liquid was analysed for the remaining silicone resin. Of the resins originally introduced, 20 to 30 per cent was found in the washings of the centrifugate, the rest remaining with the pigments, partly absorbed on the surface and partly mechanically admixed.

The treatment was carried out at −40°C, −20°C, 0°C, +20°C and +80°C*; stirring after acidification was continued for from 6 to 96h, and hydrochloric, nitric, phosphoric and sulphuric acids were used for neutralisation.

Preparation of paint

All paints were formulated with a vinyl acetate/acrylate copolymer latex to a pigment volume concentration of 40 per cent. Stainless steel panels (62.5 × 75mm) were coated and dried to constant weight at 38°C.

Experimental

Experiments were carried out at 40°C and at 70 and 100 per cent relative humidity in a xenon arc weathering machine. Under the latter condition, condensation of water vapour on the paint film took place. After exposure, the panels were kept for 24h at 38°C, weighed and then reweighed after removing the chalk with a dry cloth.

Discussion and conclusions

The results of a typical experiment with coated and uncoated zinc oxide and anatase titanium dioxide at 70°C and 100 per cent relative humidity are shown in Figs. 2 and 3 respectively. With the treated pigments, the formation of chalk is completely suppressed and the weight loss before trying to remove the chalk is considerably reduced.

The weight loss of a paint film before and after removing the chalk has been interpreted in the following way.[3] The free pigments were originally combined with resin which had been oxidised to volatile products. The quantity of binder lost in this way can be found from the known composition of the paint on the assumption that the quantity of resin still mixed with the released pigment is negligible. This has been shown by analysing the chalk for carbon. If nothing else had happened in the paint film apart from the total decomposition of the binder, the weight loss before removing the chalk should be very nearly the quantity of resin which had been originally combined with it. However, the loss is greater than that and could be due to chalk falling off the panel. Reasons for discounting this possibility have been given,[3, 5] but the observations reported here are probably more convincing because a considerable weight loss was found in spite of the fact that chalking was suppressed entirely in the paint films containing the treated pigments. It has been suggested[3, 4, 5] that this discrepancy is due to partial oxidation of the binder, possibly followed by a recombination of molecules of partly oxidised resin. Sufficient binder is left to keep the pigments in place, so that this type of change is not connected with chalking.

---

*At −40°C and −20°C the pigments were suspended in an ethanol/water mixture.

This partial oxidation is believed to be responsible for the change in mechanical properties of the paint film, and therefore in two paint films the one showing the bigger weight loss before removing the chalk will tend more to crazing and cracking. Although this assumption is likely to be correct, it has to be demonstrated by actual measurements of exposed and unexposed paint films. This is not easy, and it is therefore proposed as a first approximation that the following method be used to estimate the change in mechanical properties.

Loss of resin without a corresponding loss of pigment simply means that the PVC of the remaining film rises, and it is not unreasonable to suppose that the elastic behaviour of the weathered film will be similar to that of a new paint film of the same PVC. Calculations for the increase in PVC on exposure are given in detail for a paint film formulated with untreated anatase titanium dioxide. The film before exposure consisted of 370mg of resin, 845mg of anatase titanium dioxide and 38mg of wetting agent. After exposure, the weight loss before removing the chalk was 307mg; assuming the wetting agent was lost during weathering the loss of resin was 269mg and the remaining resin amounted to 101mg. As the loss of pigment was 311mg, the quantity of pigment remaining in the paint film amounted to 534mg, which means that, after exposure, the PVC of the remaining paint film had risen to 58 per cent. The changes in PVC after exposure are tabulated in Table 1 for the paints of Figs. 2 and 3.

Table 1

Change of PVC after weathering for 877 hours

Pigment	Pigment volume concentration (%)	
	Before exposure	After exposure
Untreated anatase titanium dioxide	40	58
Treated anatase titanium dioxide	40	45
Untreated zinc oxide	40	47
Treated zinc oxide	40	41

Films of paints formulated with untreated anatase titanium dioxide have a PVC which rises from 40 to 58 per cent during exposure. On the other hand, the PVC of coatings pigmented with untreated zinc oxide increases to only 47 per cent, although the amount of totally decomposed resin is the same in both cases. The weight loss of loose pigments is higher in the paints formulated with zinc oxide, as the ratio of pigment to resin by weight is larger for these formulations than for the titanium dioxide ones. It is reasonable to assume that the paints formulated with anatase titanium dioxide will change their mechanical properties to a much higher degree than those compounded with zinc oxide.

The paints formulated with treated pigments do not chalk, but paint films containing anatase titanium dioxide increase their PVC to 45 per cent whereas the zinc oxide paints do not show any increase. The behaviour of paints containing the untreated pigments is in a similar direction.

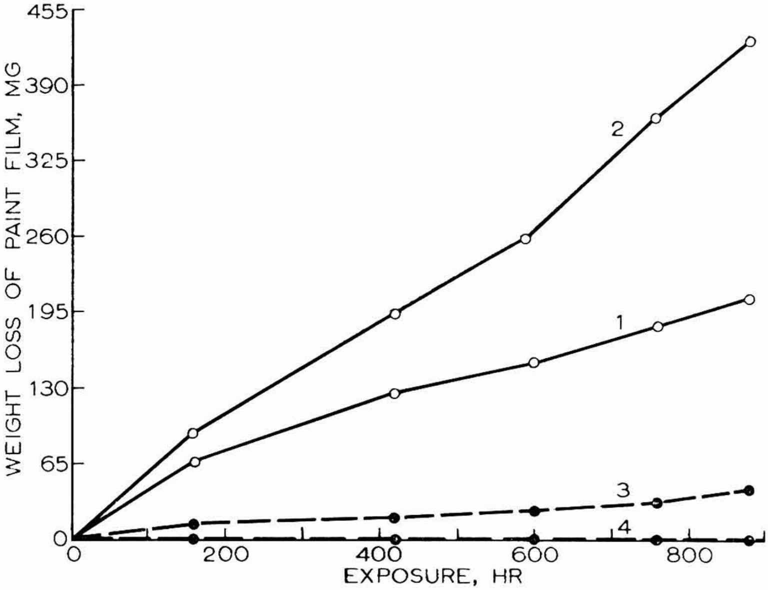

Fig. 2. Weight loss of paint film on exposure to xenon arc weathering

Curve 1—Untreated anatase titanium dioxide; loss before removing chalk.
Curve 2—Untreated anatase titanium dioxide; loss after removing chalk.
Curve 3—Treated anatase titanium dioxide; loss before removing chalk.
Curve 4—Treated anatase titanium dioxide; loss after removing chalk.

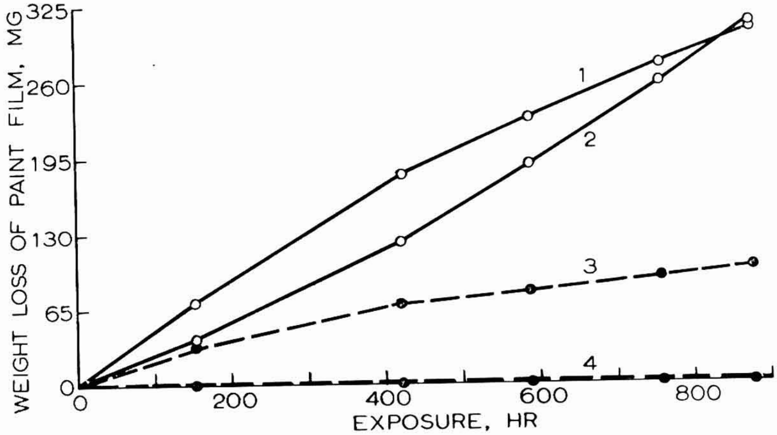

Fig. 3. Weight loss of paint film on exposure to xenon arc weathering

Paint composition: Pigment, zinc oxide; Resin, vinyl acetate/acrylate copolymer; PVC, 40 per cent.
Curve 1—Untreated pigment; loss before removing chalk.
Curve 2—Untreated pigment; loss after removing chalk.
Curve 3—Treated pigment; loss before removing chalk.
Curve 4—Treated pigment; loss after removing chalk.

The beneficial effect of the treatment of pigment does not persist if the experiments are repeated at 100 per cent relative humidity, when water actually condenses on the paint film. Under these conditions, chalking proceeds at practically the same rate as in those containing the untreated pigments. If the paint films that have been exposed to 100 per cent relative humidity are again exposed at 70 per cent, the original behaviour at this humidity level is restored. This is an indication that the high humidity did not destroy the silicone coating on the pigments but rather that under this condition other spots on the surface of the pigment become active. It is not possible in the equipment available to increase the humidity to over 70 per cent without causing condensation. It is unlikely that an increase from 70 to 90 per cent would cause an appreciable increase in the rate of chalking, as the water vapour concentration in this range increases by only about 30 per cent. Chalking starts only when humidity rises to 100 per cent and the water absorbed on the paint film increases drastically, as shown in Fig. 1.

The experiments reported here also show how important it is that the effect of changes in formulation is investigated under clearly defined conditions. If the panels had been exposed to one of the usual weatherometer cycles in which they are sprayed or water condenses on them, the effect of the treatment is likely to have been overlooked. Good results were obtained with zinc oxide pigment at +20° and +30°C, and with anatase titanium dioxide pigment at +20°C. Treatment carried out at low temperatures gave no improvement. The effects of varying the types of acid used for neutralisation, the concentration of silicone, and the duration of stirring were not large.

[*Received 28 February 1972*

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A test for ability to support combustion for liquids including paints and allied products

By A. N. McKelvie

Paint Research Association, Teddington

Summary

The paint industry, conscious of the need to reduce fire hazards, is increasingly using formulations containing substances, such as water and chlorinated solvents, that will cause a reduction in flammability. Whilst such formulations do not readily support combustion, they may contain small proportions of highly flammable substances, and will thus have a definite flash point value.

It has recently been decided that, in addition to flash point determination, a test for ability to support combustion is a necessary criterion of fire hazard regulations. An apparatus with which this test may be carried out has been designed, and the test is now incorporated as Schedule 2 of the "Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972.

Keywords

Properties, characteristics and conditions primarily associated with materials in general

ability to support combustion
flammability
flash point

Equipment primarily associated with analysis, measurement and testing

combustion tester
flammability tester

Une méthode d'essai pour déterminer l'aptitude manifestée par certains liquides, y compris peintures et produits assimilés, à soutenir la combustion

Résumé

L'industrie de peintures, ayant conscience de la nécessité de réduire les dangers d'incendie, utilise progressivement des peintures dont les compositions renferment des constituants tels que l'eau et les solvants chlorés, qui entrainent une diminution de la flammabilité. Tandis que ces peintures ne soutiennent pas fortement la combustion, elles puissent contenir de minces proportions de composés extrêmement flammables, et dans ce cas elles auront un point d'éclair bien défini.

En outre que la détermination du point d'éclair, on a décidé tout récemment qu'un essai pour déterminer l'aptitude à soutenir la combustion est un critère nécessaire dans les règlements sur les dangers d'incendie. On a conçu un appareil pour effectuer cet essai qui figure actuellement comme annexe aux "Highly Flammable Liquids and Liquefied Petroleum Gases Regulations, 1972".

Ein Test zur Unterhaltung der Verbrennung von Flüssigkeiten Einschliesslich Lacken und Verwandten Produkten

Zusammenfassung

Im Bewusstsein der Notwendigkeit Feuerrisiken zu verringern benutzt die Lackindustrie im steigenden Masse Rezepturen enthaltend Substanzen, wie Wasser und chlorierte Lösungsmittel, welche zur Verringerung der Entflammbarkeit beitragen. Während auf solchen Rezepten aufgebaute Produkte Verbrennung nicht ohne weiteres unterhalten, können sie aber doch geringe Anteile stark entflammbarer Substanzen enthalten und besitzen somit einen definitiven Flammpunktswert.

Kürzlich kam man zu dem Entschluss, dass ausser der Flammpunktsbestimmung auch eine Prüfmethode auf Unterhaltung des Brennens ein notwendiges Kriterium für Regeln zur Feuerverhütung ist. Eine Apparatur, mit welcher diese Prüfung vorgenommen werden kann, wurde entworfen. Diese Prüfung wurde nunmehr als Schedule 2 in die Highly Flammable Liquids and Liquified Petroleum Gases Regulations 1972 eingearbeitet.

Испытание способности поддерживать горение для жидкостей, включая краски и смежные продукты

Резюме

Красочная промышленность, вполне учитывая необходимость понижения огнеопасности, все чаще применяет формуляции содержащие такие вещества как например воду и хлорированные растворы, которые снижают возможность воспламенения. В то время как такие формуляции нелегко поддерживают горение, они все же могут содержать незначительную пропорцию высоко огнеопасных веществ и поэтому будут обладать известной температурой вспышки.

Недавно было принято решение, что кроме определения точки воспламенения, испытание на способность веществ поддерживать горение, является необходимым критерием для инструкций по огнеопасности. Выработан прибор для проведения этого испытания и это испытание в настоящее время включено под параграфом 2 в «Инструкциях для высоко огнеопасных жидкостей и жидких нефтяных газов, 1972».

Introduction

In the manufacture, storage and use of paint and allied products containing flammable solvents it is necessary to consider the fire hazards involved. The well established test criterion is flash point and Statutory Regulations in many countries use the results of this test as a means of deciding what precautions are to be imposed. The regulations in existence are well documented by Hughes[1] and have in the main been designed to control the use of products arising from the petroleum industry, i.e. wholly petroleum based products.

The paint industry uses many of these products in its compositions. It is very conscious of the need to reduce the fire hazards of its products and this has led to a rapidly growing usage of products containing proportions of water, chlorinated solvents and the like, which effectively reduce the fire hazards involved. These products, of necessity, still contain small quantities of highly flammable solvents and may therefore have a definite flash point value, although they will not readily support combustion.

It was therefore proposed and accepted at a recent public inquiry[2] that there should, in addition to a flash point determination, be a second criterion of combustibility or, more precisely, ability to support combustion in the consideration of fire hazard regulations. For example, if the limiting temperature for flash point was 32°C then, even if the product under test gave a flash point at 32°C, it would not be considered to be so hazardous on storage if it did not sustain combustion when ignited at a considerably higher temperature, say 50°C.

This paper describes a satisfactory test devised by the author at the Paint Research Association and now incorporated as Schedule 2 of the "Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972".*

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*These regulations are discussed in the Paint Technology Manual, Part Seven, Chapter V, published in the November issue of this *Journal*, p. 1031, *ptm 167.*

Experimental

The apparatus devised is shown in Fig. 1. It consisted of a cylindrical metal block with a concave depression or well at its centre. A thermometer to record the temperature of the block was sealed into it, with the bulb centrally positioned under the well. A small gas jet was fixed to the block in such a manner that it could be swivelled over the centre of the well in an arc and its movement was restricted by stops at 45° on each side of the centre of the well. The metal block was conveniently heated by a suitable device, such as placing it on a hot plate controlled by a simmerstat. The exact dimensions and tolerances of the apparatus are given in Schedule 2 of the "Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972". When the block had attained a test temperature, 2ml of test product transferred to the well attained the same temperature as the block in less than one minute.

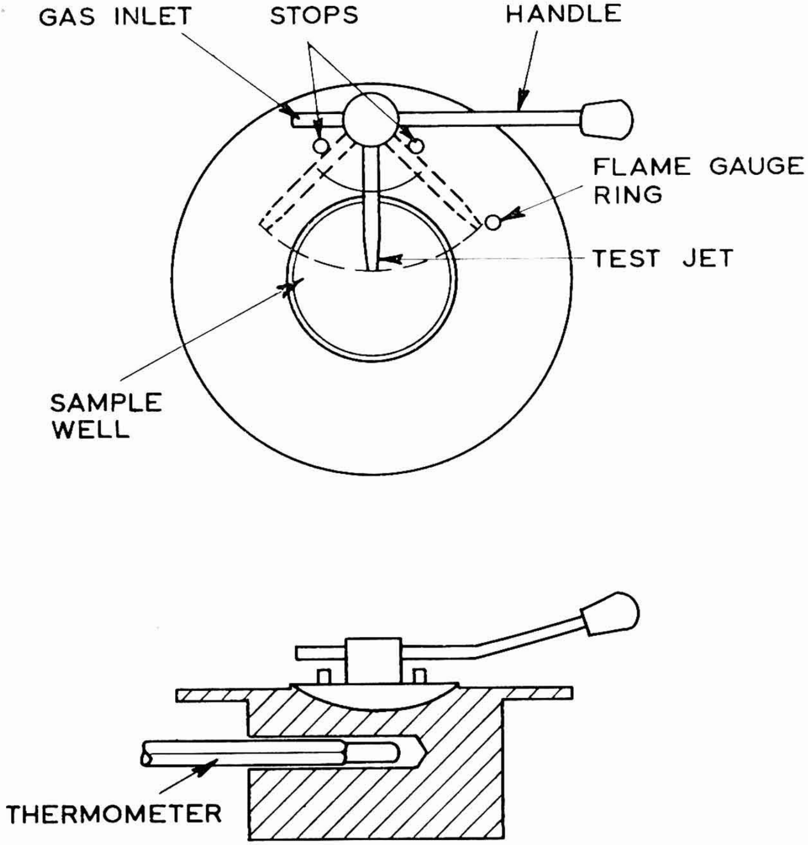

Fig. 1. Test apparatus

Tests were carried out on a wide range of products at test temperatures in the range 35°-65°C at 5°C intervals. In each experiment, 2ml of the test product was allowed to heat to the test temperature for one minute with the standard

4mm diameter gas flame lit in the off position. After one minute, the standard flame was swivelled over to the centre of the well. In initial experiments, the flame was held over the centre of the well for time intervals varying from 2 seconds to 60 seconds. It is considered from these observations that a time of stay of 15 seconds over the centre of the well gave good, reproducible results and this time of stay was standardised for all results recorded.

In carrying out the tests the phenomena noted could be readily classified into six categories and these are described in Table 1.

Table 1

Phenomena noted in carrying out tests

Category	Observations	Interpretations
1.	The product does not flash and the flame is extinguished when over the well	Product is acting as an inert diluent or flame extinguishing agent
2.	The product does not flash and does not ignite when the flame is over the well	Product has too low a vapour pressure to affect the test flame in any way
3.	The product does not flash but the flame becomes somewhat enlarged and possibly smoky even when the flame is not over the well. The flame may continue to burn when over the well but not the bulk of the product	Product is adding fuel to the test flame but does not give a flammable atmosphere over the well
4.	The product may flash and the flame becomes somewhat enlarged and possibly smoky when the flame is not over the well. When the flame is over the well the product will flash but if it ignites combustion is not sustained for more than 15 seconds when the flame is removed	Test conditions are approaching that of a flammable atmosphere over the well
5.	When the flame is over the well the product ignites and combustion is sustained for more than 15 seconds when the flame is removed	The temperature of sustained combustion is reached
6.	When the flame is in the "off" position the product flashes, ignites and combustion is sustained	The temperature of sustained combustion has been exceeded

The tables below give detailed results for a number of typical commercial electrocoat paints (Table 2), solvent/water mixtures commonly used in electrocoat paint compositions (Table 3), typical commercial paints containing chlorinated solvents (Table 4), and a range of hydrocarbon and chlorinated solvents (mixtures) of importance to the paint industry (Table 5). Table 6 records results on a range of miscellaneous commercial products and Table 7 on a range of conventional type paints.

Table 2

Flash point and ability to support combustion of a selection of electrocoat paints received from five different manufacturers

Supplier	Description of sample	Flash at 32°C	Category of ability to support combustion at stated temperatures						
			35°C	40°C	45°C	50°C	55°C	60°C	65°C
A	Primer M972-3215	No	2	2	2	2	2	2	2
	Primer M972-3215 plus 5% acetone	Yes	2	2	2	2	2	2	2
	Grey F972-2007	Yes	2	2	2	2	2	2	2
	White F972-SD92794 (acrylic)	Yes	2	2	2	2	2	2	2
B	Black concentrate (36% solids)	No	2	2	2	2	2	2	2
	Black concentrate (36% solids) plus 5% acetone	Yes	2	2	3	4	4	4	4
	Black concentrate (36% solids)/water 1 : 2	No	2	2	2	2	2	2	2
	Grey primer concentrate (63% solids)	Yes	4	4	4	4	4	4	4
	Grey primer concentrate (63% solids)/water 1 : 4	No	2	2	2	2	2	2	2
C	Stoving black SL1257	No	2	2	2	2	2	2	2
	Stoving black SL1257 plus 5% acetone	Yes	3	4	4	4	4	4	4
D	Primer	Yes	2	2	2	2	2	2	2
	Primer plus water thinner	Yes	2	2	2	2	2	2	2
G	Semi gloss black C3782	No	2	2	2	2	2	2	2
	Aluminium finish C3781	Yes	4	4	4	4	4	4	4

Table 3

Flash point and ability to support combustion of a range of solvent/water mixtures relevant to electrocoat paint solvent compositions

Description of solvent mixture			Flash at 32°C	Category of ability to support combustion at stated temperatures						
Ethanol	Butanol	Water		35°C	40°C	45°C	50°C	55°C	60°C	65°C
90	—	10	Yes	6	6	6	6	6	6	6
81	9	10	Yes	6	6	6	6	6	6	6
72	18	10	Yes	6	6	6	6	6	6	6
63	27	10	Yes	5	6	6	6	6	6	6
54	36	10	Yes	5	6	6	6	6	6	6
45	45	10	Yes	5	6	6	6	6	6	6
36	54	10	Yes	5	6	6	6	6	6	6
27	63	10	Yes	5	6	6	6	6	6	6
9	81	10	No	2	5	5	6	6	6	6
80	—	20	Yes	6	6	6	6	6	6	6
72	8	20	Yes	6	6	6	6	6	6	6
64	16	20	Yes	6	6	6	6	6	6	6

Table 3—continued

Description of solvent mixture			Flash at 32°C	Category of ability to support combustion at stated temperatures						
Ethanol	Butanol	Water		35°C	40°C	45°C	50°C	55°C	60°C	65°C
56	24	20	Yes	5	6	6	6	6	6	6
48	32	20	Yes	5	6	6	6	6	6	6
40	40	20	No	5	5	6	6	6	6	6
32	48	20	No	5	6	6	6	6	6	6
24	56	20	No	5	5	5	5	6	6	6
16	64	20	No	2	5	5	5	6	6	6
8	72	20	No	2	4	5	5	5	6	6
70	—	30	Yes	6	6	6	6	6	6	6
63	7	30	Yes	6	6	6	6	6	6	6
56	14	30	Yes	6	6	6	6	6	6	6
49	21	30	Yes	5	6	6	6	6	6	6
42	28	30	Yes	5	6	6	6	6	6	6
35	35	30	No	5	5	6	6	6	6	6
28	42	30	No	5	5	5	6	6	6	6
21	49	30	No	2	4	5	5	6	6	6
60	—	40	Yes	6	6	6	6	6	6	6
54	6	40	Yes	6	6	6	6	6	6	6
48	12	40	Yes	5	6	6	6	6	6	6
42	18	40	Yes	5	6	6	6	6	6	6
36	24	40	No	5	5	5	6	6	6	6
30	30	40	No	5	5	5	6	6	6	6
24	36	40	No	2	4	5	5	6	6	6
18	42	40	No	2	2	4	5	6	6	6
50	—	50	Yes	6	6	6	6	6	6	6
45	5	50	Yes	5	6	6	6	6	6	6
40	10	50	No	5	5	6	6	6	6	6
35	15	50	Yes	5	5	6	6	6	6	6
30	20	50	No	4	5	5	5	6	6	6
25	25	50	No	2	4	5	5	6	6	6
20	30	50	No	2	2	4	5	5	6	6
40	—	60	Yes	6	6	6	6	6	6	6
36	4	60	No	5	5	6	6	6	6	6
32	8	60	No	4	5	6	6	6	6	6
28	12	60	No	3	5	5	6	6	6	6
24	16	60	No	2	5	5	5	6	6	6
20	20	60	No	2	4	4	5	5	6	6
30	—	70	Yes	5	5	5	5	6	6	6
27	3	70	No	2	4	4	5	6	6	6
24	6	70	No	2	4	4	5	6	6	6
21	9	70	No	2	4	4	5	6	6	6
18	12	70	No	2	4	4	5	6	6	6
15	15	70	No	2	3	4	5	5	6	6
20	—	80	No	2	2	3	3	3	3	3
18	2	80	No	2	2	3	3	3	3	3
16	4	80	No	2	2	3	3	3	3	3
14	6	80	No	2	2	3	3	3	3	3
12	8	80	No	2	2	3	3	3	4	4
10	10	80	No	2	2	3	4	4	4	4
10	—	90	No	2	2	2	2	2	3	3
9	1	90	No	2	2	2	2	2	3	3
8	2	90	No	2	2	2	2	2	3	3
7	3	90	No	2	2	2	2	2	3	3
6	4	90	No	2	2	2	2	2	3	3
5	5	90	No	2	2	2	2	2	3	3
—	100	—	No	5	5	5	6	6	6	6
100	—	—	Yes	6	6	6	6	6	6	6

Table 4

Flash point and ability to support combustion of a selection of paints based on chlorinated solvents received from four different manufacturers

Supplier	Description of sample	Flash at 32°C	Category of ability to support combustion at stated temperatures						
			35°C	40°C	45°C	50°C	55°C	60°C	65°C
A	Air drying finish F655-1015	No	3	3	3	3	3	3	4
	Air drying finish F655-1015 plus 5% acetone	Yes	4	4	4	4	4	4	4
	Stoving finish F655-2041	Yes	4	4	4	4	4	4	4
	Red oxide primer F655-3001	Yes	3	3	3	3	3	3	3
	Black finish 1 (TCE/Xylol 95 : 5)	Yes	3	3	3	3	3	3	3
	Black finish 2 (TCE/Xylol 79 : 21)	Yes	3	3	3	3	3	3	3
	Black finish 3 (TCE/Xylol 62 : 38)	Yes	3	3	3	3	3	3	3
	Black finish 4 (TCE/Xylol 45 : 55)	Yes	3	3	3	3	3	3	3
	Black finish 1 plus 5% n-butanol:isobutanol 1 : 1	Yes	3	3	3	3	3	3	3
	Black finish 2 plus 5% n-butanol:isobutanol 1 : 1	Yes	3	3	3	3	3	3	3
	Black finish 3 plus 5% n-butanol:isobutanol 1 : 1	Yes	3	3	3	3	3	3	4
	Black finish 4 plus 5% n-butanol:isobutanol 1 : 1	Yes	3	3	3	4	4	4	4
B	Black trichlorethylene paint	No	3	3	3	3	3	3	3
	Red marking ink (very little trichlorethylene)	Yes	5	5	5	5	5	5	5
E	Silver lacquer containing a blend of toluol and methylene chloride	Yes	4	4	4	4	4	5	5
F	Quick air drying enamel containing some chlorinated solvents	No	3	3	3	3	3	3	3

Note—All the above paints containing chlorinated solvents give a greenish tinge to the test flame during the flash point determination, even when there is no actual flash.

Table 5

Flash point and ability to support combustion of a selection of solvent mixtures of hydrocarbon and chlorinated solvents relevant to paints based on these mixtures

Description of solvent mixture		Flash at 32°C	Category of ability to support combustion at stated temperatures						
			35°C	40°C	45°C	50°C	55°C	60°C	65°C
White spirit	Trichlorethylene								
0	100	No	3	3	3	3	3	3	3
10	90	No	3	3	3	3	3	3	3
20	80	No	3	3	3	3	3	3	3
30	70	No	3	3	3	3	3	3	3
40	60	No	3	3	3	3	3	3	3
50	50	No	3	3	3	3	3	3	3
60	40	No	3	3	3	3	3	3	3
70	30	No	3	3	3	3	3	3	3
80	20	No	3	3	3	3	4	4	4
90	10	No	3	3	3	3	4	4	6
100	0	No	2	2	2	3	5	5	6
Xylol	Trichlorethylene								
0	100	No	3	3	3	3	3	3	3
10	90	No	3	3	3	3	3	3	3
20	80	No	3	3	3	3	3	3	3
30	70	No	3	3	3	3	3	3	3
40	60	No	3	3	3	3	3	3	3
50	50	Yes	3	3	3	3	3	3	3
60	40	Yes	3	3	3	3	3	4	4
70	30	Yes	3	4	4	4	4	4	4
80	20	Yes	3	4	4	4	4	4	4
90	10	Yes	3	4	4	5	5	6	6
100	0	Yes	4	5	6	6	6	6	6

Table 6

Flash point and ability to support combustion of a miscellaneous selection of products received from manufacturers

Supplier	Description of sample	Flash at 32°C	Category of ability to support combustion at stated temperatures						
			35°C	40°C	45°C	50°C	55°C	60°C	65°C
A	Metal pretreatment product 5800-202	Yes	4	4	4	4	4	4	4
	Metal pretreatment product 5800-125	Yes	4	5	5	5	5	5	6
	Metal pretreatment product 5800-24	Yes	5	5	6	6	6	6	6
	Paint stripper	No	3	3	3	4	4	4	4
H	Tetmosol	Yes	4	6	6	6	6	6	6
	Savlon (hospital grade)	Yes	3	3	4	4	4	6	6
J	Metal treatment solution	No	3	3	4	4	4	4	6
K	Paint remover	No	3	3	3	4	4	4	4
L	Amine catalyst solution 301-8534	Yes	2	2	2	2	2	3	3
M	Fire retardant coating for wood	Yes	2	2	2	2	2	2	2
N	Watch cleaning solution	Yes	3	3	3	3	3	3	3

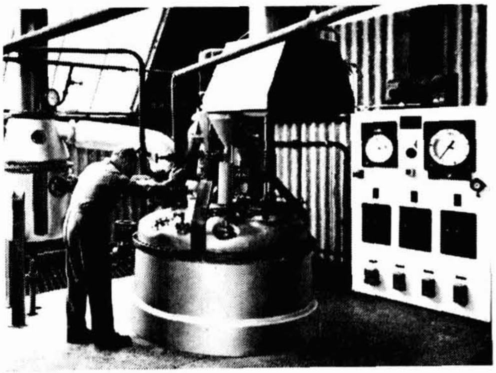

Table 7

Flash point and ability to support combustion of a selection of conventional type paints

Supplier	Description of sample	Flash at 32°C	Category of ability to support combustion at stated temperatures						
			35°C	40°C	45°C	50°C	55°C	60°C	65°C
A	Nitrocellulose brushing white	Yes	6	6	6	6	6	6	6
	Wood primer	Yes	5	5	5	5	5	5	5
	Alkyd gloss white	No	2	5	5	5	5	5	5
D	Chromate primer	Yes	5	5	5	5	5	5	5
	Metallic lead phenolic primer	Yes	5	5	5	5	5	5	5
	Metal protection finish	Yes	5	5	5	5	5	5	5
	Metallic lead modifier phenolic primer	No	5	5	5	5	5	5	5
G	Zinc phosphate pure phenolic primer	Yes	5	5	5	5	5	5	5
	Polyvinyl butyral wash primer	Yes	6	6	6	6	6	6	6
	Zinc phosphate alkyd primer	No	5	5	5	5	5	5	5
L	White alkyd gloss paint	No	5	5	5	5	5	5	5
O	Aluminium paint	No	1	5	5	5	5	5	5
P	Aluminium bilge paint	No	1	5	5	5	5	5	5
Q	Polyurethane gloss white (one pack)	No	5	5	5	5	5	5	5
R	White lead gloss paint	No	5	5	5	5	5	5	5

Conclusions

The experimental results confirm that the test devised determines the ability of a liquid product to sustain combustion.

The usefulness of the test is in differentiating between products which give a positive flash point at 32°C and which may or may not sustain combustion.

The method is incorporated in Schedule 2 of the "Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972"[3], the temperature of test being 50°C.

Achnowledgment

The author wishes to thank the Directors of the Paint Research Association and the Paint Manufacturers Association for permission to publish this paper.

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The peeling-off of paint films

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Summary

The theory that has been developed to describe creep in paint films has been expanded to describe the peeling-off of these films. From this theory, it follows that peeling-off can be described by a six-parameter model. Four of the parameters, as for the creep equation, represent the viscoelastic properties of the resin, the other two the properties of the boundary layer between the film and the substrate. The influence of the pigment present in the film is expressed by a correction factor which is solely a function of the pigment volume concentration.

Experiments with alkyd resin paints pigmented with TiO_2 or $BaSO_4$ satisfactorily confirm the theory.

Keywords

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

creep
peeling

Processes and methods primarily associated with analysis, measurement and testing

infra-red spectroscopy

L'écaillage de feuils de peintures

Résumé

La théorie mise au point pour décrire le cheminement de feuils de peintures a été élargie afin de décrire l'écaillage de ces feuils. A partir de cette théorie, il s'ensuit que l'écaillage peut être décrit à l'aide d'un modèle à six paramètres, dont quatre représentent, comme dans le cas de l'équation de cheminement, les caractéristiques de la résine, et les deux autres celles de la couche à l'interface du feuil et du support. L'influence exercée par le pigment qui se trouve dans le feuil s'exprime par un facteur de correction qui est une fonction seulement de la concentration pigmentaire par volume.

Des éxperiences sur les peintures aux alkydes pigmentées avec TiO_2 ou $BaSO_4$ donnent une confirmation satisfaisante de la théorie.

Das Abschälen von Anstrichfilmen

Zusammenfassung

Die zur Beschreibung der Verformung (creep) von Anstrichfilmen entwickelte Theorie wurde auf die Beschreibung des Abschälens solcher Filme ausgedehnt. Aus dieser Theorie ergibt sich, dass Abschälen durch ein Sieben-Parameter-Modell ausgedrückt werden kann. Davon sind vier Parameter identisch mit denen für die Verformungsgleichung; von den anderen Parametern stellt eine die rheologischen Eigenschaften, die anderen beiden stellen die der Grenzschicht zwischen Film und Substrat dar. Der Einfluss des im Film vorhandenen Pigments wird durch einen Korrekturfaktor ausgedrückt, welcher lediglich eine Funktion der Pigmentvolumenkonzentration ist.

Die Theorie wird durch mit TiO_2 oder $BaSO_4$ pigmentierten Alkydharzfarben durchgeführte Versuche zufriedenstellend bestätigt.

Шелушение красочных пленок

Резюме

Теория разработанная для описания ползучести в красочных пленках развивается для описания отслаивания этих пленок. Из этой теории следует что шелушение может быть описано шестипараметровой моделью. Четыре из этих параметров, как и в случае уравнения ползучести, описывают вязко-упругие свойства смолы, а другие два описывают свойства пограничного слоя между пленкой и субстратом. Влияние пигмента в пленке выражается поправочным коэффициентом, который является исключительно функцией объемной пигментной концентрации. Опыты с алкидными смольными красками пигментированными с TiO_2 или $BaSO_4$, удовлетворительно подтверждают теорию.

Introduction

As for unpigmented films[1] the study of peeling-off and creep of paint films should lead to a mathematical description of the peeling-off of these films. Starting from the theory for creep in paint films[2], a description of the peeling-off is given below.

Theoretical

The viscoelastic properties of a free paint film can be described by a four parameter mechanical model consisting of two springs E_1, E_2 and two pistons, viscosities η_1 and η_2[1, 2]. If it is assumed that a boundary layer with a viscosity η_3 is formed between the film and the substrate and that this layer is influenced in the same way by the pigment as is the bulk of the film, the strain Δ which has to develop in the film and the boundary layer before peeling-off occurs is:

$$\Delta = \sigma A \left\{ \frac{E_1 + E_2}{E_1 E_2} + \frac{t_c}{\eta_1} - \frac{1}{E_2} \exp - \frac{E_2}{\eta_2} t_c \right\} \text{..........} \quad (1)$$

A being the correction factor.

$$A = 1 \bigg/ \left\{ \frac{\pi C^2}{4\,(1 - C)} + \frac{4 - \pi C^2}{4} \right\} \text{ in which } C = \left(\frac{6\varphi_F}{\pi} \right)^{\frac{1}{3}}$$

where φ_F = volume fraction of the pigment,

and σ = load applied to the film.

The strain Δ is defined as the quotient of the displacement, δ, of two opposite groups forming a bond between the film and the substrate that is necessary to cause complete disruption, and the mean distance, l_0, in the direction of peeling between these bonds in the boundary layer. Therefore t_c is the time needed to peel off a unit of film length.

Rearrangement of equation (1) results in:

$$\frac{1}{\sigma} = A \left\{ \frac{E_1 + E_2}{\Delta E_1 E_2} + \frac{t_c}{\Delta\,(\eta_1 + \eta_3)} - \frac{1}{E_2} \exp - \frac{E_2}{\eta_2} t_c \right\} \text{....} (2)$$

The values of E_1, E_2, η_1 and η_2 can be obtained from creep experiments and substitution of these values in the results found in peeling-off experiments enables the calculation of Δ and η_3. The creep equation for paint films is[2]:

$$\frac{\varepsilon}{\sigma} = A \left\{ \frac{E_1 + E_2}{E_1 E_2} \frac{t}{\eta_1} - \frac{1}{E_2} \exp - \frac{E_2}{\eta_2} t \right\} \text{..............} \quad (3)$$

ε = strain developed in the film at any time t.

Experimental

In all experiments the temperature was 25°C. With glass as a substrate, the peeling-off of alkyd resin paint films with TiO_2 or $BaSO_4$ as a pigment was investigated. For films with TiO_2, some creep and peeling-off results carried out at 70 per cent relative humidity are represented in Figs. 1 and 2.

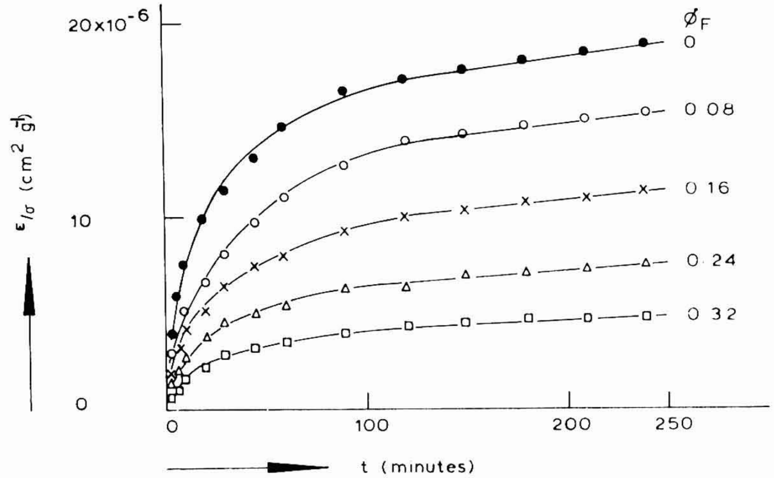

Fig. 1. The creep curves of alkyd resin/TiO_2 films for five pigment concentrations. Film age 50 days, r.h. 70%

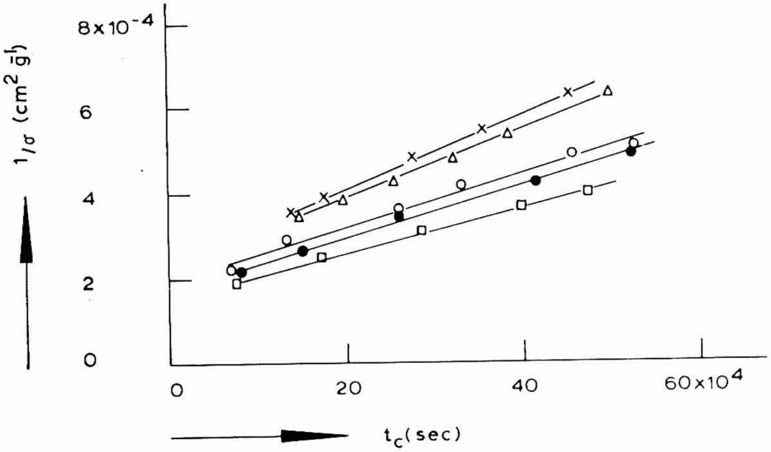

Fig. 2. The peeling-off curves for 50-day old alkyd resin/TiO_2 films; r.h. 70%
● $\phi_F = 0$; ○ $\phi_F = 0.08$; x $\phi_F = 0.16$; Δ $\phi_F = 0.24$ and □ $\phi_F = 0.32$.

If, at a fixed load σ, the peeling-off speed, v, is plotted as a function of φ_F, relations such as shown in Fig. 3 result.

It is remarkable that, although the stiffness of the films increases with φ_F, only the film with $\varphi_F = 0.32$ is more difficult to peel off than the unpigmented film.

Moreover, the peeling-off speed shows a maximum at $\varphi_F = 0.16$.

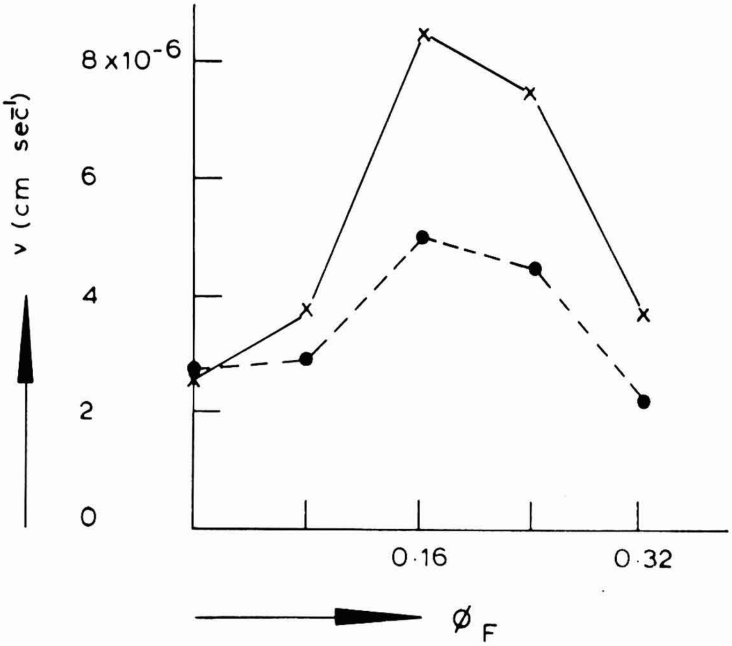

Fig. 3. The variation of the peeling-off speed with the pigment concentration in the film at a fixed value of $\sigma = 2.5 \times 10^3$ g cm^{-2}
(● 50-day old films, r.h. 70%; × film age 80 days, r.h. 74%)

Similar results are obtained with films pigmented with $BaSO_4$, but in this case the peeling-off speed shows a maximum at $\varphi_F = 0.08$. Again, only the film with $\varphi_F = 0.32$ peels off more slowly than the unpigmented film. From equations (2) and (3), the film and boundary layer properties can be calculated. The results obtained are given in Table 1.

Table 1
The calculated parameters for the creep and peeling-off of alkyd resin paint films containing TiO_2 or $BaSO_4$ as a pigment

Film	Alkyd resin—TiO_2				Alkyd resin—$BaSO_4$			
Film age	50 days				30 days			
r.h.	70%				73%			
ϕ_F	$\frac{E_1+E_2}{E_1E_2}$ (cm^2 g^{-1})	η_1 (g sec cm^{-3})	Δ	η_3 (g sec cm^{-2})	$\frac{E_1+E_2}{E_1E_2}$ (cm^2 g^{-1})	η_1 (g sec cm^{-3})	Δ	η_3 (g sec cm^{-2})
0	15.5×10^{-6}	4.3×10^9	9.1×10^{-2}	14.3×10^9	16.3×10^{-6}	2.2×10^9	1.9×10^{-2}	5.4×10^9
0.08	15.8	4.2	6.6	15.6	15.9	2.0	0.9	4.3
0.16	15.2	3.6	5.8	14.2	16.9	2.1	0.8	5.2
0.24	14.6	3.3	2.6	15.4	17.4	2.6	0.6	5.4
0.32	15.8	4.0	2.1	19.9	16.8	2.4	0.5	5.3

From these results it follows, as was assumed, that the values of $(E_1 + E_2)/E_1E_2$, η_1 and η_3 are independent of φ_F. On the other hand, Δ varies strongly with φ_F. All changes in boundary layer properties which are the result of pigmentation show themselves as variations of Δ. It has been shown earlier that such variations have a strong influence on the peeling-off speed[1, 3].

Having demonstrated the validity of the equations proposed, it seemed interesting to investigate the influence of the relative humidity on the peeling-off of paint films. A series of experiments has been carried out at different humidities and with varying values of φ_F. As an example, the creep and peeling-off curves obtained for $\varphi_F = 0.16$ are given in Figs. 4 and 5.

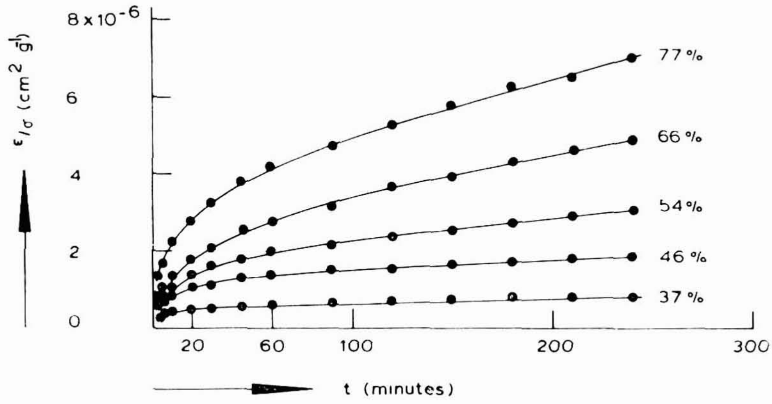

Fig. 4. The creep curves of alkyd resin films containing 16 vol. % TiO$_2$ as a function of the relative humidity

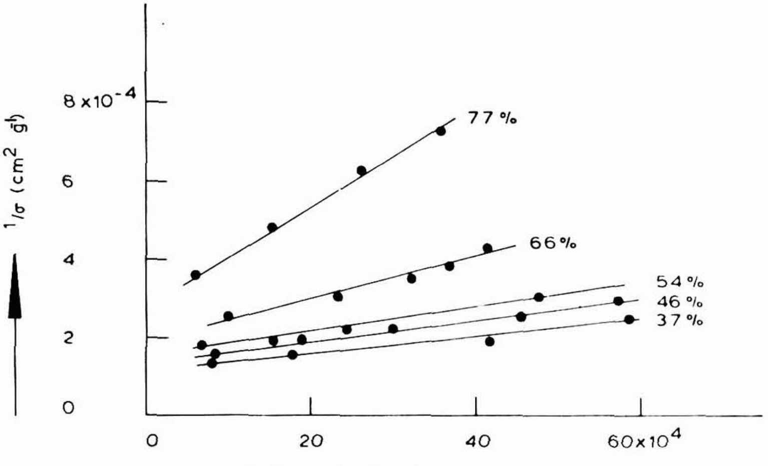

Fig. 5. The peeling-off curves of alkyd resin films containing 16 vol. % TiO$_2$ as a function of the relative humidity

From Figs. 4 and 5, it follows that the influence of the relative humidity on the creep and peeling-off of these paint films is analogous to that found for unpigmented films[1, 3]. Peeling-off is facilitated by an increasing relative humidity. The precise influence can be seen directly from Fig. 6, in which the peeling-off speed at a fixed load is plotted as a function of the relative humidity.

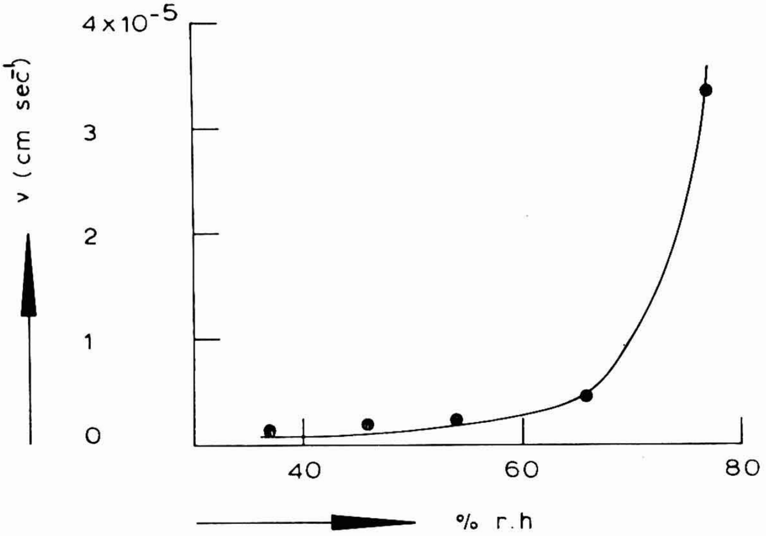

Fig. 6. The influence of the relative humidity on the peeling-off speed of alkyd resin films containing 16 vol. % TiO$_2$ ($\sigma = 3 \times 10^3$ g cm^{-2})

Up to about 60 per cent relative humidity, the influence of the humidity on the peeling-off speed is rather small, but above this value the peeling-off speed increases greatly.

The numerical results obtained from creep and peeling-off experiments at all the relative humidities and for all pigment concentrations studied are collected in Table 2. To exclude the influence of ageing as far as possible, reasonably old paint films were used.

From these results it can again be concluded that $(E_1 + E_2/E_1E_2$, η_1 and η_3 are independent of φ_F when the relative humidity and the film age are constant. Figs. 7, 8 and 9 illustrate this.

Also, Δ shows a remarkable decrease at constant relative humidity when expressed as a function of the amount of pigment present in the film.

Table 2

The values of the creep and peeling-off parameters as a function of the relative humidity for all pigment concentrations. Film age 130-155 *days*

ϕ_F	Relative humidity	$\frac{E_1 + E_2}{E_1 E_2}$ (cm^2 g^{-1})	η_1 (g sec cm^{-2})	Δ	η_3 (g sec cm^{-2})
0	35	0.94×10^{-6}	3.70×10^{9}	3.8×10^{-2}	5.2×10^{11}
0	47	2.04	1.23	4.0	2.2
0	58	3.34	0.71	4.4	1.2
0	66	3.78	0.32	4.1	0.8
0	74	5.76	0.24	4.0	0.3
0.08	37	1.00×10^{-6}	3.71×10^{9}	2.1×10^{-2}	5.4×10^{11}
0.08	45	2.03	1.24	2.2	2.1
0.08	55	3.18	0.75	2.5	1.4
0.08	64	3.74	0.32	2.3	0.6
0.08	75	5.69	0.26	2.3	0.3
0.16	37	0.97×10^{-6}	3.63×10^{9}	0.5×10^{-2}	5.2×10^{11}
0.16	46	2.09	1.21	0.9	2.6
0.16	54	3.28	0.73	1.3	1.4
0.16	66	3.86	0.31	1.2	0.8
0.16	77	5.81	0.23	1.2	0.4
0.24	58	3.38×10^{-6}	0.74×10^{-2}	1.1×10^{-2}	1.2×10^{11}
0.24	68	3.97	0.33	1.0	0.7
0.24	76	5.77	0.23	0.8	0.5
0.32	59	3.42×10^{-6}	0.69×10^{-2}	1.1×10^{-2}	1.4×10^{11}
0.32	64	3.75	0.33	0.9	0.6
0.32	77	5.83	0.24	0.8	0.3

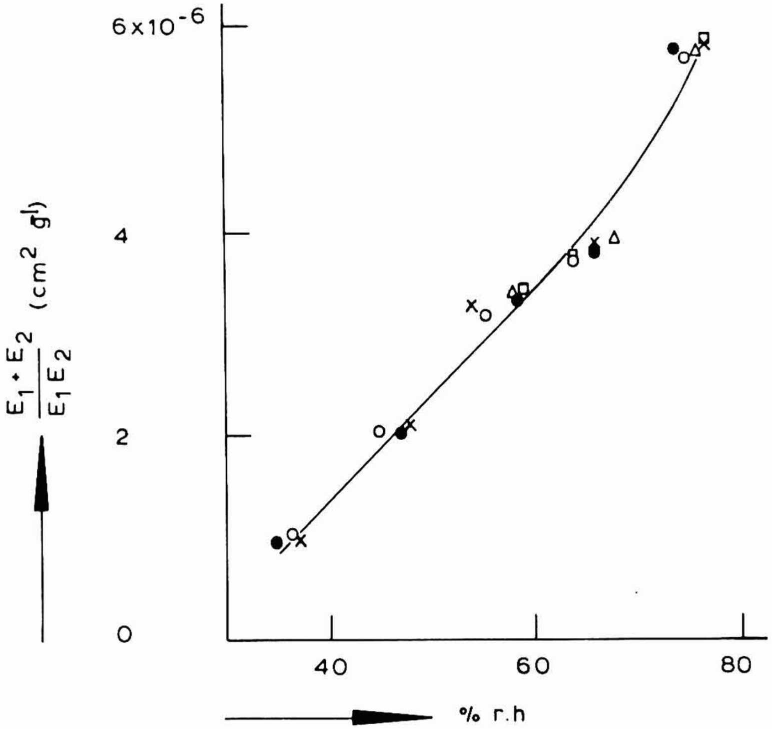

Fig. 7. The values of $(E_1 + E_2)/E_1E_2$ obtained for films with different pigment concentrations as a function of the relative humidity. (The symbols indicate the same pigment concentrations as in Fig. 2)

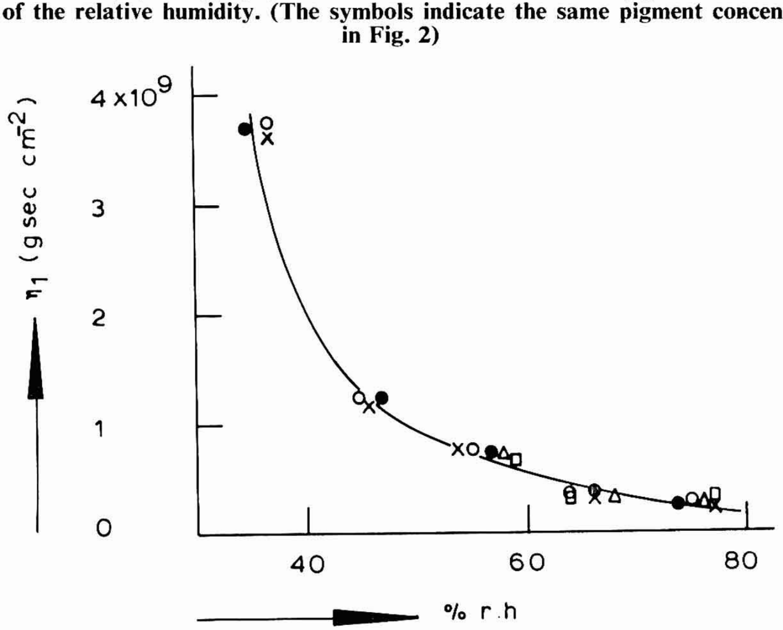

Fig. 8. The values of η_1 obtained for films with different pigment concentrations as a function of the relative humidity

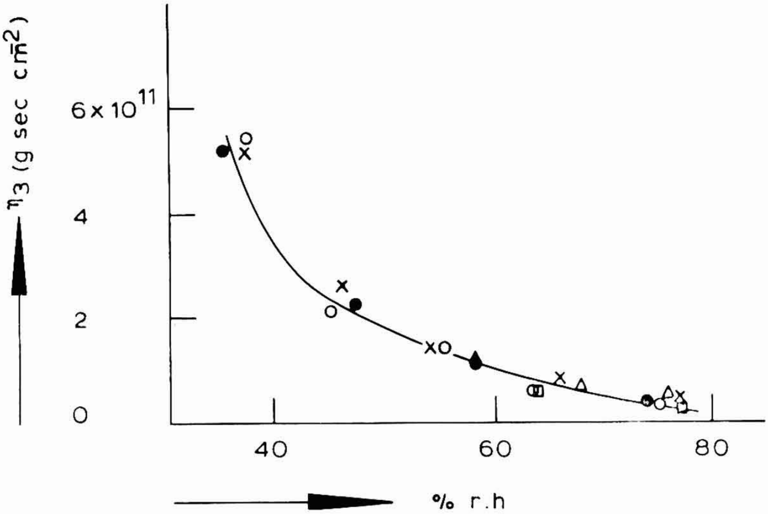

Fig. 9. The values of η_3 obtained for films with different pigment concentrations as a function of the relative humidity

Discussion

From the results described above, it can be concluded that the influence of the relative humidity on the creep and peeling-off of alkyd resin paint films containing the pigments investigated is analogous to that found with unpigmented films. The extensibility of all films increases when the relative humidity rises. The same phenomenon is found for the boundary layer of viscosity η_3 in peeling-off.

At constant relative humidity and film age, all parameters in the mechanical model for peeling off and creep are independent of φ_F. The pigments used have no measurable influence on the mechanical properties of the resin, nor on the boundary layer. This is somewhat surprising because it is known that a selective adsorption of polar resin fractions on to the pigment occurs during milling[4–10]. However, Perera and Heertjes[11] have found that incorporation of TiO_2 in an alkyd resin film did not change the properties of the resin with respect to water transport through the film. Apparently this adsorption has little influence on the mechanical properties of the film or the boundary layer. It will be clear that this adsorption influences the amount of polar resin molecules freely available in the paint for the formation of bonds with the substrate in the boundary layer. Incorporation of a pigment in the film will result in the formation of film/substrate boundary layers with less polar groups than are present in the unpigmented boundary layers, hence their mean distance l_0 will increase and Δ will decrease.

The under-surfaces of the paint films after peeling-off were examined by means of infra-red multiple internal reflection spectroscopy to determine the influence of pigments on the paint/substrate boundary composition. The film was pressed against the back of a reflection element of KRS-5, and two reflection angles ($\theta = 30°$ and $\theta = 60°$) were used. This corresponds to two different depths of penetration of the beam into the film (for $\theta = 60°$ the penetration depth at 4,000cm^{-1} is about 0.1μ and at 1,000cm about 0.25μ; for $\theta = 30°$ these values are about 0.2 and 0.6μ). As an indication of the polarity of the film region studied, the absorption ratio between the 1,710cm^{-1} band (carbonyl absorptions) and the 2,920cm^{-1} band (aliphatic hydrocarbons) was determined. For alkyd resin $BaSO_4$ paints the absorption ratio of the 610cm^{-1} band of the pigment to the 2,720cm^{-1} band gives information about the relative amount of pigment present in the region observed. Because of the lack of a sharp absorption band for TiO_2, this technique could not be used for films containing this pigment. The results are given in Table 3.

Table 3

The results of multiple internal infra-red spectroscopy on the undersurface of paint films based on alkyd resin

θ	60°	30°	60°		30°	
ϕ_F	$\frac{A\ 1710}{A\ 2920}$	$\frac{A\ 1710}{A\ 2920}$	$\frac{A\ 1710}{A\ 2920}$	$\frac{A\ 610}{A\ 2960}$	$\frac{A\ 1710}{A\ 2920}$	$\frac{A\ 610}{A\ 2920}$
0	3.7	2.7	3.5	—	2.6	—
0.08	3.7	2.8	2.7	2.2	2.6	2.6
0.16	3.5	3.1	2.6	3.8	2.9	2.7
0.24	2.2	3.6	2.3	6.2	3.6	11.9
0.32	2.2	3.7	2.3	10.0	3.7	15.7

These results are in agreement with the observations of Murley and Smith[12] and Cheever and Wojtkowiak[13] for film/air interfaces. These authors concluded that there exists a surface layer with a relatively small amount of pigment, followed by a layer which is much richer in pigment. From the results given in Table 3, it follows also that the film/substrate surface layer poor in pigment is relatively apolar (which is in agreement with the decrease of Δ found with increasing φ_F), whilst the region that is much richer in pigment contains a highly polar resin fraction

Conclusions

The creep and peeling-off of alkyd resin films pigmented with TiO_2 or $BaSO_4$ can be described with the derived equations, which are modified forms of the equations used to describe the behaviour of unpigmented resin films.

The presence of the pigments in the film has no detectable influence on the parameters in the mechanical models for the creep (E_1, E_2, η_1 and η_2) and for the peeling-off of the film (E_1, E_2, η_1, η_2 and η_3). This is in agreement with the theoretical predictions.

The influence of pigments in the film on the value of the boundary layer parameter Δ as a function of φ_F—the pigment concentration in the film—can be explained by the adsorption of polar resin fractions on the pigment during its dispersion in the resin solutions.

This adsorption results in the formation of boundary layers containing less film/substrate bonds. Multiple internal reflection infra-red spectroscopy confirms this explanation.

[*Received 1 March 1972*

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Next month's issue

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

"Fungus-resistant paints for breweries and the humid tropics," *by E. Hoffmann, R. K. Hill and A. Saracz.*

"Some aspects of drying oil technology," *by G. H. Hutchinson.*

"The micro-analysis of solvent mixtures by reaction gas chromatography," *by J. K. Haken.*

"Chromate and phosphate pigments in anti-corrosive paints," *by H. F. Clay and J. H. Cox.*

"The parameters affecting the performance of coal tar/epoxy coatings," *by N. S. Moss.*

Correspondence

SIR—Thank you for devoting so much space (*JOCCA* 1972, **55,** 836) to a review of my recent book "Applications of synthetic resin emulsions". May I make the following comments:

The Prologue to the book indicated that the original units would be used as far as possible to avoid confusion to readers looking up the original references. Some of the worst anomalies, e.g. volumes in mixed units, were corrected, and American gallons, where referred to, are clearly marked.

I was aware that quoting costs was risky with the passage of time. However, these are only intended to show the *order*, e.g. acrylic esters are two to three times the cost of vinyl acetate, and not the 0.01p per pound differences with which so many of my colleagues are obliged to waste their time reducing raw material costs. I am sorry for the few misprints—not really many in 5×10^5 words. I can only say "You should have seen those that did *not* get away".

Yours faithfully,

H. WARSON

284 Warwick Road,
Solihull,
Warwickshire.
26 September 1972.

FAT-FAX 8

FAT-FAX . . . in which Price's Chemicals Ltd — Britain's largest oleochemical manufacturer — talks a bit about its raw materials, its processes, its products and their applications. FAT-FAX 8 is the first in a series of FAT-FAXes devoted entirely to SURFACE-COATING applications. Price's might prove relatively immodest when it comes to a knowledge of oleochemicals; on second thought, read 'does' for 'might', and 'thoroughly' for 'relatively'. But when it comes to oleochemical *applications,* Price's modesty is real, and fully justified. You, gentle reader, are the expert here — and we'll not forget it. Yet we dare to hope that the information in this series will prove useful, thought-provoking, readable or (with luck) all three.

Four whys and a wherefore re fatty acids

As far as alkyds are concerned (and that's pretty far, in fact), the important chemical characteristics of fatty acids are four in number. *First,* their reactive acid carboxyl groups: these make possible reactions with alcohols to produce the big molecules. *Second,* their long straight carbon chains: these provide solubility in hydrocarbons, plus general flexibility. *Third,* their methylene groups activated by double bases: these permit the autoxidation that produces the necessary drying. *Fourth,* their unsaturation, making double bonds available for polymerisation and forming adducts via Diels-Alder reactions. When it comes to *Fatty Acids v. Whole Oils,* the wherefore that overcomes the slight price disadvantage of fatty acids is their whole spectrum of significant advantages. Some useful parts of the spectrum: more alkyd resin throughput from a given plant, easier process control, better quality control, superior resin properties, a more uniform molecular-weight distribution, freedom from contaminants, harder paints, glossier enamels, better exterior durability. But perhaps most important of all — with a fatty acid, you get exactly what you want every time, and your choice of polyol is unrestricted too.

Not every good backbone's an alkyd

Alkyds have been around a couple of decades longer than epoxides, which were first prepared in Switzerland just before the last war. Since the war, epoxide resins esterified with fatty acids have provided an increasingly popular backbone for surface coatings. This backbone, formed by ether and carbon-carbon links, isn't as easily saponified as its alkyd counterpart (which has ester links). So it exhibits excellent resistance to water and other chemicals. Both the fatty acid chosen and the degree of esterification affect the specific properties of the final coating. For example, a well-known ester suitable for air-drying brushing enamels is based on Prifac 007 White Distilled Soya Oil Fatty Acids, 80% esterified. In practice the theoretical quantity of fatty acid is not used and the degree of esterification or 'oil length' is selected according to the intended use of the ester: anything over 70% esterification is considered a long oil length. A typical short length (40%) esterification ester, based on Prifac 066 (12-hydroxystearic acid), makes a useful stoving finish with melamine/formaldehyde resin.

But to get below the surface, read the good book

The particular good book we have in mind is our Technical Publication No. 103, which we might — unforgiveably — call *The Price's Write,* because we wrote it and it's free. Instead, we call it *Price's Products and the Surface Coating Industry,* in the hope that you'll find its pages so chock full of valuable formulations, comments, graphs, references et al, that you'll wonder how you used to face yourself in the shaving mirror. May we send you one? We're Price's Chemicals Ltd, Bebington, Wirral, Cheshire L62 4UF Telephone 051-645 2020. Telex 62408.

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Student Review

Paint Technology Manuals. Part Seven: Works Practice

Chapter VII. Factory hazards and safety precautions

The primary objective of the Factories Act and perhaps most of the other legislation described in Chapter VI of these reviews is to safeguard the health, safety and welfare of workers involved in the activities covered by these regulations. Therefore, it is evident that strict compliance with the regulations will greatly reduce the risk of accidents in a factory.

However stringent legislation may be, and however carefully it may be observed, the factor which cannot be eliminated is the one that is probably the greatest cause of accidents—the human element. Operators may sometimes be unaware of a particular hazard involved in their job but, even when this is not so, they often become careless or indifferent to whatever precautions have been laid down.

It is the duty of management to foresee the possibility of accidents, to safeguard against them as far as possible, to educate all personnel in the risks involved and to keep them constantly alert about the whole subject of safety.

The prime causes of injury in the paint (and allied) industry may be summarised as:

outbreak of fire and explosion,
moving parts on machinery,
materials handling,
small tools handling (drums and case openers etc.),
accidents arising from ancillary operations, such as falls from ladders etc.

The measures which should be taken to reduce the risk of accident are more easily discussed if broken down into separate categories.

Buildings

(1) All gangways and passageways must be kept clear of any obstruction at all times and the floors kept in good condition.

(2) Fire exits must never be blocked, either inside or outside, and the release catches on doors must be checked regularly to ensure easy and rapid operation.

(3) Adequate lighting must be provided everywhere necessary, it must be fully maintained and any failures must be rectified immediately.

(4) If the factory has internal roads also used by pedestrians, no mechanically propelled vehicle should be allowed to use them when large numbers of walkers are using them, i.e. at starting and finishing times.

(5) When a factory or a department is closed, all doors should be closed (and locked if no security staff is present), all gases and fires extinguished, no lights left on (except for pilot or guide lights) and the mains power cut off.

If any likelihood of freezing arises, all water and steam pipes should be drained as far as possible and the water turned off at the main.

Plant

(6) Vent pipes from tanks and all exhaust outlets from every source must be kept free of accumulated dirt and from obstructions (e.g. moss can grow readily at the upper end of a vent pipe). Explosion caps on resin and similar plant must be checked regularly for ejectability.

(7) The outside of all "varnish kettles," resin plant and blending tanks must be kept clean and safety covers kept clearly painted and marked in positions allowing access for use. A regular check should be made on the bottoms of all apparatus heated by direct heat to ensure that no weak or thin spots are developing.

(8) All burners and heating devices requiring air for their operation must be kept free from spillages, build-up of carbon or other obstructions. All air supply ducts and fume exhaust ducting should be cleaned regularly. The actual setting of burners, their safety cut-out devices and their pilot lights should be examined regularly by a competent person.

(9) All striking gear, safety cut-out devices, starters, electric motors and lineshafts etc. should be operating efficiently and maintenance should include oiling, checking tightness of all holding bolts, checking wear on bearings etc. Safety rails and guards should always be employed and maintained in effective condition; this is a requirement of the Factories Act and no excuse can be allowed for their removal or inefficiency.

(10) Thermostatic controls, thermometers and thermographs should be checked regularly to ensure accuracy. This is very important in operations such as stand oil manufacture etc., where the use of an excessively high temperature can lead to an uncontrollable reaction and possibly fire.

(11) All moving machinery should be earthed against a risk of build-up of static electrical charges.

(12) Any mixers likely to generate internal pressure during operation should be fitted with an adequate blow-off device (e.g. ball mills should be fitted with a small tap which is opened to release any pressure before attempting the removal of the main manhole cover); such devices should be kept clear of blockage and checked daily for ease of operation.

(13) All trucks, whether power driven or otherwise, should have regular servicing to check wheels, platform etc. If fitted with sparkproof tyres, these should be kept in good condition.

(14) All driving belts, driving pulleys, loose pulleys, driving chains, belt fastenings and clutches should be inspected regularly for any malfunctioning which might cause a rise in temperature and consequent danger.

(15) If mobile tanks are used for the transport of liquids, for tinting etc., they should be absolutely firm when stationary and stable on their wheels when being moved, and should be provided with suitable covers.

(16) Compressed air or gas apparatus, steam and electrical equipment should be operated only by qualified persons who understand the risks involved in their handling.

(17) Suitable precautions must be taken when it is necessary for any person to enter any plant such as tanks etc., for purposes of cleaning, inspection or repair (e.g. breathing apparatus and safety harness).

(18) Any safety apparatus provided, such as fire extinguishers, safety harness and so on, should be clearly marked, adequate for any probable emergency and regularly inspected by a competent person.

Processes

(19) In departments handling materials with a flash point below 90°F (32°C in the forthcoming Highly Flammable Liquids Act) or cellulose solutions, the following should be enforced: no naked lights allowed, no smoking, no matches or automatic lighters may be taken into the department, no ferrous tools or other articles likely to give rise to sparks may be used, all electrical apparatus must be of flameproof type—including any mobile trucks likely to be taken in to the department. Viscous solutions left running in high speed mixers should be checked for overheating. A careful watch should be kept for any unauthorised persons entering the department, who might be unaware of the restrictions in operation and the dangers involved.

(20) In all departments using solvents, some vapour will escape: adequate ventilation is therefore essential and should be supplemented by exhaust fans if necessary.

(21) In all departments, spillage or drippings should be cleaned up immediately. All cleaning materials should be stored in metal bins with secure lids after use and removed from the factory to a safe place after every shift (oil-soaked rags are liable to spontaneous ignition). Skins removed from paint at any part of the manufacturing process should be dealt with similarly. All storage containers should be equipped with well-fitting lids, which are kept in position when the container is not in use.

(22) Employee's overalls should be kept in metal cabinets located in a room separate from manufacturing departments. The doors of the cabinets should be kept closed when overalls are within.

(23) No unauthorised persons should be allowed to enter departments where hot materials are handled.

(24) If the process carried out in a department is subject to some legal control, both the management and the employees should be well aware of the legislation, and both parties must ensure that the requirements are fulfilled.

(25) Where a process involves water washing or other wet operations, a slip-free flooring should be provided and drainage should be adequate.

(26) Any goods stacked upwards, which could topple if improperly stacked, should be handled only by trained, responsible persons. No exception to this rule may be allowed.

(27) The risk involved in opening drums likely to be under internal pressure should be indicated, as should that involved in the handling of small tools used for opening crates, drums etc. The provision of the correct tool for each operation is essential.

Personal protection

The education of personnel in safety measures is the responsibility of management and there can be no doubt that any time spent on this subject is well worth while. In spite of this, owing to genuine accident or negligence, injury to workpeople can still arise and some thought should be given to what may be referred to as personal body protection. In order to simplify discussion the body can be classified into seven parts: (a) head, (b) body, (c) arms and wrists, (d) hands, (e) legs, (f) feet and (g) internal, which includes rupture, strain, poisoning, dermatitis etc.; the following types of protection are suggested for parts (a) to (f) respectively:

(a) helmet or hat, goggles.
(b) apron, jerkin, protective garments.
(c) elasticated slip-on wrist bands or oversleeves, gauntlets.
(d) gloves, mitts, gauntlets, protective cream.
(e) gaiters, thigh boots, knee boots.
(f) clogs, boots with steel toe caps, thigh or knee boots.

Each of these devices acts simply as a barrier between the source of risk and the body, but are no substitute for the safeguards mentioned in the last section. The commoner materials for these barriers are: (1) asbestos, (2) plastic or nitrile rubber, (3) metal, (4) leather, (5) canvas or flame-proof canvas and (6) hard plastic. These are chosen according to the type and severity of the risk.

The special risks which may be encountered in the paint and its allied industries are:

R (1) splashing with hot materials,
R (2) splashing with hot liquids,
R (3) burning with acids, alkalis or other chemicals,
R (4) damage from falling objects (drums etc),
R (5) cuts and abrasions and
R (6) dermatitis.

Table 18 indicates a suitable protective material against these risks on a given part of the body:

Table 18

Materials for protective clothing

Part of body	Risks					
	R (1)	R (2)	R (3)	R (4)	R (5)	R (6)
	Material of construction					
(a)	1	2	2	3 and 6	2	2
(b)	1 and 4	4 and 2	2		4	2
(c)	1, 2 and 5	1 and 2	2		1	2
(d)	1 and 4	2 and 4	2		4	2
(e)	1, 4 and 5	2 and 4	2	3	3 and 4	2
(f)	4	4	2	4	4 with metal toecaps	2

Internal injuries, such as rupture etc. should be countered by supervisory checking that heavy or awkward loads are not manhandled, where mechanical devices should be provided and used, and/or the loads themselves are reduced in weight and size or made into a less inconvenient shape. In certain cases, regular medical examination of the worker is essential to ensure that the preventive measures are effective, e.g. the lead regulations demand periodic medical examination (see Chapter VI). Protection against dangerous fumes and gases will be dealt with by the provision of effective ventilation and by masks for the particular risk encountered.

Head protection will embrace the correct type of goggles for the eyes, whenever these are necessary; careful thought must be given to the material of the lenses, for example, ordinary glass might be dangerous if there is any risk of shattering during the process being operated. Splashing with solvent is a fairly common occurence in the paint industry; whilst this is not necessarily very dangerous, it can be extremely irritating at the time and the natural reaction is to rub the eyes with the hand, which may be dirty and thus increase the irritation. Operators should be instructed to go to the nearest supply of cold water and run plenty of this through the eye to wash out the solvent. Subsequent attention by a qualified first aid man, nurse or doctor may be necessary, but the initial washing is the quickest way to get immediate relief and minimise the danger.

Dermatitis in its various forms, badly cracked skin, and hard dry skin are the commonest hand, wrist and arm troubles encountered, and are largely attributable to the constant handling of solvents, which readily dissolve the natural oils and fats present in the skin. Mention has been made above of the protective devices suitable for these troubles, but generally it is found that either the workers will not bother with gloves, or else they find that they cannot work easily in them; in any case, until fairly recently gloves would not generally resist constant contact with many of the solvents handled over a very long period, they simply swelled or disintegrated. This has been overcome by the introduction of gloves made from nitrile rubber, but the physical difficulty of working in gloves still remains. Barrier creams (different types for solvent-based and water-based materials) provide an excellent alternative safeguard, but they must be used properly and in conjunction with adequate washing facilities: hot and cold water and a good supply of alkali free soap. The cream should be of the correct type for the particular product concerned; readily available to all operators at all times; always applied before commencing work and during work after every occasion when the hands have been washed and dried; and preferably supplied in such a manner as to eliminate any risk of contamination, for instance dispensers which do not allow the hands to reach inside, or small personal containers for each operator.

The caution regarding soap is given because a "harsh" material may undo most, if not all, the good done by a barrier cream. Dermatitis can result in a sensitivity to the product or type of product that originally caused it, so that the person becomes allergic to it and the slightest subsequent contact causes the immediate recurrence of the trouble. In such cases, it is always important to obtain medical advice and the person concerned should always be given other work which does not allow any contact with the substance involved.

Under the heading of small tools (which have been shown to cause about 8 per cent of the personal accidents reported) are the various devices used for opening drums, cases and so on. These can cause minor injuries such as cuts, abrasions or sprains. Whilst this might be regarded as the normal sort of risk met in every factory, there is a duty as far as management is concerned to ensure that the correct type of tool is available for every job, that the operators concerned understand how to use it correctly and that tools are kept in an efficient state. A worn tool may slip and, if considerable force is being exerted, may lead to serious accident.

The use of the correct tool should be continually stressed to workers, and as an ancillary to this the right tool must always be available. Often when the correct tool is provided the workers tend to mislay it, and then have to improvise by using something else. To avoid this, the work room must be kept tidy and each tool allocated a place, to which it is returned after use. One useful method is to have a board fixed to a convenient wall, from which tools are suspended, the place for each tool having its outline painted on the board to facilitate return to the correct position and making checking that no items are missing much easier. Such a system facilitates the examination of tools for wear and saves time by avoiding the necessity for workers having to search around the room for a tool. Obviously, where necessary, several such boards can be provided.

Many of the materials used in the paint industry are poisonous or irritant in an open wound, so that immediate cleaning and dressing of any cut or abrasion is essential to both the injured person and to the management. Operators should be trained to have all minor cuts and abrasions dressed immediately and a competent person with adequate facilities and equipment should be available at all times to deal with accidents (in most factories this is a legal requirement under the Factories Act.).

In cases of serious accidents an ambulance should be called immediately, and it should be remembered that where there is internal injury or a broken limb any attempt to move the injured person may aggravate the injury. Thus no such attempt should be made except of course when there is a risk of further injury.

Burns should not arise if the necessary protective devices are used properly, but hot resin etc. could be accidentally splashed on to unprotected parts of the operator. An important point to remember when dealing with a burn is its nature and cause, for instance, a set film of resin could be lying on top of the wound and the person responsible for dressing it must be aware of the best method to remove it. A knowledge of the product which caused the injury is necessary, so that the best and least painful action can be taken immediately. Should hospital treatment be required, information likely to assist the staff there should be telephoned immediately or sent with the patient.

Fire and explosion

Many of the operations carried out in factories making or using paint have a high potential fire risk. Legislation, described in Chapter VI, exists to minimise or eliminate risk of fire and/or explosion. Insurance premiums on buildings and plant subject to these risks are much higher than on those subject to normal risks; the insurance companies usually insist on the provision of adequate preventative devices before they will undertake insurance. Careful planning of a sound fire prevention system well repays the time and money expended on it. The subject may be considered under two headings (a) prevention, and (b) efficient handling of a fire should it arise.

Prevention

Fire in a paint factory can arise from two main causes, spontaneous combustion and direct ignition.

Spontaneous combustion: If materials containing drying oils, cellulose derivatives and many other organic substances (particularly if they contain oxidation catalysts, such as driers) are exposed to the atmosphere in such a manner that their surface area is large compared to their volume, rapid oxidation takes place. This generates heat and, if the heat cannot be dissipated, the rate of temperature rise increases rapidly until the ignition temperature is reached and the whole mass becomes ignited. An oil-soaked rag is a good example of this kind of condition: the surface of oil exposed to the air is large but its bulk small and the heat generated by oxidation is not readily conducted away, so that the rise in temperature is rapid once it has commenced. The initial rate of oxidation depends on the temperature of the surroundings, so that the risk of spontaneous combustion is higher in summer, in warm climates and where, owing to the process being carried out, the temperature is high. Conditions of large surface area and heat insulation exist with rags used for cleaning machinery and other equipment, collections of partially dried paint and varnish skins, rags soaked with paint, oil etc., which are left in overall pockets and residues in exhaust ducts of spray booths.

Direct ignition: All materials which are covered by the Petroleum Acts and Cellulose Regulations can be ignited, and any vapour which is allowed to escape is also capable of explosion and ignition. Materials with a flash point exceeding 90°F (32°C) are considered relatively safe, but this can be a dangerous assumption. In many cases paint materials are handled at temperatures exceeding the flash points of their solvents. Media and resin solutions immediately after thinning, and materials coming from paint mills, are obvious examples of products which may be handled at temperatures above their flash points and many more could be found. The precautions to be taken should embrace all materials which contain volatile solvents. These precautions consist of: (a) protecting the material from sources of possible ignition, and (b) preventing sources of ignition coming near to the materials.

Method (a) is achieved by keeping all material in closed containers, as far as possible; where large volumes are stored in tanks, either an inert atmosphere should be maintained above the material, or carbon dioxide or similar gas should be available and connected to the tanks in case of fire. The use of an inert atmosphere in closed storage tanks for media, varnish or pigmented products has other advantages, such as the reduction of skinning and solvent loss, thus such a method has much to recommend it when large amounts of material are handled. The precautions mentioned under 7, 8, 12, and 27 are important. Method (b) is achieved by ensuring that the precautions detailed under 19 above are rigidly enforced.

The measures listed above may be regarded as the major fire precautions to be taken. Some of them are covered by legislation which enforces their adoption. The Petroleum (Consolidation) Act 1928 (with subsequent orders in council) together with the Factories Act 1961 (which embraces the Cellulose Solutions Regulations) are the most important means of achieving the objective (see Chapter 6). However, the appropriate legislation should be fully investigated because local authorities often impose bye-laws for specific areas. Generally, legislation aims at making as safe as possible the storage, handling and transportation of inflammable or dangerous substances and it must be accepted that, on the whole, the various requirements are sensible and practical, and go a long way towards achieving their intention. Table 19 summarises the legal requirements.

Table 19

Summary of fire fighting requirements

Certificate of means of escape Sect. 40 1961 Act	Every factory employing more than 20 people or those employing less but handling highly inflammable materials must hold such a certificate from the Local Authority. Similarly in a multistorey factory built after 1937.
Fire exits	Special conditions may be laid down on the certificate. All doors and windows etc. used as fire escapes must be clearly marked, maintained and kept clear. No such doors may be locked whilst anyone is in factory. If flammable materials are used, at least two or more exits to each workroom must be provided and these must open outwards.
Fire alarms	All factories covered by the above regulations must have fire alarms capable of being heard throughout the premises. They must be maintained and tested monthly, and records of tests kept. They must be usable without risk to the user.
Fire drill	All persons employed in factories covered by the above regulations must receive regular and adequate instruction on the routine to be followed in the event of fire. A record of such instruction must be kept.
Fire-fighting equipment ..	All factories are required to provide and maintain appropriate equipment, so placed as to be readily available for use. The Petroleum Act requires special provision, otherwise the occupier must provide what he considers appropriate and justify this if requested. Convenient fire hydrants must be provided under the 1945 Water Act by the water undertaking, if factory occupier so requests, but he must defray costs.

Handling incidents of fire

If an outbreak of fire occurs during working hours, action to stem its spread must be prompt and efficient. This will be possible only if adequate, correct fire-fighting equipment is available, if it is maintained in good working order, if the personnel know where it is situated and how to use it properly, and if they are trained to react quickly and sensibly in an emergency. All of these necessities are most easily achieved by regular fire drill, but the form this takes will vary from factory to factory. Large establishments invariably maintain a full-time fire fighting staff, whose job it is to attend to the points mentioned above. In the event of an outbreak, this staff can go into action immediately and either deal with the incident entirely or contain it until outside help arrives. Smaller units, however, invariably rely on normal production personnel acting as firemen when the need arises and their instruction and training is essential if they are to fulfil their secondary role efficiently; proper use of the equipment provided necessitates a clear understanding of the particular incident. There are three types of fire risk which are generally accepted:

Class A	Carbonaceous materials, such as paper, wood, textiles and articles made from them.
Class B	Inflammable liquids, such as oils, solvents, media and resins, and paint. (Alcohols and water miscible liquids may need special consideration).
Class C	Electrical wiring and equipment.

Fires caused by each of these three sources of risk can be encountered in paint and similar factories and the most important point is to teach fire fighting personnel to recognise quickly which class of fire has to be controlled, and the right method of combatting it. Suitable fire extinguishing agents are listed in Table 20.

Table 20 should make it clear that an essential part of fire drill must be the education of all personnel on the correct method of extinguishing any particular fire. The type of extinguishers should be easily identifiable and readily accessible at all times; every operator in the factory must be conversant with the location of equipment in his immediate vicinity and with its method of working, so that some attempt to contain it may be made until the arrival of the fire fighting staff. A plan of the whole factory layout showing the exact location of all fire fighting apparatus is very helpful, since it simplifies checking of equipment and, if alterations or extensions are carried out, proper consideration may be given to whether new equipment should be obtained or whether existing fire fighting appliances should be resited. It has been mentioned that the occupier's fire insurance company may require the provision of adequate fire fighting equipment. Advice on the siting and quantity of extinguishers etc. can be obtained from them, as well as from the suppliers of the apparatus and the local fire authority.

Fire extinguishers should be checked regularly, especially those types which operate by gas pressure, and in the event of a fire all extinguishers used in fighting it must be recharged immediately and returned to their normal position. Mention has been made of either sprinkler or installed CO_2 apparatus (Table 20); the main cut-off valves of these should be clearly marked. If it has been necessary to use this apparatus, some responsible person must be given the job of ensuring the main valves are turned off as soon as the incident is over. The fusible plugs are normally replaced by the engineers of the company who installed the automatic apparatus. It is essential that this and all other apparatus used should be put back into working order as soon as possible and returned to its normal position, preferably before the resumption of production.

Table 20
Fire fighting methods

Class A Risks	Class B Risks	Class C Risks
Usually extinguished by cooling the burning material. This is most easily effected by water which is applied either as a mist or spray or in the form of a jet. Greatly increased efficiency may be achieved by the incorporation of a wetting agent in the water. This reduces interfacial tension and greatly assists in the rapid wetting of the burning material. *Methods of operation:* Sprinkler system which operates automatically when a fusible plug melts under heat. Hose attached to water supply through a tap or through a high pressure pump. Portable extinguisher containing water under CO_2 pressure which may give either spray or jet.	Usually extinguished by blanketing. Methods of operation. Dry powder under pressure which produces a non-damaging cloud; (this method allows the fire-fighter to approach very near to the incident). By CO_2, either as an automatically operated system (fusible plug) permanently installed on plant, or as portable hand operated apparatus which allows fighter to direct a large volume of gas quickly and accurately at danger spot. By air foam i.e. water containing CO_2 as propellant together with smothering agent and wetting agent. The bubbles should be "dropped" onto the flames, when they blanket them very quickly; the foam is very voluminous and a 2 gal. extinguisher yields 16 gal. of foam. Similar results can be obtained by connecting a special unit to an ordinary water supply; this introduces foam at the nozzle of the hose. Bromochlorodifluromethane in portable extinguishers can also be used.	Usually extinguished by dry powder for smothering, but the powder must be non-conductive of electricity; also by CO_2, as under "B" risks. For small items of electrical equipment chlorolbromomethane or carbon tetrachloride may be used from portable extinguishers, either hand pump operated or pressure charged, which gives much more rapid operation. These latter can be dangerous in a confined space, owing to toxic gases evolved.

Explosion

An explosion is in itself unmanageable and the major precautions must be aimed at its elimination. If, however, an incident does occur, it is the aftermath which will need attention. This is usually: damage to buildings, plant or stock; injury to personnel; and incidental fire. The latter two kinds of accident have already been considered. The most important points to check with respect to material damage are: ensure that gas, water, steam, air, solvents, chemicals or media supply lines are completely cut off and that no leaks are occurring anywhere in the vicinity or along their circuits; check that roofing, (especially glass), partitions, windows or any suspended fittings or apparatus (lights, hoisting tackle etc.) are unlikely to fall on people clearing up underneath; ensure that electricity is completely cut off and, that before any attempt is made to switch it on again, a thorough test of all wiring, switches etc. is carried out by a qualified electrician. The actual plant involved must, of course, be the subject of a separate investigation to determine the cause of the incident, and to check its suitability for re-use.

Stock, especially sacks or carton packed items, may be contaminated either by dirt, chemicals or shattered glass splinters. Great care must be taken in checking stock and, if it is regarded as usable, it may be necessary to remove it to another building pending repair of the damaged premises; this entails ensuring that everything moved is properly labelled and catalogued since, once a number of strange packages appear in an unusual place, their identification at a later date may prove difficult. (Similar remarks are applicable to any stock surviving a fire.)

Fire, resulting either from an explosion or otherwise, will also leave an aftermath of clearing up to be done, and the comments made above are equally applicable to them. In the event of either incident, any legal obligations regarding notification of the incident to the appropriate authority must be made and, apart from immediate emergency measures to eliminate further incident or waste of stock, it is usually advisable to leave everything until the insurance assessor has had an opportunity to carry out a full inspection.

Fire practice

The subject of fire drill is one which, as already stated, receives varied attention in different factories, some carrying out regular exercises and others not bothering at all. Reflection on their underlying intentions should make it apparent that their adoption can be very valuable. They need not take a very long time, they need not disrupt production and they are certainly valuable for the information they yield, if properly conducted. The following points should illustrate this. In those cases where female labour is employed, repetitive practices minimise the risk of panic should a real incident occur; the operators know exactly which route to take from their work places, which doors are their proper fire exits and, after one or two practices, will proceed quickly and quietly to the safety zone. This also enables new personnel unfamiliar with the lay-out to follow their workmates, thus eliminating any risk of going the wrong way, getting lost or causing obstruction to those working on the incident. Observers should be appointed at these practices, whose job it is to watch and see what mistakes are made and possibly suggest improvements in the system.

The actual fire-fighting crew will learn how to reach their respective posts quickly, and how to get the correct apparatus ready and working quickly, as well as what sort of obstacles or snags may be encountered in putting this into practice. (For instance, it might be necessary to take a mobile pump to the scene of the fire, but then found that the customary route was blocked by a large tanker delivering raw material; a practice run would show the necessity for an alternative approach). Each member of the team should be trained to do a specific job, so that the whole crew works as a team; changes in personnel must be kept in mind and any new member given a prior chance to learn his duties; equally absentees must be replaced, and one scheme is to form a duplicate crew who go into action with the main crew on every occasion.

An element of surprise is useful in fire practice and it is an advantage that the "incident" should be located at a different site at each practice. A practice incident precludes any real fire fighting, so that an occasional practice with a real fire on waste ground is valuable, since it gives the crew a chance to find out the capabilities of their various types of equipment, such as the maximum throw of jets, maximum area covered, at what distance to approach with foam apparatus and so on. The audibility of the alarm system throughout the works should be checked regularly by these regular practices, because the installation of new plant may render it inaudible in some places. Periodic tests of fire alarms should be made, separately from fire practices; notification of such tests should be made, so that the test does not trigger off a full scale practice.

Electrical hazards

The following comments relate to electrical hazards which are not peculiar to the paint industry, but which are of sufficient importance to warrant consideration.

The hazards considered here are:

injury due to direct contact with mains electricity,

injury or damage caused by explosion or fire attributable to vapour ignition by arcing of mains current,

injury caused by contact with static electricity.

Any operator may come into direct contact with a source of electrical potential by touching improperly insulated wires or cables (particularly when used on mobile equipment), from touching such objects as faulty electric lamp holders, faulty switches, faulty motor starter boxes, faulty plug sockets etc.; all electrical equipment must be maintained in perfect order. Management can often make a useful check by operating switches, starters etc. themselves from time to time and observing how they function; another useful check is a regular examination of fuse boxes, since loose contacts or overloading in a circuit will often cause a fuse to warm up, and this is quite easy to detect. General factory wiring should be checked professionally every three or four years by a qualified electrician who has the necessary equipment. (Insurance companies often insist on such a check before they will accept the risk of insuring the factory).

Electrical maintenance should be undertaken only by a qualified electrician, but occasions may arise when an ordinary worker may wish to effect some minor repair, such as the replacement of a bulb which he would normally do himself at home. Factory lighting, however, is subjected to much more rigorous operating conditions than is household lighting (accumulation of dust, fume, damp etc.) which may cause a bulb to become quite firmly fixed in the holder; if a worker attempts to change such a bulb and breaks the glass, having forgotten to switch off the current, a serious accident might result. Similar accidents can arise when changing fuses. A sensible approach to these matters is to make sure that any operator effecting minor repairs has been fully instructed how to do so, but it is always wise to employ a qualified electrician even for minor replacements.

Sparking and arcing (and consequent fire risks) can arise from simple causes such as:

(1) the fact that the design of normal electric motors, switches, starters, lights etc. is not such as to make them flameproof,

(2) connections and contacts becoming worn and faulty—vibration causes an "on-off" movement, which in turn gives rise to arcing,

(3) foreign matter on the commutator of an electric motor causing an almost continuous bluish spark when in operation,

(4) the use of an incorrect type of starter device for high speed machines, or the incorrect use of equipment; this may cause sparking at the starter box or occasionally at the motor,

(5) worn brushes on motors.

None of these faults are difficult to correct with the exception of (1), which is the reason why workshops coming within the Petroleum Act and the Cellulose Regulations have to be supplied with flameproof equipment. Care in use and good maintenance provide the key to safety.

Static electricity is commonly encountered in two places: machines which run continuously and where some sort of friction is involved; pumps or other devices used for the bulk movement of liquids.

The electricity generated by molecular friction charges the inside of a pipe or mixer causing it to act as a large capacitor. Close approach to the edge of such a capacitor (within an inch or so) by an earthed object (e.g. paint can, spatula or even the hand) can cause a vivid blue spark to jump across the gap, providing an obvious fire risk in an atmosphere which is explosive or inflammable. Efficient earthing of all moving machinery and pipe discharge orifices is a simple method of eliminating this hazard; machines are connected to a strip of copper which passes round the department and finally goes to earth via a suitable spike, while pipes have a flexible earthing chain attached to the discharge end. Occasionally, it has been found that even these safeguards are not completely effective and, should this be suspected, it is well worth while investigating the possibility of other methods (different material of construction or cladding, addition of anti-static compounds, alteration to the speed of movement). It should be remembered that there may be a legal requirement to take any of these precautions.

ADDENDUM

The following letter has been received from Mr K. McLaren regarding the discussion of the reason why a green paint appears to be that colour when viewed in normal daylight.

SIR,—On page 839, *ptm 119* an explanation is given of the well known fact that a mixture of yellow and blue paint appears green: the eye integrates the yellow light reflected by the yellow paint and the blue light reflected by the blue paint and interprets this as green. This explanation seems to be widely held, probably because of its simplicity and apparent logic, but it is entirely fallacious.

The laws governing the appearance of mixtures of coloured lights—additive colour mixing—state that almost every colour can be obtained by mixing together three coloured lights, red, green and blue, the additive primaries. A mixture of all three in the correct proportion appears white, and if the blue light is switched off, the residual red and green mixture appears yellow. A mixture of yellow and blue light therefore appears white, not green and if a white card were covered with spots of yellow and blue paint which did not overlap, as in a *pointilliste* painting, the colour one would expect to see when it was viewed at a distance great enough to prevent the individual spots being resolved, would be grey; it would not appear white as the total amount of light reflected from the paint spots would be less than from the white card.

The reflectance curve of such a mixture is given in Fig. 35 on page 72 of Part Six of the Paint Technology Manuals and it is incorrect for it to be labelled "theoretical additive green"; a theoretical additive yellow/blue mixture it could be, but it would not appear green.

But a mixture of yellow and blue paint never behaves like this: multiple overlapping of the particles will occur and the characteristic which is additive is absorption, not reflectance: blue paint absorbs the red, orange and yellow spectral bands mainly; yellow paint absorbs the blue and violet bands; a mixture of both therefore absorbs red, orange, yellow, blue and violet bands and thus in daylight appears green, the colour of the spectral band which is absorbed least of all. A paint made from a single, homogeneous green pigment would have the same general absorption characteristics.

The well known laws which govern the appearance of mixtures of coloured pigments also postulate the existence of three primaries, the subtractive primaries—red, yellow and blue or more correctly magenta, yellow and cyan and these laws can be deduced from the fundamental laws of colour mixing, the additive laws, by reasoning similar to that applied to the yellow/blue mixture.

Yours faithfully,

K. McLaren.

4 Manor Road,
Cheadle Hulme,
Cheshire.
9 October 1972.

Hon. Editor's comment:

Mr McLaren is, of course, correct and the point he raises was considered when editing the paragraph concerned. However, it was considered that the explanation given was acceptable in its particular context.

Part Seven of the Manuals is concerned with works practice and may be read by students who have not read the earlier parts and are not aware of the optical characteristics of pigments. An explanation in terms of the traditional three primary colours, blue, yellow and red was thought adequate since these are very generally understood.

The strictly correct explanation given by Mr McLaren needs some knowledge of the reflectance curves and it did not seem desirable to embark on a description of these in this part of the Manuals. The sole object of the paragraph is to stress that the appearance of a colour depends upon the nature of the light in which it is viewed and therefore the importance of the light source in colour matching. This enables some short consideration of metamerism to be given.

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Note: Italic numerals refer to the page number of the bound volume (prefixed ptm); the other numbers refer to the page of the *Journal*.

Paint Technology Manuals Part Seven: Works Practice

The final chapter and index of "Works Practice", the seventh of the Association's series of Paint Technology Manuals, appears elsewhere in this issue of the *Journal*. As already announced, reprints of each section of the Manual have been prepared every month, and the complete set is now to be collated, bound, and offered for sale.

The articles appearing under Student Reviews each month have been so designed that the bound volume will form a complete, coherent book with full continuity. Apart from the necessary typographical changes in maintaining consistency in the *Journal*, "Works Practice" will be exactly the same as those parts of the Paint Technology Manuals already published by Chapman & Hall Ltd.

The price of "Works Practice", which will contain 218 pages and be bound in limp covers, will be £2.40, post free in the UK. Registered Students of the Association may purchase the book at a special price of £1.40; however, this concession will be restricted to one copy per student, who should in all cases apply directly to the Association quoting his or her registered number.

It is anticipated that the book will be available towards the latter part of January 1973; orders can now be accepted.

Thames Valley Section

City and Guilds successes

The Association congratulates the following registered Students attached to the Thames Valley Section, who were successful in the Part One examination of the City and Guilds Paint Technician's Certificate, held recently at Slough College of Technology:

T. Brown
P. W. Edwards
P. McMahon
M. J. Moore
Miss M. Searle
P. Taylor

Information Received

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

Thomas Swan & Co. Ltd. has recently introduced *Casamid 360*, claimed to be a unique curing agent for epoxy resin, enabling water-based formulations to be prepared. The advantages of such paints in eliminating fire hazards were demonstrated by Thomas Swan before an invited audience of MP's and Trade Union representatives. Two demonstration tanks were painted with epoxy coatings, one solvent- and one water-based. The water-based formulation resisted efforts to ignite it, while the other composition burst into flames, eventually bursting open one side of the tank. The lack of toxic fumes in aqueous compositions is also stressed; it is claimed that the performance of the systems is equal to that of solvent-based types.

The second of the three volume series of techno-economic marketing studies planned by **Skeist Laboratories Inc.**, on electrodeposition, is now available. The third part, powder coatings, is planned to appear at the end of the year.

Cheltenham Induction Heating Ltd. has recently expanded its range of medium and radio frequency induction heating equipment to include mains frequency. Systems operating on 50 cycles are available for processing vessels, reactors, storage tanks etc., with standard heater ratings from 1kW single zone to 1,000kW multi-zone, operating up to 650°C. Designs for higher temperatures and powers can also be supplied on demand.

Heaters are tailor-made to suit the vessel shape or process, and can be supplied as fully fitted units mounted directly on the vessel or in free standing form, capable of supporting the vessel if required.

Isotrol-Rustlac, a rust treatment product claimed to have had outstanding success in Scandinavia, is to be marketed in this country by **Unibond Limited,** following an agreement with **Bigner & Co.,** the Swedish manufacturer. It is anticipated that the product will have a Unibond brand name in the UK.

Whitehall Machinery Limited recently demonstrated what is claimed to be the first effective solution to the problem of heat-sealing plastic sacks containing dusty products. By fitting a vacuum extraction head that cleans the sealing areas of the sacks immediately before the sealing operation, Whitehall claims that its machinery can be adapted to packaging a wide variety of dusty products which otherwise tend to contaminate the joining area and thus render the seal ineffective. The company has set up a new permanent demonstration centre at Bristol, where potential customers can test for themselves the complete Whitehall range of equipment.

A new double-head filling machine introduced by **MSM Electronics,** of New York, is to be marketed in the UK by **Allied International Co. Ltd.,** it was recently announced. The *MSM automatic feeder and filler* can be used to fill cans from ¼ pint to six gallons automatically, the quantity being metered by a pre-set light-sensitive level gauge. The machine features twin filling heads, one of which can be closed down for cleaning while the other is in operation, thus eliminating down time for batch changes. Cleaning is carried out by automatically recycling solvent through the filling head batch tank and lines, so that one operator can carry out the separate cleaning and filling operations at the same time.

Filling speeds of up to 60 gallons per minute are claimed; where maximum output is required for long production runs, both heads can be adapted to operate at once by running both feeder lines to a single tank.

It has recently been announced that the products and services of the four divisions of **Kollmorgen Corporation** dealing with colour and its measurement will now be handled from a single headquarters in Newburgh, New York. The new **Macbeth Colour and Photometry Division** combines the former Macbeth, Munsell Color, and Color Systems Divisions, and the Macbeth Research Laboratories. Kollmorgen considers that the new division, in combining light measurement and evaluation, the Munsell chart system, computer hardware and software for colour measurement, and comprehensive research facilities for all aspects of colour, provides a unique colour products system that will offer customers a complete range of equipment for all colour requirements.

Two new high efficiency vibratory sieving and straining machines have been introduced by **Russell Finex Ltd.** The new models are the *Finex 22*, with a 22in demountable sieve, which replaces the standard *Finex*, and the *Finex 36*, with a screen area almost three times that of the *Finex 22*, which replaces the *Super Finex*. A number of new design features have been incorporated in the new machines, notably the use of greater centrifugal forces creating large amplitudes of vibration with adjustable flow pattern control, which, together with an improved screen design and a new independently driven vibrator unit, has enabled the *Finex 22* to perform faster than its predecessor—by a factor of two or three times in many cases, claims Russell Finex. Development of these designs is continuing, and high frequency versions are anticipated in the near future.

BASF United Kingdom Limited has added a new pigment, *Iron Red 2710*, to its range. Like *Iron Red 2950*, the new product is made by combustion of iron carbonyl and has the same high degree of purity. However, *Iron Red 2710* is far more transparent and yellower in shade than *2950*, and is easily dispersible in solvent-based vehicles. The new pigment is considered to be of particular interest for metal effect and transparent lacquers.

A portable unit for the metering and dispensing of tints and additives in the paint and ink industries has been developed by the **Graco Department** of the **Steetley Company Limited.** The unit comprises an air operated pump connected to 1.5 feet of self-coiling nylon hose terminating in a combined meter and dispensing valve. In use, the unit is connected to a 25 litre drum of additive—Graco envisages a rig of six units mounted on a warehouse truck for full mobility. Operation is similar to that of a petrol pump: the quantity required is set on the dial, the nozzle placed in the mixing tank, and the valve triggered by hand to commence the flow, which is automatically cut off when the correct quantity has been delivered. Volumes from $\frac{1}{8}$ fluid ounce to four gallons may be selected.

It has recently been announced that the telephone number of **Worsdall Chemical Company** has been changed; the new number is 0474-812812.

Carl Zeiss, the West German manufacturer of optical equipment, has added a fully computerised colour matching system to its range of colour measuring instruments, announce **Degenhardt & Co. Ltd.,** Zeiss's UK representative. The *RFC3 Automatic Colorimeter* can be supplied with a *Digital pdp 8e* computer and typewriter input/read out. The colorimeter operates over the range 400-700nm (the range 380-720 nm can be supplied if required) using 25 interference filters; a range of accessories for different measuring geometries is available. Automatic read-out of tristimulus values can be obtained, and programmes are available, or under preparation, for colour difference computation according to Simon-Goodwin, Friel-McAdam-Chickering, or Nickerson-Stultz formulae, for computation of whiteness, and for pre-calculation of colorant formulation. Zeiss claims that measurement and output of reflectance or transmittance values takes 70-90 seconds, followed by 20 seconds for computation of tristimulus values and chromativity coordinates, or for computation and output of colour differences.

A new plant to produce paint on a scale and at a speed that are claimed never to have been attempted in the UK or Europe is being commissioned by the **Paints Division of ICI Ltd.** The new plant, at ICI's Stowmarket works, will make paint by a semi-automated process in 12,000 litre batches, with a capacity of 14 million litres per year, and will be in full production by January 1973.

By concentrating on the large volumes required in the *Dulux* range—the plant will be used for a significant proportion of *Dulux* gloss, eggshell and emulsion finishes, and the complete range of *Dulux* undercoats—it has been possible to design a process incorporating mechanised transporting systems, eliminating many of the manual operations which cause delays in conventional plant.

The plant is on four stories, and, in effect, the operation converts raw materials pumped to the top floor to paint at ground floor level, using pump-assisted gravity feed between operations. The entire dispersion process, from pumping pigment from the 100 tonne silos to the dispersers, can be controlled by one man at a central console; a second operator takes over at second floor level, directing the batch either to secondary dispersion or to the first floor for the final mixing and thence to the ground floor for filling and despatch.

On Thursday 19 October, the new china clay refining plant of **Kaolin Australia Pty Limited** was opened by Sir Henry Bolte, the retired premier of the State of Victoria. The company is a joint enterprise between an established Australian china clay company and **English China Clays Limited,** and it is anticipated that the availability of high grade clays in Australia will eliminate a large proportion of imports.

A new plant for the production of polypropylene glycols has been started up by **NV Bayer Antwerpen,** the Antwerp subsidiary of **Bayer AG.** The plant has a capacity of 80,000 tonnes of polyether based on polypropylene glycol per year, bringing Bayer's total capacity to 230,000 tonnes per year.

The Institute of Metal Finishing has issued a reprint of an article entitled "The use of the metric system in the metal finishing industry," written by a working party appointed to consider the matter.

It describes the use and notation of the SI Units of concern to that industry and is broadly similar to, but rather less comprehensive than, the article published in *JOCCA* 1971, **54,** 363. The booklet provides an easy source of reference and is available from the Head Office of the IMF at a price of 75p.

Hull

Plastic coated steel

The first lecture of the new session was given by Mr J. Land, Managing Director of Dufay Plastics Ltd., at the Hull College of Technology on 2 October. Mr F. D. Robinson chaired the meeting.

The subject of Mr Land's lecture was plastic coated steel for industrial cladding which, over the last 15 years, has captured business traditionally held by galvanised steel, bituminised steel and asbestos cement. The success of the newer material was attributed in part to the improved quality of the steel sheeting, the decline of heavy industry, and the increase in light engineering, and to the requirement for quickly erected attractive buildings.

In the coating operation, steel sheets cut to the sizes required for the customer's building were roller coated with a plasticised pvc paste containing pigment and heat and light stabilisers. Edge protection was provided and, currently, six coats were applied, three on each face, to give a textured finish of film thickness 5-7 mil. Formerly the plastic composition was applied to shot blasted steel sheet but, to avoid unsightly rust staining originating from scratches produced during erection, zinc coated steel was now used. After the final stoving operation, the sheet was profiled by pressing.

The estimated life of the coating, based upon the customary accelerated test methods of the paint industry, was at least 20 years; a test procedure in which the specimen was exposed to a cycle of heat, cold and humidity was now employed to assess durability.

Much discussion took place after the lecture and Mr Land was able to elaborate on a variety of interesting aspects, such as colour matching and paintability after weathering.

A vote of thanks for an interesting lecture was proposed by Mr R. Brooks. The meeting was attended by 11 members and five visitors.

J.A.H.

Midlands

Trent Valley Branch

Powder coatings

Under the chairmanship of Mr J. R. Bourne, an audience of 20 members and guests was given a very interesting lecture on the above topic by Mr D. W. Brooker of Shell Research Ltd., at a meeting held at the British Rail School of Transport, Derby, on Thursday 12 October.

Mr Brooker described the development over the past decade of epoxy powder coatings, and also dealt with the present "state of the art".

In the early 1960s the only method of application was a fluidised bed. There were inevitably problems associated with this method and, in fact, practically the only end application was for thick films that required chemical resistance, etc.

When thermosetting powders arrived in Europe from the USA, other methods were investigated. The separation of hardener from the resin was involved and the resin kettle was chosen as the main apparatus for this process. It proved to be very unsuccessful.

The next method adopted was the heated Z blade mixer and this proved to be generally more successful. It was found that with this process it was possible to obtain a thin decorative coating rather than just the thicker films mentioned above.

Mr Brooker indicated that the process was offered to the British paint industry and, in fact, three firms started production, but only in a relatively small way. However, things were happening in the European market and in 1964, for instance, there was suddenly a general boost to the French consumption of powder coatings, mainly brought about by new pollution laws that were being brought in at that time.

By this time it was found that the Z blade process had a number of limitations, but at the same time the thermoplastics industry already had suitable machinery which could generally overcome these problems, and not need to be a batch process as was the case with the Z-blade.

During the later 1960's a number of firms in Germany, including Bosch, started to produce powder coatings. They were employing the use of more reactive hardeners and, therefore, were able to offer cheaper products, mainly because of the more effective method of production. This was by the extrusion method which offered little or no chemical reaction. Thus on cooling the mass was very brittle and therefore easily ground to a particle size of 75 microns. This process, therefore, offered a very considerable step forward over the earlier processes.

It was at this stage that Mr Brooker introduced a series of slides illustrating the various items of equipment used in the production process by the extrusion method—extruders, grinding machines, etc.

A typical formulation currently employed is shown below.

Fast curing Epikote powder

	Pt. Wt.
Epikote 1004	60.0
Tioxide R-1HD4	31.5
Modaflow (5% in 1004)	5.0
Epikure 10B	3.5
	100.0

Cure schedule—5 minutes at 200°C.

The growth of epoxy powder production in Western Europe generally has been very steady and represents approximately 90 per cent of the market as far as thermosetting materials are concerned. From just a few hundred tons in the 1960's it grew to approximately 6,000 tons in 1971. The present rate of expansion is about 50 per cent, and one of the larger manufacturers estimates that, by 1975, 15,000 tons of powder coatings will be produced, the largest percentage being the epoxy type.

Mr Brooker then made a general summary of the various methods that had been used for production of powder coatings together with their apparent problems, and this is best shown in the following table.

Method	Problems
Dry blending	Separation during application
B staging	Limited shelf life
Pebble mill	Colour changes and control of particle sizes
Heated 2-roll milling	Slow production rate. High filler loading needed
Z blading	Cleaning and limit to system productivity
Extrusion	High capital cost. Colour matching.

There was very noticeable market penetration of epoxy powders during 1970, particularly in Germany, France, Scandinavia and the Benelux countries. By far the smallest area of penetration was the UK.

Mr Brooker went on to describe the various uses for powder coatings, such as spray coating processes where, for instance, any over-spray could be collected and used again. This particular process was finding increasing use on such articles as tubular furniture and bicycle frames. One of the advantages of the powder coating finish was that it reduced the amount of packing necessary for such articles as bicycle frames without fear of damage to the finish during transit.

In the automobile industry, cooling manifolds, steering column assemblies, etc. were already being spray powder coated and it had been found that car wheels were particularly resistant to impact damage when so treated. The VW and Fiat organisations were already using this process extensively.

A further use was in the spraying of car bodies with primer surfacers. Fiat, for instance, had stated that they would be in volume production shortly with this process, having found it to be cheaper than conventional systems, as well as offering less chance of pollution.

The powder coating process was also particularly successful where a mechanically tough finish was required and was being used for spin dryer tubs. Unfortunately, the chemical resistance was not sufficient for washing tubs.

In the USA, the exteriors of large diameter pipes were being powder coated. This eliminated any special transit packing and no damage to the finish was caused, despite any bending, jointing, etc. that might take place. The pipes themselves could either be completely lined with a powder coating or merely the ends might be coated, the rest of the surface being treated with a bitumen process.

Mr Brooker then went on to describe how the powder coating process was now finding use in the decorative market and also for electrical appliances. There was one main drawback, however, with epoxy powder coatings and that was that they tended to lose gloss when used for exterior purposes. There was, therefore, now a considerable interest in coatings based on acrylics, polyurethanes and polyesters, although even these offered certain problems and drawbacks. Intense research into alternative finishes to epoxies was being carried out and within the next few years there should be some positive progress.

A lot of work was also being carried out on the question of manufacturing techniques and machinery, and at this point Mr Brooker introduced a further series of slides illustrating new forms of spray drying equipment, etc.

Finally, the future market trend was discussed. It was estimated that approximately 40 per cent of the industrial stoving market was likely to move to powder coatings, mainly because of the very strict pollution laws that were now being brought in.

The big question was, of course, could the paint industry in the UK afford to ignore powder coatings? As had been mentioned earlier, the penetration here had not been nearly as positive as on the Continent, but one point that should be borne in mind was that, as far at the Continent was concerned, it was not really the paint manufacturers themselves who had promoted powder coatings. Rather the powder manufacturers had gone after the business normally held by paint companies, who in the end had been forced to merge with them. It was not altogether unlikely that this situation could well come to pass in the UK.

A very full and exhaustive question and answer period followed a most absorbing and informative lecture.

A vote of thanks was given by Mr T. Cordwell which was heartily endorsed by all present.

D.F.G.

Optional Professional Grade for Ordinary Members

First full list of successful candidates

As laid down in the report of the Working Party on Education, Training and Qualifications which was adopted in the institution of the Professional Grade, a list of all those Members who have entered the grade will be published in the December issue of the *Journal* each year. The first such list appears below, and represents a most successful beginning for this new venture. A total of 316 members have successfully applied for admission to the grade since the first notice in the Journal in September 1971; of these admissions, 119 were to Fellowship, 189 to Associateship and eight to Licentiateship. This figure represents roughly 10 per cent of total Membership, and is a most gratifying response, particularly when it is considered that a further 21 members are awaiting fulfilment of regulations before entry to the Grade, many of these at the Licentiate level, where candidates have to write a dissertation before admittance.

Members are reminded that, as from 1 November, the initial period during which the regulations requiring candidates to obtain sponsors were waived is now at an end; all those applying must be suitably sponsored as laid down in the regulations. Also, attention is drawn to the certification fees that will take effect from 1 January 1973. These are: Fellows £10.00, Associates £6.00, and Licentiates £3.00. Appropriate remittances must accompany all applications.

The regulations for admission to the Professional Grade will appear in full in the January issue of the *Journal.*

Fellows

Anderson, George (*Scottish*)
Apperley, Thomas William James (*West Riding*)
Archer, Harold (*Manchester*)
Arnold, Michael Henry Miller (*London*)
Arnold, James Eric (*London*)
Ashworth, Norman (*Manchester*)
Atherton, Donald (*Scottish*)
Austin, Denis Leonard (*Bristol*)
Banfield, Thomas Arthur (*London*)
Bell, Sydney Hector (*London*)
Bennett, Norman Arthur (*General Overseas—Malta*)
Bews, Ian Charles Randall (*London*)
Blenkinsop, Arthur Willis (*Newcastle*)
Bohringer, Eberhard (*London*)
Bourne, John Robert (*Midlands-Trent Valley Branch*)
Brown, Arthur Ernest Girdlestone (*London*)
Butcher, George Alfred (*Midlands*)
Butcher, Kenneth William George (*Manchester*)
Butler, Cecil (*West Riding*)
Caldwell, David George (*Wellington*)
Campbell, George Alexander (*Manchester*)
Ceresa, Raymond John (*London*)
Chatfield, Herbert Walter (*London*)
Clarke, Harry James (*Midlands*)
Colborn, Douglas Charles (*Thames Valley*)
Cole, Derek (*General Overseas-Australia*)
Cole, Reginald Joseph (*London*)
Collier, Claude William (*Midlands-Trent Valley Branch*)
Collings, Arthur Geoffrey (*London*)
Cook, Harold Gilbert (*Manchester*)
Coupe, Raymond Richard (*London*)
Coverdale, Peter Frederic Muir (*Midlands*)

Crowl, Victor Terrell (*London*)
Day, Keith Julyan (*London*)
Duckworth, Samuel (*Manchester*)
Duell, Arthur Albert (*Newcastle*)
Dunkley, Frederick George (*Midlands-Trent Valley Branch*)
Durrant, George Geoffrey (*Hull*)
Ellinger, Marianne Livia (*London*)
Entwistle, Thurston (*South African*)
Fillingham, Thomas Alan (*Hull*)
Finn, Stanley Russell (*Hull*)
Fullard, John Edward (*South African*)
Gate, Peter Atholl Jackson (*South African*)
Gay, Philip James (*Hull*)
Gellay, Victor Peter (*London*)
Gellman, Alexander (*London*)
Gollop, Percy Lionel (*Bristol*)
Gosling, Harry (*Manchester*)
Gray, Denis Roy (*West Riding*)
Hampton, Horace Arthur (*Manchester*)
Hawkey, John Albert Lawrence (*London*)
Hess, Manfred (*London*)
Hill, Roger Frederick (*Midlands*)
Hipwood, Hubert Allan (*London*)
Hodgson, Kenneth Vickerson (*Newcastle*)
Holbrow, Gordon Leonard (*London*)
Holt, Alfred Gordon (*Thames Valley*)
Hutchinson, Geoffrey Herbert (*Scottish-Eastern Branch*)
Inshaw, John Leslie (*Thames Valley*)
Jacob, Basil (*Thames Valley*)
Keenan, Henry Wilfrid (*London*)
Kekwick, Leslie Oliver (*London*)
Kinsman, Roy Granville (*South African*)
Landmann, Axel Wolfgang (*London*)
Lasser, Howard Gilbert (*General Overseas-USA*)
Lewin, John Buckingham Grey (*London*)
Lewis, Fred (*Manchester*)
Ley, John Barry (*London*)
Long, Denis Terence (*Irish*)
McGowan, Jesse (*Manchester*)
McKelvie, Archibald Neil (*London*)
McLean, Angus (*Scottish*)
McWilliam, Anthony (*Manchester*)
Mell, Cedric Charles (*Hull*)
Mitchell, John Edmund (*Manchester*)
Mole, Seymour Lloyd (*Manchester*)
Monk, Cyril James Henry (*Thames Valley*)
Moon, William Robert (*Manchester*)
Morgans, Wilfred Morley (*London*)
Munn, Raymond Henry Edward (*London*)
Newell, George Ashley (*London*)
Newnham, Herbert Alan (*London*)
Newton, Dennis Sydney (*Bristol*)
Newton, Donald Stringer (*Bristol*)
Nutt, William Owen (*London*)
Oostens, Emile Elie Eugène (*General Overseas-Belgium*)
Parfitt, Geoffrey Derek (*Newcastle*)
Penfold, Arthur de Ramon (*General Overseas-Australia*)
Ray, Stanley Arthur (*Midlands*)
Rechmann, Heinz (*General Overseas-Germany*)
Robinson, Ralph Sidney (*Manchester*)
Rose, Charles (*Manchester*)
Rubin, Wallace (*London*)
Rudram, Arthur Thomas Stephen (*London*)
Saunders, Laurence Frederick (*South Africa*)
Seymour, Norman Henry (*Manchester*)
Slinn, Thomas Walter (*Wellington*)
Smethurst, Jack (*Manchester*)
Smith, Francis Mark (*Manchester*)
Sowerbutts, Frank (*London*)
Stoyle, Francis Wilbert (*Irish*)
Tatton, William Henry (*Thames Valley*)
Tawn, Alec Richard Hornsey (*London*)
Taylor, Cyril James Allan (*Midlands*)
Taylor, John Roberts (*Bristol*)
Taylor, Maurice David (*Wellington*)
Thorpe, William Frederick Albert (*Midlands*)

Tickle, Trevor Cyril Kenneth (*Manchester*)
Tooth, John Henry Collins (*London*)
Touchin, Herbert Roy (*Manchester*)
Unsworth, Alfred Kenneth (*London*)
Wall, Dennis Charles (*Manchester*)
Watkinson, Leonard James (*West Riding*)
Westwood, George Ernest (*London*)
Whiteley, Peter (*London*)
Whitfield, Thomas (*Auckland*)
Wilkinson, Thomas William (*Hull*)
Willis, Gervase Hewitson (*Manchester*)

Associates

Acey, John Arthur (*London-Southern Branch*)
Adams, John Charles (*Midlands*)
Adams, Terry Ernest (*London*)
Addenbrooke, Brian John (*Midlands*)
Aitken-Smith, Frank Joseph (*Auckland*)
Allavena, Antonio (*General Overseas-Switzerland*)
Anthony, Alan Sydney (*London*)
Armstrong, Edward (*Hull*)
Arnold, Frank (*Manchester*)
Arnot, William James (*Thames Valley*)
Assink, Jo (*Auckland*)
Baker, John (*London*)
Baldwin, George William (*Manchester*)
Bannington, Donald Bertram (*London*)
Barnes, Peter James (*London*)
Barton, James Francis (*London*)
Batch, Alan James Edward (*London*)
Beachen, John Frederick (*Auckland*)
Beere, André Jaime (*Thames Valley*)
Bell, Brian Robert (*Midlands*)
Bird, George Donald Chaplyn (*Midlands*)
Bishop, Eric Harold Abbott (*Thames Valley*)
Blackledge, Amos (*Manchester*)
Bluck, Ross Steele (*Auckland*)
Bolam, Ion Barrow (*Newcastle*)
Bowerman, David Francis (*Manchester*)
Bowler, Kenneth Ernest (*Midlands*)
Brockman, Andrew Leonard Sloane (*General Overseas-Australia*)
Brooke, Leslie John (*Bristol*)
Brown, Peter Thomas (*London*)
Cartwright, Jeffrey (*London*)
Catherall, Kenneth David (*Midlands*)
Chebsey, Maurice (*Manchester*)
Chellingsworth, Horace Thomas (*Midlands*)
Chippington, Kenneth Alan (*Bristol*)
Clark, Laurence Norman (*London-Southern Branch*)
Coates, John Allen (*Manchester*)
Cole, Francis William (*Midlands*)
Constantinides, Erricos (*London*)
Cordwell, Terrence Allan (*Midlands-Trent Valley Branch*)
Cunnington, Robin Roy Carol (*London*)
Daggett, Wilfred Francis (*London-Southern Branch*)
Dalton, Frank (*Manchester*)
Dando, Vivian Charles Owen (*London-Southern Branch*)
Davies, Frank Watkin (*London*)
Davis, Reginald Albert (*Bristol*)
Delorette, Gustav Otto Hans Jurgen (*South African*)
Donkersley, Brian (*Newcastle*)
Dowsing, George Frederick (*London*)
Dunn, Paul Alan (*London*)
Eaton, Michael George (*Thames Valley*)
Ebdon, James William (*General Overseas-Rhodesia*)
Eltringham, James Norman (*Auckland*)
Evans, Carey Pearce (*Auckland*)
Fairless, Joseph (*General Overseas-Belgium*)
Fell, Alan William (*Manchester*)
Field, Lawrence Edward (*South African*)
Fisher, Leslie Alexander (*South African*)
Flood, Geoffrey Terence (*Manchester*)
Ford, Keith Sydney (*Manchester*)

Frazee, Jerry Daniel
(*General Overseas-USA*)
Garratt, Peter Garth
(*General Overseas-Switzerland*)
Gay, Alan Stanley (*Midlands*)
Ghosh, Sunil Kumar
(*General Overseas-India*)
Gibson, John Carrington (*Hull*)
Green, Brian James (*London*)
Greenall, Brian John (*Wellington*)
Greenfield, Eric (*Midlands*)
Griffiths, Henry James (*Midlands*)
Grime, David (*London*)
Groom, John Robert (*London*)
Gunn, Reginald F. E. (*Thames Valley*)
Harrison, Cyril Geoffrey (*Hull*)
Hasnip, John Anthony (*Hull*)
Hayes, Gerard Francis
(*Thames Valley*)
Heald, Desmond (*Manchester*)
Heffer, Victor George (*Manchester*)
Herriott, Charles Edward (*London*)
Hickman, Edwin Peter (*Midlands*)
Hill, Gilbert Victor Geoffrey
(*Thames Valley*)
Hill, Raymond Forsyth (*Scottish*)
Hodge, Robert Alexander Paul
(*Auckland*)
Holden, William Desmond
(*Manchester*)
Holmes, David James
(*Midlands-Trent Valley Branch*)
Holt, Clifford (*Manchester*)
Homden, Kenneth James Arthur
(*London*)
Hopper, Derek Edgar (*Midlands*)
Hossack, James (*Scottish*)
Howard, Eric (*Manchester*)
Howells, Barry John (*Hull*)
Howes, Edward John (*London*)
Hughes, Gilbert William (*Manchester*)
Humphrey, Thomas Lawson Myles
(*Scottish*)
Johnstone, James William
(*Manchester*)
Jones, Derek Frederick Arthur
(*London*)
Kelly, Peter Graeme
(*General Overseas-Australia*)
Kenna, Frank William (*Manchester*)
Kerr, Michael Anthony (*Manchester*)
Khan, John Mohammed (*London*)
King, Charles William Henry
(*Midlands*)
King, Raymond John (*Midlands*)
Kirlew, Charles Wesley
(*General Overseas-Jamaica*)
Kitchen, John Robert
(*Midlands-Trent Valley Branch*)
Knight, Richard Charles (*London*)
Laker, Bernard George (*London*)
Lakshmanan, P. R.
(*General Overseas-USA*)
Lang, Robert (*Scottish*)
Langley, Robert (*Scottish*)
Lawton, Cyril Victor (*Midlands*)
Lewis, John David (*Thames Valley*)
Macdonald, Alan (*Auckland*)
Mandelson, Jack (*Scottish*)
Maple, Donald Peter (*London*)
Maynard, Albert William David
(*London*)
McDonald, Kenneth Roy
(*South African*)
McKay, Alan Gordon (*London*)
McKay, Robert Bruce (*Scottish*)
McKean, James Newlands
(*General Overseas-Hong Kong*)
McMillan, James (*Manchester*)
McQuirk, Peter John (*London*)
Mepham, Brian Edwin (*London*)
Mikucki, Wiktor (*London*)
Miller, James (*Scottish*)
Mitchell, Seward John (*Midlands*)
Moore, Frank Roden (*West Riding*)
Moore, James (*Midlands*)
Moore, Ronald Henry (*West Riding*)
Morpeth, Frederick Johnson
(*Manchester*)
Morris, David (*West Riding*)
Munro, Hugh Anderson (*Scottish*)
Murray, Robert Frederick (*London*)
Mynett, Raymond John (*Midlands*)

Ness, Robert Alexander (*Wellington*)
Norton, Douglas Kent (*Midlands*)
Oakley, Ernest (*Newcastle*)
O'Connor, Eugene Daniel (*Manchester*)
Orpwood, John Leonard (*London*)
Pace, Graham (*Midlands*)
Parry, Martin Gerald (*London*)
Pemberton, Joseph James (*London*)
Perry, Leonard C. (*Bristol*)
Pessall, Robert George (*Midlands*)
Poborca, Stefan (*Midlands*)
Rackham, John Michael (*Newcastle*)
Redman, Frank Benson (*Manchester*)
Reeve, Frank Nicholson (*South African*)
Robinson, Arthur Graham (*London*)
Robinson, Francis Derrik (*Hull*)
Rothwell, Gerald William (*London*)
Rout, Peter George (*West Riding*)
Routley, Alan Francis (*London-Southern Branch*)
Scott, Neville (*Manchester*)
Sharp, Peter Frank (*Auckland*)
Sharpe, David (*Hull*)
Shirt, John Michael (*West Riding*)
Shoham, Joseph (*General Overseas-Israel*)
Silsby, Denys John (*Midlands*)
Silverwood, David (*Manchester*)
Smith, Alexander Borland (*Scottish*)
Smith, David Dorman (*Scottish*)
Sowerby, Alan Hope (*Auckland*)
Speding, George (*London—Southern Branch*)
Springett, Robert Arthur Edward (*London*)
Sreeves, John Ernest (*Midlands*)
Stewart, Donald (*Manchester*)
Stone, James Bryan (*London*)
Stott, Raymond (*Manchester*)
Suthers, Peter (*Manchester*)
Sutton, Peter Michael (*London*)
Talwalkar, Vinayak Sakharam (*Manchester*)
Tasker, Leonard (*General Overseas—Iran*)
Taylor, Terence (*Manchester*)
Thomas, Anthony (*General Overseas—Brazil*)
Thoms, Hugh Sydney (*Manchester*)
Tozer, Edwin John (*General Overseas—Argentina*)
Trevitt, Edwin William (*London*)
Triggs, Francis Cyril (*London*)
Troparevsky, Alejandro (*General Overseas—Argentina*)
Tye, Terence Thomas (*Thames Valley*)
Unri, Madhavan T. N. (*General Overseas—Malaysia*)
Walker, Peter (*Thames Valley*)
Weineck, Terrence Graham (*South Africa*)
Westbrook, Ernest Louis Edward (*London*)
Whetstone, Peter John (*London*)
White, Robert Arthur (*Auckland*)
Williams, Adrian Arthur Owen (*London*)
Williams, Cyril (*Manchester*)
Wooll, Frederick James (*London*)
Zissell, Martin John (*London*)

Licentiates

Boxall, John (*London*)
Canterford, Barry Albert (*London*)
Churchman, Anthony Edward (*London*)
Cox, Garth Anthony (*West Riding*)
Downham, Stephen Airey (*Thames Valley*)
Hemmens, Anthony John (*Bristol*)
Moss, Noel Sydney (*London*)
Schierbaum, James Helmut (*Midlands*)

SILVER JUBILEE · OCCA 25 · OLYMPIA·LONDON·MAY·1973·

25th Technical Exhibition

21-24 May 1973

Allocation of space to exhibitors from 11 countries

The allocation of space for OCCA 25 has now been made by the Exhibition Committee, and exhibitors are drawn from 10 overseas countries as well as the UK; the overseas countries represented are Belgium, Finland, France, Germany, Holland, Italy, Norway, Sweden, Switzerland and the USA. The full list of companies participating is given below and includes six who have not previously participated in an OCCA Exhibition and 31 who were not at the Exhibition in 1972.

The Exhibition will be composed of over 90 stands and the description of exhibits to be shown will be given in the Official Guide, which is to be published in the New Year. Advertising space can still be booked in this important reference book and any company wishing to take advantage of this should contact the Association immediately.

Leaflets in six languages containing an invitation to visit the Exhibition have been prepared and will be sent out to many companies and individuals in the UK and overseas. It is also proposed that these leaflets will be circulated in other journals allied to the industries served by the Association; if any reader would like copies of the leaflet to send to colleagues, copies are available without charge from the Association's offices.

First List of Exhibitors at OCCA 25

Amoco International SA
Anchor Chemical Co. Ltd.
*APV-Osborne Ltd.
Arco Chemical Company
Akzo Chemie NV
*Willy A. Bachofen
Baker Castor Oil Co.
†BASF United Kingdom Ltd.
†Bayer AG
BIP Chemicals Ltd.
Victor Blagden & Co. Ltd.
William Boulton Ltd.
Bowater Industrial Packaging Ltd.
†Buckman Laboratories SA
†Buhler Brothers (England) Ltd.
Cabot Carbon Ltd.
Rex Campbell & Co. Ltd.
CdF Chimie
†Chemische Werke Huls AG
†Ciba-Geigy (UK) Ltd.
Cornelius Chemical Co. Ltd.
†Croda Chemicals Ltd.
†Croda Processed Oils Ltd.
†Croda Universal Ltd.
Croxton & Garry Ltd.
Daniel Products Co.
Degussa
DH Industries Ltd.
*Diffusion Systems Ltd.
Durham Raw Materials Ltd.
†Dynamit Nobel AG
†Dyno Industrier AS
Eastman Chemical International AG
G. J. Erlich Ltd.
Ferranti Ltd.
†Guest Industrials Ltd.
Henkel & Cie GmbH
Hercules Powder Co. Ltd.

First List of Exhibitors at OCCA 25—*Continued*

†Harold Heydon & Co. Ltd.
†Hoechst UK Ltd.
Imperial Chemical Industries Ltd.
†Industrial Colours Ltd.
International Colloids Ltd.
Kemira Oy
Kollmorgen Colour Systems
†Kunstharsfabriek Synthese NV
Laporte Industries Ltd.
Lennig Chemicals Ltd.
Marchant Brothers Ltd.
Mastermix Engineering Co. Ltd.
†Rudolph Meijer's Inc.
*H. E. Messmer Ltd.
Microscal Ltd.
†Millroom Accessories & Chemicals Ltd.
Montecatini Edison
†A/S Norwegian Talc
†Plastanol Ltd.
Polymers, Paint & Colour Journal
†Polyvinyl Chemie Holland NV
Research Equipment (London) Ltd.
Rhone-Poulenc Group
RK Chemical Co. Ltd.
†Roehm GmbH
Sachtleben Chemie GmbH
†Sandoz Ltd.
Pigment & Resin Technology (Sawell Publications Ltd.)
Schering AG
Sheen Instruments (Sales) Ltd.
†Shell Chemicals UK Ltd.
Peter Silver & Son (Engineers) Ltd.
†Silverson Machines Ltd.
Society of Dyers and Colourists
†Spelthorne Metals Ltd.
†Synres Internationaal NV
Tioxide International Ltd.
Titanium Intermediates Ltd.
Torrance & Sons Ltd.
Torsion Balance Co. (GB) Ltd.
Transportmaschinen Export/Import
Ugine Kuhlmann
†Union Carbide Europe SA
†Veba-Chemie AG
†Wacker-Chemie
†Wentworth Instruments Ltd.
*Westerlins Maskinfabrik AB
Winn & Coales (Denso) Ltd.
Winter Osakeyhtio
Worsdall Chemical Co. Ltd.
*Carl Zeiss (Oberkochen) Ltd.

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*Denotes companies who have not previously shown at an OCCA Exhibition.

†Denotes companies who were not at the 1972 Exhibition.

OCCA Biennial Conference

towards 2000

eastbourne 19-23 june 1973

The final programme for the Association's biennial conference to be held at the Grand Hotel, Eastbourne, from 19-23 June 1973, has now been arranged, and is shown below. Some amendments to the first provisional programme will be noted.

Wednesday 20 June

Session 1 (09.30-12.30)

Chairman: Mr A. R. H. Tawn (Hon. Research & Development Officer)

Plenary Lecture: "Polymers—Developments for the future" by Prof C. E. H. Bawn (University of Liverpool)

"The influence of supermolecular structure on the properties of polymer films" by Dr V. Zorll (Forschungsinstut für Pigmente und Lacke eV)

"The hardening of organic coatings with infra-red lasers" by Drs E. Ladstädter and H. D. Hanus (Vianova Kunstharz AG)

Session 2 (14.30-16.30)

Chairman: D. E. Eddowes (Chairman, London Section)

"Britain and the EEC—technico-commercial aspects". Panel discussion

"The American paint industry"—present trends and future possibilities, by Mr F. Armitage (Sherwin Williams Co. Inc.)

"Relations with the developing countries" by Mr A. T. S. Rudram (Donald Macpherson & Co. Ltd.)

Thursday 21 June

Session 3 (09.30-12.30)

Chairman: Dr J. B. Ley (Coates Brothers Ltd.)

Plenary Lecture: "The challenge of metal finishing" by Mr G. Isserlis (Polytechnic of the South Bank)

"The role of coatings in corrosion prevention—future trends" by Drs R. P. M. Procter and V. Ashworth (UMIST)

"Electrochemical activity of conductive extenders for zinc rich coatings" by Dr V. P. Simpson and Mr F. A. Simko Jr. (Hooker Research Center, Niagara Falls)

"The chloride ion in epoxy/polyamide films and the substrate effect" by Dr J. D. Murray (Mats QAD), Woolwich)

Session 4: Techno-economic aspects (14.30-16.30)

Chairman: Dr F. M. Smith (CIBA-GEIGY UK Ltd.)

Plenary Lecture: "Environmental problems of the chemical industry" by Dr H. Gysin (CIBA-GEIGY, Basle)

"Tomorrow's packaging" by Prof G. Scott (University of Aston-in-Birmingham)

"The future for colour measurement" by Mr K. McLaren (ICI Ltd.)

Friday 22 June

Session 5 (09.30-12.30)

Chairman: Dr S. H. Bell

"100 years of standards" by Mr C. Meredith (BSI)

"Finish first—fabricate later. The continuing story of coil coating" by Mr D. S. Newton (British Steel Corporation)

"A consideration of powder coating problems" by Mr S. T. Harris (Arthur Holden & Sons Ltd.)

"The characterisation of mechanical properties of paint films" by Mr R. L. J. Morris (Mats QAD, Woolwich)

Workshop Sessions (14.30)

Sales forecasting

The changing influence of "do-it-yourself" on the retail paint market

The measurement of research output

Registration forms

Full details of registration fees, and a registration form, will be sent to all Members of the Association at the turn of the year. Non-members wishing to receive these items, when available, should apply to the Director & Secretary at the Association's offices.

Summaries and biographies

Summaries of all the papers are given below, and it is hoped that photographs and short biographies of the authors will appear in the January issue.

Conference papers

Plenary Lectures

Polymers: developments for the future by C. E. H. Bawn

During the past ten years a considerable number of new plastics has been introduced to the market, and this trend will continue because existing plastics are a long way from meeting the demands of new effects and high performance. Despite these developments, low-cost and large-scale plastics are made from a small group of inexpensive monomers, and it does not appear probable at the moment that other cheap and plentiful molecules will be added to the list in the 70's. However, there remains considerable opportunity for the improvement of existing materials and the production of new materials with attractive properties from these products. This may be by chemical modification, by improving stability, by copolymerisation and blending, and by a combination of these techniques. Another approach is to use physical (manufacturing) processes for the making of orientated films, laminates, paper-like material based on fibres, multicomponent structures and reinforced materials.

Progress in these areas will be reviewed and some predictions and forecasts for the future indicated, for example conductive polymers, high temperature plastics and rubbers and stereospecific polymerisation.

The challenge of metal finishing by G. Isserlis

After a brief review of the progress of metal finishing since the early post-war days, the present scope of this technology and its relation to other technologies will be indicated. The need for specialist education, particularly at the highest level, will be explained.

On the basis of current trends, likely developments over the next decade will be considered and an attempt will be made to predict the role of metal finishing in industry and everyday life at around the year 2000.

Environmental problems of the chemical industry by H. Gysin

Although the production of all goods is inevitably associated with the formation of waste, the worldwide concern about pollution has only become evident in recent years. Pollution as such is not new, it has existed ever since man started his activity—only the order of magnitude has changed. However, bearing in mind that the growth of the production volume during the last few decades has exceeded the production volume attained before in the whole history of mankind, then the difference becomes very clear.

Rivers were no longer capable of coping with the effluents produced by industry and the communities, air pollution became a serious problem in many highly populated areas and city dumps were more and more criticised. But it was only after some severe incidents such as the smog case in London in 1952 that the seriousness of the whole environmental problem became evident. In the United Kingdom this resulted not only in new legislation, such as the Clean Air Act, but also prompted a campaign for better air and cleaner water systems.

It is a widespread belief that industry alone is responsible for the pollution problems existing today. In reality, traffic and energy production are by far the largest air polluters. Industry, however, is responsible for almost 50 per cent of the effluent problems, while agriculture and municipalities account for the balance. For some of the most important air pollution problems—such as the exhaust gases from combustion engines—no acceptable technical solutions have been found as yet. Mechanical-biological effluent treatment plants are being built to get rid of a considerable proportion of the organic materials in rivers. It must be stressed that additional steps will have to be taken to eliminate the non-biodegradable organic and the inorganic materials from water systems. In the long run, the final solution is to reduce the amount of waste at the production site by improved production processes. It should not be overlooked that, even with the application of the best possible technology, some waste will always be produced. But its percentage will have to be decreased drastically if life on this planet is to be agreeable in the future.

Not only industry but also each individual has to contribute in order to get better air and cleaner water to keep living conditions life-worthy.

Other papers

The influence of supermolecular structure on the properties of polymer films

by Dr U. Zorll

The homogeneous structure of the binder in a paint film should by no means be considered as the most favourable state for achieving adequate mechanical and other essential film properties, quite apart from the fact that many films previously considered as amorphous show a supermolecular structure depending on some more or less fortuitous conditions during film formation. By introducing special supermolecular structures it is also possible to improve the properties of paint films. There are several ways to obtain characteristic heterogeneous structures, of which employing graft or block copolymers with defined internal compatibility or using a solvent mixture of a certain composition, respectively, turned out to be the most important ones.

The benefits of dispersing butyl acrylate, as one component of a graft copolymer system, as a soft phase within a matrix consisting of methyl methacrylate, can be seen from the advantageous viscoelastic properties of such films, which would appear brittle if composed of the matrix material alone. It can be shown that the adhesion at the interface of the two phases remains intact up to elongations of film of about 20 per cent.

The employment of solvent mixtures consisting of solvent and non-solvent of different volatilities leads to films exhibiting a heterogeneous structure characterised by the occurrence of voids, the size of which may vary from colloidal to microscopic dimensions according to the composition of the mixture. At a certain void size, optimal mechanical properties can be obtained: this can be explained by considering the dissipation of internal fracture energy on mechanical loading. The formation of this peculiar structure should be viewed in conjunction with the degree of coiling of the macromolecules in solution and their tendency to develop aggregate structures during film formation. This phenomenon can be studied in particular in films of polyvinyl chloride, vinyl acetate, and cellulose acetate butyrate. The formation of the structure is already beginning in such solutions, as can be verified by their viscous behaviour. It is also possible to confine the formation of heterogeneous structures to the surface area, so that adhesion to another coating may be promoted, while the bulk of film remains in a less structured state.

It is becoming increasingly difficult to synthesize new polymers which have both improved properties and an economically interesting basis for production. Therefore, methods which may improve the properties of conventional polymer material by creating special supermolecular structures provide a promising way for the future development of coatings possessing superior qualities.

Hardening of organic coatings with infra-red lasers by E. Ladstädter and H. D. Hanus

Infra-red sources have been used to harden varnishes for 50 years, but the newly discovered IRASERs (Infra Red Amplification by Stimulated Emission of Radiation) open completely new possibilities for the curing of organic coatings.

Using a 100 watt CO_2-laser emitting at a wavelength of 10.6μm, the possibilities of high-speed curing have been investigated. The experiments carried out so far with this equipment, although not complete, indicate that commercially used stoving systems only need very short irradiation times. The areas hardened in this way are of excellent quality and, despite extreme hardening conditions, are without faults. One of the more important advantages of the new system is the exact control over the area and period of the irradiation, even when the source is at a considerable distance from the irradiated object.

At the moment the process is limited to curing of small areas. However, the intense development in the field of CO_2-lasers is expected to lead both to more efficient equipment and to their use for objects with large surface areas.

The role of coatings in corrosion prevention—future trends by V. Ashworth and R. P. M. Procter

Metallic corrosion involves a complex, electrochemical interaction between a material and its environment. However, in addition to its electrochemical basis, corrosion is affected by chemical engineering factors such as flow rate, heat and mass transfer etc., by metallurgical factors such as microstructure, alloy composition etc., engineering factors such as tensile stress levels, vibrations etc., and chemical factors such as adsorption, film growth, environment composition etc. There are a correspondingly wide variety of approaches to corrosion prevention. In general however, these may be divided into five categories, namely: design, for example elimination of dissimilar metal contacts, reduction of tensile stress level, elimination of moisture traps etc.; materials selection, for example the use of lead in sulphuric acid plant, the avoidance of copper alloys in the presence of ammonia etc.; environmental control, for example the use of inhibitors, the elimination of chloride ions when austenitic stainless steels are used etc.; anodic and cathodic protection, for example by the use of impressed currents and sacrificial anodes; and protective coatings, which in the widest sense of the term includes paints and other organic coatings, metallic coatings and inorganic coatings. In any particular instance a combination of methods would normally be adopted and, of course, with very few exceptions, economic factors are of overriding importance.

In the paper, these and other factors are discussed in rather more detail to put into perspective the present role in corrosion prevention of coatings in general and of paints in particular. An attempt will then be made to outline possible future trends in corrosion prevention and in the role of coatings in protection.

Finish first—fabricate later. The continuing story of coil coating by D. S. Newton

The status of the coil-coating industry in the USA and Europe is reviewed, with an account of the newer types of coating that are appearing on the scene, and the technical requirements which they fulfil. The developments which are likely to take place in the next quarter-century are examined from the standpoint of increasing line speeds and the availability of new markets. The accommodation of the process to reduce effluent and solvent waste to a minimum is considered, and means of enabling polymer technology to be utilised for coil-coating on a broader basis than at present are suggested.

A consideration of powder coating problems by S. T. Harris

The problems of formulation have been discussed at length in many articles, and it is not proposed to elaborate this aspect. Powder coatings will only be firmly established in the paint industry if attention is paid to methods of manufacture, the rheological behaviour of powders and their charge acceptance properties. A subjective appraisal of application and auxiliary equipment is a necessary first step in the design of a foolproof industrial process.

Tomorrow's packaging by G. Scott

The change from traditional materials such as paper, glass and metals to plastics has presented the packaging industry with the problem of ensuring that its products cause minimal pollution of the environment. This has involved a reversal of the trend over the past 20 years toward making polymers more stable. A new policy is emerging which is to design the package for the purpose it is intended to fulfil.

Recent advances in the knowledge of

the mechanism of stabilisers for polymers has led to the development of practical stabilisers which permit the polymer to be subjected to normal fabrication operations unchanged, but which act as activators for the destruction of the polymer in the presence of ultra-violet light.

The practical and social implications of these discoveries will be discussed.

The future for colour measurement by K. McLaren

Three developments in technology are likely to have a marked impact on all industries engaged in producing products in which colour is an important characteristic. These are, first the revolution in the design of colorimeters, which by the use of modern techniques such as integrated circuitry and digital display are able to combine reliability with speed and reasonable cost. Secondly, current work on colour difference measurement can be expected to result in objective methods of specifying tolerances which will be more reliable than the subjective judgment of a single expert colourist. Thirdly, powerful digital computers are now available at reasonable cost which can be linked to spectrophotometers and colorimeters so that the complex mathematics of match prediction and colour difference calculation can easily be carried out.

These developments will make it possible, long before the year 2000, to define the shade required by twelve digits obtained from a spectrophotometer/computer combination, to predict how the shade can best be obtained, and to calculate how the first attempt to produce it must be adjusted to bring the closeness of the match within a numerically specified tolerance which will have replaced the subjective judgment of an expert colourist.

Hundred years of standards by C. Meredith

In the year 2000 the BSI, the world's oldest standards organisation, will be very nearly 100 years old.

Standards-making is essentially a service—to industry, government, the professions, and the community at large—that strives to keep pace with technical advance. Each of the expert forecasts relating to other subjects, therefore, has implications for the standards that will be needed and made possible, but it is hard to make even intelligent guesses on just how far these may have developed by the year 2000. It is easier to study past developments and present trends which already help to shape the future, e.g.

- increased co-operation and alignment of national and international standards on the one hand, and of national and sectional (industrial, government, consumer) standards on the other;
- standardisation of product performance rather than the precise means by which it is achieved;
- paints and varnishes in competition and co-operation with other surface coatings and with self-coloured materials;
- the number and form of standards as a facet of the general "information explosion."

Electrochemical activity of conductive extenders for zinc rich coatings by V. P. Simpson and F. A. Simko Jr.

Refractory ferro alloys which are both conductive and inert to most relevant corrosive environments have been studied as partial replacements for zinc in zinc rich coatings. Electrochemical phenomena, corrosion resistance and welding data have been obtained for iron phosphide (ferrophosphorus) extended systems. Potentiostatic studies of the conductive extender alone have shown it to have very low anodic activity, with a cathodic activity equivalent to mild steel.

Cathodic inhibitors such as Zn^{2+} reduced this activity by several orders of magnitude. The zinc and extender particles initially behave as galvanic couples, allowing initial increased activity of the zinc particles. However, on weathering, the adsorption of zinc salts leads to very low anodic zinc dissolution rates.

Studies of extended coatings on steel using the 10mV linear polarisation method together with salt fog testing have tended to confirm these initial observations. They also show that the products of both zinc dissolution and cathodic reduction are more evenly distributed throughout the coating, thus leading to reduced blistering between the coating and substrate, and the primer and topcoat. This phenomenon is especially evident for synthetic sea water immersion, where iron phosphide extended zinc rich primers give greatly reduced activity at the air/water interface.

The random angular particle shape, reduced CPVC and high conductivity of these extenders have also contributed to the overall weldability of zinc rich primers. All facets of both the resistance and arc welding process have been improved by their incorporation. Weathered films have also been successfully welded owing to the remaining inert conductive skeleton.

Both organic and inorganic bound systems have been studied extensively.

The chloride ion in epoxy/polyamide films and the substrate effect by J. D. Murray

In the study of permeability properties of thin films there are several advantages to be gained from an approach involving sorption or desorption methods. Experimentally the efficiency of the sealing of a film is no longer a problem and, whereas small imperfections on a permeated thin membrane can completely alter the permeation rate, they have very little effect on sorption kinetics.

The permeation method also suffers from theoretical drawbacks. Since the concentrations measured relate to outside the film the amount of transported species relates directly to the permeability coefficient (*P*) and not to the fundamental parameter of the system, the diffusion coefficient (*D*). Even the "time lag" method of deriving *D* from permeation data is susceptible to considerable error.

Lastly, sorption or desorption techniques can be applied to films adhering to a substrate, which is the real situation experienced in the surface coatings field.

By modification of the design of the permeation equipment, desorption rates for free and attached films of epoxy polyamide have been measured. Sorption rates have been investigated by means of neutron activation analysis on film samples.

Even though this polymer medium interacts with the aqueous medium, by application of initial rate analysis the average diffusion coefficient for the range of concentration encountered can be calculated. So too can the partition or solubility coefficient, and the product of the diffusion and solubility coefficients gives the permeability coefficient (*P*).

The diffusion of Cl^- in attached films appears to occur at a similar but higher rate to that in free films. However, the solubility is substantially lower for attached films. This latter effect can be understood in terms of a constraint on polymer movement which limits the accessibility of ionogenic sites. The value of *P* is consequently lowered for attached films, although for this particular system the difference is relatively slight.

The characterisation of mechanical properties of paint films by R. L. J. Morris

The physical testing of paints has hitherto been conducted, in general, by attempting to reproduce in a standardised manner the type of behaviour or property that the paint is required to meet in practice. In recent years, a trend has been discernible towards less subjective methods of assessment in the desire for greater quantification of results and a less equivocal interpretation of data. If benefits can be shown to exist then this trend will surely develop in the coming decades.

Micro-indentation as a technique, well established over the past thirty years in the field of rubber technology, is attracting increased current attention with regard to its applicability to paint testing. The data derived from this technique has been classified in terms of a log load/log indentation relationship and the infinitesimal hardness and three micrometre temperature behaviour of paint films.

The results of micro-indentation testing have been correlated with glass transition temperatures, brittle point, extensibility and permeability.

It is proposed in this paper that each paint has a characteristic indentation/temperature curve which on ageing is displaced with respect to temperature. It is also shown that changes in the curve occur after periods of ageing which should reflect changes occurring in the molecular constitution of the film. The intercept of the log load/log indentation straight line relationship is shown to give the same order of value as for a tensile modulus of a free film.

Although it is too early to be able to assess the validity of this approach to being able to predict and interpret behaviour of paints in practice, it is nevertheless probable that a greater understanding of their mechanical behaviour will be achieved.

Techno-economic aspects

The American paint industry—present trends and future prospects by F. Armitage

A brief review of published patents and commercial exploitation in such fields as electrodeposition, powder coatings, non-aqueous dispersions, ultraviolet and electron beam curing and so-called "bubble" coatings may lead to forecasts about future developments in the light of economic considerations and the possible continuation of the current emphasis on anti-pollution measures in the States.

The present and future influence of American know-how on European technology, and movement in the opposite direction, will be examined, and the growing commercial influence of the larger American companies scrutinised.

Relations with developing countries by A. T. S. Rudram

Attitudes are changing daily, but an attempt will be made to relate political, economic and social patterns to the relationship likely in the approaching years. The scale of development varies depending upon date of independence, location and ethnic factors, but one factor is common to all emergent nations, namely, the nationalistic one. There is a desire to control in whole, or in part, local industries and the desire is marked by a range of interests from expropriation, at one end, to some degree of equity participation at the other. As far as is possible an opinion will be offered about the likely impact of these local attitudes.

Britain and the EEC—technico-commercial aspects

The probable effects on the British paint industry of the UK membership of the EEC will be considered from a variety of viewpoints. Market requirements vary considerably from country to country, and the question of whether there will be greater uniformity in requirements in future will be discussed. In some markets there are already very similar technologies in various countries but in others, different solutions have found favour.

The growth of multi-national paint and raw material producers must be considered.

Factors affecting trends towards greater uniformity include differences in raw material prices, standards, and safety regulations, and examples are provided. EEC regulations and precedents on such matters as technical agreements, licensing and sales agreements will be treated, together with trends in international trade and marketing.

The EEC cannot, however, be considered in isolation in paint technico-commercial matters, and its relation to other sources of technology must also be considered.

Foundation Lecture

The Association's Foundation Lecture, held biennially to commemorate its inception in 1918, took place on 3 October 1972. The evening's proceedings began with a commemorative service at the church of St. Vedast-alias-Foster, Foster Lane, the venue of the service held as part of the Association's 50th Anniversary celebrations in 1968. Members gathered for a short service of hymn and prayer conducted by Reverend C. G. How, during which the President, Mr A. W. Blenkinsop, read the lesson, taken from Psalm 139.

Later, the company assembled at the Painters' Hall, Little Trinity Lane, where Mr Blenkinsop introduced the Foundation Lecturer, Sir James Tait, Vice-Chancellor of the City University, who was to speak on "The City, a technological university—are tradition and technology compatible?"

In a witty and wide-ranging talk, Sir James outlined his view of the position of a technological university—an emotive term in the context of traditional universities, which had been set up to teach the sons of the well-to-do Greek, Latin and Theology. Yet all art was a realisation of a technique or a technology, and technological education must hold at least an equal place in the overall scheme today.

He went on to outline the history of the City University, starting with the formation in 1896 of the Northampton College, following the realisation brought on by the Great Exhibition of 1851 that Britain was falling behind other nations because of its attitude to technical education. It was interesting to note that the objectives of the college at its formation were: "to promote the industrial skill, general knowledge, health and well-being of young men and women," exactly those of the St. Bride Institute, where OCCA held its early meetings.

Sir James felt that, as Principal of the Northampton Institute, he was privileged in being one of the few men who had had an opportunity to build a university, particularly one such as the City, one of the few in a very big city, and set as it was in an area that still contained a high concentration of skilled craftsmen in almost forgotten trades—watchmakers, jewellers, antique repairers. The City University was in a unique position, where students could get out easily to mix in society, a need which many older universities could not supply. Its position was perhaps most advantageous in the case of the City Business Centre, from which 90 students graduated each year. Set midway between the Guildhall and the Bank of England, the Business Centre enjoyed an excellent selection of visiting lecturers, since business men could leave their office, give the lecture and be back in the office for the afternoon without difficulty or in many cases reliance on transport.

Sir James gave many more detailed insights into the planning and working of the City University, all illuminated by his obvious and lively enthusiasm for the project. He ended by saying that it was his belief that the real purpose of education was to prepare students to serve mankind, and that such preparation took place best in a living city, where science and society, future and traditional skills were side by side.

The President complimented Sir James on his most interesting and amusing presentation, which it is hoped will be published in the *Journal* in the near future, and called upon Mr D. S. Newton, the Honorary Secretary, to propose the vote of thanks, which was carried with acclamation.

The company then adjourned for a short break for aperitifs before gathering for the dinner, at which the top table party was clapped to its seats in the now traditional manner. Following the meal, the President proposed the loyal toast, and went on to give an address of welcome to the guest of honour, together with the Past Presidents and past Honorary Officers present. Dr H. W. Keenan, President 1944-47, replied on behalf of the guests, and the formal proceedings closed with a toast to the ladies by Mr F. D. H. Sharp, Chairman, Irish Section, to which Mrs K. Driver, Chairman, West Riding Section, responded.

R.W.

Foundation Lecturer Sir James Tait (centre) seen with the President, Mr A. W. Blenkinsop (left), and Mr R. H. Hamblin (Director & Secretary)

Report of Meeting of Council

A meeting of Council was held at Wax Chandlers' Hall, Gresham Street, London, on Tuesday 31 October 1972, when the President, Mr A. W. Blenkinsop, was in the chair. There were 34 members present.

Council were saddened to learn of the death of a former Chairman of the Hull Section, Mr. E. A. Brown, and stood in silence in his memory.

It was reported that two appointments to BSI Committees had been made; Dr L. A. O'Neill to Committee PVC/3/5—Test Methods for Paint Media and Mr W. A. Ledger to Committee CIC/6—Glycerol.

Mr C. J. A. Taylor, because of ill-health, had tendered his resignation from two Committees of the Council and the following were appointed to replace him—Dr J. G. Gillan on the Professional Grade Committee and Mr J. R. Taylor on the Publications Committee.

It was reported that arrangements had been made for the capitation fees charged for the next three years to OCCA Australia and that the Australian Federal Committee had accepted the suggestion that Mr A. G. Holt should serve for this session as a co-opted member of the Council to speak on behalf of OCCA Australia.

Council examined the Commemorative Scroll which had been prepared for presentation at the Fiftieth Anniversary Meeting of the Federation of Societies for Paint Technology, to be held in Atlantic City later that month, by the President, Mr A. W. Blenkinsop.

Council were informed of the very great difficulties which had been encountered in finding alternative accommodation for the Association's offices, and that the search had been made in many parts not only of Central London but in the surrounding suburban areas. Council empowered the President's Advisory Committee to take whatever action was necessary, since the current lease expired at the end of the year.

The fees for the 1973 Conference were discussed and agreed at £30 for Members, £10 for Wives and £50 for Non-Members, with a daily registration fee, restricted to Members of the London and Thames Valley Sections only, of £12 per day. The Conference Programme of 18 papers in five sessions, together with three Workshop Sessions, was reported fully to the Council and is published in another part of this *Journal*. Council further discussed the venue for the 1975 Conference and possible alterations in the format for the 1977 Conference.

As the closing date for applications for the Exhibition had been the preceding day, Council were informed that the space requested had been substantially greater than for the 1972 Exhibition and that the support for the Exhibition was widespread both by countries and by products. Since the Exhibition opening hours had been changed on this occasion to allow for a longer time for the Exhibition to be open on the Monday, an Exhibition Dinner was to be organised on the Monday in place of the Exhibition Luncheon. It was pointed out that many exhibitors had on numerous occasions asked for a function of this kind to be organised, so that it was confidently expected that this will be well supported.

Arrangements to hold the Exhibition at Olympia in April 1974 and April 1975 were confirmed.

The accounts for the half-year and estimates for the second half of the year were submitted by the Hon. Treasurer and approved, and it was also reported that the number removed from the Register of Members for non-payment of the current year's subscription was very much lower than for 1971.

The Hon. Treasurer also reported that the advertisement rates for the *Journal* had been increased with effect from 1 January 1973, when the *Journal* would take the A4 size, but it was pointed out that the difficulty in amending rates charged for Association activities was that they took a considerable time to come into effect. This was particularly noticeable with Membership subscriptions, where the Articles laid down a procedure by which any amendment to the rates had to be passed by two successive Council Meetings and then by a General Meeting of the Members. This meant, therefore, that the next possible occasion on which the Membership fees could be increased would be 1974, and it was recalled that the last increase had been made in 1968.

Members of Council had received information with the Agenda on the way in which the proposed Value Added Tax, which would come into effect on 1 April 1973, would affect the Association's finances and this was discussed at length.

The Hon. Editor reported that the membership as a whole had seemed to approve of the Publications Committee's and the Council's decision to change the *Journal* size to A4. With regard to the Paint Technology Manuals, the situation here was both encouraging and disappointing at the same time. So successful had the Manuals been that only the second edition of Part III was now available for sale, but the Publications Committee had been disappointed that it had not been possible to obtain manuscripts for the revisions of Parts IV and V by this time. Council congratulated Mr Finn on the way in which Part VII had been appearing in the Student Reviews during the year and it was reported that reprints of this Volume would be available during the early part of 1973.

Mr H. C. Worsdall was appointed to represent the Association on the Technical Training Board for the Printing Ink and Roller Making Industry to replace Mr N. C. Locke whose term as one of the Association's representatives thereon terminates at the end of December.

It was reported that arrangements had been made for papers to be given on behalf of the Association at both the SLF Conference in 1973 and the FATIPEC Congress in 1974.

The Association's representative (Mr S. A. Ray) on BSI Technical Committee PVC/11—Glossary of Paint Terms has asked for assistance with the revision of BS 2015—Glossary of Paint Terms and this was referred to the Association's Technical Committee.

Details of the first year's working of the Professional Grade were reported to Council; these had been published in the November issue of the *Journal*. Council decided that, with effect from 1 January 1973, the Certification Fees payable would be: Fellows £10, Associates £6, and Licentiates £3.

Council were pleased to learn from recent membership applications that there was a considerable interest in the Association in Madrid, and a Past President, Mr F. Sowerbutts, would be meeting a Member there later in the month to discuss possible future activities. It was also reported that a Past Chairman of the London Section, Mr H. A. Newnham, would be lecturing to the Wellington Section, and Council approved two Commendation Awards to Past Chairmen of that Section, Mr T. W. Slinn and Mr A. C. McEwan.

Reports on activities in the Sections were then presented to the Council.

There being no other business the President thanked members for their attendance and reminded them that the Commemorative Service would be held at St. Vedast-alias-Foster at 6.15 p.m. and that this would be followed by the Foundation Lecture, to be given by Sir James Tait, Vice-Chancellor of the City University, and the Foundation Dinner at the Painters' Hall. Full details of these functions are reported in another part of this *Journal*.

London Section

Symposium: Implications of pollution for the coatings industry

The London Section is to organise a one-day symposium under the above title to be held at the Thamesside Polytechnic, Woolwich, at 10.00 a.m. on Wednesday 24 January.

Four papers will be presented: "Printing waste" by Mr K. Pond of Shuck MacLean & Co. Ltd., "Pollution, industry and responsibility" by Dr R. C. Denney of Thamesside Polytechnic, School of Chemistry; "Pollution of water by industrial waste products" by Mr M. D. Longstaff of the Trade Effluent Section, GLC; and "Solvents" by Mr A. J. Goodfellow of Carless, Capel & Leonard Ltd.; and they will be followed by a film made by Farbwerke Hoechst AG entitled "The yellow trail".

Fees for the symposium will be £2.50 for Members, and £3.50 for non-members, including morning coffee, lunch, and afternoon tea; students may attend free of charge.

South African Section

Possible revival of Cape Town Branch

The attendance of 25 Members at a recent lecture held in Cape Town has encouraged hopes that the once active Branch of the South African Section based in the city might be revived. The lecture, arranged at the instigation of Mr A. G. Shepherd, a past-Chairman of the Transvaal Branch who has recently moved to Cape Town in the course of business, was presented by Mr T. Entwhistle of S. A. Titan Products, and was entitled "Secondary effects of paint additives."

At present there are 28 Members living in Cape Province, but eight of these are situated too far from Cape Town to travel to meetings, and thus another 20 members must be found before Branch status can be conferred. Mr Shepherd hopes to recruit sufficient new Members by the end of the year, and until this time will act as Cape Secretary and arrange occasional meetings.

Obituary

Mr E. Evensen

We record with regret the recent death of Mr E. Evensen, an Ordinary Member attached to the Manchester Section. Mr Evensen had served as a Member of the Association for over 25 years.

News of Members

Mr J. B. Davis, an Ordinary Member attached to the Manchester Section, has been appointed production director of Goodlass Wall & Co. Ltd., with responsibility for production, warehousing, transport and purchasing at both the Speke and Hebburn works. Mr Davis was previously technical director.

Dr D. B. Bruce, an Ordinary Member attached to the Manchester Section, has been appointed development director of Goodlass Wall, with responsibility for all laboratories, quality control and technical liaison throughout the company. Dr Bruce was previously technical manager.

Mr M. J. Shirt, an Ordinary Member attached to the West Riding Section, has been appointed technical director of International Colloids Ltd., having previously been technical manager.

Mr L. H. Silver, an Ordinary Member attached to the West Riding Section and President-Designate of the Association, was presented by the staff of Silver Paint & Lacquer Company with a silver miniature paint can at a staff dinner held in September as the last in a series of functions organised to commemorate the company's 25th anniversary.

Lady members of the SPL staff were presented with a silver bracelet embossed with the company initials, and all men with silver cufflinks similarly treated.

Association Notices

Applications for membership

It is felt that the members would like to be reminded of the standard of competence for the election of candidates to Ordinary Membership of the Association, as laid down by the Council, when they are sponsoring candidates for election. The qualifications for the granting of Ordinary Membership at the present time are:

1. A degree in a scientific subject or any generally accepted equivalent qualification; or an approved technological qualification in a subject covered by the Association.

2. Or where there is adequate evidence of the technical competence of the candidate other than the obtaining of the qualifications mentioned above, the qualifying period of practice in the

industries covered by the Association shall be normally not less than seven years.

Associate Membership is open to those employed in the industries who do not qualify for Ordinary Membership.

The Council has further resolved that Student Membership should be open without restriction to the age of 21 years and may be extended to 25 years of age, where candidates are following courses of technical study to the satisfaction of their employers or technical college lecturers.

Retired members

Council also wishes it to be known widely that in 1962 it introduced a reduced membership subscription rate for members who have retired from business. This applies to a member who has completed 20 years as an Ordinary or Associate Member and has retired from business, and normally has reached the age of 60; he may apply for his name to be retained on the Register of Members at an annual subscription rate of £1.05 and he will retain the same rights of membership as the class of membership to which he was attached upon retirement.

Members wishing to avail themselves of this concession should write, in confidence, to the Director & Secretary at the address shown on the front cover of this *Journal*, giving the relevant information under the four headings: (*a*) name, address and Section, (*b*) date of election, (*c*) date of retirement, (*d*) age.

Change of address

Members changing their address are urged to inform the Association's office immediately so as to avoid any misdirection of mail. This is particularly important as far as the *Journal* is concerned.

Will members please note that since membership of the Association is entirely on an individual basis, if notification of the change of an address for a company is sent to the Association's office this will not necessarily guarantee the change of address in the Association's records of the member concerned unless the name of the member is stated on the communication.

Binding of the "Journal"

Members will be pleased to know that W. Heffer & Sons Ltd., Hills Road, Cambridge, will undertake the binding of back volumes of the Association's *Journal* sent in by individual members at a cost of £2.50 per volume.

Members wishing to avail themselves of this facility should send the parts direct to W. Heffer & Sons Ltd., enclosing a remittance of £2.50 and ensuring that notes bearing their names and addresses are enclosed with the parcels.

1973 members' subscriptions

Members are reminded that 1973 Membership subscriptions to the Association are payable on 1 January 1973. Forms were despatched to all Members in October or November, depending upon address.

New members may like to know that the Commissioners of Inland Revenue have approved of the Association for the purpose of the Income and Corporation Taxes Act, Section 192, so that a member subject to United Kingdom income tax is entitled to a deduction from the amount of his emoluments assessable to income tax for the whole of his annual subscription to the Association, provided the subscription is defrayed out of the emoluments of his office or employment and that the interests covered by the objects of the Association are relevant to such office or employment.

Claims for adjustment of PAYE code numbers should be made on form P.358, copies of which may be obtained from local tax offices.

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

CHANG, VINCENT Y. S., No. 45, Section 2, Hankow Street, Taipei, Taiwan, Republic of China. (*General Overseas*)

FITZPATRICK, THOMAS JAMES, BSc, Box 4636, Cape Town, South Africa. (*South Africa*)

GRIFFITH, ROBERT C., BS, 4801 N. Harlem, Chicago, Illinois 60656, USA. (*General Overseas*)

LILLY, ERIC GORDON, 18 Warwick Road, Rainham, Essex RM13 9XU. (*London*)

MORTIMER, ARTHUR, AMCST, 11 Duke Street, Glossop, Derbyshire. (*Manchester*)

NORWOOD, TERENCE JAMES, BSc, PO Box 38073, Petone, New Zealand. (*Wellington*)

PACO, BERNARDINO, BSc, 13 Road B, St. Anthony Village, Quezon City, Philippines. (*General Overseas*)

SAUNDERS, JAMES, BSc, PhD, Ciba-Geigy (UK) Limited, Pigments Division, Hawkhead Road, Paisley PA2 7BG, Renfrewshire, Scotland. (*Scottish*)

Associate Members

ADESANYA OSINOWO, OLUSOLA, 13 Araromi Street, Shomolu, Lagos State, Nigeria. (*General Overseas*)

LEOKITA, JOANES SOENDORO, Gondangdia Ketjil 11A, Djakarta, Indonesia. (*General Overseas*)

WHIFFIN, JOHN HUGH, c/o PO Box 9101, Wellington, New Zealand. (*Wellington*)

Student members

BURRISON, ROBERT ERNEST, Burrell & Co. Ltd., 262 West Ferry Road, Millwall, London E14. (*London*)

CLARK, STEPHEN, 8 Middlesex Road, Ings Road Estate, Hull. (*Hull*)

DREW, GRAHAM, 248 Summergangs Road, Hull. (*Hull*)

GOFORTH, GRAHAM GEOFFREY, 7 Coverdale, Sutton Park, Hull. (*Hull*)

LINFORD, COLIN EDWARD, 208 Biggin Avenue, Bransholme, Hull. (*Hull*)

LOVE, ALEXANDER, Smith & Rodger Ltd., 34 Elliot Street, Glasgow, Scotland. (*Scottish*)

MACKENZIE, WILLIAM GEORGE, 75 Ivyhouse Road, Dagenham, Essex. (*Thames Valley*)

MUSSON, CLIVE EVERITT, 19 Salisbury Street, Hessle, East Yorkshire. (*Hull*)

OVERTON, STUART, 18 Feldane, Dane Park Road, Orchard Park Estate, Hull. (*Hull*)

WILD, JAMES CHARLES, 521 Bolton Road, Darwen, Lancashire BB3 2JP (*Manchester*)

Forthcoming Events

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

Monday 4 December

Hull Section: "Technology—kill or cure" by Dr C. Stoneman of Hull University, to be held at the Queens Hotel, George Street, at 7.00 p.m.

Wednesday 6 December

London Section: Ladies Invitation Evening. "Colour in decoration" by Mr D. C. Mason of ICI Ltd., Paints Division, to be held at the Polytechnic of the South Bank at 7.00 p.m.

Thursday 7 December

Midlands Section—Trent Valley Branch: "Wallpaper manufacture" by Mr S. Duckworth of WPM Ltd., to be held at the British Rail School of Transport, London Road, Derby at 7.00 p.m.

Newcastle Section: "Accelerated testing of durable coatings" by Mr A. Oakley of Tioxide International Limited, to be held at the Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne, at 6.30 p.m.

Thames Valley Section—Student Group: "Powder coatings" by Mr H. T. Chellingsworth of Ault & Wiborg Industrial Finishes Ltd., to be held in the main Lecture Theatre, Slough College at 4.00 p.m.

Friday 8 December

Bristol Section: Joint meeting with the Institute of Metal Finishing, South West Branch. "The economics of powder coating" by Mr R. Mansell of Dunlop Ltd., to be held at the Royal Hotel, Bristol at 7.15 p.m.

Irish Section: Ladies' Night. Film show and social evening. To be held at the Clarence Hotel, Dublin at 8.00 p.m.

Midlands Section—Trent Valley Branch: Christmas buffet social, to be held at the Cross Keys Inn, Turnditch, at 8.00 p.m.

Monday 11 December

London Section: Joint with the SCI Colloid and Surface Chemistry Group, "Zeta potential, its use and abuse" by Dr A. L. Smith of the Liverpool Polytechnic, to be held at 14 Belgrave Square, London SW1, at 6.00 p.m.

Tuesday 12 December

West Riding Section: Chairman's Lecture: "Wood, our oldest friend" by Mrs K. Driver, to be held at the Griffin Hotel, Leeds at 7.30 p.m.

Wednesday 13 December

Manchester Section: "Water pollution control: objectives and methods" by Mr F. Buckley of the Lancashire River Board, to be held at the Royal Institution, Colquitt Street, Liverpool 1, at 6.30 p.m.

Newcastle Section—Student Group: "Titanium dioxide" by a speaker from Tioxide International Ltd, to be held at the Newcastle Polytechnic, Ellison Place, Newcastle at 3.00 p.m.

Thursday 14 December

Scottish Section: Joint meeting with the Society of Dyers and Colourists—Scottish Region. "Industrial relations 1972" by Mr J. F. Shaw of the Department of Employment and Productivity, to be held at the St. Enoch Hotel, Glasgow at 6.00 p.m.

Saturday 16 December

Scottish Section—Student Group: Joint meeting with Eastern Branch. Works visit to Linwood Plant of Chrysler

Scotland Ltd. with a lecture on "Automotive finishes" by Mr J. McQuade.

Wednesday 20 December

Scottish Section—Eastern Branch: Joint meeting with BPBMA "Adhesives for paper and board in packaging" by Mr D. L. C. Childs of Harlow Chemical Co. Ltd., to be held at the Carlton Hotel, North Bridge, Edinburgh at 7.30 p.m.

Thursday 4 January

Newcastle Section: "Business planning; only a numbers game?" by Mr J. Willey of Berger, Jenson & Nicholson Ltd., to be held at the Royal Turks Head Hotel, Grey Street, Newcastle, at 6.30 p.m.

Monday 8 January

Hull Section: "Is the paint industry on the move?" by Mr D. E. Eddowes of Polymers Paint & Colour Journal, to be held at the Queens Hotel, George Street, Hull, at 7.00 p.m.

Tuesday 9 January

West Riding Section: "High speed milling" by Mr D. W. Wilkinson of Augusts Limited, to be held at the Griffin Hotel, Leeds, at 7.30 p.m.

Wednesday 10 January

London Section: "The inkmaker and heat transfer inks" by Mr D. W. Woods of Coates Bros. Inks Ltd., to be held at the South Bank Polytechnic at 7.00 p.m.

Newcastle Section—Student Group: "Fields of application of synthetic resins" by Dr A. F. Everard of Berger Chemicals Ltd., Resinous Chemicals Division, to be held at Newcastle Polytechnic, Ellison Place, Newcastle, at 3.00 p.m.

Thursday 11 January

Thames Valley Section—Student Group: "Marine coatings" by a speaker to be announced. To be held at the Main Lecture Theatre, Slough College, at 4.00 p.m.

Friday 12 January

Manchester Section: "Design is where you find it", a talk on the psychology of colour and design, by Mr E. Pond of WPM Ltd., to be held at the Manchester Literary and Philosophical Society at 6.30 p.m.

Scottish Section: Annual Dinner Dance, to be held at the Central Hotel, Glasgow.

Wednesday 17 January

Manchester Section—Student Group: "Solvents in paints and printing inks" by Mr C. J. Nunn of Shell Research Ltd., to be held at the Manchester Literary and Philosophical Society at 4.30 p.m.

Scottish Section: Joint meeting with BPBMA, Technical Section. "Adhesives", speaker and venue to be announced.

Scottish Section—Eastern Branch: "Modern analytical techniques" by Mr P. S. Nisbet of A. B. Fleming & Co. Ltd., to be held at the Carlton Hotel, North Bridge, Edinburgh, at 7.30 p.m.

Friday 19 January

Irish Section: "Marketing in the context of the small firm" by Mr Rock of the Irish Management Institute, to be held at the Clarence Hotel, Dublin, at 8.00 p.m.

Midlands Section: Annual Dinner Lecture "Purchasing in the paint industry" by Mr D. F. Brocklehurst of BJN Group Supplies Ltd., to be held at the Birmingham Chamber of Commerce and Industry, 75 Harborne Road, Birmingham 15, at 6.30 p.m.

Saturday 20 January

Scottish Section—Student Group: "Pigments for plastics" by Mr S. T. Bebbington of ICI Ltd., to be held at the St. Enoch Hotel, Glasgow, at 10.00 a.m.

Wednesday 24 January

London Section: Whole day symposium at Thamesside Polytechnic, Woolwich. "Implications of pollution for the coatings industry." Papers: "Printing waste" by Mr K. Pond of Shuck MacLean & Co. Ltd.; "Pollution, industry and responsibility" by Dr R. C. Denney of Thamesside Polytechnic; "Pollution of water by industrial waste products" by Mr M. D. Longstaff of the Trade Effluent Section, GLC; "Solvents" by Mr A. J. Goodfellow of Carless, Capel & Leonard Ltd. Film "The yellow trail".

Thursday 25 January

Thames Valley Section: "Recent aspects of anti-corrosive pigments" by Mr M. Rendu of Imperial Smelting Corp. (Alloys) Ltd., to be held at the Beech Tree Hotel, Maxwell Road, Beaconsfield, Bucks, at 7.00 p.m.

Friday 26 January

Bristol Section: "Gravure printing", speaker to be announced. To be held at the Royal Hotel, Bristol, at 7.15 p.m.

Index to volume 55—1972

Key:

(C)—Correspondence
(D)—Discussion
(E)—Editorial and Comment
(N)—Notes and News
(R)—Reviews
(S)—Section Proceedings
(SC)—Short Communications
(SR)—Student Review
(T)—Transactions and Communications

Authors

Subjects

Keywords

Reference list of papers

The number given opposite each keyword in the index below is the key number allocated to the paper to which the keyword refers, as shown in the above reference list. It is not a page number; this can be obtained from the reference list.

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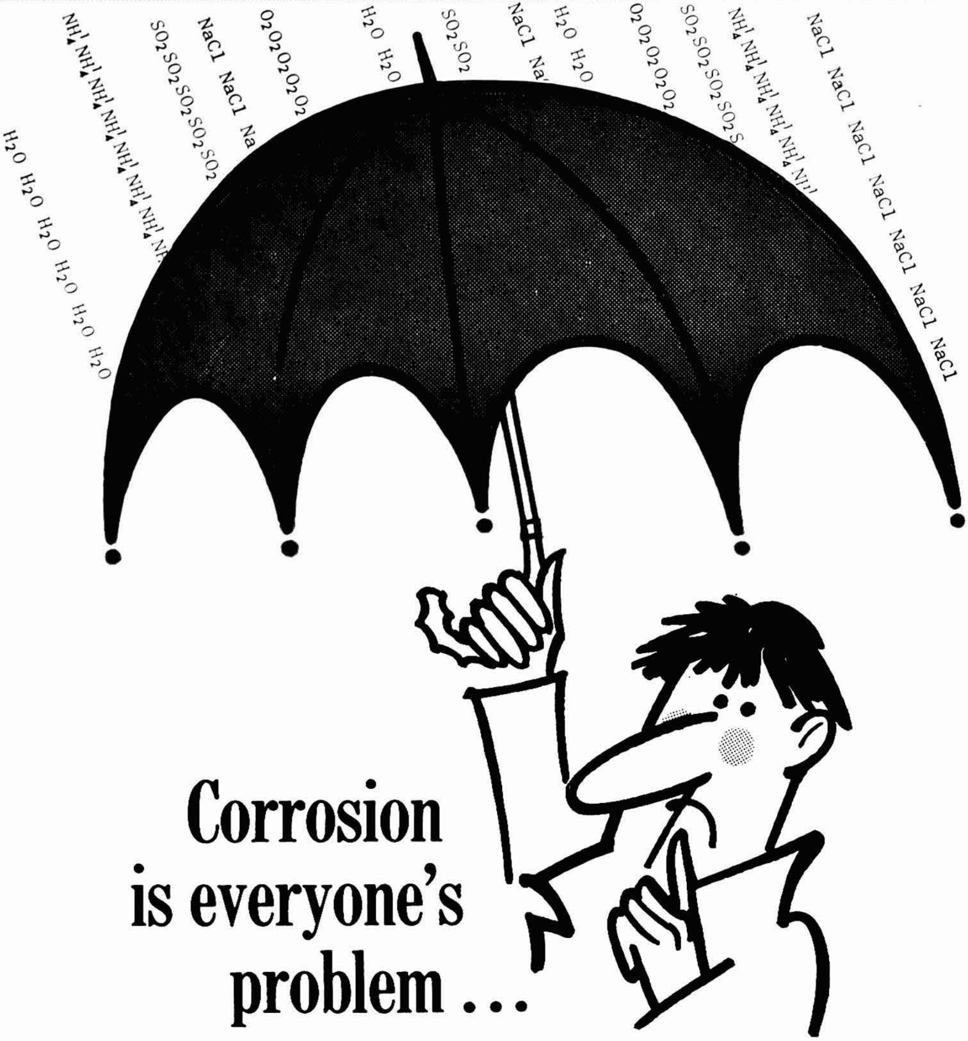
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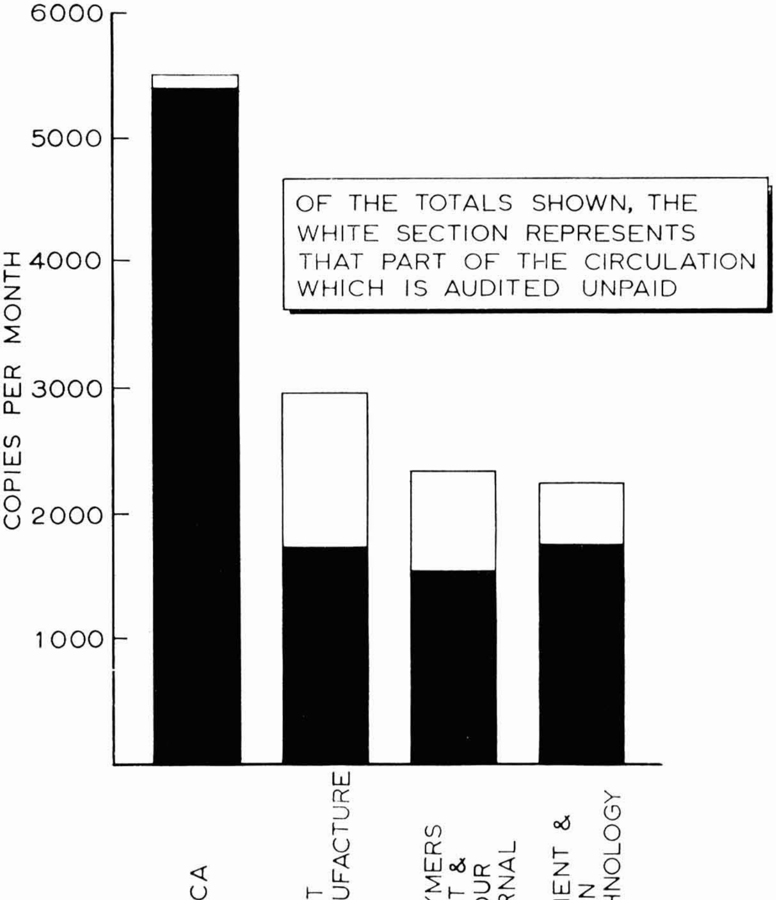

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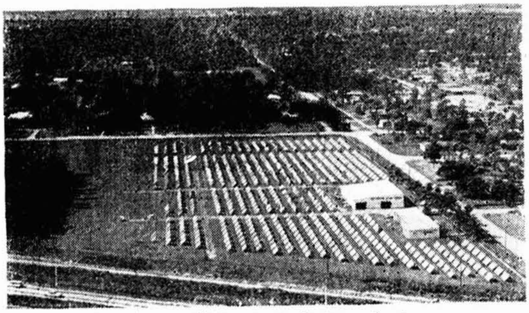

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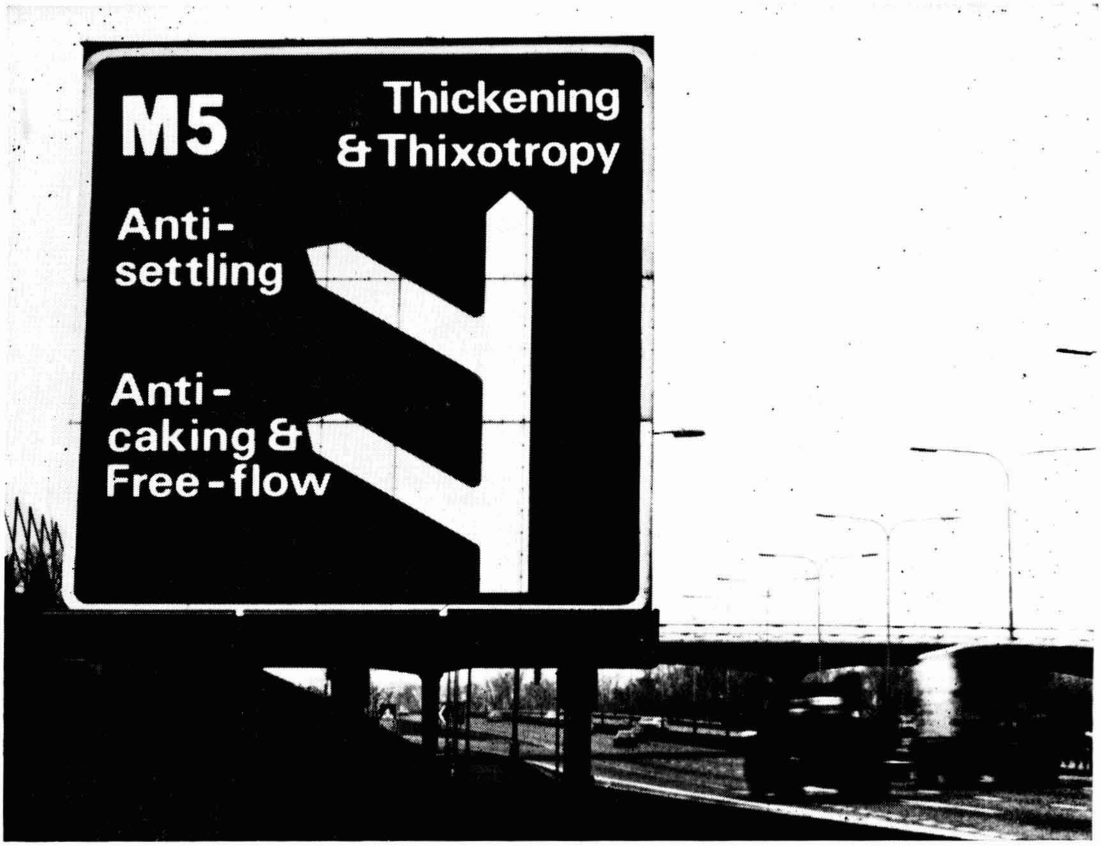
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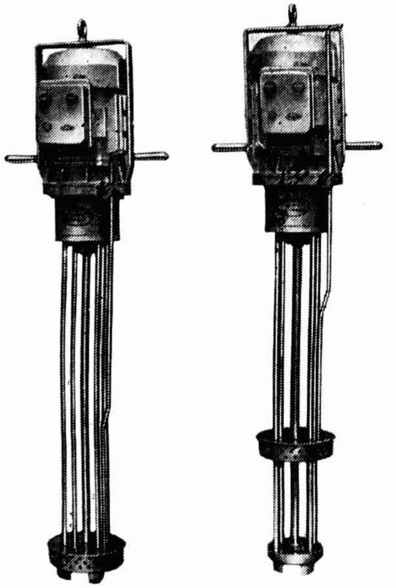

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