

# JOURNAL

OF THE

# OIL AND COLOUR CHEMISTS' ASSOCIATION



Vol. 44, No. 12 COPY 2 December, 1961

*TRANSACTIONS AND COMMUNICATIONS* DEC 27 1961

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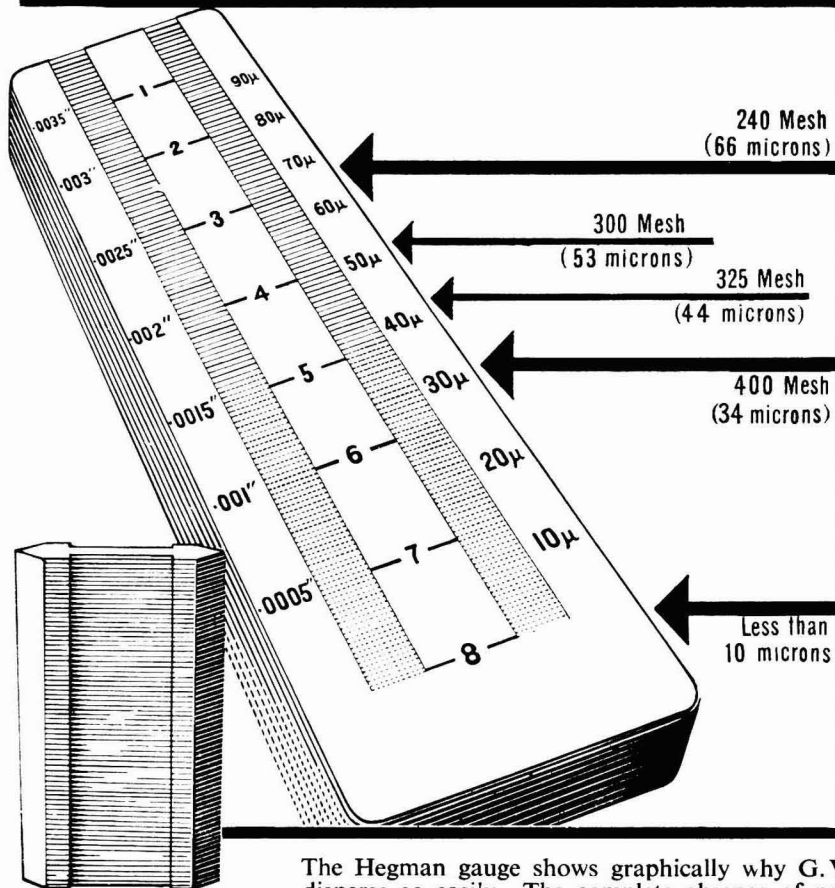
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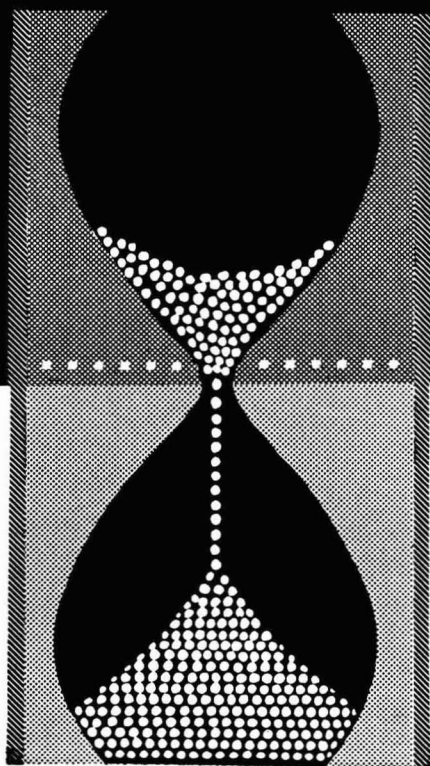
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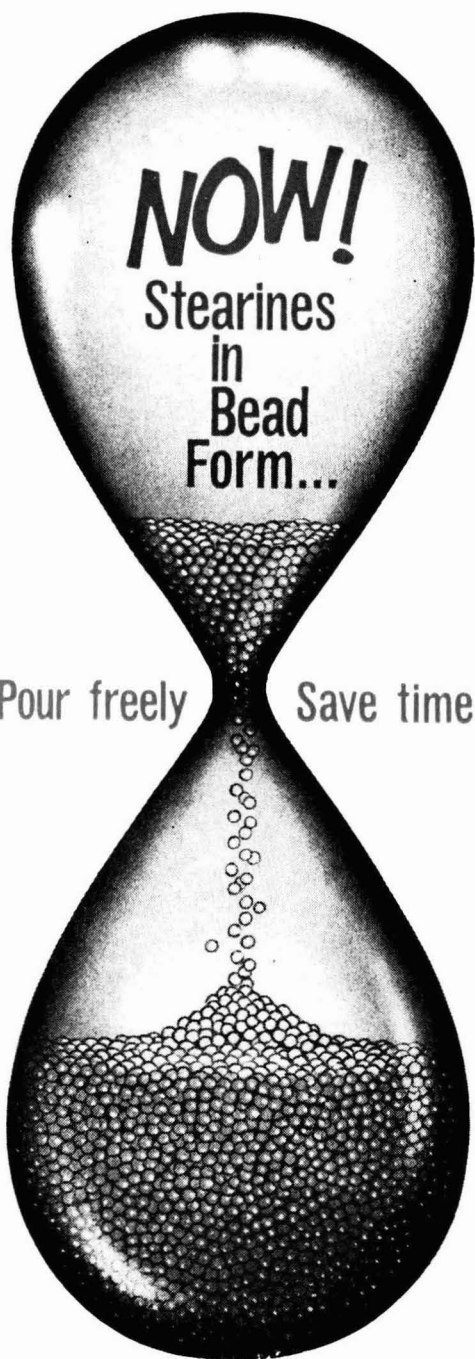


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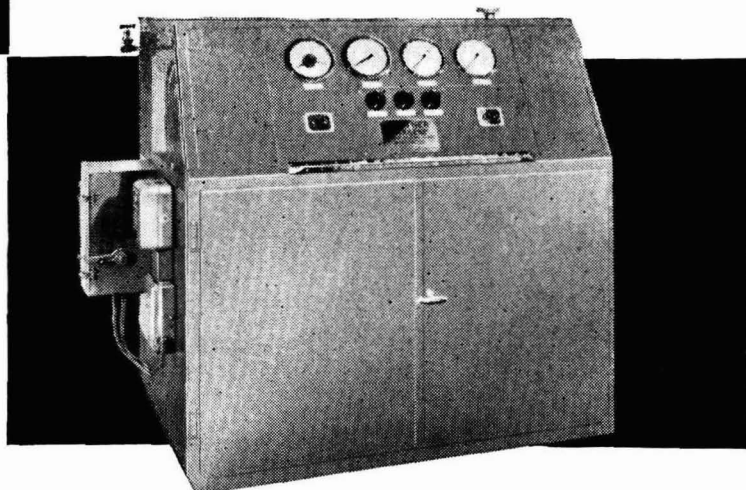
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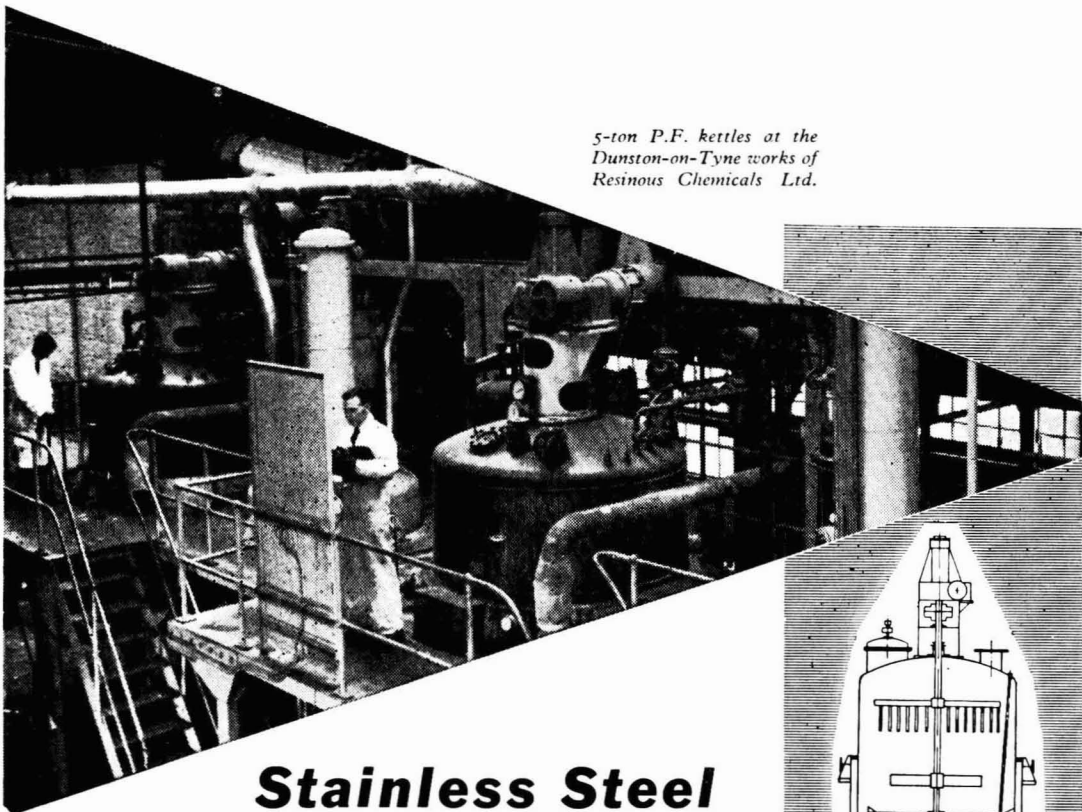


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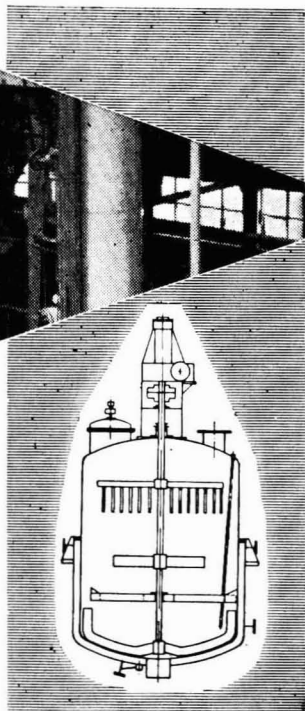
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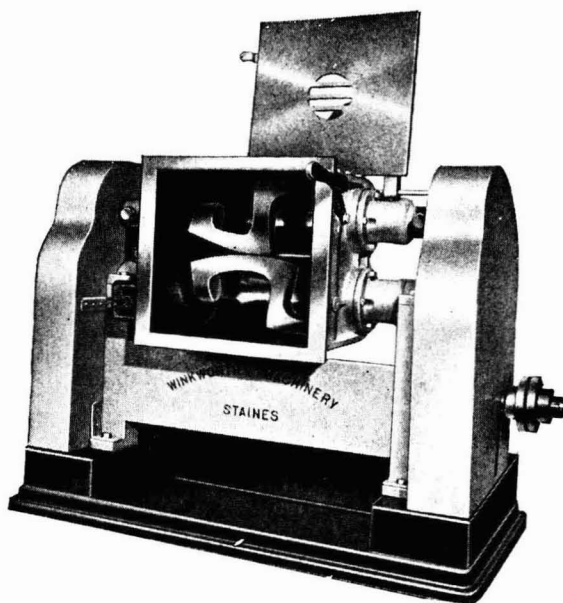
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### SPECIFICATION (tentative) & PROPERTIES

Type.....	Styrenated Epoxy Ester
Non volatile .....	50%
Volatile .....	Xylol
Viscosity .....	ZZ-Z1
Colour .....	5-6
Acid No. ....	1.8
Specific Gravity .....	0.949
White Spirit Tolerance .....	1.0
Suggested thinner proportions :	
Xylol .....	100%

Rosin and/or Derivatives.....	Absent
Modifiers .....	Epoxy
Compatible with :	
Amino Resins .....	Good
Alkyds .....	Poor

Recommended Driers: 0.01% Co, 0.04% Zr on base resin

Average Drying Time: Surface dry in 15-20 minutes.

Stoving Schedule: 30 minutes at 140°C.

**RECOMMENDED USES:** Industrial air-drying and stoving enamels, primers, refrigerator finishes, light engineering products, agricultural equipment, scientific apparatus, kitchen furniture, hospital furniture.

**OUTSTANDING PROPERTIES:** Rapid touch-dry, economic curing schedules, chemical resistance, hardness combined with flexibility, good adhesion

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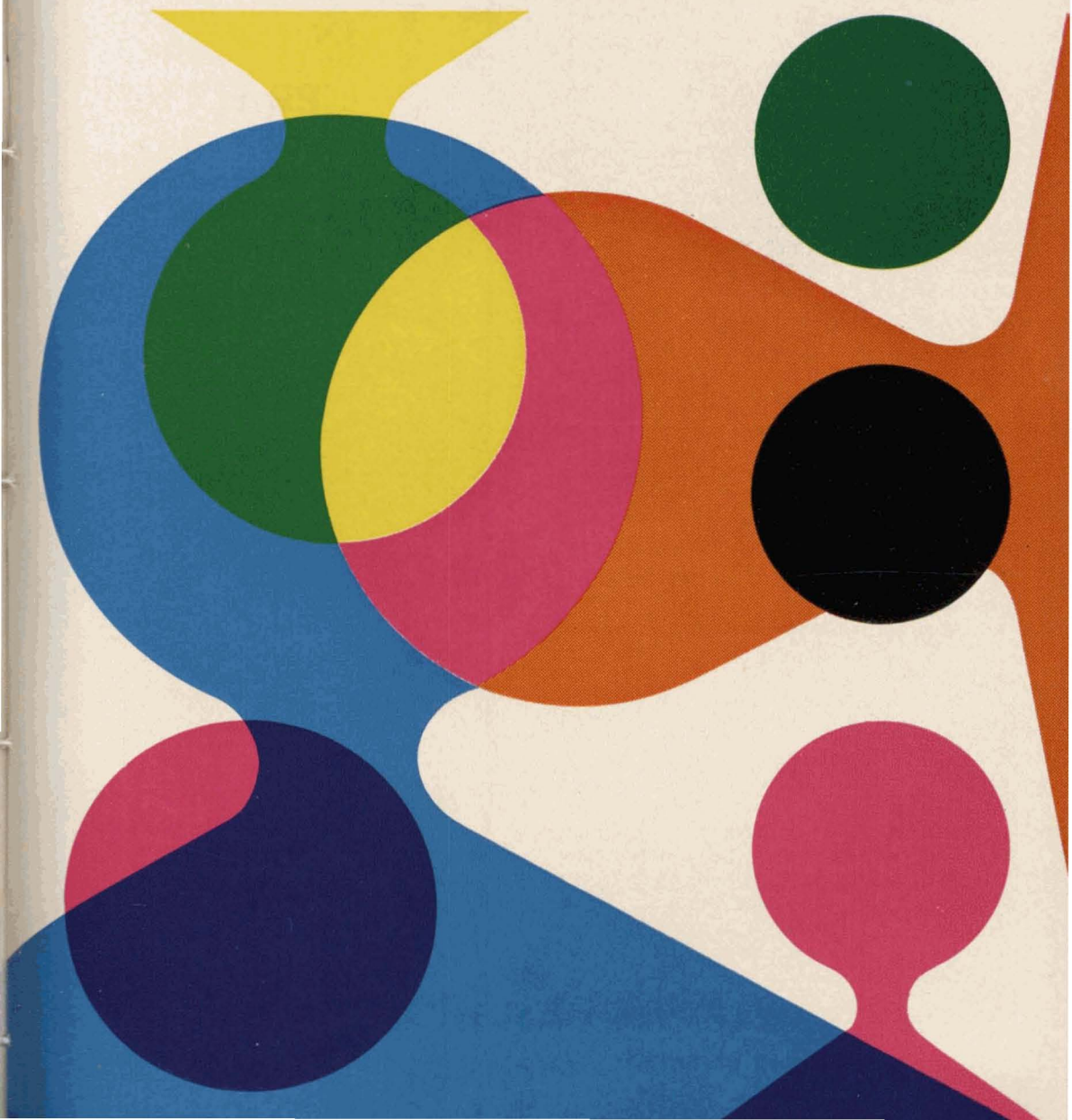
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Manchester



# Hexylene Glycol

By NEIL R. FISK

What is it? Although not to be found anywhere in a reference book recently brought out, the solvent itself is not unimportant: it aids coalescence, and hence levelling, of emulsion paints, and penetration of inks, and it was mentioned after Dr. Talen's stimulating paper on film formation at the London Section meeting on 10 October, and in one of Dr. Barakan's tables the following week.

Hexylene glycol properly so called is the 1 : 2-compound, that is to say, hexane-1 : 2-diol. But the hexylene glycol of industry is not that substance . . . nothing like it, in fact. One's next guess would be the 1 : 6, but, wrong again, for this is hexamethylene glycol. (Nobody makes either in bulk, by the way.)

So when I had to place the substance in *Fisk's Paint Year Book and A-Z Buyers' Guide* there was nothing for it but to ask one of the manufacturers, and then I was told at once that in reality it is 2-methylpentane-2 : 4-diol. In other words it is not really a hexylene glycol at all, but a branched-chain pentylene glycol, and, even at that, not the one that would be expected by a "pure" chemist.

The next thing was to ask the other manufacturers to identify their product, and each gave me the same answer as the first. So, naturally, we have called it 2-methylpentane-2 : 4-diol in *FPYBBG*, but of course we have cross-referred it from "hexylene glycol" as well.

This is "just one of those things" to which I alluded in my little piece on homonymy and synonymy in the November *J.O.C.C.A.* There were scores of problems of that sort in the two-and-a-quarter thousand headings in the book, and that is why I am not yet quite ready to invite orders for it, although a fair number have come in, some from overseas.

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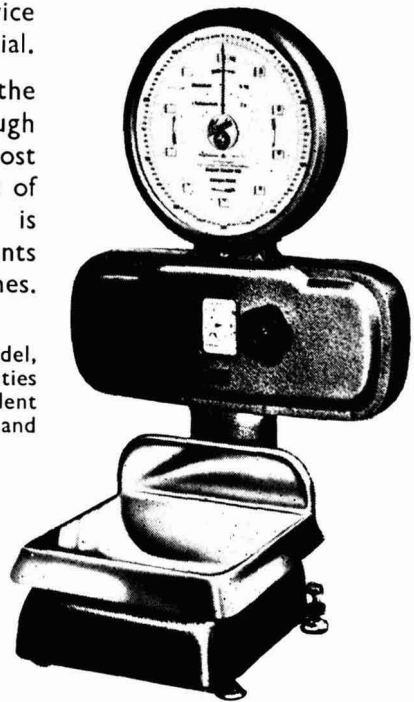
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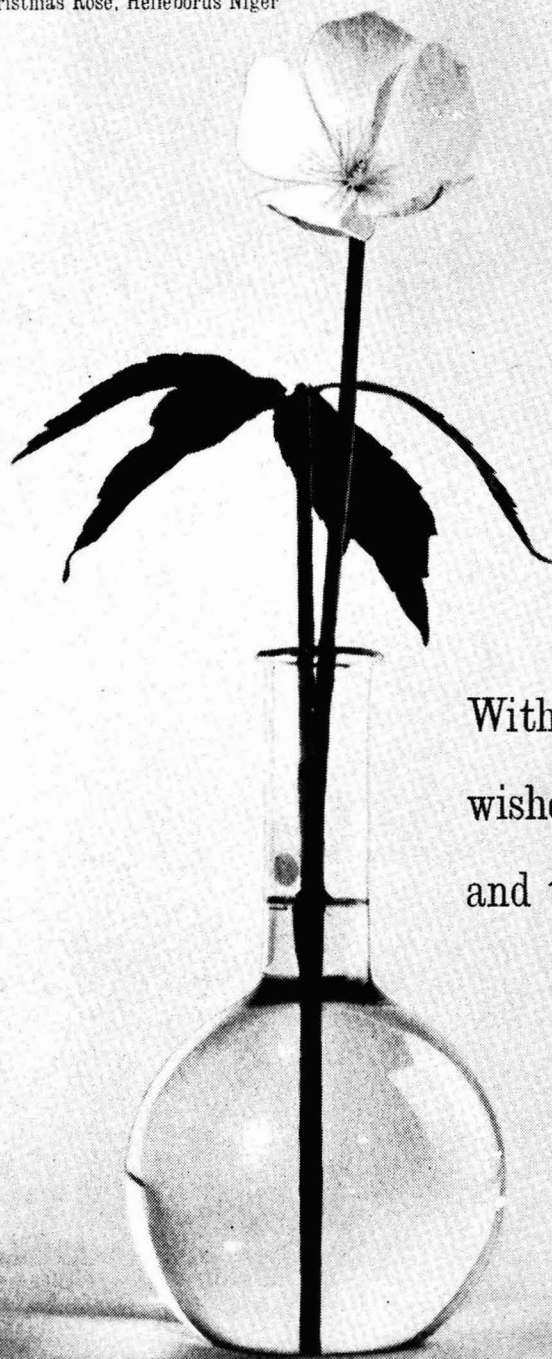


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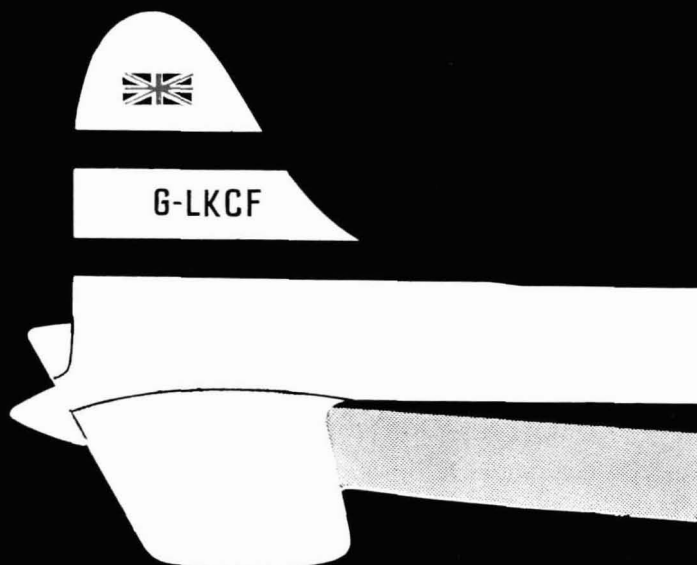
**OIL AND COLOUR CHEMISTS'  
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# JOURNAL OF THE OIL & COLOUR CHEMISTS' ASSOCIATION

Vol. 44

DECEMBER 1961

No. 12

## TRANSACTIONS AND COMMUNICATIONS

### The Exterior Durability of Paints Based on Lithopone & Zinc Sulphide\*

By D. S. NEWTON and J. G. RIGG

*Imperial Smelting Corporation, Research Department, Avonmouth, Bristol.*

#### Summary

Co-operative exposure tests are made by members of the Zinc Pigment Development Association Technical Committee using 28/30 lithopone or zinc sulphide, mixed with leaded zinc oxide and micronised mica as the pigment. The media are based on linseed oil, phenolic and alkyd varnishes and exposures are made for a 26-month period, at 45° South exposure, in industrial, marine and rural environments.

Results indicate that, with white paints, serious faults other than loss of gloss and erosion are prevented by use of the mixed formulations. The addition of stable tinting pigments gives considerable improvement in the general performance of these paints. All 28/30 lithopone- and zinc sulphide-based paints are in excellent condition for repainting at the end of the exposure period and require only a minimum of preparation prior to recoating.

#### INTRODUCTION

Zinc sulphide pigments have for a long time been used with success by paint manufacturers in undercoats for both interior and exterior paint systems. They have not, however, found a similar acceptance as the main pigmentary constituents of exterior finishing paints, since their presence introduces a tendency towards rapid failure on weathering by chalking, checking and heavy erosion.

Assertions have appeared occasionally in the technical literature that this breakdown is due to oxidation of the zinc sulphide with the eventual formation of water-soluble zinc sulphate. The late Noel Heaton, in particular, perpetuated this assumption in his classical text-book<sup>1</sup> "Outlines of Paint Technology". Nevertheless, satisfactory proof that such a breakdown occurs in exterior finishing paints on exposure to natural sunlight and weathering has never been established.

One of the authors has, indeed, spent a considerable effort in endeavouring to oxidise zinc sulphide and has found that this material is extremely resistant towards breakdown of this type. Even uncalcined zinc sulphide of very fine

\*Co-operative exposure tests by members of the Zinc Pigment Development Association Technical Committee.

particle size, when suspended in water suspensions with oxygen passed through for a period of several weeks, shows only very slight zinc sulphate formation. The presence of short-wave ultra-violet light slightly increases the oxidation, but radiation of this type is, for practical purposes, absent from visible light under normal atmospheric conditions. Even if it were not, it would be difficult to correlate the slight amount of oxidation with the heavy breakdown on weathering of zinc sulphide in exterior paints.

There are indications in the literature<sup>2,3</sup> that the durability of films based on zinc sulphide can be greatly improved by modification of the formulation, notably by the addition of zinc oxide (to increase absorption of longer wave ultra-violet light and to impart basicity) and mineral extenders of a fibrous or plate-like structure (to give reinforcement and flexibility). In this manner the breakdown can be reduced to eventual failure by mild chalking and erosion, leaving surfaces which can be repainted with a minimum of surface preparation. This improvement might be expected to be more pronounced with coloured paints, provided that the coloured pigments are themselves stable to the action of light and weathering.

With the object of testing paints of this type, particularly coloured paints, the Technical Committee of the Zinc Pigment Development Association produced a series of paints and exposed them at various sites in November, 1954.

#### PREPARATION OF THE PAINTS

All the undercoats and finishing paints were prepared in the laboratories of the Imperial Smelting Corporation Ltd. at Avonmouth, by pre-mixing, followed by three passes through a *Holmes* laboratory single-roll mill. After milling they were allowed to mature for seven days after which, where necessary, the consistency was adjusted with white spirit to give a paint which could be brushed easily. The viscosities were determined, after the thinning operation, with a *Krebs-Stormer* viscometer. The values recorded in Tables I-VII are the number of grams required to rotate the paddle at 200 r.p.m. Viscosity measurements were also made after a period of 18 months' storage. Full details of the compositions of the paints are given in Tables I-VII (see Appendix 1).

#### Primers

For metal panels, a zinc-rich primer based on chlorinated rubber was used:

Constituents	Per cent by weight
Zinc dust (95-97 per cent metallic) .. ..	76.0
<i>Alloprene B</i> (chlorinated rubber) .. ..	2.4
<i>Cereclor I</i> (chlorinated wax plasticiser) ..	1.6
Xylol .. .. .	20.0
	<hr/> 100.0 <hr/>

For wooden panels, the primer was a conventional pink lead paint:

Constituents	Per cent by weight
Dry white lead .. .. .	71.83
Non-setting red lead .. .. .	3.29
Acid refined linseed oil .. .. .	23.20
16 per cent lead naphthenate solution ..	0.188
6 per cent cobalt naphthenate solution ..	0.047
White spirit .. .. .	balance

### *Undercoat*

This was a common undercoat for all systems based on 28/30 lithopone, acicular zinc oxide and micronised mica, in a ratio of 4 : 1 : 1 by weight, respectively. The medium was a mixture of acid refined linseed oil and 30-poise linseed stand oil, in a ratio of 4 : 1 by weight, respectively, with lead and cobalt naphthenate driers. The undercoat was tinted grey with vegetable black to enable erosion of the weathered paint systems to be more easily detected. The composition of the undercoat is given below:

Constituents	Per cent by weight
28/30 Lithopone .. .. .	47.29
Acicular zinc oxide .. .. .	11.82
Micronised mica .. .. .	11.82
Acid refined linseed oil .. .. .	18.92
30-poise linseed stand oil .. .. .	4.73
16 per cent lead naphthenate solution ..	1.47
6 per cent cobalt naphthenate solution ..	0.05
Vegetable black .. .. .	0.12
White spirit .. .. .	3.78
	<u>100.00</u>

### *Finishing Coats*

White paints were pigmented with either 28/30 lithopone or zinc sulphide, with additions of 25 per cent leaded zinc oxide (*Ledzinox 25*) and water-ground mica.

The white bases were then tinted to close matches with *Monolite Red GRS*, *Ferrite Yellow MY 50*, *Monastral Green GS*, chromium oxide green and *Monastral Blue LBS*.

The following three media were used:

(i) *Linseed/linseed stand oil* with a low-acid value.

Constituents	Per cent by weight
Acid refined linseed oil .. .. .	80.0
30-poise linseed stand oil .. .. .	20.0

(ii) *Phenolic resin varnish*.

Constituents	Per cent by weight
<i>Epok R.710</i> .. .. .	10.80
30-poise linseed stand oil .. .. .	36.45
Tung oil stand oil .. .. .	12.15
16 per cent lead naphthenate solution ..	0.68
6 per cent cobalt naphthenate solution ..	0.17
White spirit .. .. .	39.75
	100.00

(iii) *Alkyd varnish*.

*Epok A1060/75* with 75 per cent total solids in white spirit. White and red paints based on white lead in linseed/linseed stand oil medium were included for comparison.

The compositions of the finishing paints are given in Appendix 1.

#### PAINING OF THE PANELS

The painting of the panels was carried out in the laboratories of Amalgamated Oxides (1939) Ltd. at Dartford. Wooden and mild steel panels were used, each measuring 30 in. × 9 in. The wooden panels were planed and sand papered, and after the backs had been primed, a previously-primed wooden batten (8¾ in. × 1½ in. × ½ in.) was screwed to the backs, near to each end. The metal panels, which were bright and mill-scale free, were degreased with white spirit prior to painting; the faces of the panels were rubbed with emery paper to roughen the surface and provide a suitable key.

Each panel carried six separate finishing coats of a similar colour with common primer and undercoating systems. The white lead finishing paints were, however, painted on separate panels of smaller size.

## EXPOSURE OF PANELS

One complete set of wooden and steel panels was exposed at each of three sites in November, 1954. The sites were at Avonmouth (Industrial), Frodsham (Cheshire—Rural) and Burry Port (South Wales—Marine). All the panels were exposed at an angle of 45°, facing due South.

## EXAMINATION OF PANELS

Panels were examined at three-monthly intervals by members of the staff of McKechnie Brothers Ltd. and Imperial Smelting Corporation Ltd. for the following properties.

*Gloss*

This was assessed against a series of standards with ratings from 1 to 6: 1—high gloss, 2—fairly high gloss, 3—medium gloss, 4—low gloss, 5—gloss at grazing angle only, and 6—flat.

*Tint Retention*

A series of colour standards was prepared for each colour in the laboratories of McKechnie Brothers Ltd. at Widnes by:

- (a) reducing the shade of one of the tinted paints by the addition of varying amounts of white paint, made from the same white pigment and extender composition, so that the amount of coloured pigment in the paint fell from 100 per cent of that present in the original tinted paint, in 10 per cent steps, to 0 per cent (the shade of the white paint).
- (b) increasing the intensity of shade by the addition of further paint prepared from the same tinting pigment to give shades above the 100 per cent colour content, in increasing steps of 10 per cent of additional colour content.
- (c) applying the above paints in strips to painted cards and using these for assessing the tint retention of the weathered paints.

$$\text{Per cent tint retention} = \frac{\text{Per cent colour in matching strip}}{\text{Per cent colour in original matching strip}} \times 100$$

*Checking, Cracking, Chalking, Flaking and Erosion*

The standards given in the Exposure Standards Manual of the Federation of Paint and Varnish Production Clubs (1941) were used for assessing these failures. The numbering was, however, modified in the following way:

- 0=no failure, 1=slight failure, 2=moderate failure,  
3=appreciable failure and 4=heavy failure.

## RESULTS OF TESTS

The abridged results of the examination over a 26-month period are given in Appendix 2. In these tables the figures given are averages of the ratings recorded on wooden and steel panels. Generally there was little difference between the behaviour of respective paints on each of these two substrates,

apart from a slightly greater tendency of a few paints to show more erosion on the metal than on wood, particularly at the Burry Port site.

### *General Results*

The results indicate that both 28/30 lithopone and zinc sulphide give a useful degree of durability in all three media and that the performance is improved considerably when coloured pigments are present.

The loss of gloss is fairly rapid with mixed pigment formulations of the type employed. The more serious defects such as cracking and flaking are, however, either absent entirely or present in a few cases only to a very slight degree. Chalking occurred to varying and erratic degrees, depending on the climatic conditions, but it was never heavy for a prolonged period. As might be expected, chalking took place only to a slight degree with the alkyd medium and was worst with the linseed oil medium. Checking was not a serious defect with any of the paints. Erosion developed with the white and red tinted paints towards the end of the 26-month period. However, all the 28/30 and lithopone panels were in good condition for repainting at the end of the exposure period. Erosion was particularly low on the coloured paints, apart from where *Monolite Red* had been used as the tinting pigment. The dirt retention tended to be worst with the alkyd medium, probably because this showed lower chalking and self-cleansing properties.

The red tints showed very poor colour retention and within a few months faded nearly to the colour of the white panels. It was unfortunate that the red pigment had been used for tinting the comparative white lead paints, since they also were subject to this severe fading. In general there was little difference in performance between the white paints and the red tinted paints. The other colours gave appreciable enhancement of durability.

Tint retention, apart from the red tinted paints, was relatively good with all colours. Some fading took place initially, particularly with the linseed oil medium, but this was counteracted by a tendency for the mixed zinc sulphide pigment/zinc oxide/extender to intensify the depth of colour, so that a number of panels actually showed a greater depth of colour after exposure than before. This tendency seemed to be more pronounced at the Frodsham site.

No general difference in performance between the zinc sulphide—and 28/30 lithopone—pigmented paints was detected. In some cases one proved to be more satisfactory and in other cases the effect was reversed. The variations were random and not associated with site or medium. The zinc sulphide pigments behaved at least as well as the comparative white lead paints in cases where direct comparisons were possible.

### CONCLUSIONS

It is possible to formulate white paints from zinc sulphide pigments mixed with zinc oxide and mica which will weather for over two years without serious failure other than loss of gloss developing. Since the tests were made at an inclination of 45° facing South, it seems likely that the durability would be more than doubled under more normal aspects.



The durability of these paints is definitely enhanced by the addition of stable coloured pigments, including ferrite yellow, chromium oxide green and *Monastral Blue*. In particular chalking and erosion are improved considerably.

All the paints based on 28/30 lithopone and zinc sulphide were in a good condition for repainting at the end of the 26-month period and would have required little pretreatment other than a light rubbing down to remove surface chalking.

## ACKNOWLEDGEMENTS

The authors are indebted to Mr. D. P. Bayley and to members of the Zinc Pigment Development Association Technical Committee for help given during this work and to the Zinc Pigment Development Association Council for granting permission to publish.

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[Received 14 June, 1961]

## APPENDIX 1

TABLE I  
LITHOPONE-LINSEED/LINSEED STAND OIL FINISHING PAINT

Constituent	Composition of paints (%)					
	1.A.1	1.A.2	1.A.3	1.A.4	1.A.5	1.A.6
28/30 lithopone .. .. .	38.05	35.46	36.28	36.80	30.80	37.76
25 per cent leaded zinc oxide ..	9.51	8.87	9.07	9.20	7.70	9.44
Micronised mica .. .. .	9.51	8.87	9.07	9.20	7.70	9.44
Linseed/linseed stand oil medium	38.10	39.28	37.17	37.42	33.62	37.96
16 per cent lead naphthenate solution .. .. .	2.34	2.41	2.54	2.34	2.11	2.36
6 per cent cobalt naphthenate solution .. .. .	0.09	0.09	0.09	0.09	0.08	0.09
<i>Parathane</i> (Dipentene) .. .. .	0.60	0.75	0.58	0.53	0.49	0.59
White spirit .. .. .	1.80	2.72	2.54	2.61	3.61	1.94
<i>Monolite Red GRS</i> .. .. .	—	1.55	—	—	—	—
<i>Ferrite Yellow MY 50</i> .. .. .	—	—	2.66	—	—	—
<i>Monastral Green GS</i> .. .. .	—	—	—	1.81	—	—
Chromium oxide green .. .. .	—	—	—	—	13.89	—
<i>Monastral Blue LBS</i> .. .. .	—	—	—	—	—	0.42
	100.00	100.00	100.00	100.00	100.00	100.00
*Viscosity as made (units) ..	490	490	490	490	490	490
*Viscosity after 18 months ..	595	590	550	575	600	700
Settlement after 18 months ..	—	—	—	—	—	—

\*All viscosities were determined with a *Krebs-Stormer* viscometer, the values given being the number of grams required to rotate the paddle at 200 r.p.m.

TABLE II  
LITHOPONE-PHENOLIC MEDIUM FINISHING PAINT

Constituent	Composition of paints (%)					
	1.B.1	1.B.2	1.B.3	1.B.4	1.B.5	1.B.6
28/30 lithopone .. ..	30.40	28.45	28.90	29.30	25.40	30.32
25 per cent leaded zinc oxide .. ..	7.60	7.11	7.22	7.32	6.35	7.58
Micronised mica .. ..	7.60	7.11	7.22	7.32	6.35	7.58
Varnish V.33002 .. ..	50.60	52.11	50.50	49.40	45.78	50.46
Parathane .. ..	0.95	1.00	1.00	1.30	0.79	0.92
White spirit .. ..	2.85	2.92	2.96	3.86	4.22	2.79
Monolite Red GRS .. ..	—	1.30	—	—	—	—
Ferrite Yellow MY 50 .. ..	—	—	2.20	—	—	—
Monastral Green GS .. ..	—	—	—	1.50	—	—
Chromium oxide green .. ..	—	—	—	—	11.11	—
Monastral Blue LBS .. ..	—	—	—	—	—	0.35
	100.00	100.00	100.00	100.00	100.00	100.00
Viscosity as made (units) .. ..	275	275	275	275	275	275
Viscosity after 18 months .. ..	300	325	325	300	300	300
Settlement after 18 months .. ..	Hard	—	—	Soft	—	—

TABLE III  
LITHOPONE-ALKYD MEDIUM FINISHING PAINT

Constituent	Composition of paints (%)					
	1.C.1	1.C.2	1.C.3	1.C.4	1.C.5	1.C.6
28/30 lithopone .. ..	33.45	32.50	32.35	32.70	29.90	33.30
25 per cent leaded zinc oxide .. ..	8.37	8.12	8.09	8.17	7.48	8.33
Micronised mica .. ..	8.37	8.12	8.09	8.17	7.48	8.33
6 per cent cobalt naphthenate solution .. ..	0.11	0.15	0.10	0.10	0.10	0.10
Parathane .. ..	1.67	4.86	4.85	4.90	4.47	4.97
Epok A1060/75 .. ..	40.50	41.10	39.80	39.98	38.23	40.30
46-poise dehydrated castor oil .. ..	2.51	2.44	2.42	2.48	2.24	2.49
White spirit .. ..	5.02	1.11	2.30	2.00	—	1.80
Monolite Red GRS .. ..	—	1.60	—	—	—	—
Ferrite Yellow MY 50 .. ..	—	—	2.00	—	—	—
Monastral Green GS .. ..	—	—	—	1.50	—	—
Chromium oxide green .. ..	—	—	—	—	10.10	—
Monastral Blue LBS .. ..	—	—	—	—	—	0.38
	100.00	100.00	100.00	100.00	100.00	100.00
Viscosity as made (units) .. ..	250	325	300	300	325	300
Viscosity after 18 months .. ..	375	700	200	600	875	675
Settlement after 18 months .. ..	—	—	—	Soft	—	—

TABLE IV  
ZINC SULPHIDE-LINSEED/LINSEED STAND OIL FINISHING PAINT

Constituent	Composition of paints (%)					
	2.A.1	2.A.2	2.A.3	2.A.4	2.A.5	2.A.6
Zinc sulphide .. .. .	38.05	33.72	35.60	35.60	28.12	37.42
25 per cent leaded zinc oxide ..	9.51	8.43	8.90	8.90	7.03	9.36
Micronised mica .. .. .	9.51	8.43	8.90	8.90	7.03	9.36
Linseed/linseed stand oil medium	38.10	40.82	36.81	36.73	32.06	37.65
16 per cent lead naphthenate solution .. .. .	2.34	2.40	2.30	2.33	1.85	2.34
6 per cent cobalt naphthenate solution .. .. .	0.09	0.09	0.09	0.09	0.09	0.09
Parathane .. .. .	0.60	0.51	0.50	0.50	0.42	0.47
White spirit .. .. .	1.80	2.78	1.80	3.20	4.42	2.14
Monolite Red GRS .. .. .	—	2.82	—	—	—	—
Ferrite Yellow MY 50 .. .. .	—	—	5.10	—	—	—
Monastral Green GS .. .. .	—	—	—	3.75	—	—
Chromium oxide green .. .. .	—	—	—	—	19.00	—
Monastral Blue LBS .. .. .	—	—	—	—	—	1.17
	100.00	100.00	100.00	100.00	100.00	100.00
Viscosity as made (units) ..	550	550	550	550	550	550
Viscosity after 18 months ..	575	500	500	575	500	450
Settlement after 18 months ..	—	—	—	—	—	—

TABLE V  
ZINC SULPHIDE-PHENOLIC MEDIUM

Constituent	Composition of paints (%)					
	2.B.1	2.B.2	2.B.3	2.B.4	2.B.5	2.B.6
Zinc sulphide .. .. .	30.40	28.00	25.70	28.50	20.24	29.85
25 per cent leaded zinc oxide ..	7.60	7.00	6.42	7.12	5.06	7.46
Micronised mica .. .. .	7.60	7.00	6.42	7.12	5.06	7.46
Varnish V.33002 .. .. .	50.60	52.50	45.20	48.40	41.00	49.99
Parathane .. .. .	0.95	0.80	3.11	1.44	3.16	0.93
White spirit .. .. .	2.85	2.50	9.35	4.32	9.48	3.37
Monolite Red GRS .. .. .	—	2.20	—	—	—	—
Ferrite Yellow MY 50 .. .. .	—	—	3.80	—	—	—
Monastral Green GS .. .. .	—	—	—	3.10	—	—
Chromium oxide green .. .. .	—	—	—	—	16.00	—
Monastral Blue LBS .. .. .	—	—	—	—	—	0.94
	100.00	100.00	100.00	100.00	100.00	100.00
Viscosity as made (units) ..	225	225	225	225	225	225
Viscosity after 18 months ..	270	275	275	260	260	260
Settlement after 18 months ..	Hard	—	—	—	—	—

TABLE VI  
ZINC SULPHIDE-ALKYD MEDIUM

Constituent	Composition of paints (%)					
	2.C.1	2.C.2	2.C.3	2.C.4	2.C.5	2.C.6
Zinc sulphide .. .. .	33.45	31.10	31.40	33.20	25.36	33.00
25 per cent lead zinc oxide .. .. .	8.37	7.77	7.85	8.30	6.34	8.25
Micronised mica .. .. .	8.37	7.77	7.85	8.30	6.34	8.25
6 per cent cobalt naphthenate solution .. .. .	0.11	0.10	0.10	0.11	0.08	0.10
Parathane .. .. .	1.67	1.70	1.75	1.70	3.78	4.95
Epok A1060/75 .. .. .	40.50	41.71	39.00	40.25	35.15	40.03
46-poise dehydrated castor oil .. .. .	2.51	2.30	2.30	2.49	1.88	2.48
White spirit .. .. .	5.02	5.05	5.25	2.15	3.37	1.90
Monolite Red GRS .. .. .	—	2.50	—	—	—	—
Ferrite Yellow MY 50 .. .. .	—	—	4.50	—	—	—
Monastral Green GS .. .. .	—	—	—	3.50	—	—
Chromium oxide green .. .. .	—	—	—	—	17.70	—
Monastral Blue LBS .. .. .	—	—	—	—	—	1.04
	100.00	100.00	100.00	100.00	100.00	100.00
Viscosity as made (units) .. .. .	300	300	300	300	300	300
Viscosity after 18 months .. .. .	450	700	280	550	550	800
Settlement after 18 months .. .. .	—	—	—	—	—	—

TABLE VII  
WHITE LEAD-LINSEED/LINSEED STAND OIL

Constituent	Composition of Paints (%)	
	3.A.1	3.A.2
Dry white lead .. .. .	72.75	72.46
Acid refined linseed oil .. .. .	23.63	23.40
16 per cent lead naphthenate solution .. .. .	0.19	0.19
6 per cent cobalt naphthenate solution .. .. .	0.05	0.05
White spirit .. .. .	3.38	3.36
Monolite Red GRS .. .. .	—	0.54
	100.00	100.00
Viscosity as made (units) .. .. .	700	700
Viscosity after 18 months .. .. .	—	—
Settlement after 18 months .. .. .	—	—

APPENDIX 2

TABLE VIII  
WHITE FINISHING PAINT  
(Mean readings for wood and metal panels)

Panel	Finishing paint (No. and type)	Rating of film defects after indicated period (months)																		
		Gloss		Darkening		Chalking		Checking		Cracking		Erosion		Flaking						
		0	6	9-26	6	9	14	18	26	6	9	14	18	26	9	14	18	26	9-18	26
<i>Avonmouth</i>																				
F1A1	1A1 Lithopone/linseed	2½	6	6	0	1	1	1	1½	1	2	3	4	2	0	0	0	0	0	0
F1A2	2A1 ZnS/linseed	2½	6	6	0	1	1	1	1½	1	3	3	4	1	0	0	0	0	0	0
F1A3	1B1 Lithopone/phenolic	2½	6	6	1	1	1	1	1	2	2	2	2	1	0	0	0	0	0	0
F1A4	2B1 ZnS/phenolic	2½	6	6	1	1	1	1	1	3	3	3	2	1	0	0	0	0	0	0
F1A5	1C1 Lithopone/Alkyd	2½	6	6	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0
F1A6	2C1 ZnS/alkyd	2½	6	6	1	2	2	3	3	0	1	1	1	0	0	0	0	0	0	0
F1A7	3A1 White lead/linseed	3	6	6	1	4	4	4	4	1	1	1	0	1	0	0	1	2	0	2
<i>Frodsham</i>																				
F1B1	1A1 Lithopone/linseed	2½	6	6	1	1	1	1	2	1	2	2	4	4	0	0	0	0	0	0
F1B2	2A1 ZnS/linseed	2½	6	6	1	1	1	2	3	0	1	0	2	3	0	0	0	0	0	0
F1B3	1B1 Lithopone/phenolic	2½	6	6	1	0	1	2	3	0	1	0	2	3	0	0	0	0	0	0
F1B4	2B1 ZnS/phenolic	2½	6	6	1	0	1	1	1	0	0	0	1	2	0	0	0	0	0	0
F1B5	1C1 Lithopone/alkyd	2½	6	6	1	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0
F1B6	2C1 ZnS/alkyd	2½	6	6	1	1	1	3	1	0	0	0	0	0	0	0	0	0	0	0
F1B7	3A1 White lead/linseed	3	6	6	3	2	1	1	1	0	0	0	0	4	0	4	4	4	0	0
<i>Burry Port</i>																				
F1C1	1A1 Lithopone/linseed	2½	6	6	0	1	1	1	1	1	2	3	2	4	0	0	0	0	0	0
F1C2	2A1 ZnS/linseed	2½	6	6	1	0	1	1	1	1	2	2	1	4	0	0	0	0	0	0
F1C3	1B1 Lithopone/phenolic	2½	6	6	0	0	2	1	1	1	1	1	1	4	0	0	0	0	0	0
F1C4	2B1 ZnS/phenolic	2½	6	6	1	0	1	1	1	0	1	1	1	4	0	0	0	0	0	0
F1C5	1C1 Lithopone/alkyd	2½	6	6	1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	0
F1C6	2C1 ZnS/alkyd	2½	6	6	1	0	1	1	1	0	0	1	1	1	0	0	0	0	0	0
F1C7	3A1 White lead/linseed	3	6	6	2	1	0	0	0	1	1	1	1	4	0	0	0	4	2	2

2½ (wood worst)

TABLE IX  
RED FINISHING PAINT  
(Mean readings for wood and metal panels)

Panel	Finishing paint (No. and type)	Rating of film defects after indicated period (months)																											
		Gloss		Darkening		Chalking		Checking		Cracking		Erosion		Flaking		Tint retention (%)													
		0	6	9-26	6	9	14	18	26	6	9	14	18	26	9	14	18	26	9-18	26	0	6	9	14	18	26			
<i>Avonmouth</i>																													
F2A1	1A2 Lithopone/linseed	2½	6	6	1	1½	1	1	1	3	3½	4	3		0	0	0	0	0	0	0	0	0	100	8	5	0	0	0
F2A2	2A2 ZnS/linseed	2½	6	6	1	1	1	1	1½	3½	4	3	3		0	0	0	0	0	0	0	0	0	100	7	5	0	0	0
F2A3	1B2 Lithopone/phenolic	2½	6	6	1	1	1½	1½	1½	3½	4	3	3		0	0	0	0	0	0	0	0	0	100	5	5	0	0	0
F2A4	2B2 ZnS/phenolic	2½	6	6	1	1	1½	2	2	3½	3	3	3		0	0	0	0	0	0	0	0	0	100	5	5	0	0	0
F2A5	1C2 Lithopone/alkyd	2½	6	6	1	3	3	3	3	0	1	1	1½	2	0	0	2	2	0	0	0	0	0	100	6	5	0	0	0
F2A6	2C2 ZnS/alkyd	2½	6	6	1	2½	3	3	3	0	1	1	1½	2	0	0	1	1½	0	0	0	0	0	100	5	5	0	0	0
F2A7	3A2 White lead/linseed	3	6	6	1½	4	4	4	4	1	2	1½	1	1½	0	1	2	3	1	0	0	0	0	100	0	0	0	0	0
<i>Frodsham</i>																													
F2B1	1A2 Lithopone/linseed	2½	6	6	0	0	0	0	3	0	2	2	3	4	0	0	0	0	0	0	0	0	0	100	12	5	0	0	0
F2B2	2A2 ZnS/linseed	2½	6	6	1	1	1	1	2	0	1	0	1	2	0	0	0	0	0	0	0	0	0	100	9	4	0	0	0
F2B3	1B2 Lithopone/phenolic	2½	6	6	1	0	0	0	3	0	1	0	1	3	0	0	0	0	0	0	0	0	0	100	12	6	0	0	0
F2B4	2B2 ZnS/phenolic	2½	6	6	1	1	1	1	1	0	0	0	1	2	0	0	0	0	0	0	0	0	0	100	9	5	0	0	0
F2B5	1C2 Lithopone/alkyd	2½	5	6	1	1	0	0	1	0	1	0	0	0	0	0	1	1½	0	0	0	0	0	100	10	6	0	0	0
F2B6	2C2 ZnS/alkyd	2½	5	6	1	1	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	100	6	6	0	0	0
F2B7	3A2 White lead/linseed	3	6	6	3	2	1	1	1	0	0	1	0	4	0	0	1	2	1	0	0	0	0	100	26	8	6	0	0
<i>Burry Port</i>																													
F2C1	1A2 Lithopone/linseed	5	6	6	0	0	0	0	1	2	1	4	4	0	0	0	0	0	0	0	0	0	100	5	5	5	5	5	
F2C2	2A2 ZnS/linseed	2½	6	6	0	0	0	0	0	1	2	1	4	4	0	0	0	0	0	0	0	0	0	100	4	4	4	4	4
F2C3	1B2 Lithopone/phenolic	2½	6	6	0	0	0	0	0	1	1	1	4	4	0	0	0	0	0	0	0	0	0	100	4	4	4	4	4
F2C4	2B2 ZnS/phenolic	2½	6	6	0	0	0	0	0	0	1	1	4	4	0	0	0	0	0	0	0	0	0	100	4	4	4	4	4
F2C5	1C2 Lithopone/alkyd	2½	6	6	0	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0	0	0	0	100	5	5	5	5	5
F2C6	2C2 ZnS/alkyd	2½	6	6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	100	5	5	5	5	5
F2C7	3A2 White lead/linseed	3	6	6	0	0	0	0	0	1	1	1	4	4	0	0	0	0	0	0	0	1	1	100	5	5	5	5	5

TABLE X  
FERRITE YELLOW FINISHING PAINT  
(Mean readings for wood and metal panels)

Panel	Finishing paint (No. and type)	Rating of film defects after indicated period (months)												Tint retention (%)										
		Gloss		Darkening		Chalking		Checking		Cracking		Erosion		0	6	9	14	18	26					
<i>Avonmouth</i>																								
F3A1	1A3 Lithopone/linseed ..	2 1/2	5	1	2	2	2	3 1/2	2	1 1/2	0	0	0	0	0	0	0	0	100	80	47	111	111	106
F3A2	2A3 ZnS/linseed ..	2 1/2	5	1	1 1/2	1 1/2	2	4	2	2	1	0	0	0	0	0	0	0	100	67	44	100	100	106
F3A3	1B3 Lithopone/phenolic ..	2 1/2	5	1	1 1/2	1 1/2	2	3 1/2	2	2 1/2	1	0	0	0	0	0	0	0	100	84	54	104	104	92
F3A4	2B3 ZnS/phenolic ..	2 1/2	5	1 1/2	1 1/2	1 1/2	2	2 1/2	1	1	0	0	0	0	0	0	0	0	100	59	67	111	111	96
F3A5	1C3 Lithopone/alkyd ..	2 1/2	5	1 1/2	2	2	2	1	1	1	0	0	0	0	0	0	0	0	100	81	110	143	133	110
F3A6	2C3 ZnS/alkyd ..	2 1/2	5	1 1/2	2 1/2	2 1/2	3	1	1	0	0	0	0	0	0	0	0	0	100	106	89	161	161	155
<i>Frodsham</i>																								
F3B1	1A3 Lithopone/linseed ..	2 1/2	6	1 1/2	2	0	0	1	0	1 1/2	1 1/2	1	1	1 1/2	1	1 1/2	1	1	100	176	65	106	106	100
F3B2	2A3 ZnS/linseed ..	2 1/2	6	1 1/2	2 1/2	0	0	1	0	0	1	1	1	0	0	1	1	1	100	121	79	121	72	91
F3B3	1B3 Lithopone/phenolic ..	2 1/2	6	1 1/2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	100	158	68	90	68	105
F3B4	2B3 ZnS/phenolic ..	2 1/2	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	100	115	154	115	73	88
F3B5	1C3 Lithopone/alkyd ..	2 1/2	4	1	1 1/2	1	0	0	0	0	0	0	0	0	0	0	0	0	100	145	242	115	115	109
F3B6	2C3 ZnS/alkyd ..	2 1/2	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	100	145	242	142	139	127
<i>Burry Port</i>																								
F3C1	1A3 Lithopone/linseed ..	2 1/2	5 1/2	0	0	0	0	1 1/2	1	1	4	1	2	0	0	0	0	0	100	60	55	90	100	70
F3C2	2A3 ZnS/linseed ..	2 1/2	5 1/2	0	0	0	0	1	1	1	4	3	0	0	0	0	0	0	100	47	58	105	121	105
F3C3	1B3 Lithopone/phenolic ..	2 1/2	5	0	0	0	0	1	1	1	4	0	0	0	0	0	0	0	100	100	88	100	106	82
F3C4	2B3 ZnS/phenolic ..	2 1/2	5	0	0	0	0	1	1	1	3	0	0	0	0	0	0	0	100	77	77	115	112	115
F3C5	1C3 Lithopone/alkyd ..	2 1/2	4 1/2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	100	100	75	100	115	75
F3C6	2C3 ZnS/alkyd ..	2 1/2	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	100	90	167	150	156	167

TABLE XI  
ORGANIC GREEN FINISHING PAINT  
(Mean readings for wood and metal panels)

Panel	Finishing paint (No. and type)	Rating of film defects after indicated period (months)																														
		Gloss			Darkening			Chalking			Checking			Cracking			Erosion			Tint retention (%)												
		0	6	9	14	18	26	6	9	14	18	26	9	14	18	26	9	14	18	26	0	6	9	14	18	26						
<i>Avonmouth</i>																																
F-4A1	1A4 Lithopone/linseed	2 1/2	5	5	5	5	5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	3 1/2	3	3	2	1	0	1	1	1	0	0	0	0	0	100	44	44	100	139	172
F-4A2	2A4 ZnS/linseed	3	5	5	5	5	5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	2	2	2	1 1/2	0	0	1	1	0	0	0	0	0	0	100	36	50	109	136	159
F-4A3	1B4 Lithopone/phenolic	2 1/2	5	5	5	5	5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	3	3	2	0	0	0	0	0	0	0	0	0	0	0	100	52	56	108	160	140
F-4A4	2B4 ZnS/phenolic	2 1/2	5	5	5	5	5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1	0	0	0	0	0	0	0	0	0	0	0	0	100	52	100	120	160	136
F-4A5	1C4 Lithopone/alkyd	2 1/2	4	5	5	5	5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1	1	0	1/2	0	0	1	1	0	0	0	0	0	0	100	75	158	208	250	259
F-4A6	2C4 ZnS/alkyd	2 1/2	4	5	5	5	5	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	1/2	1/2	1/2	1/2	0	0	0	0	0	0	0	0	0	0	100	50	111	167	222	222
<i>Frodoham</i>																																
F-4B1	1A4 Lithopone/linseed	2 1/2	6	6	6	6	6	1 1/2	0	0	0	0	1/2	0	1 1/2	2	1 1/2	1 1/2	2	1	1	1 1/2	0	0	0	0	100	278	90	90	122	139
F-4B2	2A4 ZnS/linseed	2 1/2	6	6	6	6	6	1 1/2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	100	238	86	190	167	167
F-4B3	1B4 Lithopone/phenolic	2 1/2	6	6	6	6	6	1 1/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	209	84	67	104	139
F-4B4	2B4 ZnS/phenolic	2 1/2	6	6	6	6	6	1 1/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	200	68	160	140	140
F-4B5	1C4 Lithopone/alkyd	2 1/2	3	6	6	6	6	1 1/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	320	152	128	144	144
F-4B6	2C4 ZnS/alkyd	2 1/2	3	6	6	6	6	1 1/2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	235	106	235	177	206
<i>Burry Port</i>																																
F-4C1	1A4 Lithopone/linseed	2 1/2	6	6	6	6	6	0	0	0	0	0	0	2	1 1/2	4	0	1	1	2	0	0	0	0	0	0	100	70	60	60	70	50
F-4C2	2A4 ZnS/linseed	2 1/2	6	6	6	6	6	0	0	0	0	0	0	2	1 1/2	4	0	1	1	1	0	0	0	0	0	0	100	67	95	190	167	190
F-4C3	1B4 Lithopone/phenolic	2 1/2	5	6	6	6	6	0	0	0	0	0	0	0	0	2 1/2	0	0	0	0	0	0	0	0	0	0	100	125	92	113	104	83
F-4C4	2B4 ZnS/phenolic	2 1/2	5	6	6	6	6	0	0	0	0	0	0	0	0	2 1/2	0	0	0	0	0	0	0	0	0	0	100	125	135	167	146	167
F-4C5	1C4 Lithopone/alkyd	2 1/2	4	6	6	6	6	0	0	0	0	0	0	1	0	1 1/2	0	0	0	0	0	0	0	0	0	0	100	133	108	200	167	68
F-4C6	2C4 ZnS/alkyd	2 1/2	4	6	6	6	6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	100	112	188	250	225	250



TABLE XII  
CHROMIUM OXIDE GREEN FINISHING PAINT  
(Mean readings for wood and metal panels)

Panel	Finishing paint (No. and type)	Rating of film defects after indicated period (months)																						
		Gloss			Darkening			Chalking			Checking			Cracking	Erosion			Tint retention (%)						
		0	6	9-26	6	9	14	18	26	6	9	14	18	26	26	14	18	26	0	6	9	14	18	26
<i>Avonmouth</i>																								
F5A1	1A5 Lithopone/linseed	2½	6	6	½	2	2	2	2	0	3½	3	3½	2	0	0	0	0	100	78	56	50	100	83
F5A2	2A5 ZnS/linseed	2½	6	6	1	2	2	2	2	0	3	3	2½	1	0	0	0	0	100	65	70	88	100	88
F5A3	1B5 Lithopone/phenolic	2½	5½	6	1	2	2	2	2	0	3	2	2	1½	0	0	0	0	100	95	67	92	109	95
F5A4	2B5 ZnS/phenolic	2½	5½	6	1	1	1	1	1	0	3	2	1½	1½	0	0	0	0	100	80	80	92	112	108
F5A5	1C5 Lithopone/alkyd	2½	4½	6	1	1½	1½	1½	1½	0	1	1	1	1	0	0	0	0	100	106	113	113	125	100
F5A6	2C5 ZnS/alkyd	2½	4½	6	½	2	2	2	2	0	2	1	1	½	0	0	0	0	100	85	110	125	140	125
<i>Frodsham</i>																								
F5B1	1A5 Lithopone/linseed	3	6	6	1	0	0	0	0	0	1	1	2	1	½	0	0	0	100	200	94	103	83	128
F5B2	2A5 ZnS/linseed	3	6	6	1	0	0	0	0	0	0	0	1	2	0	0	0	0	100	133	103	127	85	158
F5B3	1B5 Lithopone/phenolic	2½	5½	6	1	0	0	0	0	0	0	0	1	1	0	0	0	0	100	211	74	97	90	137
F5B4	2B5 ZnS/phenolic	2½	6	6	1	0	0	0	0	0	0	0	1	1	0	0	0	0	100	154	77	115	96	104
F5B5	1C5 Lithopone/alkyd	2½	4½	6	1	0	0	0	0	0	0	0	1	1	0	0	0	0	100	133	133	110	107	153
F5B6	2C5 ZnS/alkyd	2½	4½	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	100	126	111	158	121	158
<i>Burry Port</i>																								
F5C1	1A5 Lithopone/linseed	3	6	6	0	0	0	0	0	0	1½	1	4	4	0	0	0	0	100	74	42	90	90	90
F5C2	2A5 ZnS/linseed	3	6	6	0	0	0	0	0	0	1½	1	4	4	0	0	0	0	100	78	56	156	167	167
F5C3	1B5 Lithopone/phenolic	2½	5	6	0	0	0	0	0	0	0	1	4	4	0	0	0	0	100	125	60	130	120	125
F5C4	2B5 ZnS/phenolic	2½	5	6	0	0	0	0	0	0	0	1	4	4	0	0	0	0	100	96	77	119	119	115
F5C5	1C5 Lithopone/alkyd	2½	4½	6	0	0	0	0	0	0	0	1	4	4	0	0	0	0	100	113	81	113	113	69
F5C6	2C5 ZnS/alkyd	2½	4½	6	0	0	0	0	0	0	0	0	4	4	0	0	0	0	100	111	100	167	167	144

TABLE XIII  
BLUE FINISHING PAINT  
(Mean readings for wood and metal panels)

Panel	Finishing paint (No. and type)	Rating of film defects after indicated period (months)												Tint retention (%)																	
		Gloss			Darkening			Chalking			Checking			Cracking			Erosion			Tint retention (%)											
		0	6	9	14	18	26	6	9	14	18	26	6	9	14	18	26	9	14	18	26	14	18	26	0	6	9	14	18	26	
<i>Avonmouth</i>																															
F6A1	1A6 Lithopone/linseed ..	2½	6	6	6	6	6	1½	2	2	2	2	0	3	3	3	3	1½	1½	2	2	0	0	1	100	72	36	64	80	64	
F6A2	2A6 ZnS/linseed ..	2½	6	6	6	6	6	1½	2	2	2	2	0	3	3	3	3	1½	2	2	2	0	0	1	100	71	43	96	107	68	
F6A3	1B6 Lithopone/phenolic ..	2½	5	6	5	5	6	1½	2	2	2	2	0	2	2	2	2	0	0	0	0	0	0	0	100	119	56	85	119	74	
F6A4	2B6 ZnS/phenolic ..	2½	5	6	5	5	6	1½	2	2	2	2	0	2	2	2	2	0	0	0	0	0	0	0	100	103	76	79	110	103	
F6A5	1C6 Lithopone/alkyd ..	2½	4	5	4	5	6	1½	1	1	1	1	0	1	0	1	1	0	0	1	1	0	0	0	100	110	110	117	117	121	
F6A6	2C6 ZnS/alkyd ..	2½	4	5	4	5	6	1½	2	2	2	2	0	1	0	1	1	0	0	0	0	0	0	0	100	113	107	113	113	140	
<i>Frodsham</i>																															
F6B1	1A6 Lithopone/linseed ..	3	6	6	6	6	6	0	0	0	0	0	0	2	0	1	3	1½	1	2	2	1	1	1	100	137	42	79	121	105	
F6B2	2A6 ZnS/linseed ..	3	6	6	6	6	6	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	100	120	76	120	96	120	
F6B3	1B6 Lithopone/phenolic ..	2½	5	6	6	6	6	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	100	143	43	86	83	86	
F6B4	2B6 ZnS/phenolic ..	2½	6	6	6	6	6	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	100	129	55	97	90	97	
F6B5	1C6 Lithopone/alkyd ..	2½	3	4	3	4	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	97	77	97	116	113	
F6B6	2C6 ZnS/alkyd ..	2½	3	4	3	4	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	88	63	75	105	113	
<i>Barry Port</i>																															
F6C1	1A6 Lithopone/linseed ..	2½	5	6	6	6	6	0	0	0	0	0	0	2	2	2	4	1	0	0	0	0	0	0	100	56	24	36	36	48	
F6C2	2A6 ZnS/linseed ..	2½	5	6	6	6	6	0	0	0	0	0	0	1	1	1	4	0	0	0	0	0	0	0	100	47	40	53	53	43	
F6C3	1B6 Lithopone/phenolic ..	2½	5	6	6	6	6	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	100	103	57	53	53	53	
F6C4	2B6 ZnS/phenolic ..	2½	5	6	6	6	6	0	0	0	0	0	0	0	0	1	4	0	0	0	2	0	0	0	100	73	67	70	67	67	
F6C5	1C6 Lithopone/alkyd ..	2½	4	5	4	5	6	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	100	110	100	60	67	67	
F6C6	2C6 ZnS/alkyd ..	2½	4	5	4	5	6	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	100	110	100	83	90	53	

# An Investigation into Drying Phenomena Experienced with Alkyd Resins Based on Soya Bean Oil\*

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## Summary

The problem of variable drying, particularly with regard to the variation in the length of induction period experienced with long oil pentaerythritol soya alkyds, is examined with a view to establishing its cause and how it can be resolved. The observed differences between the drying of the pigmented and unpigmented alkyds are shown and a method is given for effecting an improvement in the basic drying ability of the resin. The role of some drier metals is also reviewed, with particular reference to calcium and barium as additives to the standard 10/1, lead/cobalt drier mixture.

## INTRODUCTION

The subject of this paper concerns a particular problem encountered in the course of the authors' work and which in itself led to a variety of phenomena, each a problem in its own right. The bulk of the work outlined was carried out using a typical long oil (65 per cent) penta soya bean oil alkyd prepared by the monoglyceride process, but the phenomenon was not confined to this particular alkyd; it was also observed in other soya alkyds, both pentaerythritol and glycerol types. The work originated from the result of an observation that the drying time, or more correctly the induction period, of a dried soya alkyd varied from batch to batch, the effect being greatly increased when the alkyd was pigmented.

When pigmented finishes are mentioned, unless otherwise stated, rutile titanium dioxide was used at a pigment/binder ratio of 0.8/1.0 and the paints were made up by triple roll milling. It must be noted that unless otherwise stated the drier level used was fixed at 0.5 per cent lead and 0.05 per cent cobalt as metal on alkyd base, this level being employed in both clear and pigmented finishes, and in every case the finishes were reduced to a medium solids of 53.6 per cent in order to keep the composition constant.

The variable drying properties of the different batches of resin were, as mentioned previously, confined chiefly to the induction period of the drying film. Once normal drying commenced the dry was then rapid and satisfactory. This final process was similar whether the resin possessed a long or a short induction period. The instrument used for comparing the variations in drying was the *B.K. Drying Recorder*, which gave a permanent record of the results obtained. In every case a standard film thickness of 0.0015 in. was employed, all tests being carried out at 20°C and 65 per cent relative humidity. The type of record obtained is shown in Fig. 1, and the differences between "good" and "bad" resins can readily be seen. The difference between the drying properties of clear and pigmented finishes is particularly marked; the clear

\*Read before the Midlands Section on 20 January, 1961, and the West Riding Section on 14 February, 1961.

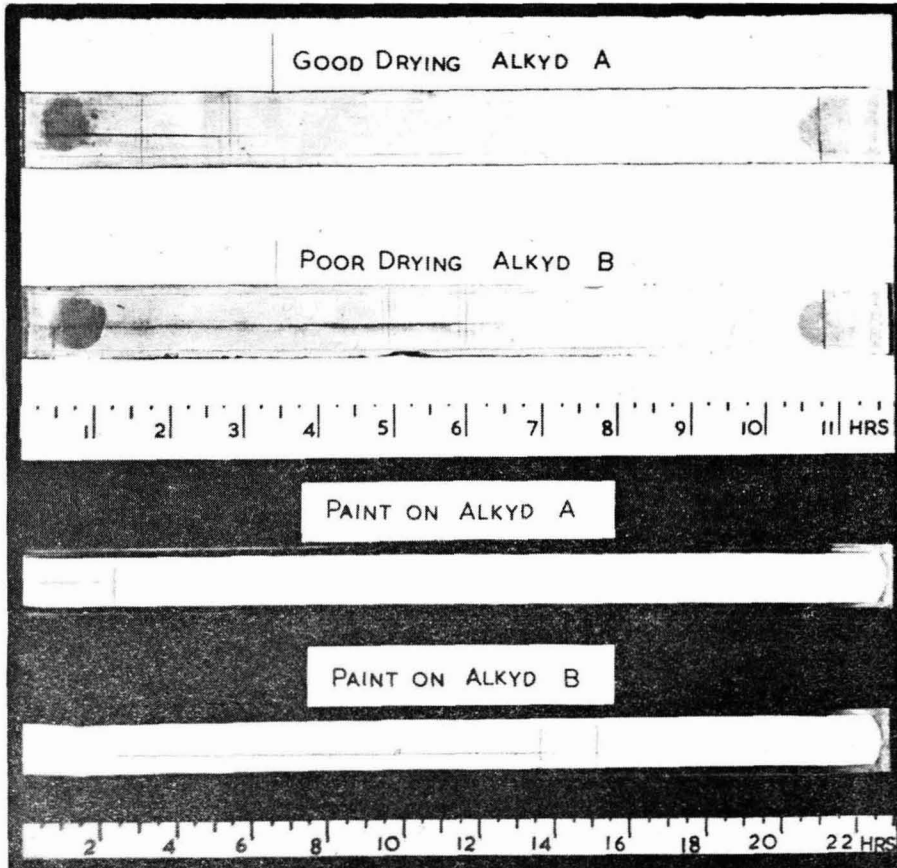


FIG. 1. DRYING OF SATISFACTORY AND UNSATISFACTORY ALKYDS

finish result is obtained on a twelve-hour run, while the pigmented finish requires a twenty-four-hour run in order to record the greatly extended induction period of the poor drying paint.

An examination of the general characteristics of undried resins with variable dry showed no marked differences, the only minor observation being that the poor drying resins were paler in colour than their good drying counterparts. When it came to an examination of the dried resins, however, a significant observation was made, namely that, although on drier addition all the resins became pink in colour from the cobalt drier present, a gradual colour change to green took place. The rate of change varied from batch to batch of resin: where a rapid change took place the resin had a short induction period; where the change was slow the resin had a long induction period. In order to confirm this observation, three samples of resin with known varying drying differences were tested on the *B.K. Recorder*, in correlation with *Lovibond Tintometer* measurements; the results are shown in Table I. The faster drying the resin, the more quickly the solution developed the yellow (Y) and blue (B) ratios, with a corresponding drop in the red (R).

TABLE I  
COLOUR CHANGE OF DRIERED SOLUTION V. DRYING TIME

Maturing period (hr.)	Alkyd 1—Good drying				Alkyd 2—Fair drying				Alkyd 3—Poor drying			
	D.T.	R	Y	B	D.T.	R	Y	B	D.T.	R	Y	B
1	1½-1½	2.3	6.4	0.3	2½-3½	3.1	5.4	—	4-4½	3.1	5.4	—
2	1½-2	2.0	6.6	0.6	2½-3	3.0	5.4	—	3½-4	3.1	5.4	—
3	1-1½	1.3	6.6	0.5	1½-2½	2.7	5.7	—	2½-3½	3.0	5.4	—
4	1½-1½	1.2	6.6	0.5	2-2½	2.4	5.7	—	3-3½	2.6	6.8	—
5	1-1½	1.1	6.6	0.6	1½-2½	2.3	6.5	—	2½-3	2.6	6.8	—
6	¾-1½	1.1	8.1	1.1	1-1½	2.2	7.1	—	1½-2½	2.5	6.9	—
7	1-1½	1.0	8.8	1.3	1½-1½	1.8	7.0	0.3	2-2½	2.5	7.0	—
8	1-1½	0.9	8.8	1.5	1-1½	1.6	7.3	0.4	1½-2½	2.2	7.5	0.3
24	1½-1½	—	19.0	4.1	1-1½	0.8	13.0	2.6	1½-2	0.8	13.0	2.1

Since the induction period of a resin solution on drying as a film varied with both the state of oxidation of the drier metal and the time of maturing, the method employed for testing the drying properties of the clear and pigmented resins was standardised. The drying time was determined after four-hour and twenty-four-hour maturing periods, the four-hour test giving an indication of the rapidity of the colour change in relation to the dry. The twenty-four-hour test was used as a standard control test, since it was considered that a good resin should be capable of optimum drying properties on maturing for twenty-four hours.

Since the colour change is one observed on drier addition, and is obviously connected with the "coloured metal" cobalt, it appears that in order to obtain a short induction period the cobaltous cobalt originally added must achieve a certain degree of oxidation in the resin solution. In unpigmented finishes, although the colour change may be very slow, oxidation will eventually occur, particularly if the resin is cast in a thin film in the presence of air. Therefore, although clear finishes do show variations in drying properties, particularly when very short maturing periods are used, after a reasonable time these variations become less noticeable. The initially poor drying resins thus eventually attain the drying properties (and green colour) of the satisfactory materials.

However, early observations had shown (see Fig. 1) that once a resin was pigmented the variation in drying power was greatly increased, the problem becoming much more serious because the pigmented finish, unlike the clear finish, failed to attain satisfactory drying properties on maturing. This phenomenon at first was difficult to explain, but the explanation below appears to be the most probable.

In the pigmented finish the following processes occur:

- (i) The resin reacts with the drier, oxidising the cobalt from the pink cobaltous to the green cobaltic state.
- (ii) Simultaneously the pigment begins to adsorb the drier metals.

If reaction (i) is slow the drier is preferentially adsorbed on the pigment and becomes inactivated, with a consequent loss of drying power. If reaction (i) is fast the formation of cobaltic cobalt is largely completed before drier adsorption reaches a degree that will affect the dry; when this change has been effected good drying properties are obtained. Further detailed study is required to determine whether the reason for this is that cobaltic cobalt resists adsorption or that the reacted resin remains in an activated state after the valency change and regardless of adsorption.

A number of experiments bearing on the above explanation was therefore carried out with the following results.

- (a) Paints based on anatase titanium dioxide were greatly inferior in drying properties to similar paints based on rutile titanium dioxide when made on poor drying resin. Anatase was found to adsorb driers much more readily and more quickly than rutile, which was determined by adding a white spirit solution of drier to a white spirit pigment slurry, then filtering and observing the filtrate colour compared with a blank containing driers alone. The filtrate from the anatase slurry was colourless while that obtained from rutile showed from its colour that a fair quantity of cobalt remained in solution.

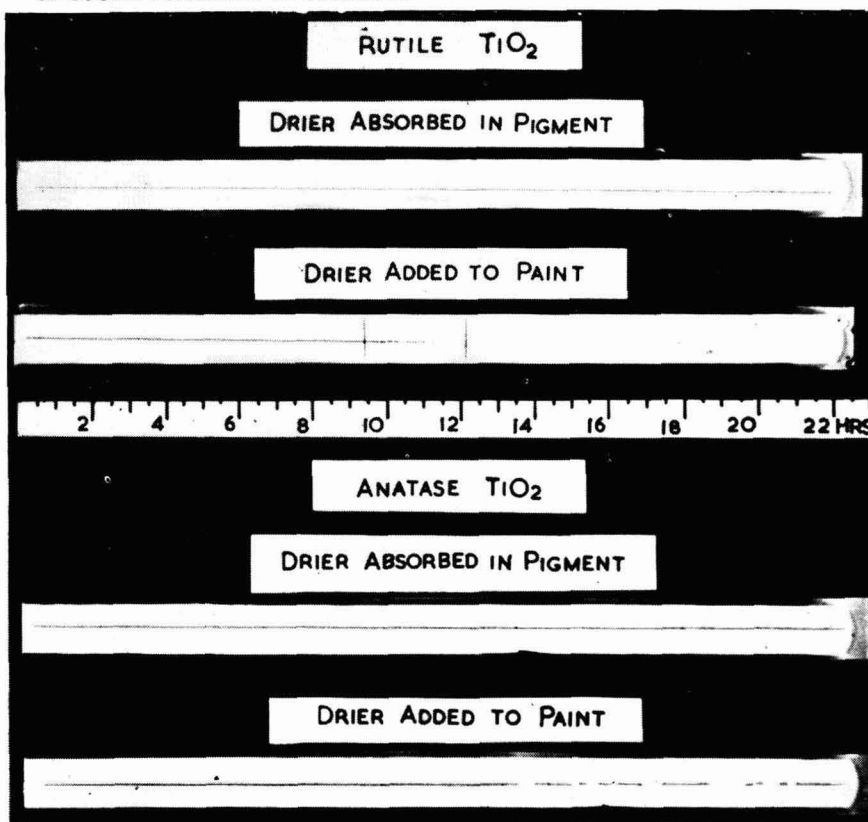


FIG. 2. DRYING POWER OF PRE-ADSORBED DRIER METALS

- (b) A pigment was allowed to adsorb drier equivalent to the normal quantity required in a paint, then dried (in a low temperature oven) and made into a paint; the results are shown in Fig. 2. Where the drier was absorbed into the pigment, the paint had no drying properties at all, whether anatase or rutile titanium dioxide were used. Where the resin was pigmented and driered in the normal manner, the paint based on rutile showed reasonable drying properties while that based on anatase showed very poor drying properties. In other words, adsorbed drier metal was effectively removed and played no part in catalysing the drier reaction.
- (c) If a resin with known poor drying properties was driered, matured to a green colour and then pigmented, the pigmented finish was superior in drying properties to a similar finish made in the conventional manner.

In the light of work done so far the factors influencing the pink-green colour change were examined. It was found that an alkyd could be rendered capable of effecting this change by a number of treatments including prolonged air blowing, peroxidation with organic peroxides, or filtration. This indicated the possible presence in the alkyd of a material which inhibited the drying mechanism, either by the prevention of the formation of hydroperoxides in the alkyd, or in some other way retarding the cobalt/alkyd reaction. This material appeared to be neutralised in the presence of excess oxygen, hence the eventual satisfactory dry of a clear finish. The fact that filtration improved the dry led to the possibility that the inhibitor (if such existed) was in such a form that it was capable of removal by filtration.

Now that the general scope of the problem was thoroughly understood, the next step was to investigate the basic alkyd, its processing and the raw materials used in its production with a view to establishing the identity of the trouble-maker, determining its source, and eliminating it if possible.

#### EXPERIMENTAL

This poor drying problem could only be brought to light for examination by using a special laboratory technique. Prior to this investigation good drying of soya alkyds was always achieved in the laboratory, using the usual factory procedure of pressing the alkyd into solvent and then filtering the solution thus obtained. In order to accentuate drying differences care was taken to impose the most adverse conditions by omitting filtration and excluding air completely. The special technique adopted, therefore, was to pour every alkyd as base into a container, to which the lid was immediately fitted. The base resin thus produced was cold-cut into mineral spirits and examined for drying as a pigmented finish in the manner previously outlined. All the drying times quoted in the following tables will therefore refer to pigmented finishes and are the times when the finishes are just surface-dry.

The alkyd type chosen for the investigation was of the type in which the problem was exceptionally noticeable, *i.e.* a fusion-cooked 65 per cent soya oil, pentaerythritol, phthalic alkyd, all the raw materials being of high quality and the soya oil having an iodine value between 130 and 135. (This is mentioned in order to show that drying differences should not be due to the variability of the soya oil unsaturation.)

As litharge was the alcoholysis catalyst being used where this drying difficulty was experienced, the investigation began by considering the filtration aspect. Litharge naturally forms insoluble lead salts during the alkyd preparation, which are removed partially or completely during a filtration process, depending on the efficiency of the filtering. As has been stated in the introduction, it was noticed that with more efficient filtering the drying of the alkyd was improved. This could be due to removal of the lead salts, which could therefore be the cause of the poor drying experienced with an unfiltered alkyd.

TABLE II  
VARIATION OF ALCOHOLYSIS CATALYSTS

Resin No.	Catalyst (%)	Viscosity † (poise)	Drying time (hr.)	
			(Maturing period) 4 hr.	24 hr.
1	PbO-0.02	26.3	>12	9 $\frac{3}{4}$
2	LiOH-0.02	31.6	>12	>12
3	KOH-0.02 PbO-0.0025	33.1	>12	>12
4	PbO-0.02 + H <sub>3</sub> PO <sub>4</sub> (to ppt. as PbHPO <sub>4</sub> )	30.0	>12	>12
7	Ca nap = PbO-0.02	33.1	>12	8 $\frac{1}{2}$
10	PbO-0.02 + H <sub>3</sub> PO <sub>4</sub> (to ppt. as PbHPO <sub>4</sub> *)	33.1	>12	>12

\*This was filtered off at end of alcoholysis resulting in a clear final alkyd.  
†70 per cent solution in white spirit, at 25°C.

In Table II is shown a series of alkyds in which various alcoholysis catalysts are used, and it can be seen that poor drying results in every case. Even in alkyd No. 10, where the lead was removed as the phosphate immediately after the alcoholysis stage resulting in a perfectly crystal clear base resin, the drying was extremely poor. This could only mean that the alcoholysis catalyst used was not the cause of the problem and that some other component of the alkyd must be responsible.

The oil was the obvious first suspect and hence its replacement by fatty acid and glycerine would show whether it was responsible. The results obtained when this replacement is carried out are given in Table III.

Alkyd No. 6 had a form of alcoholysis carried out by first cooking the fatty acid and polyols together to bring it as near as possible to the previous alkyd cookings in Table II. Alkyd No. 9 had all the materials charged together, and Alkyd No. 11 had the alcoholysis quantity of litharge added in order to examine the alcoholysis catalyst question once again. It can immediately be seen that good drying occurs in all cases and that litharge had no effect. Since the pentaerythritol and phthalic anhydride were from the same source in all cases, no doubt remained as to the oil being the source of the drying problem.



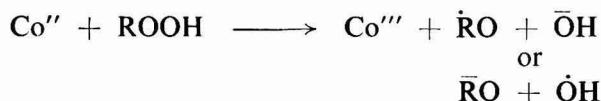
TABLE III  
REPLACEMENT OF OIL BY FATTY ACID AND GLYCERINE

Resin No.	Remarks	Viscosity † (poise)	Drying time (hr.)	
			(Maturing period) 4 hr.	24 hr.
6	Soya fatty acids and glycerine cooked together as a monoglyceride before addition of dibasic acid. No catalyst.	34.6	3½	4
9	All ingredients charged together. No catalyst.	33.1	1¾	1¾
11	Exactly similar to No. 6 except 0.02 per cent PbO added to "alcoholysis" stage.	33.1	2¼	2

†70 per cent solution in white spirit, at 25°C.

This conclusion poses the question as to what in the oil can be responsible for the poor drying, as the iodine value of the oil is exactly the same as the iodine value of the fatty acids used and the speed of drying is quite different. The normal drying mechanism is obviously upset or retarded and a good indication as to where it is retarded is given by the previous observation that a good drying soya resin turns the cobalt driers quickly to the green cobaltic state, while a poor drying resin produces this change only very slowly.

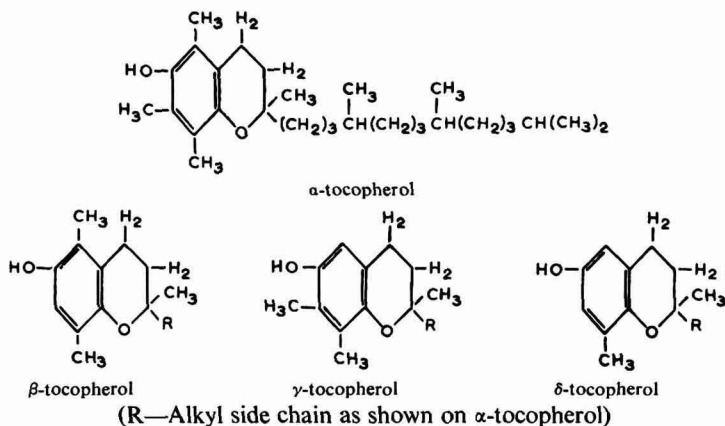
Taking an accepted drying mechanism, the cobaltous cobalt is converted to the cobaltic state by any preformed oil hydroperoxide decomposing:



The fact that reaction does not occur, or only does so very slowly, means that either this reaction is prevented, or that the preformed hydroperoxides are decomposed by something before the cobalt can react with them, or that preformation of the hydroperoxides is suppressed by the presence of an oxidation inhibitor in the oil. The third explanation seems to be the most probable; such oxidation inhibitors are known to be present naturally in vegetable oils and particularly in soya oil. These natural inhibitors are the tocopherols and possibly some other materials which have not been fully identified.

The tocopherol structures are given below and they are well known as the "E" vitamins.

In actual fact the tocopherols have been known and used for some time as anti-oxidants in the cooking or edible fats industry to prevent high temperature oxidative degradation during the various processes carried out on the oils. The effect these natural anti-oxidants have on air-drying of the oils has also been known for some time as indicated in a U.S. patent by Vogel<sup>1</sup>.



In this patent air is blown through the oil in the presence of one of the drying metal catalysts. This preferentially oxidises the anti-oxidant, hardly affecting the iodine value of the oil. Boyer<sup>2</sup> *et al.* stated that tocopherols have no anti-drying power in linseed oil, but act as synergists with any acid phosphatides present in the oil, these phosphatides being powerful anti-oxidants.

The type of oil utilised in this investigation was a good grade alkali-refined soya oil from which virtually all the phosphatides had been removed, to the extent that spectrographic examination failed to detect a measurable quantity of phosphorus. The only natural inhibitors known to remain in this type of soya oil, therefore, were the tocopherols and it is to be presumed that they were the reason for the drying difficulties experienced.

Previously it had been shown that by using a fatty acid ankyd with good or uninhibited drying resulted. In order to examine the possibility of tocopherols being responsible for the poor drying of oil-based alkyds, a quantity of  $\alpha$ -tocopherol equal to the amount normally found in soya oil was added to the fatty acid alkyd. The result of  $\alpha$ -tocopherol addition on these alkyds is shown in Table IV. It is very evident that compared with the good drying of alkyd No. 9, the drying of alkyd No. 48 has been completely inhibited by adding 0.1 per cent  $\alpha$ -tocopherol.

TABLE IV  
THE EFFECT ON DRYING TIME OF  $\alpha$ -TOCOPHEROL ADDITION

Resin No.	Type of cooking	Treatment	Viscosity † (poise)	Drying time (hr.)	
				(Maturing period) 4 hr.	24 hr.
9	Fatty acid full fusion	No additives	33.1	1½	1½
48	Fatty acid full fusion	$\alpha$ -tocopherol added = 0.1 per cent oil§	28.5	> 12	> 12*

† 70 per cent solution in white spirit, at 25°C.

\* Wet after 24 hours.

§ *i.e.* similar to proportion found in soya oil.

This is proof that the tocopherol can exist unaffected by the alkyd preparation and act as a strong anti-oxidant. The  $\alpha$ -tocopherol addition is of the order of published total tocopherol contents of oils. This is given in Table V, together with that of some other oils, for the purpose of full illustration and comparison.

TABLE V  
TOCOPHEROL CONTENT OF FATS AND OILS<sup>3</sup>

Oil	Alpha (%)	Gamma (%)	Delta (%)	Total (%)
Linseed oil	—	—	—	0.11
Safflower, crude	—	—	—	0.080
Soybean, refined	0.020–21	0.074–78	—	0.094–99
Soybean	0.020	0.098	0.050	0.168
Sunflower seed	—	—	—	0.07

When it had thus been shown that  $\alpha$ -tocopherol had the identical effect on a good drying alkyd as was experienced when using an oil, a series was prepared as shown in Table VI, where the tocopherol content of the oil or fatty acid was varied by subjecting the same oil or fatty acid to various treatments.

TABLE VI  
EFFECT OF TOCOPHEROL CONTENT ON OIL OR FATTY ACID FROM THE SAME SOURCE

Resin No.	Oil or F.A. used	Tocopherol content (mg./100g.)	Catalyst	Viscosity † (poises)	Drying time (hr.)	
					Ma'uring period 4 hr.	24 hr.
59	Sample No. 1 neutralised unbleached Soya oil	64	PbO	31.6	>12	3½
60	Sample No. 2 neutralised bleached soya oil	56	PbO	33.1	8½	2¾
61	Sample No. 3 autoclave split undistilled soya fatty acids	25	—	31.6	8½	2¾
62	Sample No. 4 autoclave split distilled soya fatty acids	0	—	34.6	2½	1¾
63	Sample No. 5 chromatographically refined soya oil	0	PbO	31.6	1¾	1¾
64	Sample No. 6 specially refined soya oil	64	PbO	31.6	10¼	4¾

†70 per cent in white spirit, at 25°C.

The oils and fatty acids were all derived from the same unrefined batch of soya oil and the separate samples obtained as stated in Table VI, the sample No. 6 having been refined by an alternative unspecified process. In Table VI it will be seen that where tocopherols are absent from the oil or fatty acid there is no inhibition of the drying. In fact the chromatographically refined oil gave an alkyd with exceptionally good drying although the iodine value for this oil was only 128. Where there is a quantity of tocopherol present in the fatty acid-based resin No. 61, inhibition of the drying occurs, and although the fatty acids for both resin No. 61 and No. 62 were derived from the same source, the tocopherol-free fatty acid gave alkyd No. 62 which dried extremely well. Similarly, where there were quantities of tocopherols present in the oil-based alkyds, inhibition of the drying occurred, larger tocopherol contents giving more inhibited drying.

The determination of the tocopherol contents for this series was carried out by a modified Emmerie-Engel test. The tocopherols were extracted after saponification of the oil and dissolved in a known quantity of alcohol. By taking a portion of this alcoholic solution, adding excess alcoholic ferric chloride solution and then excess 2-2' dipyridyl in alcohol, a red coloration was produced, the intensity of which was measured on an adsorptiometer. Estimation was based on the tocopherols quantitatively reducing the ferric ions to ferrous ions. The ferrous ions form a coloured complex with the dipyridyl which will be in proportion to the concentration of the tocopherol content.

As a matter of interest, due to the possibility of any other semi-drying oil having this inhibited drying problem, two alternative oils were examined, as shown in Table VII. There the segregated sunflower oil, which contained a

TABLE VII  
ALKYDS BASED ON SEMI-DRYING OILS

Resin No.	Type of oil	Tocopherol content of oil (mg./100g.)	Alcoholysis catalyst	Viscosity† (poise)	Drying time (hr.)	
					(Maturing period) 4 hr.	24 hr.
56	Segregated sunflower oil	40	PbO	30.1	> 12	3
57	Tobacco seed	10	PbO	31.6	3½	2

†70 per cent solution in white spirit, at 25°C.

moderate quantity of tocopherols, dried as expected, with some definite inhibition, whilst the tobacco seed oil, which contained only just detectable quantities of tocopherols, dried without any real sign of inhibition.

This then fairly well established the cause of the problem, but it remained for a method to be found to overcome the drying difficulty.

INVESTIGATION INTO METHODS OF REMOVING THE  
DRYING PROBLEM

One obvious conclusion from the first part of the investigation was that the use of a good distilled soya fatty acid would produce alkyds which did not exhibit the drying difficulty at all. The only dangers arising with the method were associated with the use of a cheaper, inadequately distilled soya fatty acid which would contain some inhibitors.

Trying to find a method for using oil was a lot more difficult. The use of chromatographically refined soya oil had been shown to give the desired result, but this method was definitely uneconomical and about the only known way of actually removing the tocopherols. The only remaining solution was to destroy the tocopherols in the oil before cooking the alkyd.

TABLE VIII  
OIL TREATMENTS TO OVERCOME INHIBITION OF DRYING

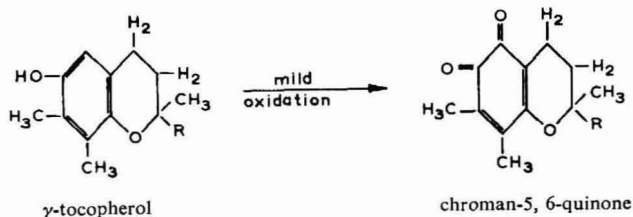
Resin No.	Oil treatment	Catalyst	Viscosity† (poise)	Drying time (hr.) (Maturing period)	
				4 hr.	24 hr.
30	Oil exposed U.V. light for 6 hr. under air bubbling	PbO	31.6	>12	>12
33	Oil treated with 0.05 per cent M.E.K.P. and 0.05 per cent T.B.H.P.	PbO	34.6	>12	>12
36	Oil air blown for 90 min. at 130°C in presence of 0.001 per cent Co	PbO	31.6	>12	>12
45	Oil treated with 0.2 per cent T.B.H.P. in the presence of 0.001 per cent Co for 1 hr. at 120°C	PbO	41.25	>12	>12
51	Oil washed three times at 55°C with methanol	PbO	37.8	>12	>12

†70 per cent solution in white spirit, at 25°C.

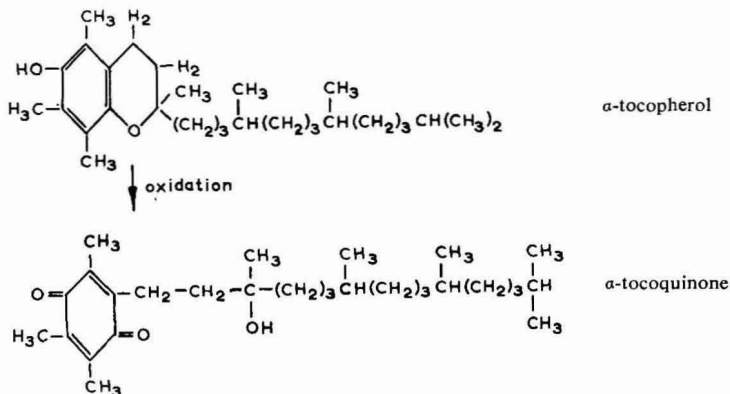
Some of the various processes which have been tried to destroy the inhibitors in the oil before preparation of the alkyd are indicated in Table VIII; none of them has been found to show any improvement.

For alkyd No. 30 the oil treatment was based on the fact that the tocopherols are known to oxidise readily under ultra-violet light, particularly when exposed to air. The oil treatment for alkyd No. 33 was based on supplying a large quantity of oxidising material in the form of peroxide, which would decompose on heating the oil and accordingly oxidise the inhibitors. The basis for the treatment carried out on the oil for alkyd No. 36 was taken from the previously mentioned patented process by Vogel<sup>1</sup>, which definitely claimed to oxidise the inhibitors and render them inactive. Similarly, the treatment used on the oil in alkyd No. 45 gave visual proof that oxidation of the tocopherols was taking place in that the oil on reaching 120°C, with the peroxide and cobalt, developed a pronounced red coloration which subsequently disappeared on

prolonged holding at 120°C. This coloration was attributed to the formation by mild oxidation, of chroman-5, 6-quinone from the  $\gamma$ -tocopherol present in the soya oil. This oxidation process is shown below. Since this quinone is highly coloured, as little as 50 mg./100 g. of oil is enough to produce quite a pronounced coloration of the oil.



The subsequent disappearance of this coloration was presumably due to further oxidation splitting the ring system and producing a yellow coloured *p*-quinone. Other tocopherols must similarly be oxidised to their respective quinone, *e.g.* as illustrated for  $\alpha$ -tocopherol.



A treatment not relying on oxidation was the basis for the oil treatment used for alkyd No. 51 in Table VIII, in that it was found that hot washing of the oil with methanol removed a portion of the tocopherols each time. However, three washings apparently failed to remove sufficient of the tocopherols to give any improvement in drying. Nor was there any improvement in drying obtained by the oxidation treatments as can be seen from Table VIII. This can only mean that during the alkyd cooking process any oxidised inhibitor can be reactivated to a form which will again act as an inhibitor.

In order to ascertain the validity of this statement a further series of resins was prepared, to which the oxidation product of  $\alpha$ -tocopherol, *i.e.*  $\alpha$ -tocopheryl-quinone, was added. The results obtained in this series are shown in Table IX, where all the resins were full fusion soya fatty acid alkyds prepared in the same way, except for the variation indicated in the table.

Resin No. 9 showed no inhibition (see also Tables III and IV). The addition of  $\alpha$ -tocopherol to this resin as shown in resin No. 9 (*a*) produced definite

TABLE IX  
EFFECT OF  $\alpha$ -TOCOPHEROL AND  $\alpha$ -TOCOPHERYL QUINONE ADDITION

Resin No.	Remarks	Viscosity† (poise)	Drying time (hr.)	
			(Maturing period) 4 hr.	24 hr.
9	No addition . . . . .	34.7	1½	1¼
9 (a)	0.1 per cent $\alpha$ -tocopherol, based on the oil content, added to the completed resin	34.7	10¼	4¼
9 (b)	0.1 per cent $\alpha$ -tocoquinone, based on the oil content, added to the completed resin	34.7	1¾	1¾
70	0.1 per cent $\alpha$ -tocoquinone, based on the oil content, added to the initial charge of the resin	30.0	7	2¼

†70 per cent solution in white spirit, at 25°C.

inhibition, while the addition of  $\alpha$ -tocopheryl-quinone in resin No. 9 (b) produced no inhibition. This proved that tocopheryl-quinone was not an anti-oxidant, but by incorporating it in the initial charge of the resin preparation anti-oxidant properties were produced, as shown by the inhibited drying of resin No. 70.

Thus actual removal from the oil of the inhibitors or their oxidation products is necessary before a suitably good drying alkyd can be produced without fail. Removal is completely impracticable, but there still remains the possibility of treatment of the finished alkyd resins as the means of overcoming the problem.

As mentioned in the introduction, the addition of organic peroxides to the alkyd was found capable of improving the drying properties, the most suitable peroxides being the type more readily decomposed at low temperatures, *e.g.* M.E.K.P., M.I.B.K.P., *etc.* Unfortunately, their effect was only short lived, presumably owing to their decomposition leaving the system inhibited as before. Their sole purpose would therefore appear to be one of providing a "bank" of available oxygen to initiate the drying mechanism and not to affect the nature of the inhibitor in any way.

During the study of work that had been carried out on edible oils, where anti-oxidants were a necessity for stability and where the tocopherols were particularly desired both as a source of anti-oxidant and of vitamin E, it had been observed that metal ions, particularly copper, must be absent or deactivated by chelation<sup>4</sup>, otherwise the tocopherols were rapidly destroyed by catalytic oxidation<sup>5</sup>. As it was necessary in this investigation to destroy these inhibitors, the introduction of metal ions in the presence of oxidising agents was examined as a possible means of improving poor drying alkyds.

From this satisfactory results were obtained using metals, such as copper, cobalt, ferric ion and many others, for catalytically oxidising the tocopherols with such oxidising agents as air, oxygen, peroxides or hydroperoxides, the

reaction being carried out at temperatures above 50°C. The process at present forms the basis for a patent application<sup>6</sup> and Table X shows the type of improvement obtained by a typical treatment using copper naphthenate as the source of metal (0.5 p.p.m.) and M.E.K.P. as the oxidising agent (0.12 per cent active peroxide on base alkyd), the treatment being carried out on the mineral spirit thinned solution.

TABLE X  
CATALYTIC OXIDATION TREATMENT ON A POOR DRYING SOYA ALKYD SOLUTION

Resin	Viscosity† (poise)	Drying time (hr.)	
		(Induction period) 4 hr.	24 hr.
Soya alkyd solution before treatment .. ..	26.3	12	8
Soya alkyd solution after 2 hr. treatment ..	26.3	1½	1½

†70 per cent solution in white spirit, at 25°C.

It will be seen from Table X that this method affords a satisfactory means of ensuring that regardless of variation in the anti-oxidant content of a soya oil alkyd, the anti-oxidant can be reduced to a level which renders the alkyd satisfactory in drying properties without affecting any other properties.

#### THE EFFECT OF SOME DRIER METALS ON SOLVING THE PROBLEM

Although a satisfactory process for overcoming the phenomenon had been obtained, this was not the only line of work that had been investigated. Before the nature of, and the cure for, the main problem above had been determined, further work had been in progress on the resin in order to determine whether a particular addition or combination of drier metals could effect an improvement in the drying properties of the alkyds, particularly when pigmented, and the following general results were obtained.

The obvious course of action was to increase the drier level already being used, and, as was to be expected, an increase in the drier level improved the dry. However, this was not regarded as a satisfactory approach to the problem, since the quantity of drier had to be varied to meet the specific requirements of a particular resin sample. If the resin had particularly poor drying properties, excessive quantities of drier would be required. However, an interesting observation noted was that a resin with initial good drying properties retained better dry after two years' storage when dried at a level of 0.07 per cent cobalt, 0.7 per cent lead, rather than at the level of 0.05 per cent cobalt and 0.5 per cent lead. The paint containing the higher drier level had an induction period of 2½ hours after two years' storage compared with four hours with the standard drier. Any further increase failed to improve the retention of dry beyond this point.

A number of very interesting facts were observed when 0.1 per cent calcium naphthenate was examined with 0.5 per cent lead, 0.05 per cent cobalt as a



dry improver in paints. First, with a poor drying resin pigmented with rutile titanium dioxide the method of incorporation of the drier greatly affected the resulting paint. If the three drier metals were pre-mixed and stood for some time, and the drier blend then added to the paint, very poor drying properties resulted. However, if in the same drier combination the calcium were added first, followed after a suitable period by the lead-cobalt mixture, or if the lead-cobalt were added first, followed after a time by the calcium, greatly improved drying properties resulted.

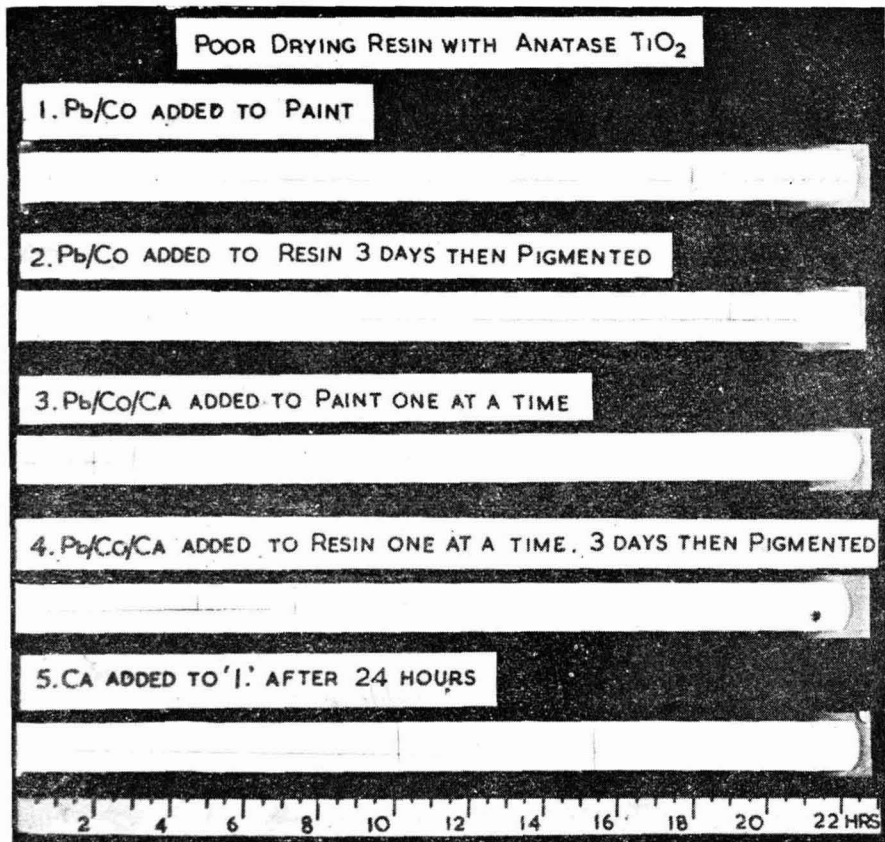


FIG. 3. THE EFFECT ON INDUCTION PERIOD OF METHOD OF DRIER ADDITION

An example of the effect drier metals play on this type of sensitive drying material is demonstrated in Fig. 3. In this experiment a series of paints was made up on a poor drying resin sample, the effect being enhanced by pigmenting with anatase titanium dioxide. Initially only paint No. 1 had a poor dry, the remaining paints being very satisfactory. The figure shows the results obtained after two years' maturing of the paints, and immediately the differences become apparent. Both the paints containing lead and cobalt have lost their drying properties, while the paint in which the lead, cobalt and calcium were added one after the other has retained a very good dry. The remaining paints,

which contain the same drier concentration as No. 3, vary appreciably in dry retention, depending on the method of incorporating the driers in the paint.

The reasons for the peculiar differences with calcium which are dependent on the method of incorporation are still to be fully investigated, but it is significant that calcium is a very "active" metal; addition of calcium to an alkyd or oil can cause an immediate viscosity increase or, in the case of lightly bodied oil, the formation of tiny gel-like particles. In other words, calcium appears to react with the medium, possibly forming complexes with low viscosity, slow drying material. Similarly, calcium also appears to form a complex with cobalt, for when the two drier metals are blended together an intense "lilac" colour develops. This "lilac" material, unlike cobalt alone, is resistant to ready oxidation (difficult to obtain pink-green change) and is also resistant to adsorption to pigments, even anatase titanium dioxide. This resistance to adsorption is similar to the effect obtained when cobalt is complexed with a known complexing agent such as 1 : 10 phenanthroline; in both cases after slurring with anatase there remained a coloured filtrate.

A further drier metal examined with promising results was barium, but the work carried out on this metal is only in its early stages in pigmented finishes. However, this preliminary work appears to show that barium, like calcium, when mixed with cobalt produces a blend which is resistant to adsorption, but unlike calcium, barium activates cobalt, making the cobalt more readily oxidisable.

A level of about 0.25 per cent barium was required to give equivalent dry retention to that obtained with 0.1 per cent calcium, but these figures resulted from only three months' observation. A series of experiments were, however, carried out using a sample of unpigmented resin with a control based on lead/cobalt, and additions of lead/cobalt/calcium and lead/cobalt/barium (both calcium and barium being employed at 0.1 per cent concentration). In one case the calcium and barium were pre-mixed with the lead/cobalt before addition to the resin and in the other case the calcium and barium were added one hour before the lead/cobalt. All of the resins had similar drying properties after twenty-four hours' maturing ( $1\frac{1}{2}$ -hour induction period), but after one year these had changed appreciably with the results shown in Fig. 8. The control based on lead/cobalt alone had deteriorated to an induction period of nine hours, and similarly the pre-mixed calcium and the separately added barium trials both showed long induction periods ( $6\frac{1}{2}$  and seven hours respectively). The induction periods of the resins with the separately added calcium and the pre-mixed barium were, however, quite short, both being  $1\frac{1}{4}$  hours.

It is thus evident that both calcium and barium are satisfactory drying improvers when added correctly, the barium preferably being mixed with the lead/cobalt before addition to the paint and the calcium being added separately.

Zinc with lead/cobalt, unlike calcium or barium, renders the drying properties of the resin less satisfactory than lead/cobalt alone. Similarly, the replacement of 10 per cent of the paint thinner (white spirit) with dipentene caused poor initial dry and a rapid loss of dry in a pigmented finish on storage.

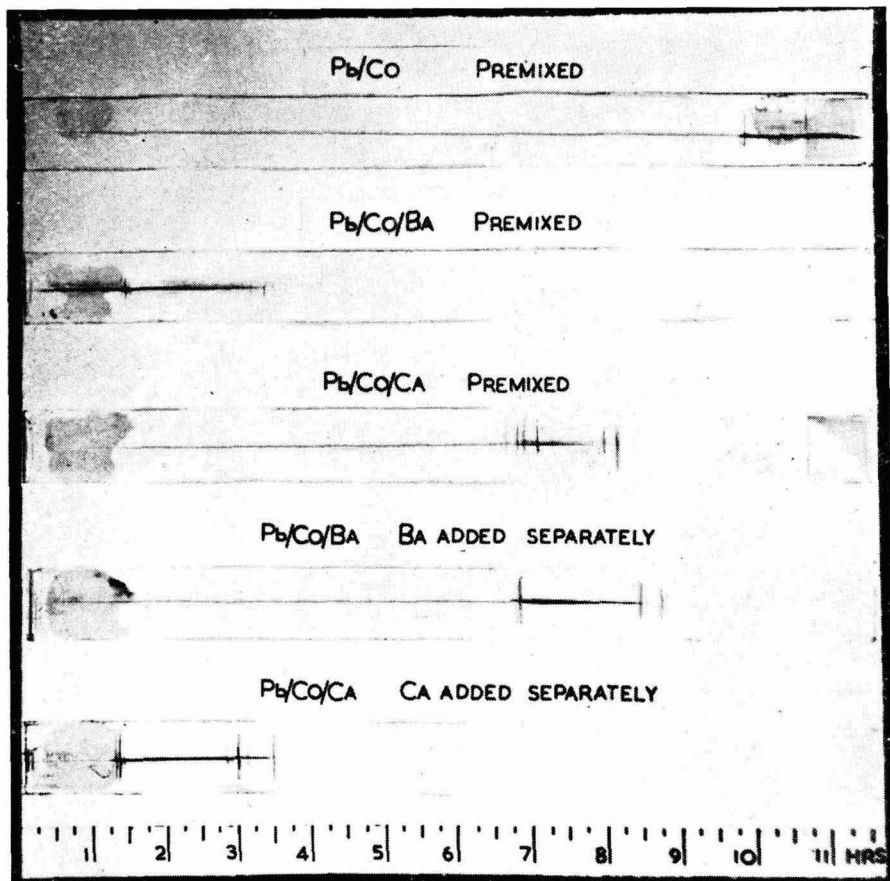


FIG. 4. THE EFFECT ON INDUCTION PERIOD OBTAINED USING BARIUM OR CALCIUM

#### CONCLUSIONS

A chance observation that was routine in itself initiated a series of interesting experiments and the accumulation of much useful information. The investigation has revealed that the anti-oxidant materials known to be present in soya bean oil remain active even after the incorporation of the oil in an alkyd, and a method has been developed for destroying or rendering innocuous these anti-oxidants present in the resin. A number of useful drier recommendations and facts concerning the resin/drier/pigment relationship were also obtained, although the work is far from complete. In fact some of the aspects of the problem have not yet been examined at all fully and will need to be the subject of future work.

#### ACKNOWLEDGEMENTS

The authors would like to thank the Directors of Beck, Koller & Co. (England) Ltd. for granting permission to publish this paper and in particular Dr. Swann and Dr. Keenan for their help and encouragement. They would also like to acknowledge with thanks the assistance of the laboratory staff

of the above company, the help of B.O.C.M. Ltd. in supplying soya oil and fatty acids, and Roche Products Ltd. for supplying  $\alpha$ -tocopherol,  $\alpha$ -tocopheryl-quinone and technical assistance.

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[Received 18 May, 1961]

#### DISCUSSION

##### (West Riding Section)

MR. P. HAIGH asked what was the effect of an anti-skinning agent, such as methyl ethyl ketoxime, on the sensitive soya alkyds.

MR. WILLIAMS replied that these products evaporated off normally and did not retard the drying properties. However, in very bad conditions of high humidity and low temperature their effect was observed.

MR. N. F. LYTHGOE inquired whether cobalt naphthenate affected the colour retention of the dried film.

MR. WILLIAMS felt that cobalt naphthenate used as a drier metal in soya alkyds should not affect the colour retention of the dried film any more than when used with any other type of alkyd at a similar concentration.

MR. D. GRAY wondered whether the authors had approached oil manufacturers to produce tocopherol-free soya oil.

MR. COX confirmed that this had been done and that pure material had been obtained chromatographically for several experiments. Unfortunately the cost of the process was far too high for commercial production.

MR. GRAY further inquired whether the authors had any evidence that the source of the soya beans had any effect on the variation of the different batches of alkyds made from that oil.

MR. COX stated that they had not been able to follow this up, since the source of the seed was unknown to the suppliers of the oil.

# The Limitations of Leaching Rate Determinations of Anti-Fouling Compositions

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## Summary

The leaching rate technique is described and the experimental method for its determination is outlined. Several limitations of this technique are mentioned, together with some unusual and anomalous results that have been obtained by some workers in this field. Experiments are carried out to establish a suitable technique for leaching rate determination, with the ultimate object of devising an accelerated test which will predict the performances of anti-fouling compositions in service, and further to examine the relationship between leaching rates and different methods of storage—raft, speed apparatus, agitator, laboratory tank and power station outfall.

## INTRODUCTION

The leaching rate technique was published in England by Harris<sup>1</sup> and in America by Ketchum<sup>2</sup> as a means of assessing the efficiency of anti-fouling compositions. It is based on the concept that an anti-fouling composition acts by producing a surface layer of a poisonous solution which repels, or is lethal to, the spores or larvae of marine organisms which attempt to settle on the composition. The maintenance of a lethal concentration of poisons in the surface layer necessitates a gradual wastage of the poisons. If an anti-fouling composition is to be efficient, the rate of loss of poisons from it must be neither too high nor too low; otherwise a composition would either have a very short life or would be ineffective. The leaching rate technique was designed to measure the rate of loss of poison under standardised conditions of test and is expressed in micrograms of poison—as metallic radical—liberated from one square centimetre of film per day ( $\mu\text{g./cm.}^2/\text{day}$ ). For any single poison the leaching rate which just prevents fouling is known as the critical leaching rate. In the case of cuprous oxide it has been demonstrated by several investigators<sup>1, 2, 3, 4</sup> that the critical leaching rate is  $10 \mu\text{g./cm.}^2/\text{day}$ . When used in the presence of toxic mercury compounds the critical value is lower than  $10 \mu\text{g./cm.}^2/\text{day}$ , but there is no reliable information regarding the critical value when the two poisons are used together; certainly, the effect is not simply additive.

## Experimental Technique

A brief description of the experimental method<sup>1, 2, 5, 6</sup> used in determining leaching rates now follows. Ground glass slides are painted with anti-fouling compositions and, after standard drying times, are immersed in sea water either in the sea itself or in a tank of flowing sea water in the laboratory. The slides are removed periodically from storage and leaching rate determinations are carried out by immersing them for a certain period of time in an appropriate volume of continuously aerated sea water. The slides are then removed and the quantity of copper or mercury in the leachates is determined colorimetrically using sodium diethyl dithiocarbamate and diphenylthiocarbazone, respectively. A modification of the technique for use at inland stations has been described by Hanson and Jervis<sup>7</sup>, and another modification consists of rotating

painted glass tubes permanently in a certain volume of sea water which is replaced periodically and analysed. Evidence of the composition industry's interest in leaching rate techniques is also shown by the joint correspondence in connection with the report by Harris<sup>1</sup>, the contributions by Keenan and Brooks to the discussion of the paper by Lawrence and Gale<sup>14</sup> at the O.C.C.A. Conference in 1947, and again in a contribution by Keenan<sup>15</sup> at the Premier Congr s Technique in Paris, also in 1947.

There are several complications in the technique. If zinc or iron is present it can react with the sodium diethyl dithiocarbamate and either produce turbidity or interfere with the determination. Alternative colorimetric reagents for copper have been studied by Gran<sup>8</sup> and Tuck and Osborn<sup>9</sup>.

Bacterial slime may form on the anti-fouling compositions during storage and slough off during the leaching rate test to produce turbidity. The slime may also contain appreciable accumulations of copper which will result in apparently higher leaching rates.

If the concentration of copper in the sea water exceeds 0.5  $\mu\text{g./ml.}$ , the leaching of the copper from the anti-fouling composition is suppressed. Copper also interferes with mercury estimations, but a method has been developed by Barnes<sup>10</sup> which eliminates the interference.

### *Limitations*

The advantages of leaching rate determinations over raft trials of anti-fouling compositions are that the former can be used at any time of the year when fouling organisms are absent and, by using tank storage, such determinations are independent of location. As used to date, however, they cannot be regarded as a substitute for raft trials, although these also have limited uses, the ultimate test of an anti-fouling composition being, of course, on a ship in service.

Leaching rates do not provide any estimate of the amount of residual poisons in a composition or, alternatively, the amount of poison lost. Consequently, they are of no use in predicting the effectiveness of a composition at some future date: the rate of loss of copper during leaching rate determinations is not necessarily the same as the rate of loss during raft or tank storage. Likewise, the leaching rate technique cannot be considered as an accelerated method, since the test must be continued up to the point where the anti-fouling composition would fail in raft trials; it is only accelerated in the sense that it can be used in winter to indicate the probable performance of an anti-fouling composition. In view of the above limitations, the "conventional" leaching rate technique can be used satisfactorily only for the following purposes:

- (i) The elimination in the laboratory of completely unsatisfactory experimental anti-fouling compositions.
- (ii) The observation of trends in performances of anti-fouling compositions as a result of gradual variations of the ingredients.
- (iii) The routine checking of batch productions.
- (iv) An indication at any particular time that an anti-fouling composition is in such a condition that it would prevent or allow settlement of fouling organisms.

### *Unusual and Anomalous Results*

A survey of the literature shows that when using the leaching rate technique several unusual and anomalous results can be obtained, some being mentioned below. Harris<sup>1, 11</sup> showed that when an anti-fouling composition contained mercuric oxide in addition to cuprous oxide, the leaching rate of copper necessary to prevent fouling was less than that required when cuprous oxide was used alone in the same medium. The leaching rate of mercury from copper/mercury compositions was variable and unconnected with anti-fouling efficiency. A copper leaching rate of 5-7  $\mu\text{g./cm.}^2/\text{day}$  appeared to indicate satisfactory anti-fouling performance, provided that the mercury was also lost at a rate of at least 0.5  $\mu\text{g./cm.}^2/\text{day}$ . Also, mercury leaching rates did not give a true indication of the rate of loss of mercury from a composition.

Barnes<sup>12</sup> demonstrated that considerable changes in the mercuric oxide content of the same matrix had little or no effect on the mercury leaching rate, in contrast to cuprous oxide where variations in content resulted in marked changes in the copper leaching rate. The analysis of paint films containing different percentages of mercuric oxide showed, however, that equal additions of mercuric oxide produced similar rises in the actual rate of loss of mercury and that the losses as estimated by analysis were greater than those indicated by leaching rate determinations.

Ketchum<sup>13</sup> *et al.* used the same matrix in the preparation of a series of compositions containing different proportions of cuprous oxide and magnesium silicate at a total pigment volume fraction of 0.12. From the average steady-state leaching rates over a period of two to five months they calculated the intrinsic rate of solution of the matrix. The calculated values decreased from 46 at a poison weight fraction of 0.04 to 31 at a poison weight fraction of 0.30. Since the same matrix was used for all compositions, the calculated rate of solution would be expected to remain constant, irrespective of the cuprous oxide contents. This result was possibly caused by the matrix combining to some extent with the cuprous oxide.

The rate of loss of copper from an anti-fouling composition, as determined from the leaching rate, has been found to be 1.2 times the actual rate of loss on a raft, and the rate of loss in service twice the mean rate of loss on a raft<sup>3</sup>.

### EXPERIMENTAL

When it was decided to undertake leaching rate determinations at the R.O.S.C.M. Laboratory, an experiment was carried out in order to select a technique to be eventually employed, the desideratum being ultimately to devise, if possible, an accelerated method which would enable an accurate forecast to be made of the performances of anti-fouling compositions under service conditions. From a consideration of the work which had been done previously it was decided that the experiment should be designed not only to test the accuracy of the technique chosen at Poole but also to determine the relationship between leaching rates and different methods of storage, since this was thought to be a very important factor.

Five methods of storage were therefore employed: raft, speed apparatus, agitator, laboratory tank and power station outfall, in conjunction with the leaching apparatus illustrated in Fig. 1.

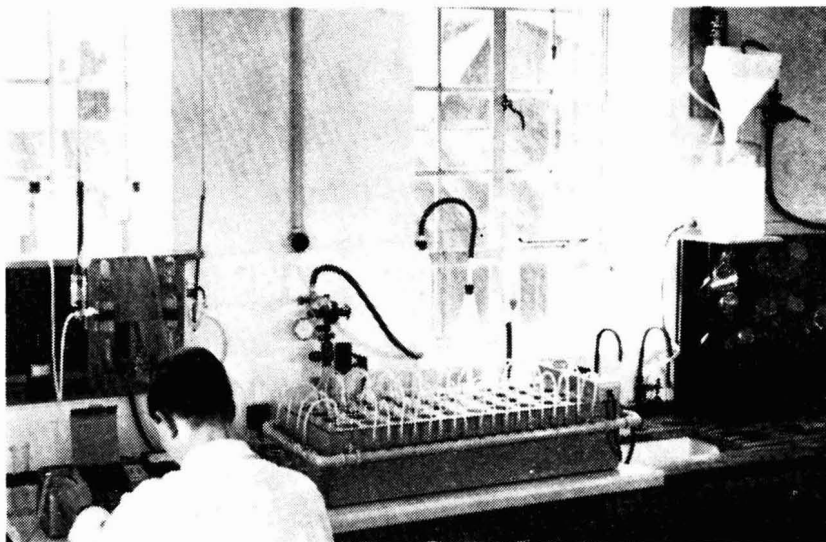


FIG. 1. LEACHING RATE APPARATUS

The apparatus is based on that described by Harris<sup>1</sup>. It consists of a water bath (36 in.  $\times$  13 in.  $\times$  8 in.) thermostatically controlled at a temperature of 23°C and designed to accommodate forty hydrometer jars of internal measurements approximately 6½ in.  $\times$  1½ in. Air is supplied from a compressor storage tank to each jar by means of 0.7 mm. bore glass capillary tubes attached to a ¾ in. galvanised pipe fitted around the sides of the bath. The air is supplied at 50 lb./in.<sup>2</sup> and reduced to 8 lb./in.<sup>2</sup>, enabling 5 litres per hour to be delivered to each jar. In order to prevent any possible contamination from copper supply lines, the air is dried before use with calcium chloride and then re-saturated by bubbling through sea water. Sea water for the apparatus is drawn from a 10-litre aspirator jar and is aerated continuously before use in order to stabilise the pH.

The panels consist of pieces of p.v.c. extrusion (6 cm.  $\times$  3.33 cm. = 20 cm.<sup>2</sup>) with a projection on the back which slides into another type of p.v.c. extrusion. The panels are sandpapered, weighed and then placed in a jig so that replicate panels may be painted simultaneously. The wet and dry weights of the anti-corrosive and anti-fouling compositions are recorded, and the rates of application adjusted as near as possible to pre-selected values. The final coats of compositions are allowed to dry overnight before weighing and immersion in sea water (Fig. 2).

When carrying out leaching rate determinations, 100 ml. of aerated sea water are introduced into each hydrometer jar by means of an automatic pipette; the jars are placed in the water bath (cold) and air bubbled through by inserting the capillary tubes. The thermostat is then switched on to increase the temperature to 23°C and, in the meantime, the panels are removed from storage, washed with a jet of sea water and placed in dishes. The slime is removed from all unpainted parts of the panels with a foamed plastic sponge and the panels again rinsed in sea water before being placed in the jars. After two



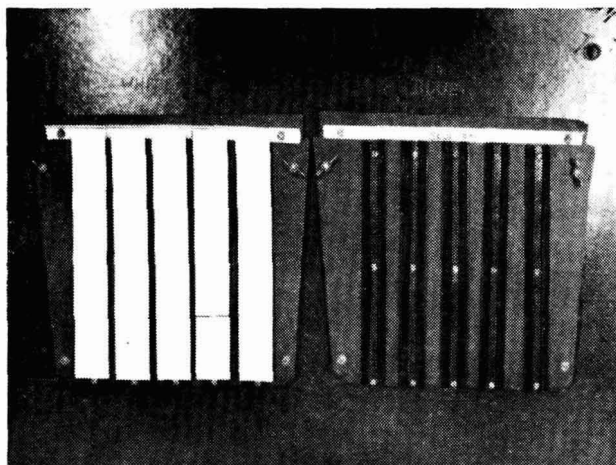


FIG. 2. METHOD OF MOUNTING PANELS FOR RAFT STORAGE

to four hours, according to the leaching rates, the panels are returned to storage and the leaching jars removed from the bath. The copper in the leachate is determined by adding, with shaking, 5 ml. of 20 per cent citric acid, 5 ml. of 10 per cent ammonium hydroxide and 2 ml. of a 0.1 per cent solution of sodium diethyl dithiocarbamate in distilled water. The solutions are added in that order as soon as possible, and the leachate is then left undisturbed for forty minutes before measuring the intensity of the colour by means of a 10 cm. cell in an electrical absorptiometer fitted with a 601 violet filter. By using a calibration curve for the instrument the concentration of copper is determined and from this the leaching rate, *i.e.* the rate of loss of copper in  $\mu\text{g./cm.}^2/\text{day}$ , is obtained.

In order to study the effect of speed of storage, the apparatus shown in Fig. 3 was used. It consists essentially of a plastic cylinder which can be rotated

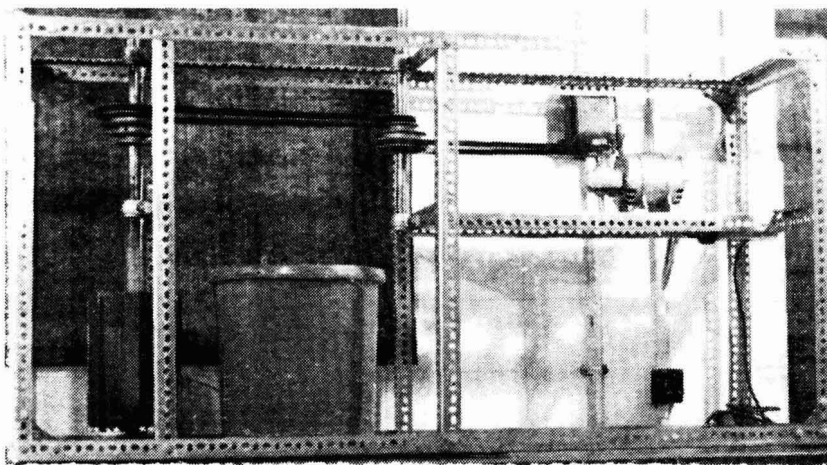


FIG. 3. APPARATUS USED FOR THE STUDY OF SPEED OF STORAGE BETWEEN LEACHING RATE DETERMINATIONS

in sea water at peripheral speeds varying from  $\frac{1}{8}$  to three knots. The panels are mounted in slots on the sides of the cylinder and are removed periodically for leaching rate determinations. Agitated conditions of storage were obtained by mounting panels in a domestic washing machine.

The experiment was confined to copper determinations and included compositions based on five types of modified rosin matrices:

- (i) Boiled oil/pine oil/hydrogenated methyl abietate.
- (ii) Vinylite/tritolyol phosphate.
- (iii) Bedesol oil.
- (iv) Chlorinated rubber/hydrogenated methyl abietate.
- (v) A neutral resin.

The first four matrices contained varying quantities of cuprous oxide. Compositions based on the fifth matrix contained equal amounts of cuprous oxide and different proportions of a neutral resin.

## RESULTS

The results showed in the middle stages of test that:

(a) Compositions containing equal quantities of cuprous oxide and based on matrices modified with different proportions of the same neutral resin gave almost identical minimum leaching rates when stored under agitated conditions between leaching measurements. The results are illustrated in Fig. 4. Also

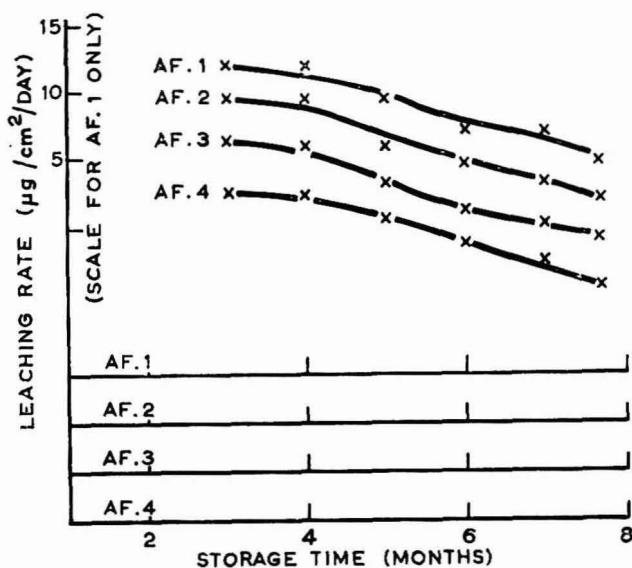


FIG. 4. EFFECT OF AGITATION ON LEACHING RATE—SIMILAR CUPROUS OXIDE CONTENTS

when stored under static conditions the leaching rates approached a constant maximum. Widely separated curves were given by the same four compositions when using raft storage.

(b) Compositions based on the same matrix and containing different percentages of cuprous oxide gave almost the same minimum leaching rates when stored under agitated conditions between leaching measurements. These results are illustrated in Fig. 5.

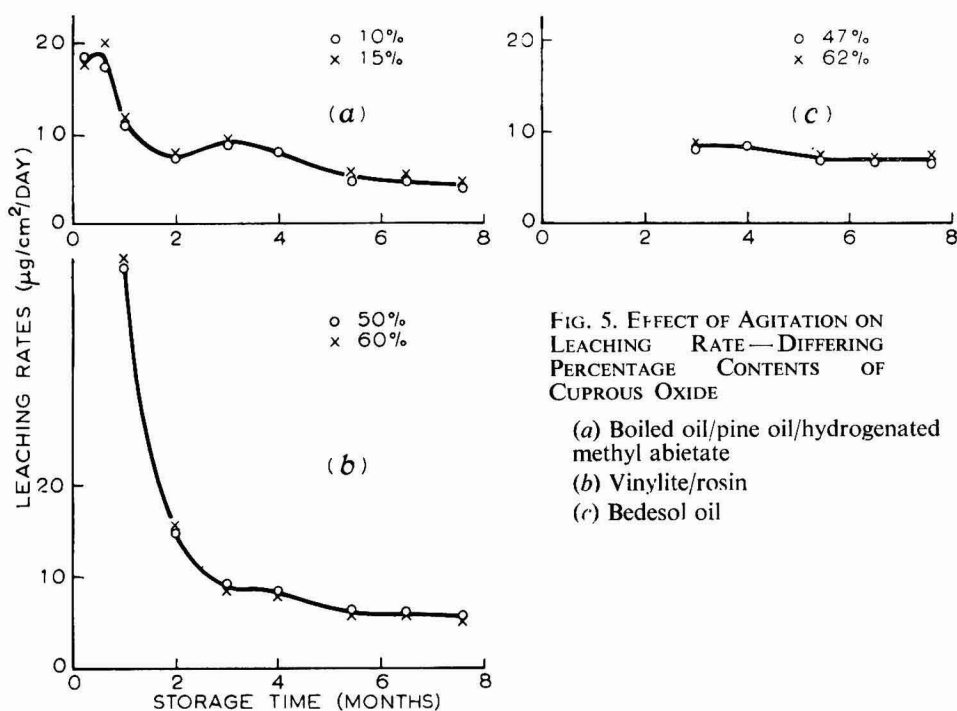


FIG. 5. EFFECT OF AGITATION ON LEACHING RATE—DIFFERING PERCENTAGE CONTENTS OF CUPROUS OXIDE

- (a) Boiled oil/pine oil/hydrogenated methyl abietate  
 (b) Vinylite/rosin  
 (c) Bedesol oil

(c) The maximum leaching rates for compositions based on soft matrices or containing low percentages of cuprous oxide were obtained by using static storage between leaching rate determinations, *i.e.* sea water which was changed periodically but did not flow over the panel surfaces (Fig. 6 (a)). Intermediate rates between the maxima and the minima (agitator storage) were obtained by using raft storage or by storing in flowing sea water. Maximum leaching rates for compositions based on hard matrices (*e.g.* Vinylite or Bedesol oil) containing high percentages of cuprous oxide were obtained either by storing the panels in flowing sea water or by using raft storage between leaching measurements (Fig. 6 (b)). The lower rates for static storage are considered to be attributable to the accumulation of resins and comparatively insoluble basic copper salts on the surface.

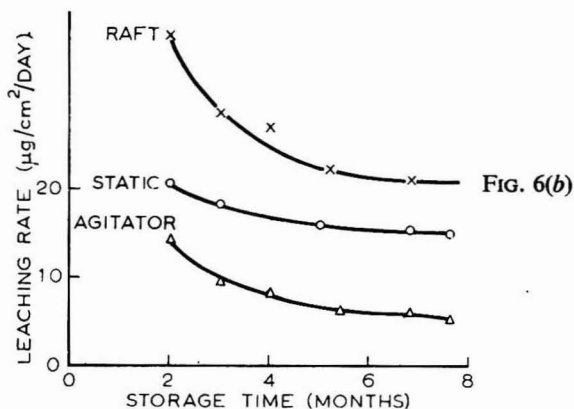
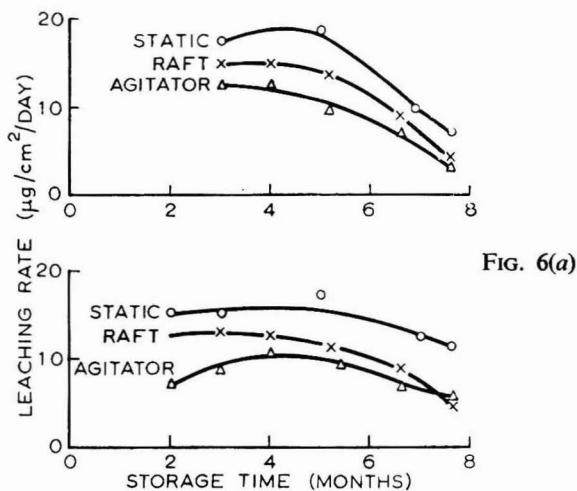


FIG. 6. EFFECT OF CONDITIONS OF STORAGE ON LEACHING RATES  
 (a) Soft matrices with low cuprous oxide contents  
 (b) Hard matrices with high cuprous oxide contents

### DISCUSSION

These results can best be explained in terms of the following concepts of the mode of release of poisons from an anti-fouling composition. A soluble matrix anti-fouling composition, based on rosin/neutral resin and cuprous oxide, in the middle stages of its life is considered to consist of a matrix receding at a constant rate and containing a sparingly soluble salt, cuprous oxide, which may or may not form a "pebble dash" on the surface of the composition. If a "pebble dash" is formed then some mechanism would be expected to obtain which would allow cuprous oxide to persist on a surface such as rosin, which has a solubility rate of about one-third that of cuprous oxide. The solution of the matrix is essentially a slow chemical reaction which should be almost independent of the rate of movement of water over the surface. On the other hand, the rate of solution of the cuprous oxide will depend on the concentration of

copper (mainly as  $\text{CuCl}_2$ ) in the surface layer, or the rate at which the surface layer is removed. Under sufficiently agitated conditions of storage any exposed particles of cuprous oxide would be dissolved comparatively rapidly to leave "craters". Further, under almost static conditions of storage the matrix would recede to leave a "pebble dash" of cuprous oxide which may be in excess of its proportion in the formulation.

From this it follows that the leaching rate determination, as normally carried out after raft or static tank storage, is merely a measure of the relative intensities of the "pebble dash" on the surface of the matrix. Under such conditions the leaching rate is approximately proportional to the cuprous oxide content when using the same total pigment volume concentrations and matrix. The leaching rate cannot, however, be considered as a measure of the loss of copper unless, fortuitously, the rate of agitation in the leaching jars is the same as the average rate of agitation during storage. Paradoxically, high leaching rates may indicate a low average rate of loss if cuprous oxide particles have accumulated on the surface during storage. There still, however, remain several points which require elucidation. Immediately after storage under highly agitated conditions, the anti-fouling compositions had appreciable leaching rates. Further, the leaching rates were almost independent of the cuprous oxide contents when using the same matrix, and were almost identical when using the same amounts of cuprous oxide in matrices modified with different proportions of the same neutral resin. It is suggested that under such conditions copper is liberated entirely by diffusion through the matrix and this can best be illustrated by Fig. 7.

The simplified theory outlined above refers only to anti-fouling compositions that are formulated to give steady-state leaching conditions during the middle stages of their lives. Certain soluble matrix anti-fouling compositions give continuously falling leaching rates during the whole of the middle and later stages of their lives, and in such cases copper is considered to be lost by diffusion through the matrix; these types of compositions usually contain high percentages of rosin or rosinsates or liquid plasticisers such as hydrogenated methyl abietate. Further, the simplified theory does not apply to matrices containing high percentages of cuprous oxide or insoluble resins. If insoluble resins or basic copper salts accumulate on the surface, then even under static conditions of storage the leaching rates would be expected to approach a constant lower value irrespective of the cuprous oxide contents, owing to the rate of release of copper being limited by the comparatively insoluble copper salts and by diffusion through the film of insoluble resins. In such cases the maximum leaching rates would be obtained by providing just sufficient agitation between leaching determinations so as to prevent the formation of insoluble basic copper salts on the surfaces of compositions and by ensuring that the concentration of copper in the storage water was below  $0.5 \mu\text{g./cc}$ . This is illustrated in Fig. 8, which shows the types of curves obtained from three anti-fouling compositions containing 20, 30 and 40 per cent cuprous oxide.

After reaching steady-state leaching conditions the compositions were stored in static unchanged sea water for fourteen days and then subjected to increasing speeds of rotation between leaching rate determinations. Immediately after

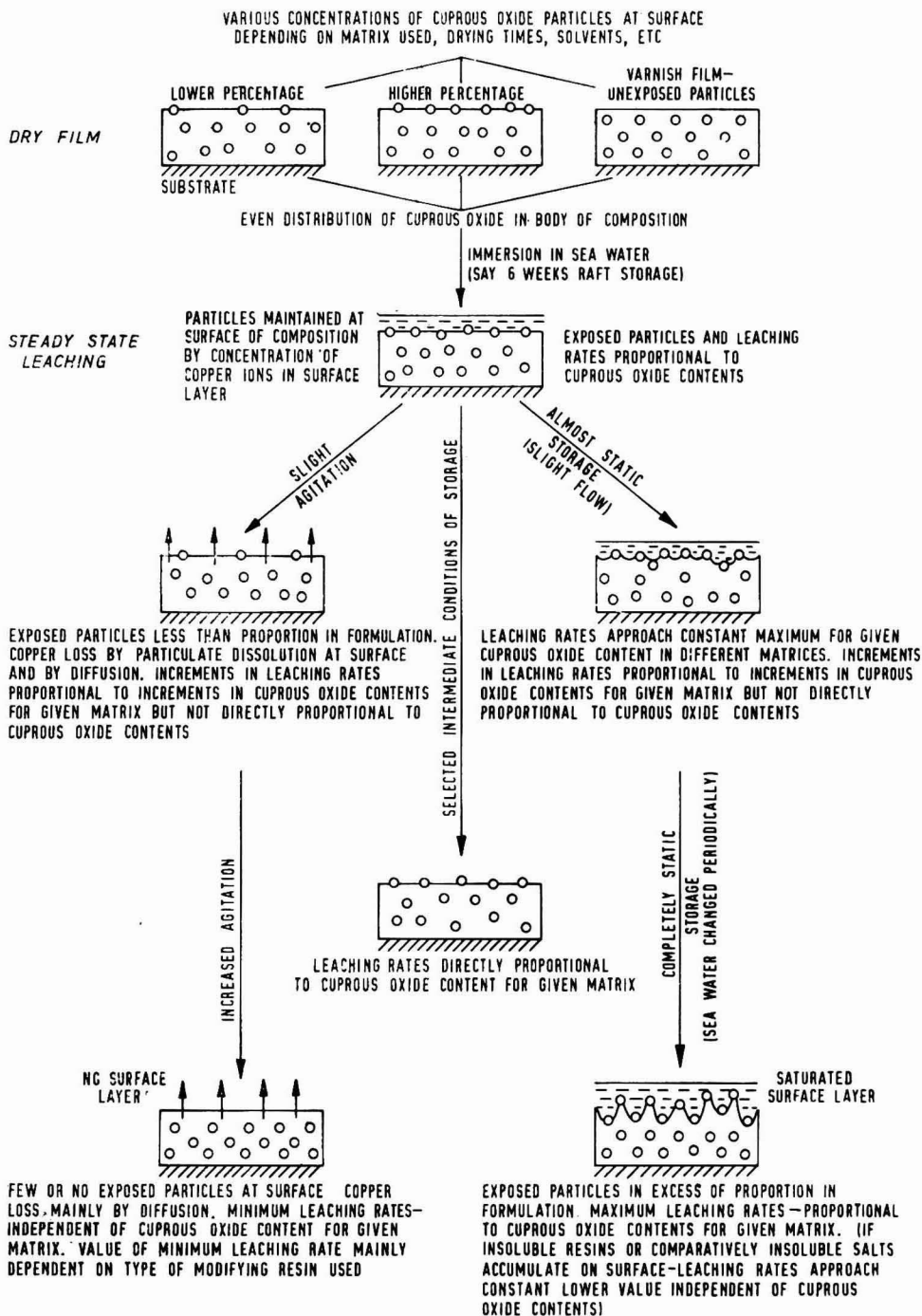


FIG. 7. ILLUSTRATION OF THE EFFECT OF STORAGE CONDITIONS ON LEACHING RATES OF SOLUBLE MATRIX ANTI-FOULING COMPOSITIONS CONTAINING MODERATE PROPORTIONS OF CUPROUS OXIDE

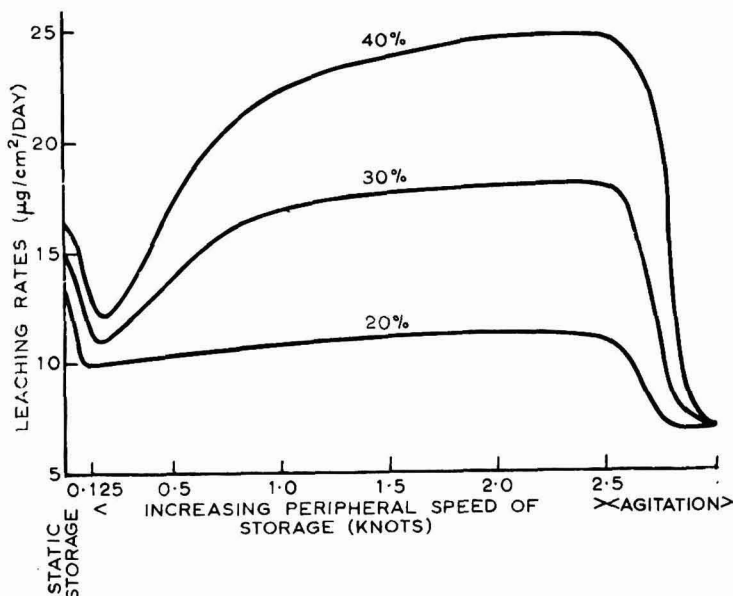


FIG. 8. EFFECT OF STORAGE CONDITIONS ON LEACHING RATES—COMPOSITIONS CONTAIN DIFFERENT PERCENTAGES OF CUPROUS OXIDE

storage in static unchanged sea water there were only slight differences in the leaching rates of the three compositions and only that containing 20 per cent cuprous oxide had attained its maximum leaching rate. The compositions containing 30 and 40 per cent cuprous oxide gave maximum leaching rates after storage at peripheral speeds in excess of one knot, although the actual rate of water flow over the surfaces was almost certainly considerably lower than one knot because of the laminar layer effect. These results are considered to indicate that, when using tank storage between determinations, the peripheral speed of rotation must be adjusted according to the leaching rate in order to obtain conditions of steady-state leaching. In the case of a satisfactory composition with a leaching rate in the region of  $10 \mu\text{g./cm.}^2/\text{day}$ , for example, the peripheral speed in excess of  $\frac{1}{8}$  knot would be sufficient. In all cases it would, of course, be essential to maintain the concentration of copper in the storage water below  $0.5 \mu\text{g./cc.}$ , *i.e.* to prevent the storage water becoming saturated with basic copper salts.

In these experiments the compositions were subjected to agitated conditions of storage after a peripheral speed of  $2\frac{1}{2}$  knots had been reached. The agitation was sufficient to remove the laminar layer and results confirmed those obtained in previous experiments, *i.e.* for a given matrix the leaching rate after agitated conditions of storage was independent of the cuprous oxide content. It will also be noted that after agitated conditions of storage the leaching rates of all three compositions were below the critical value of  $10 \mu\text{g./cm.}^2/\text{day}$ .

The practical application of the foregoing concepts is that, under the comparatively stationary conditions in port, copper is considered to be lost from an anti-fouling composition by particulate dissolution at the surface; when underway the loss is mainly due to diffusion through the matrix. The

most "dangerous" time in the life of an anti-fouling composition is when it is subjected to potential fouling conditions in port immediately after a voyage<sup>3</sup>, for its efficiency will then depend on the time required for it to present a lethal surface layer. This will necessitate eventual exposure of particulate cuprous oxide, but in the interim period there will be some anti-fouling action as a result of diffusion. In most cases, however, the leaching rate of copper in the interim period will be below the critical value of  $10 \mu\text{g./cm.}^2/\text{day}$  and at such times the use of compounds such as mercury rosinate would ensure that the composition presented a lethal layer at its surface.

The above concepts can be applied to anti-fouling compositions containing particulate mercuric oxide, but it is not necessary to consider agitation; the high solubility of mercuric oxide ensures that any particles exposed during storage dissolve rapidly to leave "craters" and the rate of solution is not limited by the concentration in the surface layer. When subjected to the leaching test mercuric oxide is lost entirely by diffusion through the matrix and, apart from odd particles which become exposed, the rate is independent of the mercuric oxide content.

Further, if these concepts for the mode of release of copper and mercury are correct, then it is not surprising that difficulties are encountered when attempting to incorporate organic poisons in anti-fouling compositions. Unless the solubilities are very low the leaching rate after a voyage or turbulent conditions on a raft would be almost zero—there would be no diffusion—until sufficient matrix had dissolved to expose more poison.

#### CONCLUSIONS

The leaching rate test can be satisfactorily employed only to eliminate completely useless anti-fouling compositions, to check batches of a formulation, to observe trends in the performances of a series and to indicate at any particular time whether an anti-fouling composition will prevent fouling. It is an arbitrary test and the values obtained depend largely on storage conditions between determinations. Even with raft storage the readings will vary not only according to design and siting of the raft, but also according to prevailing tidal conditions, both during storage and at the time of the determinations. It gives no indication of the future performance of an anti-fouling composition or any indication of the ability of a composition to recover its lethal surface layer either after turbulence on a raft or after a long voyage in service, which is the *sine qua non* of anti-fouling properties.

Alternative methods of carrying out leaching rate determinations, such as rotating painted glass tubes in sea water and analysing periodically the leachate, have the disadvantage that, whilst they give an indication of the true rate of loss of poison, they do not give an indication of the ability of a composition to retain or produce a lethal concentration of poisons at the surface where it is required. From a consideration of the defects and the results of work which has been done, it is thought that the best approach to the laboratory testing problem would be to rotate an anti-fouling composition in sea water at a progressively increasing speed and determine periodically the leaching rate by rotation at a constant speed. Work is now being carried out on these lines at the R.O.S.C.M. Laboratory.



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[Received 26 May, 1961

## Reviews

### CHEMISTRY OF NATURAL PRODUCTS

International Union of Pure and Applied Chemistry. London: Butterworths Publications Ltd., 1961. Reprinted from *Pure and Applied Chemistry*, Volume 2, Nos. 3-4, 347-635. Price 70s.

At the outset it is necessary to say that this is not a textbook on natural product chemistry and that the contents do not have any direct bearing on chemical problems of concern to the paint industry. The book consists in fact of the special lectures presented at an International Symposium in Australia in 1960. Included therein are, however, some of the most exciting stories of modern organic chemistry. At this point of history it is fascinating to compare the classical organic and the modern organo-physical approaches to current problems.

In many cases the two are used in combination, but the extremes are admirably illustrated by the story of the total synthesis of chlorophyll by Woodward, using a bewildering variety of organic reactions, and the description of the techniques for determining three-dimensional molecular structure from empirical formulae and X-ray diffraction data only by Mathieson. Biological chemistry is well represented, and in the paper on bacterial lipids by Lederer it can be noted how little some of the fatty acids responsible for pathological phenomena differ chemically from the acids of the common glyceride oils. For example, tuberculostearic acid, responsible for tubercules, differs from stearic acid only by one methyl side chain. There are many other interesting papers and the book is divided into sections on heterocyclic chemistry, physical methods, aliphatic and homocyclic chemistry and biological chemistry.

L. A. O'NEILL.

### ELECTRONIC PACKAGING WITH RESINS

By C. A. HARPER. London: McGraw Hill Publishing Co. Ltd., 1961. Pp. 339. Price 85s. 6d.

The sub-title "A Practical Guide for Materials and Manufacturing Techniques" establishes the aims of the book. There is little chemical theory but a great deal of information of value to engineers and others who wish to apply the techniques of encapsulation and embedding to electrical and electronic equipment.

A range of encapsulating and embedding resins is dealt with but, quite rightly in view of their widespread use, epoxides occupy 63 pages against 30 for all other types. Fillers are well covered as are low density resins, and a very interesting section dealing with processing equipment demonstrates the wide range of such equipment available in the United States. In the United Kingdom, much of the processing equipment has been individually built by the user company because of the lack of suitable commercial equipment.

The most serious criticism of this book is that it deals only with materials of American origin, many appearing under trade names unknown in the United Kingdom. An example is on p. 35 where the only European manufacturing

company mentioned is British Resin Products Ltd., perhaps the least known suppliers of epoxide resins in the United Kingdom. There is no mention of C.I.B.A., British Bakelite, Shell or other British suppliers.

Inevitably when so much information is provided, a large amount of it originates in manufacturers' literature; this results in a multiplicity of units. Examples are on pages 27 and 34; in the former power factor is stated as 2.27, 2.48, *etc.*, presumably (but not stated) expressed as a percentage; in the latter it appears as 0.002, 0.003, *etc.* Similarly °F and °C appear in a more or less random order.

An interesting and novel section is that devoted to the effects of environment, including radiation hazards. Fortunately, the curing agents are stated by their chemical names, but the resin *ERL 2774* does not appear to be the same as any marketed in the United Kingdom; this detracts from the usefulness of this information.

Most of the criticisms are minor ones. This book should prove of great value to the many engineers, technologists and others concerned with the applications of resins to electrical and electronic equipment. The printing and binding are well up to the usual high standard expected from the McGraw-Hill Publishing Co. Ltd.

H. G. MANFIELD.

### ISOPROPYL ALCOHOL

By L. F. HATCH. London: McGraw-Hill Publishing Co Ltd., 1961. Pp. x+184. Price 54s. 6d.

Isopropyl alcohol was first produced in quantity in 1920 and is the first petroleum chemical. Its annual production from propylene, of which a good account is given in this volume, now approaches half a million tons. Much of this is diverted for conversion into acetone, aliphatic esters and aromatic derivatives, but isopropyl alcohol is also consumed directly for many purposes. Indeed the reader will be surprised to see listed at the outset no less than 250 applications. Descriptions of its uses as solvent cover twenty pages and include varnishes, nitrocellulose lacquers, adhesives, cosmetics, perfumes, detergents, pharmaceutical preparations, reaction and crystallisation media and drying agents. Brief mentions follow of isopropyl alcohol as an extraction medium for vitamins, anti-oxidants, vegetable oils and petroleum products. Some miscellaneous uses cited are its possible exploitation as a major constituent of motor fuels, for de-icing aeroplane wings, in anti-freeze mixtures, as a corrosion and foam inhibitor and for the recovery of fuel oil. Another chapter surveys its pharmacological applications.

Somehow or other the whole field of chemical and physico-chemical industry seems to be embraced, but the author omits theoretical discussion of the principles which may be involved in these very varied uses and makes no claim to evaluate the efficacy ascribed to isopropyl alcohol for any particular purpose. Although industry will find a use for this monograph, it cannot have been intended for the use of students.

There are forty-five pages (twenty-two tables) of physical data relating to isopropyl alcohol and its derivatives as well as 1,203 literature references. The book is attractively produced, as is usual with books from this publishing house.

A few minor points: the English reader is nowadays not unprepared for "color", "odor" and "sulfur", but he will look twice at "molds" (p. 72), "carburetor" (p. 65), "mediums" (p. 49), "Soybean" (p. 58), "preignition" (p. 66), "fulfills" (p. 75) and "makeup" (p. 4). What is the usefulness of printing recipes which include such ill-defined materials as *Aquaresin GMC* (p. 42), *LPG* (p. 71), and *TEL* (p. 65)? "Caustic" (p. 59 *et seq.*) would be better replaced by "Sodium hydroxide" and "glycerine" (p. 61 *et seq.*) by "glycerol".

S. MARKS.

### POLYPROPYLENE

By O. J. KRESSER. New York: Reinhold Publishing Corporation, 1960. Pp. 268+ix. Price 52s.

The author of this book has gathered together all the information available on polypropylene at the time of writing. Items covered are properties, chemistry, processing, and applications in packaging, durable goods and soft goods. There is also a chapter on possible future developments. The processes and applications involved in the use of the plastic are so varied that the treatment has had to be, in some cases, brief.

Nevertheless, anyone capable of processing, say, polyethylene should be able to obtain enough information to handle polypropylene. Paper and printing are good, and the illustrations are clear. Altogether this is a useful book for anyone interested in the manufacture of products ranging from transparent films to filter funnels, from water pipes to textiles.

G. L. FULTON.

## Correspondence

### TECHNICAL EDUCATION IN THE PAINT INDUSTRY

The Report of the Study Group of the Paint Manufacturers' Co-operation Committee is an interesting and intelligently constructed document which is no doubt even now playing a useful part in helping people to grasp the confused and confusing position obtaining in technical education and technical qualifications. It will, however, be of substantial value in the framing of policy only if two fundamental questions are first considered. These are: What field is to be open to the technically trained man in the paint industry? What is the relationship to be between the paint industry and the rest of the chemical industry?

#### *Openings for the Technical Man*

It does not seem to me to matter all that much whether we consider the technical man as having O.N.C., H.N.C., City and Guilds, Dip. Tech., B.Sc., or Ph.D. The only point to remember is that the higher the qualification the broader the range of subjects the man can tackle. The main thing is a training which will result in an inquiring mind which takes nothing for granted. Having got that inquiring mind, how far can the technical man get? Or—what *ought* to be the same thing—what salary can the technical man hope to get? This matter has two aspects: Can the able technical man hope to become Managing Director? Can the competent but limited technical man expect to get as good a salary as he would get for the same kind of job in another industry? Unless the answer is *yes* to both questions the paint industry cannot expect to get good recruits; why should it?

I am rather afraid that the answer at the present time is *no* to both questions. Many firms still cling to the outworn idea that the technical man should be *on tap but not on top*, that the place of the technical man is the laboratory, and that questions of cost and management should be left to persons whose only qualification to deal with them is a complete lack of training in clear thinking. I have even heard the argument advanced that, because of the shortage of technologists, firms cannot afford to promote technical staff. I am not, of course, saying that all senior jobs should be filled by technical people—although that is not such a bad idea—but simply that the possession of technical training ought not to be a bar to promotion. The very structure of the paint industry makes for difficulties in this direction, since the large number of family firms implies a large amount of nepotism—using the word purely descriptively and in no pejorative sense. All that can be suggested here is that the families concerned will have to exercise some degree of self-restraint in making senior appointments.

The other aspect is more serious; it matters less, in a sense, that the Managing Director is able than that the formulating staff is competent. And it is of no use expecting to have a pool of promising juniors if you pay twelve pounds a week to an O.N.C. man of twenty-eight or £850 a year to a B.Sc. of forty; these are both cases within my knowledge. Ignorance is no excuse; the R.I.C. publishes from time to time a salary survey of its members which is not a recommended

scale but a statement (more or less) of fact, while the A.Sc.W. publishes a recommended scale for unqualified staff. This latter scale, while somewhat divorced from the facts of life at the higher levels, ties up nicely with the bottom end of the R.I.C. survey. It may thus fairly be adopted for men of National Certificate or City and Guilds level: those who do not graduate at the expected age can have their scales assimilated to the lower quartile or lower octile of the R.I.C. scale. Salary increases are always a hard matter; the guidance obtainable from published scales should be accepted gladly.

### *Relationship with the Chemical Industry*

Because there are so many small firms in the paint industry the opportunities for promotion by change of job are fewer than occur in other industries. Yet there must be such opportunities if able men are to be attracted, quite apart from the general point that people in this country do not change their jobs often enough. I see no way out of this difficulty except by a conscious acceptance by the paint industry of the fact that it is a part of the chemical industry. The paint industry must be ready to accept staff from other parts of the chemical industry, taking advantage of their probably superior scientific status and accepting the necessity for teaching newcomers its own mysteries. More important, the paint industry must allow its technical staff to fit themselves to depart to other parts of the chemical industry by encouraging the broadest contacts with technical matters in general. Industries (and firms) can attract good staff only if they are prepared to lose them. In this connection the proposed establishment of a special technological qualification for the paint industry would appear to be a retrograde step; I cannot welcome the idea that competent paint technologists are going to become *adscripti glebae*, economic serfs, as it were, bound to a single industry. It would be far better to explore the possibility of some kind of liaison with the Plastics Institute, the Institute of Physics, and the Society of Dyers and Colourists, so that their well-recognised qualifications could, with suitable modification, be made available to the paint technologist. It is a very happy chance that recognised qualifications exist in the main three technological directions in which a paint technologist would wish to develop.

But the real point is that the problem presents difficulties which are quite likely unique, and that this uniqueness has not been fully appreciated. We have an industry mainly composed of small family firms, an industry which has been slow to accept the concept of applied science, an industry whose technical disciplines involve in the main three different widely separated scientific disciplines, highly specialised and offering unusual difficulties to any attempt at simplification. We need to construct an educational system based essentially on the physical chemistry of high polymers, the theory of colour, and rheology. To that we must add the requirement that this formidable trinity is to be presented at an intellectual level essentially below that of a pass degree. We then have to warn the candidates that the intellectual climate of the industry is not such as to welcome or even to accept such a scientific approach, that the salaries are lower than those obtaining elsewhere, that substantial promotion is unlikely, and that they run the risk of disqualifying themselves from moving outside the paint industry. Put this way it is surprising that anyone ever comes in at all.

I am old-fashioned enough to believe that supply is related to demand. If the paint industry really wants good technical people it must offer the appropriate rewards of salary and status. (To get the ball rolling it may have to offer salaries higher than appropriate.) When that is done the mechanics of training will sort themselves out.

*Ivy Cottage,  
Moore, via Warrington.*

M. H. M. ARNOLD  
15 October, 1961

## Information Received

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

Information has been received from THOMAS INDUSTRIAL AUTOMATION LTD. concerning a new version of their *Leveltron* Industrial Level Controller, the *CS 101*, together with a new continuous level indicator and controller—the *Leveltrator*—which will operate visual and audible alarms. Further, they have supplied information on their *Add-on* alarm unit which gives signal light or annunciator display of plant conditions. It was designed to meet the demand for a complete “pre-packaged” alarm unit and is intended for flush mounting on instrument panels.

It has been announced by HOWARDS OF ILFORD LTD., a member of the LAPORTE INDUSTRIES GROUP, that they are undertaking two further projects. One is a unit for the production of the plasticiser dicyclohexyl phthalate which should be completed in 1962. The second plant will produce cyclohexanol and cyclohexanone by the direct oxidation of cyclohexane in air; this unit should be completed in 1963.

A magnetic level indicator for radioactive, corrosive, toxic, inflammable, volatile, pressurised or valuable liquids has been developed by ALAN COBHAM ENGINEERING LTD. It can be fitted from above or below on any tank and is reported to be simple to operate.

JOHNSON, MATTHEY & CO. LTD. have announced that they have acquired the majority of the shares of the leading Belgian precious metal company Pauwels Freres S.A. The new company will operate under the title JOHNSON, MATTHEY & PAUWELS S.A.

The following publications have been received: *The Cellobond Polyester Story* from BRITISH RESIN PRODUCTS LTD.; *Plasticised PVC Film, Polypropylene Film, Polythene Film, Nylon Film and Polyvinyl Alcohol Film* from BRITISH CELLOPHANE LTD.; *C.V.P. Versamid Polyamide Resins: Specifications and Compatibility Data, Protective and Decorative Coatings* from CRAY VALLEY PRODUCTS LTD.; *Micronised Pigments in the Cowles Dissolver*, and the *Torrance High Speed Cavitation Dispenser*, together with an information sheet on *Spun Phthali—Chrome Green ZE. 64505* from GOLDEN VALLEY COLOURS LTD.; *Kestner Fluid Heat Transmission Systems* from KESTNER EVAPORATOR & ENGINEERING CO. LTD.; *Dispercel Cellulose Lacquer Chips: Colour Range Card and Information Booklet 102* from RUNNYMEDE DISPERSIONS LTD.; *Flooring Based on Epikote Resins* from SHELL CHEMICAL CO. LTD.; a complete set of Information Sheets, complete with folder, giving details, and specifications and uses of SPELTHORNE METALS LTD.'s metallic lead.

Several hundred aerosols collected from all over the world will be on display at a small exhibition, “More and More in Aerosols”, staged by THE METAL BOX CO. LTD. in their showrooms in Baker Street until 15 December.

### COMMENT

The stated object of a new film entitled “Why Thixotropy?”, presented by CRAY VALLEY PRODUCTS LTD., is to demonstrate the benefits of thixotropic paints, particularly in relation to a reduction in labour costs. This it does very persuasively and in a straightforward manner which will be readily comprehensible to non-technical users, at whom it is aimed. The film is in beautiful colour and extremely well produced by FILMS OF INDUSTRY.



## Bristol Section

### PATENTS AND THE PAINT CHEMIST

The first meeting of the Section's 1961-2 session took place at the Royal Hotel, Bristol, on 29 September, when Mr. F. Armitage took as his subject "Patents and the Paint Chemist", twenty-seven members and friends being present.

The lecturer gave details of the historical origins of the Patent Rolls and letters patent, and described the development of patent law and the organisation and responsibilities of the Patent Office. The steady increase in the number of patents granted was commented on.

The method of applying for a patent and the cost involved were then discussed, and the lecturer illustrated these by reference to the patent history of styrenated media, a product in which his own company had a considerable interest, acrylic resins and unsaturated polyesters. Dealing with patents in general, the lecturer produced an analysis of the filing of British Patents, and showed that, whereas in 1956 43 per cent of all British Patents dealing with surface coatings were filed by the United Kingdom companies, in 1961 52 per cent of all British Patents were filed by American companies, 25 per cent by European firms and only 23 per cent by the United Kingdom concerns. His conclusions from these figures were that, first, British companies as a whole were not putting enough effort into research, and that they preferred to allow continental and United States firms to carry out research and to obtain the patents, and then to negotiate a licence to use them. The lecturer considered this to be a dangerous trend which could well lead to trouble in the future, both from the economic and the scientific manpower aspect.

The discussion was opened by Mr. A. B. Lock and questions dealing with patent infringement, blocking patents, the terms of reference of the Patent Office, and the patent position in the U.S.S.R. were posed by Mr. Phillips, Mr. Woodbridge, Mr. Thompson and others. A vote of thanks was proposed by the Publications Secretary and unanimously endorsed.

D. S. N.

## London Section

### THE OTHER MAN'S TECHNOLOGY

The first meeting of the twenty-fourth session took place on 27 September at Manson House when, in accordance with established custom, the new Chairman, Mr. A. T. S. Rudram, addressed the Section, taking as his subject "The Other Man's Technology".

Mr. Rudram discussed the functions of Research Associations and the relations existing between them and industry. The development of the idea behind the original foundation of the Research Associations was traced, and the objections put forward by industry at various times were noted, in order to show that the Research Association development had not always been wholly acceptable to industry: in some cases this was true even today. Mr. Rudram thought that this development represented a factor of major importance in British industrial development and had provided a pattern for similar developments abroad. The changes in the functions of the Research Association as technological research in industry had increased in quantity and quality were reviewed and possibilities of the Research Association undertaking studies in operational procedures with a view to increased efficiency and productivity were put forward. He thought that the original main work of the Research Associations could be classified under the following headings:

- (i) Basic research on the raw materials and processes of the industries they served, and

- (ii) Applied research on technical problems of general concern to their industries;

but under present conditions the following five should be added:

- (iii) Development of research results to levels required by their industry, or such sections of it as may be unable to do so for themselves;
- (iv) Operational surveys with a view to increased efficiency and productivity;
- (v) Library and information;
- (vi) Liaison and advisory services to their members;
- (vii) Technical and technological education.

The speaker continued by discussing operational research, quoting various authorities in defining the subject, and he suggested that success in this field might be achieved by an objective approach which might suggest that Research Associations could apply the techniques very effectively. At the same time it had to be remembered that the human being was a vital factor in industrial efficiency and all operational approaches should take human welfare into consideration. He quoted the D.S.I.R./Medical Research Council Committee on Human Relations final report which said: "It is a peculiar condition of social science that the best results come from those persons who are able to operate at both the practical and theoretical levels." He suggested that this should be the aim of all members of the staff of Research Associations.

Mr. Rudram then turned his attention to education for industry and mentioned the training courses held at the Paint Research Station and the way in which they had been supported by industry so that they had always been oversubscribed. The interests of the professional societies and groups connected with the paint and printing ink industries had been shown by such activities as the Apprenticeship Councils and publications such as the *Printing Ink Manual* and the O.C.C.A. Training Manuals. He stressed the support given by the industry to this educational activity and surveyed the recommendations given in the report *Technical Education in Industry* produced by the Study Group on Technical Education in the Paint Industry. He suggested that the drive for better professional status for the paint and ink industries and the broadening of training policies to embrace techniques and knowledge in other industries should be intensified, quoting Dr. L. Valentine's use of this theme and his development of it in his address at the last annual meeting of the Paint Research Association. He concluded by examining the way in which the technologies in the plastics industry were developing and to some extent usurping those of the surface coating industries. He suggested finally that these latter industries should apply the same principle and learn from the other man's technology and, having learnt, improve it, and further, that the stimulus for this should be provided by the co-operative Research Associations, O.C.C.A. and the National Trade bodies.

Following the address the meeting was continued by a discussion to which several of Mr. Rudram's predecessors in the Chair contributed. Mr. H. A. Newnham inferred that the paint industry seemed to be far from efficient. He was worried about the effects of diversification, either by the dispersal of manufacturing units or by increase of departments. He thought that this might lead to a diminution in progress in the original purpose of the industry—the manufacture of paint. Mr. Rudram remarked that his idea was that diverse industries had hints and tips to give the paint industry which were worth consideration.

Mr. N. R. Fisk quoted a report, summarised in *The Times* of 31 July, 1961, of a committee on which stockbrokers had been largely represented and in which the paint and pigment industry had been rated as sixth in efficiency out of thirty seven industries surveyed. The ability of such a committee to pass judgment on such matters was doubted by Mr. Rudram.

Mr. J. A. L. Hawkey queried the wisdom of equating efficiency with profits and the possibility of complacency arising from the showing of good sales and profits by the industry. He thought that this tendency to look backwards and at figures sometimes led to a reluctance to plan for the future by undertaking long term research. Mr. Hawkey also suggested that it should be acknowledged frankly that the industry was less efficient than it might be and that, even in a mainly efficient factory, it was always possible to find pockets of inefficiency which should be eliminated. He thought that in a Research Association approach to operational research, the first object should be to educate the management. Mr. Rudram replied that the D.S.I.R. had an operation unit which ran courses for management.

Mr. F. Armitage raised again the question of diversification and quoted American and German paint companies who had entered into the adhesive and laminating fields. He suggested that in fifty years' time the paint industry might no longer be making paint.

Dr. H. G. Rains cited figures given in the Paint Research Station Monthly Memorandum comparing personnel employed and output in the United Kingdom and the United States; he suggested that they gave considerable food for thought on the question of efficiency.

Mr. G. W. Mack suggested that the time of a Research Association should be divided into 50 per cent fundamental, 25 per cent general and 25 per cent propaganda, publication and education. He thought that in particular Research Associations could well combine the experience of the industry by a survey technique. The education of the user and consumer was a problem requiring serious thought for, in some cases, if a manufacturer were honest, an order could be lost, and he wondered whether that function might devolve on a new Development Association or even D.S.I.R.

Mr. D. E. Roe commented on the professional animosity which existed between the chemist and the accountant; he felt that this might be due to the lack of skill of the chemist in this industry in presenting his story in a form understandable to the accountant. He quoted the obvious difference in the pharmaceutical industry where accountants authorised large expenditure on research projects that must be beyond their understanding.

Mr. Rudram concluded the meeting by commenting on the liveliness of the discussion, typifying a statement made by Mr. Roe that the subject of the address was one on which everyone was an expert.

#### SOME CONSIDERATIONS ON THE FORMATION OF FILMS

The second technical meeting of the session was held in the lecture room of the Chemical Society at Burlington House on 10 October. Dr. H. W. Talen, Director of the Paint Research Institute, Delft, Holland, gave a lecture entitled "Some Considerations on the Formation of Films".

Dr. Talen divided film formation methods into nine types involving three classes: purely physical, physical/chemical, and purely chemical; and three mechanisms within each class. He defined each type by example and proceeded to discuss three types in detail. In type 2, the physical class involving the evaporation of a non-solvent, he discussed the various theories put forward to explain the formation of coherent films by the coalescence of polymer particles from aqueous emulsions. He showed how the theory most relevant to practical observations and experimental facts was that put forward by Brown. He considered the forces applying in film formation and the way in which the spherical polymer particles were squashed together into polyhedra, illustrating this by some excellent electron micrographs.

In type 4, the physical/chemical class involving the evaporation of solvent followed by reaction with outside agents, he considered linseed stand oil and alkyd paints and discussed the effects on film properties of segregation of stand oils by molecular distillation and acetone extraction. The effect of method of cooking on the properties of alkyds was postulated as being more important than time of cooking, and Dr. Talen demonstrated that mechanical properties correlated with hydroxyl value rather than with viscosity or phthalic anhydride content. He concluded that the length of the glyceryl phthalate chain was the factor most influencing the film properties.

The speaker continued by considering type 6, the physical/chemical class involving solvent evaporation followed by the chemical reaction of the components, and itemised in particular two-can coatings of the epoxy/amine and epoxy/polyamide type. He showed how film properties could change by the neglect of changes in conditions during drying, and illustrated the methods of following the chemical reaction by infra-red spectroscopy or methyl ethyl ketone extraction. The effects of solvent retention on apparent drying were well illustrated by this technique where, in two formulations with the same reactants ratio but different solvent mixtures, film properties varied considerably due to retention in the film of high boiling solvents although the chemical reaction was completed in the same time.

Dr. Talen concluded by a consideration of class C, the purely chemical class. After itemising the advantages of solventless systems, he pointed out that one of the outstanding examples of this class of materials was linseed oil. The artistic use of this film-former was delightfully illustrated by a number of excellent slides of the work of such masters as Rembrandt and Van Gogh.

During the discussion which followed the lecture, and to which contributions were made by Dr. L. Valentine, Dr. R. F. Bowles, Dr. M. L. Ellinger, Mr. J. J. Scowron, Mr. J. A. L. Hawkey, Mr. H. A. Idle, Mr. W. H. Moss, Mr. P. N. Whitby, Dr. L. A. Jordan and Dr. S. H. Bell, the whole field covered by Dr. Talen in his lecture was surveyed. The influence of water-soluble constituents and coalescing agents in emulsion paints, the effect of high boiling solvents on film gloss, the effect of selective evaporation of solvent/non-solvent mixtures, and the artistic use of film-formers as opposed to the more utilitarian uses, were some of the points raised.

The meeting was concluded by the proposal of a vote of thanks by Mr. H. A. Idle, who said that in the printing ink field the types and classes enumerated by Dr. Talen could not be so readily accepted in view of the necessity to consider in addition the effects of the medium upon which the print was applied and, in particular, penetration, filtration, pH, *etc.*

#### SOLVENTS IN THE SURFACE COATING INDUSTRY

The third meeting of the session was held at Manson House on 10 October, when Dr. L. M. Barakan, of the Distillers Co. Ltd., presented a paper entitled "Solvents in the Surface Coating Industry".

Dr. Barakan discussed solvents on the basis of the different types of surface coating and stated that the choice of solvent for any particular use was dependent, first, on the type of resin to be used, secondly, on the method of application and, thirdly, on the drying process. The properties of solvents which could be of importance were compatibility, solvent power, evaporation rate, dilution ratio, blush resistance, electrical characteristics, flammability, odour, toxicity and price. It was usually necessary when making a final choice to adopt a compromise. In the case of alkyd resin-based formulations, the usual solvents were hydrocarbons, and generally there were few difficulties in obtaining suitable blends. Odourless solvents had become more popular in the United States than in the United Kingdom; these had low solvent power, but this could be offset by the addition of solubilising agents.

Dr. Barakan then proceeded to a detailed consideration of the properties required in solvents for nitrocellulose lacquer formulations. He commented on the use of alcohols as latent solvents and demonstrated the effect on dilution ratios of the addition of alcohols, such as methylated spirit and butanol, to ketones and esters. The problem of blushing and solvent balance was also discussed. The question of toxicity and odour and their interrelation was considered, the lack of an objective method of measurement of odour being regretted. The use of threshold limit values and the comfort level of odour were mentioned as guides to the imminence of a dangerous concentration of solvent in the atmosphere.

The use of vinyl resins in lacquer formulations involved an appreciation that the solids/viscosity relationship with this type of resin was even more important than with nitrocellulose; and ketones were the most important of solvents in this field. Acrylic lacquers were in use in the automobile industry in the United States, where a larger use was made of air-drying formulations. Ketones, esters, aromatic hydrocarbons and glycol ethers were the solvents necessary in this field. So far as the speciality formulations based on epoxy and polyurethane resins were concerned, it was important to remember that only anhydrous solvents could be used with the isocyanates, and esters, particularly the glycol ether esters, had been recommended for this use. Dr. Barakan continued by discussing the way in which application method affected the choice of solvent and, in relation to electrostatic spraying, he listed the dielectric constant and resistivity of a number of well-known solvents. He ended by suggesting that, although the impact of water as a solvent was increasing and had obvious advantages over organic solvents, the two would ultimately lead a life of peaceful co-existence.

During the course of the discussion after the lecture, Mr. W. F. Daggett enquired about the possibilities of the use of nitroparaffins in the United Kingdom. Dr. Barakan said that these solvents were not produced in this country and that might have hampered their development. He referred to a paper by Bennett in *Official Digest*, September, 1960, when an extensive survey of the properties of 2-nitropropane was given, and developed on the basis of solubility parameters. Mr. R. A. May asked for advice on a suitable solvent system for a urea-formaldehyde resin surface coating unmodified by alkyd resins. Dr. Barakan replied that, although he did not know of any such coatings, the normal xylene/butanol mixtures should be the most suitable. Mr. R. N. Wheeler requested further enlightenment on the matter of the importance of the electrical properties of the solvent in electrostatic spray application. Dr. Barakan said that there seemed to be little fundamental knowledge on the subject. From his own experience diacetone alcohol, glycol ethers and mesityl oxide as solvents improved the performance of paints in an electrostatic field, but he could give no explanation of the causes. He thought that it was a subject which required very much more study than had been given to it so far.

Mr. J. R. Berry asked whether there was an aromatic hydrocarbon solvent which, when mixed with butanol, would give a flash point above 73°F. Dr. Barakan suggested solvent naphtha. Mr. N. R. Fisk raised the question of odour measurement, pointing out that some original work not confined to threshold values had been carried out on the subject which had been noted in correspondence appearing in the technical press about five years ago. He continued by making a very strong appeal that the correct chemical nomenclature for solvents should be used in trade literature and the industry generally. He thought that the misuse of synonyms and homonyms was probably at its worst in the solvents section of the raw materials industries and quoted hexylene glycol as a conspicuous example of a misleading misnomer. Dr. Barakan agreed that the use of misnomers was very reprehensible, but suggested that it was so prevalent because of convenience. On the matter of odour measurement he stated that he had mentioned odour in conjunction with threshold values only when the level of a powerful odour might give early warning of danger. Mr. P. E. Randall continued the discussion on

odour and threshold limit values in relation to toxicity and said that threshold limit value depended on the comfort level. He thought that it would be wrong to use a table of threshold limit values as a basis for the deduction of the relative toxic effect of solvents. He also commented on the uses of alcohols as latent solvents in combination with methyl isobutyl ketone and the use of isopropanol with this solvent and with methyl ethyl ketone. Dr. Barakan agreed that threshold limit values had to be treated with caution and due allowance made for both the odour and volatility of the solvent.

Mr. S. Kettle asked whether wet on wet spray application complicated the selection of solvent mixtures. Dr. Barakan replied that there was complication in the formulation, particularly when the two coats were not of the same product.

The meeting concluded by the proposal of a vote of thanks to the lecturer by Dr. R. J. Wicker, who commented on his experiences with misnomers in the solvent field. He was relieved that Dr. Barakan had not attempted to introduce any new solvent and he noted the interesting and devastating effects on transport in the United States caused by nitromethane.

C. R. P.

### SOUTHERN BRANCH

#### FLOODING AND FLOATING IN PAINTS

The second meeting of the current session was held on 9 October at the Royal Beach Hotel, Portsmouth, when a paper entitled "Flooding and Floating in Paints" was read by Mr. L. A. Logue.

After defining the terms "flooding and floating" as he meant them, the speaker described some of the research that had been directed towards the solving of this problem. Experiments concerning various alkyds and pigment combinations had shown many effects without pointing to the cause. Mr. Logue showed evidence of the control by additives which, if incorporated correctly, could cure or at least minimise these defects.

More recent work on the study of the nature of the molecules of titanium dioxide and phthalocyanine blues had indicated possible reasons for flooding and floating. However, since the defects were also found in varying degrees, depending on the vehicle and solvent used, the findings could not be conclusive.

Mr. Logue concluded by saying that an awareness of correct and balanced formulating, choice of additive if needed and true balance of solvent could do much to reduce these faults.

Following the lecture an interesting discussion took place in which Mr. P. Targett, Mr. J. Smith, Mr. R. D. Orwin and Mr. F. W. Davies took part. Mr. J. Smith proposed the vote of thanks which was endorsed by the meeting. In conclusion, Mr. Logue introduced a new film entitled "Titanium Oxide", which presented the aspects of manufacture and use of this pigment in a most pleasing manner.

A. F. R.

## Manchester Section

### THE MODERN CHEMISTRY OF ORGANIC PIGMENTS

To a very good attendance in Manchester, Dr. Gartner presented the first lecture of the season on 13 October, dealing with "The Modern Chemistry of Organic Pigments". The lecturer gave a brief survey of those developments in pigment chemistry which had led to the creation of particularly high grade organic pigments. He described how the advent of the phthalocyanines had provided pigments suitable for universal use, since they possessed maximum all-round fastness. However, their shade range was still restricted to blues and greens, despite tremendous efforts to extend it.

The search for similar fastness in other shades had led to the investigation of other chemical classes, and had produced the thioindigo pigments, anthraquinone pigments, and the perinone and perylene pigments, all of which were either identical with or chemically related to vat dyestuffs. Further, this work had led to the development of the dioxazines and the quinacridones which were polycyclic compounds no longer related to vat dyes. Quite a number of these new pigments approached the fastness of the phthalocyanines, and a few actually reached it.

In addition, work in the field of azo pigments, still by far the most important class, had led to remarkable improvements in fastness properties. One line of work had been to use complicated diazo components and to prepare various metal salts and metal complexes in the production of pigments by the usual coupling method. Another line of work had been the production of azo pigments of higher molecular weight by reversing the reaction sequence in synthesis. These "azo condensation" pigments differed from conventional azo pigments in that their fastness properties were well balanced and of a higher general standard. Up to the present time they had been mainly used in the coloration of plastics. The leading brands of the range approached the fastness standard of the phthalocyanines and could thus be employed in high quality organic coatings.

A survey of the chemistry of high grade pigments showed that most of them were neutral compounds without salt-type or complex groups, and that many of them stemmed from chemical classes not previously used in pigment chemistry.

A further survey showed what shades the various chemical classes had yielded to date as a result of the search for high-grade pigments. One specific group of shades dominated in each class with the exception of the anthraquinones, which covered a remarkably wide range. However, the phthalocyanine standard in respect of both fastness and brilliance had by no means been reached in all shades. Furthermore, in no case had it been possible to get down to the phthalocyanine price level with other high-grade pigments.

An interesting discussion followed the lecture, covering the relation of molecular weight to light fastness, dispersion properties, polymorphic forms of quinacridone pigments and the flocculation of phthalocyanine blue. Dr. Gartner was congratulated in a vote of thanks for the excellent presentation of his lecture which had provided a most enjoyable evening for the large audience present.

I. S. M.

## Midlands Section

### THE PERFORMANCE OF METALLIC AND ORGANIC FINISHES

On 22 September at Regent House, Birmingham, Mr. R. J. Brown who is Materials Engineer for B.M.C. Ltd., presented a paper on "The Performance of Metallic and Organic Finishes"; Mr. N. H. Seymour was in the chair.

Mr. Brown began by describing the conditions which cars and spare parts had to resist, particularly during shipment to and operation in tropical and Arctic conditions. The main objective in applying organic finishes was corrosion resistance, combined with the covering of surface blemishes and the production of an attractive appearance.

The performance requirements were specified for each type of paint. For finishing coats the film had to withstand wide temperature and humidity variations, abrasion, weathering and possibly chemical attack, whereas for engine parts, oil and chemical resistance were of paramount importance.

Certain standard routine tests, such as viscosity thinning ratio, total solids content and pigment/vehicle ratio, were carried out on the paint itself. Tests on the finished coating included gloss, hardness, adhesion, flexibility, chip resistance, corrosion resistance and freedom from blemishes.

The speaker discussed the tests which had been developed for assessing these requirements and how the results from these related to results under actual performance conditions. It was evident that considerable work had been carried out, particularly on resistance to staining and blistering and the factors affecting durability.

Of the three main metallic finishes, chromium plating, stainless steel and anodised aluminium, the first of these was dealt with in some detail and mention made of the duplex processes. Performance tests on metal finishes were severe, being mainly accelerated corrosion tests. A number of interesting examples of finishes were shown and their properties described during the lecture.

The discussion which followed was lively, and questions by the Chairman Mr. Edwards, Mr. Clarke, Mr. Morris, Mr. French and Mr. Taylor were dealt with very comprehensively by Mr. Brown. Mr. Northeast proposed the vote of thanks to Mr. Brown for his competent and interesting talk.

R. D. C.

## Newcastle Section

### JOINT MEETING

On 18 October the Section were guests of the local branch of the National Federation of Master Painters and Decorators at a pot-pie supper in the Crown Hotel, Newcastle. The branch President, Mr. Robson, was in the chair.

After the meal, Mr. D. C. Wall gave a short talk on corrosion and this was followed by a two-hour discussion on the lines of an informal brains trust. Considerable interest was expressed by the decorators in rapid drying enamels, and although none had adverse comments to make on thixotropic paints there was no enthusiasm either. On the assumption that only reputable paints were used, price seemed to be the prime factor in making any selection, yet it was obvious at the same time that water-thinned systems were being approached with great caution.

The use of emulsion paints as exterior undercoats was condemned, but it was agreed that certain advantages were apparent for interior work. Some time was spent in discussing the durability of clear varnishes and the effect on this property of pigmentation. The demand for clear varnishing work was decreasing as graining became a lost art.

The decorators appreciated the improvement in colour retention shown by first-class enamels over the past few years, but they considered that the development of a good, one-pack, fast drying knifing stopper with no shrinkage and excellent durability would be a worthwhile research project.

The O.C.C.A. members who answered most of the questions were Mr. J. Clark, Mr. D. C. Wall and Mr. E. A. Watson, whilst Mr. Gow and Mr. R. A. Bibby led for the decorators. The Chairman of the Section, Mr. A. W. Blenkinsop, thanked their hosts for a pleasant and useful evening.

J. A. W.

### SOME CONSIDERATIONS ON THE FORMATION OF FILMS

The first meeting in the 1961-62 programme was held in the Royal Turks Head Hotel, Newcastle, on 5 October. Mr. A. Blenkinsop in the chair, welcomed the members to this session and thanked all those who had contributed in various ways by assisting Mr. E. Farrow at the very successful local O.C.C.A. Exhibition which had been held in Newcastle in connection with the Commonwealth Training Week.

Dr. H. W. Talen of the Paint Research Institute T.N.O., Delft, presented a paper entitled "Some Considerations on the Formation of Films". He introduced this by pointing out that film-formation was the last and very important stage in the sequence



of chemical and physical processes leading to the end product of the paint industry, *i.e.*, the protective or decorative coating.

He differentiated between nine types of film-formation, these being divided equally into three distinct classes, namely formation by (a) purely physical processes, (b) purely chemical processes and (c) a combination of (a) and (b).

A fuller description was furnished of the processes involved during the drying, of three typical examples, *viz.*, a p.v.a. emulsion, linseed oil and alkyd resins and an amine cured epoxy system.

Mr. A. Duell proposed the vote of thanks to Dr. Talen and said that he felt that the great interest in the paper lay in the fundamental nature of the work, being of the type which the average paint technologist found little opportunity to tackle.

E. A. G.

## West Riding Section

### METAL PREPARATION AND PAINTING

At the first meeting of the session held on 12 September at the Hotel Metropole, Leeds, Mr. D. H. du Rieu, a member of the Section, delivered a paper on "Metal Preparation and Painting". Introducing the subject, Mr. du Rieu said that it would be restricted to the surface preparation of structural steel work and would not include factory production systems of surface preparation. He did not intend to deal with painting schemes in detail, but would mention painting where it was particularly related to the method of surface preparation.

Mention was made of the fact that, although everyone was made very conscious of the cost of corrosion now, owing to the considerable publicity the matter received, in practice the advice was often disregarded. The case for good surface preparation was primarily a matter of economics. In an average painting job the cost of preparation and application was approximately 80 per cent of the total cost and only the remaining 20 per cent was for materials. Consequently, it was sound economics to use good quality materials and good surface preparation. Since labour costs were increasing, it was likely that the differential between the cost of preparation and application and the cost of materials would be increased further.

In the first section the lecture dealt with physical adhering contaminants, such as oil, dirt and old paint. General methods were given for removing these contaminants, but it was pointed out that because of the wide variety of possible contaminants, particularly chemical ones, each individual case had to be considered separately.

The next section dealt with the removal of chemically bonded contaminants, which included rust and mill scale. The four main methods for effecting removal were then described, being manual cleaning, including the use of power driven tools, flame de-scaling and abrasive blasting. In each case the equipment required, the method used, and the various safety precautions necessary were outlined. The lecturer discussed the advantages and disadvantages of each method, drawing considerably on his own practical experience. Finally, a comparison was made between the various methods available, and the speaker stated that, although other methods had their place, the only reliable one in the majority of cases was abrasive blasting, and that this method should always be used wherever possible.

The lecture was concluded by a vote of thanks from Mr. Cass, who mentioned that he was very pleased to hear a lecture from one of the members of the Section and hoped that more local members would give papers in the future. After a short break there was a question time and it was obvious from the number and character of the questions that those at the meeting were extremely interested in this particular subject.

L. J. W.

## FOURTEENTH TECHNICAL EXHIBITION, 1962

### MINISTER FOR SCIENCE TO OPEN EXHIBITION

The Exhibition Committee is pleased to announce that The Rt. Hon. Viscount Hailsham, Q.C. (Lord President of the Council and Minister for Science), has accepted its invitation to be the Guest of Honour at the Fourteenth Technical Exhibition Luncheon and to reply to the Address of Welcome by the President, Dr. H. A. Hampton.



THE RT. HON. VISCOUNT HAILSHAM, Q.C.

The Exhibition Luncheon will take place at the Criterion Restaurant, Piccadilly, London, W.1, at 12.15 p.m. for 12.45 p.m. on Monday, 26 February, 1962. At 3 p.m. on the same day, Lord Hailsham will declare open the Exhibition (which takes place at the Royal Horticultural Society's Old and New Halls, London, S.W.1) by cutting a tape at the entrance to the Old Hall. The Exhibition will be open until

7 p.m. on 26 February and on the following three days it will be open from 10 a.m. to 7 p.m.

The charge for Exhibition Luncheon tickets will be £1 12s. 6d. and forms of application for these will be included in all copies of the Exhibition *Official Guide*, which will be sent individually to all members of the Association in the New Year. They will also be sent to manufacturing companies in the United Kingdom as well as to chemists and technologists individually in Western Europe and Scandinavia. Non-members wishing to obtain copies of the *Official Guide* may obtain them, without charge, by making application in writing to the General Secretary of the Association, at the address given on the front cover of this *Journal*.

The Exhibition provides a focus for the technical display of advances in raw materials, plant and machinery for use in the paint, printing ink and allied industries. The Fourteenth Technical Exhibition will cover a larger floor area than any previous Exhibition, and there is participation from companies in countries in both the European Free Trade Area (Denmark, Sweden and Switzerland), the European Common Market (France, Germany and Holland) as well as in the United States of America. There are, of course, many overseas companies who will be showing through associated companies in the United Kingdom.

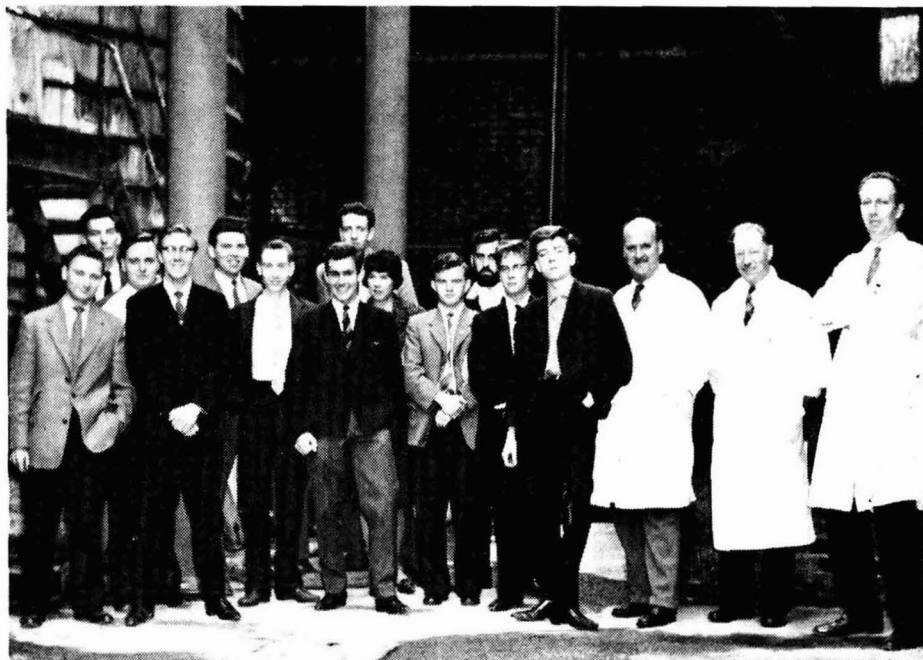
A feature of recent Exhibitions has been the marked attendance of overseas visitors, and interpreters will be present to help both visitors and exhibitors from overseas. On this occasion the invitation cards to the Exhibition are being printed in four languages.

### Alphabetical List of Exhibitors

- Albro-Fillers & Engineering Co. Ltd.  
 Allied Colloids Ltd.  
 \*Amoco Chemicals Corporation  
 A.P.V. Company Ltd., The  
 Armour Hess Chemicals Ltd.  
 Associated Lead Manufacturers Ltd.  
 \*Astles Chemical Co. Ltd.  
 Bakelite Ltd.  
 Baldwin Industrial Controls  
 \*Barter Trading Corporation Ltd. (Kemisk  
 Vaerk Koge, A/S)  
 Beck, Koller & Co. (England) Ltd.  
 Berk, F. W., & Co. Ltd.  
 B.I.P. Chemicals Ltd.  
 Boehm, Frederick, Ltd.  
 Boulton, William, Ltd.  
 British Celanese Ltd.  
 British Oil & Cake Mills Ltd.  
 British Oxygen Chemicals Ltd.  
 British Resin Products Ltd.  
 British Titan Products Co. Ltd.  
 \*Buhler Brothers (England) Ltd.  
 Burts and Harvey Ltd., incorporating  
 Alchemy Ltd.  
 \*Bush, Beach & Segner Bayley Ltd.  
 Campbell, Rex, & Co. Ltd. and the  
 Chemical Supply Co. Ltd.  
 Carless, Capel & Leonard Ltd.  
 \*Chemische Werke Huel A.G.  
 Ciba (A.R.L.) Ltd.  
 Ciba Clayton Ltd.  
 Cornelius Chemical Co. Ltd.  
 \*Coulter Electronics Ltd.  
 Cray Valley Products Ltd.  
 Crosfield, Joseph, & Sons Ltd.  
 Croxton & Garry Ltd.  
 Distillers Co. Ltd. and Honeywell &  
 Stein Ltd.  
 \*Dow Chemical Co. (U.K.) Ltd.  
 Dunlop Chemical Products Division  
 Durham Raw Materials Ltd.  
 Elliott, H. J., Ltd.  
 Esso Petroleum Co. Ltd.  
 Evans Electroselenium Ltd.  
 Farbenfabriken Bayer Aktiengesellschaft  
 Ferranti Ltd.  
 Geigy Co. Ltd.  
 Golden Valley Colours Ltd.  
 Goodyear Tyre & Rubber Co. (G.B.) Ltd.  
 Hardman & Holden Ltd.  
 Hercules Powder Co. Ltd.  
 Imperial Chemical Industries Ltd.  
 Johnson, Matthey & Co. Ltd.  
 \*Joyce, Loebel & Co. Ltd.  
 Kek Ltd.  
 \*Kingsley & Keith (Chemicals) Ltd.  
 Kunstharsfabriek Synthese, N/V  
 Laporte Titanium Ltd.  
 \*Lennig, Chas., & Co. (G.B.) Ltd.  
 Marchant Brothers Ltd.  
 Metal Propellers Ltd.  
 Micafine Ltd.  
 Mitchell, L. A., & Co. Ltd.  
 Monsanto Chemicals Ltd.  
 \*Morris & Ingram (London) Ltd.  
 National Adhesives Ltd.  
 \*Noss Mayo Dispersion Products Ltd.  
 Novadel Ltd.  
*Paint Manufacture*  
*Paint, Oil & Colour Journal*  
 Paint Research Station, The  
*Paint Technology*  
 Pascall Engineering Co. Ltd.  
 \*Pechiney-Saint-Gobain  
 Plastanol Ltd.  
 Premier Colloid Mills Ltd.  
 Price's (Bromborough) Ltd.  
 Research Equipment (London) Ltd.  
 Resinous Chemicals Ltd.  
 \*Runnymede Dispersions Ltd.  
 \*Scado-Archer Daniels, N.V.  
 Schenectady-Midland Ltd.  
 Scott Bader & Co. Ltd.  
 Shawinigan Ltd.  
 Sheen Instruments (Sales) Ltd.  
 Shell Chemical Co. Ltd.  
 Silverson Machines (Sales) Ltd.  
 Spelthorne Metals Ltd.  
 Surface Coating Synthetics Ltd.  
 Svenska Oljeslageri Aktiebolaget  
 Swada Ltd. & H. Haeffner & Co. Ltd.  
 Tin Research Institute  
 Trade & Industrial Press Ltd. (*The Paint  
 Journal*)  
 \*Translation & Technical Information  
 Service  
 Union Carbide Ltd.  
 Universal Oil Co. Ltd., Premier Oil &  
 Cake Mills Ltd. & J. L. Seaton & Co.  
 Ltd.  
 Vinyl Products Ltd.  
 Winkworth Machinery Ltd.  
 Wolf, Victor, Ltd.  
 Youngusband Stephens & Co. Ltd.  
 Technical Education Stand  
 O.C.C.A. Information Bureaux

\*Denotes exhibitors who have not shown at previous Exhibitions

## London Section



[Photograph by

Halifax Photos]

Members of the London Section Junior Group pictured here with their hosts at the works of Burrell & Co. Ltd. during a recent visit. Present on this occasion were Mr. T. Whitby, Mr. H. Elliott, Mr. C. Condon, Mr. R. Furner, Mr. M. Heath, Mr. R. Golds, Mr. J. Bird, Mr. K. Shaw, Mrs. J. Horvath, Mr. G. Gully, Mr. P. Pitfield, Mr. A. Ferris and Mr. J. O'Neill

### JUNIOR GROUP'S WORKS VISIT

Fourteen members of the Junior Group took part in the works visit on 21 September to Burrell & Co. Ltd. The members of the party were met by Mr. Maloney and Mr. Dennett from the company and a short discussion developed during the serving of light refreshments.

The party then split up and the tour commenced, covering the wide field of extenders, *etc.*, toners and lakes. Finally,

the party reunited to visit the processing and blending departments. This proved to be a most interesting and comprehensive visit.

Refreshments were then supplied and their hosts were most helpful in answering questions. Mr. C. Condon, the Junior Group's Chairman, proposed a vote of thanks which brought the visit to a close.

M. H.

## Midlands Section

### PRESENTATION TO MR. S. MARKS

On 5 October the Midland Sections of O.C.C.A. and the Royal Institute of Chemistry, together with the Midland Varnish, Paint and Colour Manufacturers'

Association and the Midland Paint Students' Association, joined the Birmingham Paint, Varnish and Lacquer Club in a presentation to Mr. Sidney Marks on his retirement from teaching at the Birmingham College of Technology.



Photograph taken at the presentation of a silver tray and an illuminated address to Mr. S. Marks on his retirement. *From left to right are: Mr. G. King (Chairman, Midlands Section of the Royal Institute of Chemistry), Mr. N. H. Seymour (Chairman, Midlands Section, O.C.C.A.), Mr. C. J. A. Taylor, who made the presentation, Mr. S. Marks, Mr. H. J. Clarke (President, Birmingham Paint, Varnish and Lacquer Club) and Mr. L. V. Jennings (President, Midlands Paint Students' Association).*

Mr. C. J. A. Taylor, who made the presentation, had been closely associated with Mr. Marks during this period and was also a member of each of the five associations represented. During his time in the Department of Chemistry, Mr. Marks had not only instructed and guided so many students in paint and other industries but had also won their respect and affection. Mr. Taylor also described in particular Mr. Marks's close association with Dr. R. S. Morrell and his long and valuable services to the City and Guilds Institute.

The presentation, an illuminated address

showing the emblems of the five associations, together with a silver tray, was a token of the esteem and affection held for Sidney Marks and Mrs. Marks.

Mr. Marks recalled his early days at the College of Technology and how the pattern of lectures had changed since 1922. A whole new technology in resins, pigments and paint manufacture had been built since the days when Mr. Sturge and Dr. Newton-Friend carried out the preliminary work. In thanking Mr. Taylor and the associations concerned, Mr. Marks expressed his great pleasure in seeing so many of his friends present. N. H. S.

## Register of Members

The following elections to membership have been approved by the Council. The Sections to which the new members have been attached are given in italics.

### Ordinary Members

ADAM, RICHARD, "Dunedin", 40 Ashtown Grove, Navan Road, Dublin 7, Eire.

*(Bristol)*

ASTLES, PHILIP GOOLDEN, B.SC., CHEM. ENG., 75 Mashiters Walk, Romford, Essex.

*(London)*

- BLACKMAN, FRANCIS ALLEN, Hercules Powder Co. Ltd., Church Manorway, Erith, Kent.  
(London)
- BOWKER, KENNETH, L.I.R.I., Industrial Dyestuffs Ltd., Bonding House, 26 Blackfriars  
Street, Manchester, 3. (Manchester)
- BOYLE, JAMES JOSEPH, B.SC., M.I.C.I., Shell Chemical Co. Ltd., 33/34 Westmoreland  
Street, Dublin, Eire. (Bristol)
- CATHERALL, KENNETH DAVID, B.SC., 15 Swan Street, Alvechurch, Worcs. (Midlands)
- CHRISTENSEN, GUNNAR, M.SC., 14 Kastрупvej 3 sal., Copenhagen S, Denmark.  
(Overseas)
- HILL, WILLIAM VICTOR, A.S.T.C., 19 Macdonald Avenue, Auburn, New South Wales,  
Australia. (New South Wales)
- JACOB, DEREK ERNEST, Armour-Hess Chemicals Ltd., 6 Arlington Street, St. James's,  
London, S.W.1. (London)
- KOTWAL, HOSHIDAR PESHOTAN, B.SC., 20 Eduwi Dinshaw Building, Preedy Street,  
Karachi (3), Pakistan. (Overseas)
- MOLE, LEONARD WILLIAM, 35 Strode Road, Forest Gate, London, E.7. (London)
- O'BRIEN, BARRIE JAMES, 354 Avoca Street, Randwick, New South Wales, Australia.  
(New South Wales)
- OTT, EUGENE H., B.SC., Grand Rapids Varnish Corporation, 1350 Steele Avenue S.W.,  
Grand Rapids 2, Michigan, U.S.A. (Overseas)
- ROZEMA, PIETER, 101 Ryde Road, Pymble, New South Wales, Australia.  
(New South Wales)

#### Associate Members

- ELLIS, RONALD, 11 Ash Street, Wardley, Swinton, Manchester. (Manchester)
- FERGUSON, JOHN RICHARD, 261 Worona Road, Engadine, New South Wales, Australia.  
(New South Wales)
- HARLEY, ROY ERNEST, 21 Adelaide Street, West Ryde, New South Wales, Australia.  
(New South Wales)
- JONES, JAMES BRUCE, I.C.I. Ltd., 4 Blytheswood Square, Glasgow, C.2, Scotland.  
(Scottish)
- JONES, THOMAS JAMES, Bitumen & Oil Refineries (Australia) Ltd., Bunnerons & Military  
Roads, Matraville, New South Wales, Australia. (New South Wales)
- YOUNG, GRAHAM BISSET, I.C.I. Ltd., Templar House, 81/87 High Holborn, London,  
W.C.1. (London)

#### Junior Member

- KNUCKEY, CHARLES HOWARD, 22 Queens Road, Skewen, Neath, Glam. (Bristol)

## Obituaries

### MR. HUGH REYNOLDS

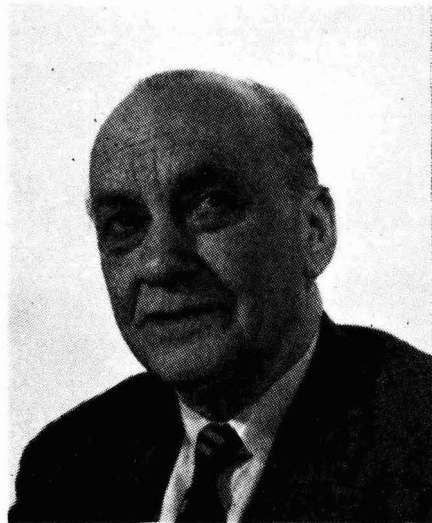
Mr. Hugh Reynolds, Technical Director of Cowan Bothers (Stratford) Ltd. of Stratford, London, E.15., died on Friday, 13 October, aged 65. His health had been poor for the past two years and became worse during the past few months.

Mr. Reynolds was educated at Tottenham Grammar School, the Borough Polytechnic, and Sir John Cass Institute. He joined Cowan Brothers in 1912 in the Laboratory and Works and became a Director in March 1921.

He had an extensive knowledge of pigments and allied materials and was a keen member for years of the Borough Old Students Society and the Oil and Colour Chemists' Association. He also served for several years on the Pigment Panel of the Paint Research Station.

A very modest and courteous man, he was highly respected by his many friends in the pigment, paint, printing ink and plastic industries for his sincerity and integrity. He leaves a widow and two sons.

W. P.



PROFESSOR H. V. A. BRISCOE

PROFESSOR HENRY VINCENT AIRD BRISCOE,

D.S.C., A.R.C.S., D.I.C., 1888-1961

A Vice-President: 1950-51

### An Appreciation

On discovery: "*Whether the discovery be great or small, the making of it affords the keenest satisfaction we scientists can enjoy*".

On serendipity in research: "*It is important for any investigator or any research institution to do a sufficient proportion of 'd . . . silly' experiments*".

On assisting in the revision of a well-known chemical dictionary: "*It taught me to read and write and to cope with tyrants*".

On motoring: "*I am a hardened motorist, who bought a motor cycle in 1911 and have owned some kind of petroliferous vehicle ever since*".

On having his cigarette lighted: "*With a match for a cigarette you're the quickest man on the draw I know*".

These are some of the things said by "H.V.A.B." (many people referred to him with affectionate brevity by his initials) from which those who did not know him could deduce much about him, including his somewhat dry humour. But only those who knew him can have the pleasurable remembrance of the thoughtful smile and the occasional exuberant laugh that accompanied such remarks.

He was a man of parts, of skills, of versatility, and of wide service to others collectively and individually. He was habitually pleasant and gentle in manner,

and could be gay. He could tell a good story and could cloak wisdom in humour; he could be firm, but seldom stern.

For many years he suffered physical discomfort and pain, but it seemed to disturb none of his characteristic readiness to give a friendly ear to individuals' problems and, having listened (a virtue this), to give advice which in the event was so frequently found to be sound. Such an appreciation of him could be written only by one who knew him well and experienced such things, but many others could testify similarly.

So strong are these personal impressions that one could almost wish to write only of the man (and that extensively) and omit his works; but the record of his considerable and diverse activities tells so much of his character and helpfulness. His range of interests was enormous, which revealed his ability and energy rather than diffuseness, for he was much concerned lest excellence should be sacrificed to conformity.

A Londoner and proud of it, he went in 1906, at the age of 18, to the Royal College of Science, which was soon to become a constituent college of the Imperial College of Science and Technology. After graduation, he assisted Sir Edward Thorpe in the revision of the famous Dictionary of Applied Chemistry, and became a demonstrator to, among others, a young student named Louis Arnold Jordan.

Resigning his full-time academic appointment in 1916, he became concerned with chemicals and munitions, but maintained contact with the college by lecturing in engineering chemistry. He also assisted the Sir John Cass College. Then followed a series of university appointments: Armstrong College (now King's College) Newcastle, Professor of Inorganic and Physical Chemistry (1921), Head of the Chemistry Department (1925); University of Durham, Dean of the Faculty of Science; Imperial College, Professor of Inorganic Chemistry (1932), Director of the Laboratories of Inorganic and Physical Chemistry (1938), and, finally, Emeritus Professor on his retirement (1954).

Such, briefly, was his academic career, and of the many subjects which engage

his attention he will perhaps be best remembered for his work on the "newer" elements and his even earlier work on the precise determinations of atomic weights.

He was ever mindful of practical applications of scientific knowledge and made contributions to studies of industrial dust hazards, anti-pest measures for stored foodstuffs, the chemistry of dairy products and the purity of water supplies.

His interest in paints and hence in our own Association was in parallel with his advisory work for the Walpamur Company from 1926 onwards, and with his close interest in the Research Association of British Paint, Colour and Varnish Manufacturers (from 1927) of which, after considerable Council service, he became the Chairman of the Technical Advisory Committee in 1945 and President in 1951. Many will remember his address at the 21st birthday celebrations at the Paint Research Station entitled "Following the Unexpected"; it was then that he made the memorable utterance about doing "d . . . silly experiments".

He was always interested in the welfare of young people and of those who taught them; the two came together in his investigations of the accuracy of the marking of examination papers. He gave much attention to the training of technicians in university service. He was Chairman of technician training committees at the

Imperial College and the University of London, and of a National Joint Committee on Recruitment and Training of Science Laboratory Technicians. He was for many years Treasurer of the Association of University Teachers, and his election in 1958 to the Fellowship of Imperial College (a rare honour) was in special recognition of his services to his college and to university education generally.

Many other chairmanships and committee memberships could be noted, but would serve only to emphasise the major trends of his diverse interests, already apparent. One activity however is perhaps especially significant in rounding off the story of this remarkable man, whose first occupation on graduation, additional to his laboratory work, was to assist with Thorpe's Dictionary. Just before his death he was actively engaged editorially in the preparation of supplementary volumes to Mellor's monumental "Comprehensive Treatise on Inorganic and Theoretical Chemistry".

Finally, it is proper we should return from his works to the man; to one who, in the words of *The Times* obituary notice, "loved contact with men of all varieties of experience and outlook, for he always argued that education is acquired mainly 'through the skin'".

We shall remember him.

S. H. B.

#### NEWS OF MEMBERS

Mr. H. Warson, an Ordinary Member attached to the Midlands Section, has been appointed Development Manager, Polymers, of Dunlop Chemical Products Division.

#### APPLICATIONS FOR ORDINARY MEMBERSHIP

At the Council meeting held on 15 February, 1955, the Council passed a resolution in accordance with Association Rule 5 (ii), reaffirming the standard of competence for the election of candidates to Ordinary Membership of the Association, and it is felt that members would like to be aware of this information when sponsoring candidates for election.

The Council's resolution reads as follows:

THAT the qualifications for the granting of Ordinary Membership shall be—

1. A degree in a scientific subject or any generally accepted equivalent qualification; or any 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 normally be not less than seven years.



#### BINDING OF THE ASSOCIATION'S 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 18s. 6d. per volume.

Members wishing to avail themselves of this facility should send the parts direct to Heffer & Sons Ltd., enclosing a remittance of 18s. 6d. and ensuring that notes bearing their names and addresses are enclosed with the parcels.

#### CHANGE OF ADDRESS

Since membership of the Association is on a personal basis, members are asked to note that, although the General Secretary's office may be notified of the change of address of companies, this does not mean that such changes are automatically noted on the record cards of members employed by those companies.

Where a member uses his company's address for communication purposes, it is necessary for him to inform the General Secretary's office of any change in the address and, at the same time, to quote his personal number, if possible.

#### THE F. W. CLARK MEMORIAL PRIZE

It has been announced that the 1960 F. W. Clark Memorial Medal and Prize has been awarded to Mr. D. P. Maple, a plastics chemist and a student of East Ham Technical College, London. Mr. G. Copping, now an Honorary Member of the Association, raised a sum of approximately £250 from friends in the Paint Industries Club to commemorate his colleague, Mr. F. W. Clark, who was killed during the war while on a technical mission to the United States. The fund was passed to the Association, who in turn passed it to the City & Guilds of London Institute to provide an Annual award.

#### A.P.T. 1962 MEETINGS

The first meeting of the Association of Printing Technologists, to which members of the Scientific and Technical Group of

the Royal Photographic Society are invited, will take place on 23 January and will consider two papers by Mr. F. Pollak (Kodak Ltd.). His subjects are "The Contrast of Moiré Patterns in Half-Tone Gravure" and "Split Filter Exposures in Colour Reproduction".

Operational research, what it is and what it can do for the industry, will be discussed by a panel of experts on 21 February. The last meeting will be addressed by R. C. McIntosh and H. V. Purdy (Pan World Press Ltd.) on "A New System of High-Speed Photocomposition".

The Sixth Conference will be held on 16 April and the programme details will be announced early in the New Year.

#### CENTENARY OF PLASTICS, 1862-1962

A Joint Committee of the Plastics Institute and the British Plastics Federation has been set up to organise a number of events in connection with a Centenary of Plastics, 1862-1962.

It has been decided to celebrate the centenary in 1962 because it was at the International Exhibition in London in 1862 that Alexander Parkes, patentee and exhibitor, of Birmingham, showed for the first time to the public *Parkesine*.

The programme of events to be organised by the Joint Committee includes the following:

- (a) A banquet in Guildhall in June.
- (b) The preparation of historical records on tape and possibly on film.
- (c) The publication of a book giving the story of plastics and containing a detailed history of celluloid.
- (d) Supplements in the national press on the history of plastics.
- (e) Specially designed stickers for letters and for office franking machines.
- (f) Contributions in the national and technical press and on radio and television.
- (g) Open days in firms in the plastics industry.
- (h) Special meetings and lectures throughout the centenary year culminating in Interplas 1963.

## SIXTH I.S.F. CONGRESS

As already announced in the July issue of the *Journal*, the Sixth I.S.F. Congress will take place from 9-13 April, 1962. The Congress will be formally opened by the Lord Fleck, President of the Society of Chemical Industry, at the plenary meeting on 10 April, when he and the President of the Congress, Dr. E. G. Woodroffe, will welcome delegates.

A programme of some sixty scientific papers has been arranged, copies of which may be obtained in advance by intending participants. Lectures will occupy two and a half days and will be held at the Imperial

College of Science and Technology, London, finishing on the morning of 12 April.

The Congress banquet will take place at the Hyde Park Hotel on 11 April. Visits have been arranged to research and industrial establishments in the London area for 12 April, while there will also be visits to both Oxford and Cambridge the following day. A separate social programme has been arranged for ladies accompanying the delegates. The preliminary programme of the Congress will be available soon and copies may be obtained from the Congress Secretariat, 14 Belgrave Square, London, S.W.1.

## Forthcoming Events

(Note: Details are given of meetings arranged in the U.K. up to the 15th of the month following publication, and in South Africa and the Commonwealth up to the 15th of the second month after publication.)

### Friday, 1 December

*Midlands Section.* Ladies' Evening at the George Hotel, Solihull. Reception 7 p.m. for 7.30 p.m.

*Newcastle Section Junior Group.* "Decorative Paints", by Dr. A. J. Seavell, in the Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, at 3 p.m.

### Monday, 4 December

*Bristol Section.* Annual Dance at the Arnos Court County Club, Bristol.

*Hull Section.* "The Alkali Fusion of Fatty Acids", by Professor Weedon. Joint meeting with Oil and Fats Group of the S.C.I. and Hull Section of the R.I.C., at the Royal Station Hotel, Hull, at 7.15 p.m.

### Wednesday, 6 December

*Victorian Section.* Annual Dinner, Melbourne University Union, Main Buffet. Guest speaker to be announced.

### Thursday, 7 December

Association Council Meeting at 11.30 a.m. at Wax Chandlers' Hall, Gresham Street, London, E.C.2.

*New South Wales Section.* Annual Dinner at the "Amory".

*London Section.* "Aircraft Paints", by A. Macmaster, M.Sc., A.R.I.C. (Ministry of Aviation), in the Lecture Theatre, Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1, at 7 p.m.

*Newcastle Section.* "Driers: Past, Present and Future", by C. T. Morley-Smith, at the Royal Turks Head Hotel, Newcastle upon Tyne, at 6.30 p.m.

*Bristol Section.* "Paint Progress—a Myth?"—Debate. Joint meeting with Birmingham Paint, Varnish and Lacquer Club, in Birmingham, at the Imperial Hotel, at 6.30 p.m.

### Friday, 8 December

*Manchester Section.* "Architectural Approach to Colour in Building", by A. E. Hurst, F.I.B.D., to be given at the Manchester Literary and Philosophical Society, 36 George Street, Manchester, at 6.30 p.m.

### Monday, 11 December

*London Section—Southern Branch.* "The Interaction of the Pigment with the Medium", by Dr. V. T. Crowl (Paint Research Station), at the Royal Beach Hotel, Southsea, Hants., at 7.30 p.m.

**Thursday, 14 December**

*Scottish Section.* "Wines Tasting and Testing", by H. F. Barnes, in the Grand Hotel, Charing Cross, Glasgow, at 7.30 p.m.

**Friday, 15 December**

*Bristol Section.* A paper by I. C. R. Bews, B.Sc., A.R.I.C. (Honorary Editor, *J.O.C.C.A.*), at the Royal Hotel, College Green, Bristol, 1, at 7.15 p.m.

**Saturday, 16 December**

*Scottish Section Student Group.* Film Show at More's Hotel, 18 India Street, Glasgow, C.2, at 10 a.m.

**Wednesday, 27 December**

*Western Australian Branch.* Dinner and Golf Day.

**Thursday, 4 January**

*Newcastle Section.* "Have Cationic Surfactants Any Use in the Manufacture of Paints?", by M. K. Schwitzer, at the Royal Turks Head Hotel, Newcastle upon Tyne, at 6.30 p.m.

**Saturday, 6 January**

*London Section—Junior Group.* Lecture by A. R. H. Tawn (preceded by a short Annual General Meeting) in the Memorial Hall, Farringdon Street, London, E.C.4, at 7 p.m.

**Monday, 8 January**

*London Section—Southern Branch.* A paper from I.C.I. Ltd. (Paints Division) on colour appreciation, at the Polygon Hotel, Southampton, at 7.30 p.m.

*Hull Section.* "Milling of Titanium Oxide Pigments in Various Paint Machinery", by H. D. Jefferies (British Titan Products Co. Ltd.), at the Royal Station Hotel, Hull, at 7.15 p.m.

**Tuesday, 9 January**

*West Riding Section.* "The Preservation of Timber", by Dr. Crook, at the Hotel Metropole, Leeds, at 7.30 p.m.

**Friday, 12 January**

*Newcastle Section—Junior Group.* Film Show in the Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, at 3 p.m.

*Manchester Section.* "Thermo-Setting Acrylics", by K. E. Piggot, B.Sc., A.Inst.P., at the Manchester Literary and Philosophical Society, 36 George Street, Manchester, at 6.30 p.m.

*Scottish Section.* Annual Dinner-Dance in Kintyre Suite, Central Hotel, Glasgow. 6.30 p.m. for 7 p.m.

**Monday, 5 February**

*Victorian Section.* Works Visit to Altona Petrochemical Co. Pty. Ltd., Steam Cracking Plant.

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(D) = Discussion  
(E) = Editorial and Comment  
(N) = Notes and News  
(R) = Reviews  
(S) = Section Proceedings  
(T) = Transactions and Communications

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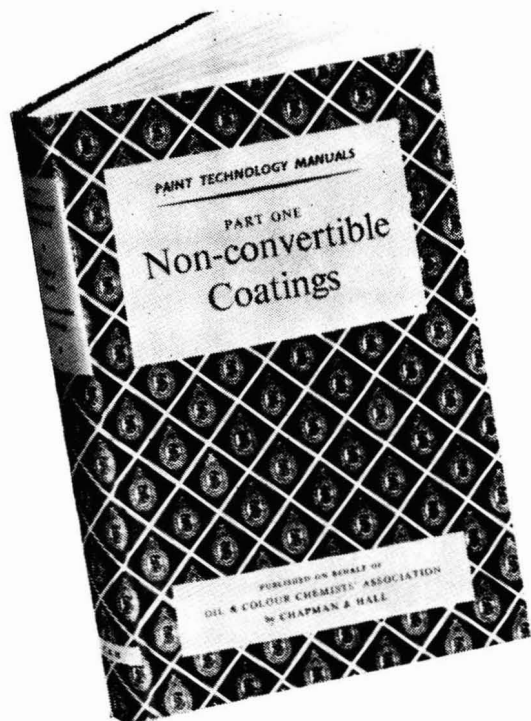
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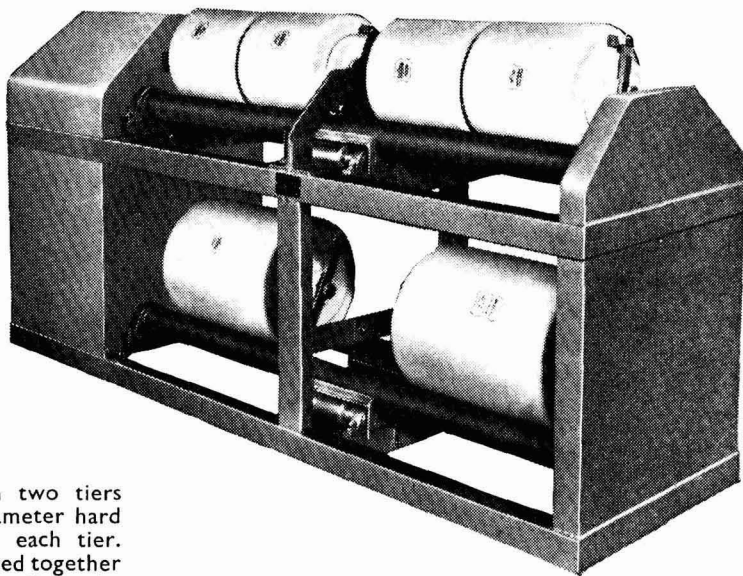
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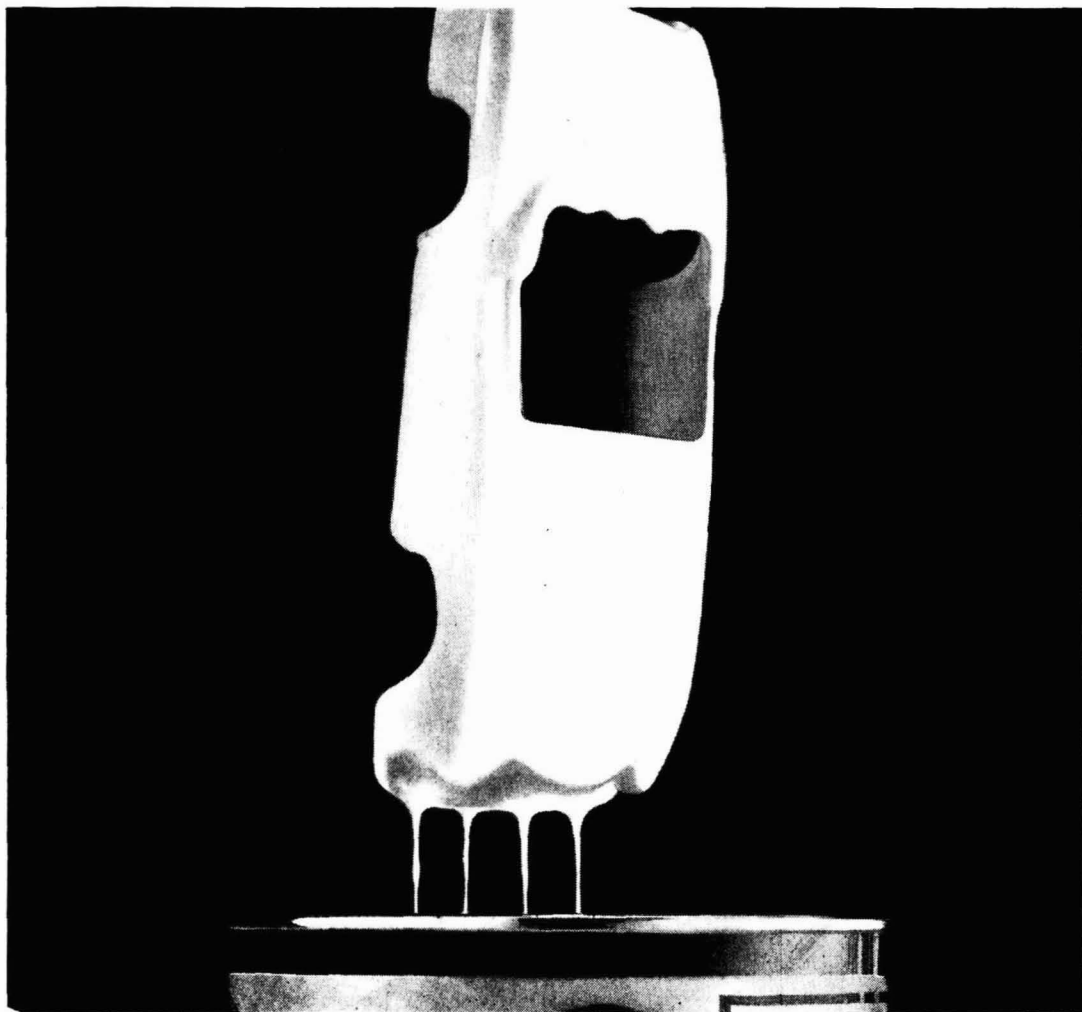
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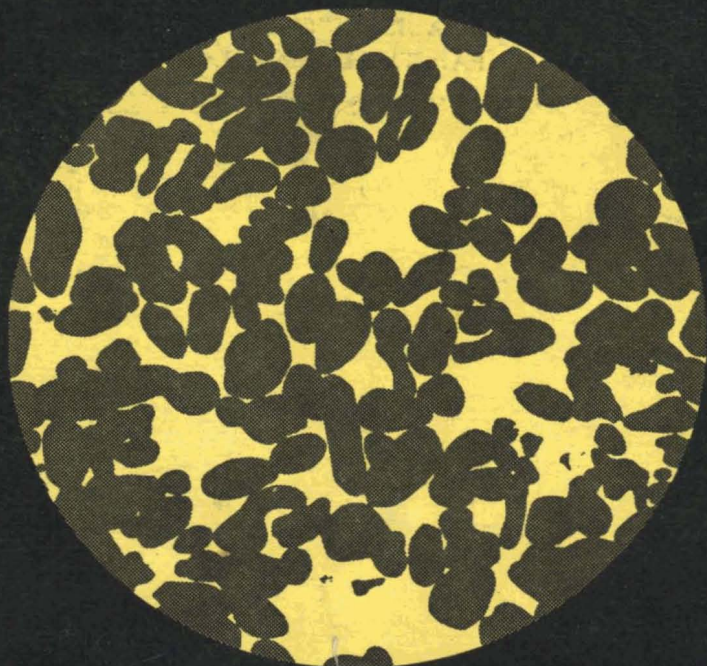
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