

JOURNAL OF THE OIL AND COLOUR CHEMISTS' ASSOCIATION



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Weathering of paint films: IV. Influence of the radiation intensity on chalking of latex paints

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The glycerolysis step in the production of oil-modified alkyd resins: Part V. Glycerolysis of castor oil and dehydrated castor oil

N. A. Ghanem, M. A. El-Azmirly and Z. H. Abd El-Latif

A mathematical review and comparison of ink transfer equations

M. Cropper

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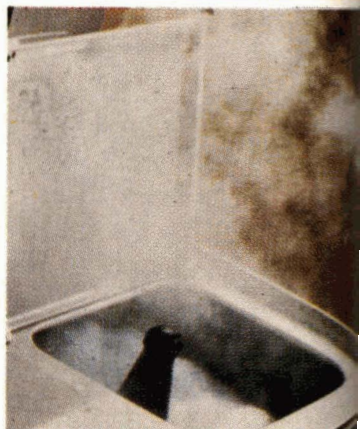
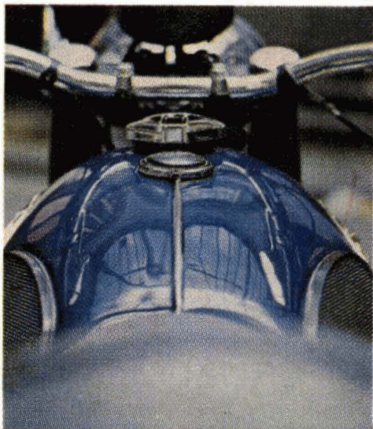
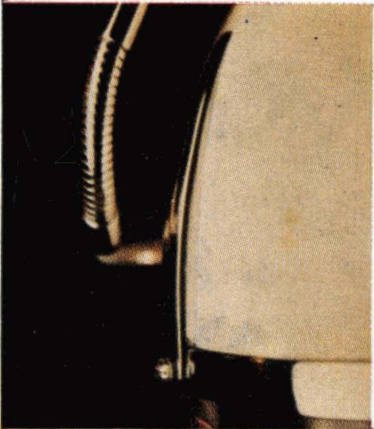
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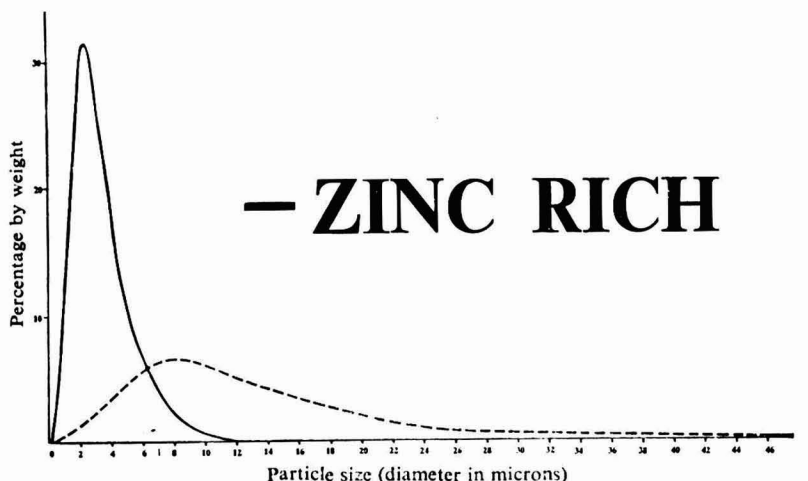


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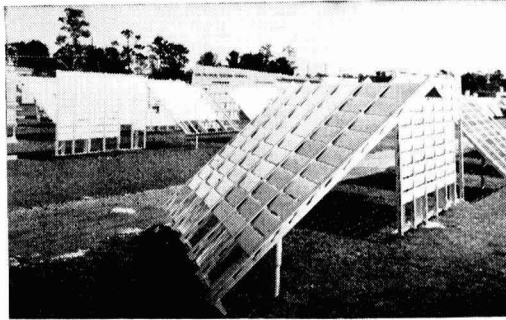
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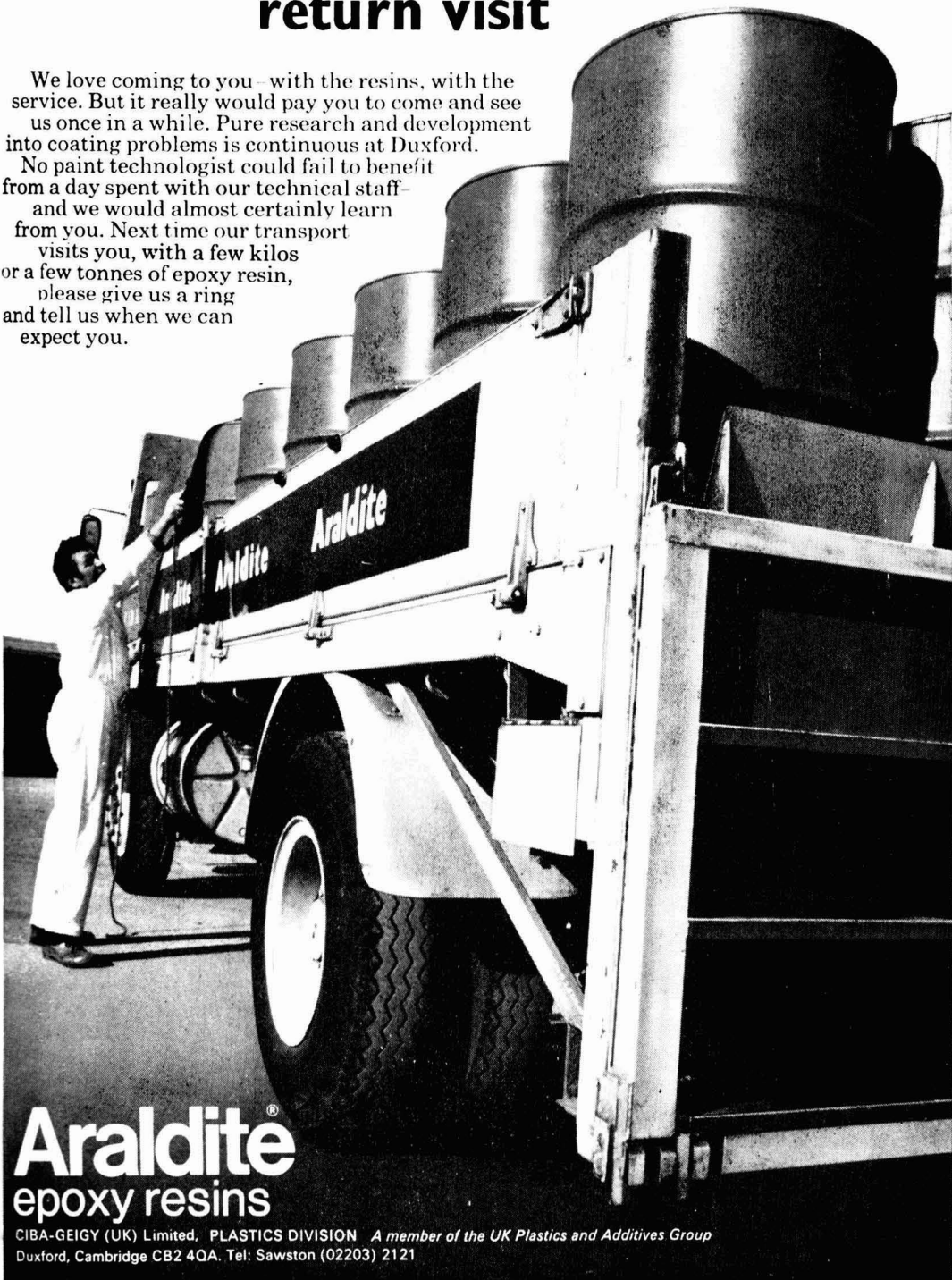
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INDEX TO ADVERTISERS

A	
Ashby, Morris, Ltd.	iii
B	
Banner, Samuel, & Co. Ltd.	xv
BIP Chemicals Ltd.	xii
C	
Cabot Corporation	i
CIBA-GEIGY (UK) Ltd. (Resins & Plastics)	vii
Cory, Horace, & Co. Ltd.	Cover
E	
Elsevier Sequoia SA	xvi
G	
Greaves, Joshua, & Sons Ltd.	xv
H	
Hardman, E., Son & Co. Ltd.	xiii
K	
Kunststoffsabrik Synthese NV	ii
M	
Metchim & Son Ltd.	vi
S	
SCC Colours Ltd.	v
Shell International Chemical Co. Ltd.	Cover
Sub-Tropical Testing Service Inc.	vi
Suter, A. F., & Co. Ltd.	xvii
T	
Tioxide International Ltd.	x
V	
Vinyl Products Ltd.	iv

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Vol. 55 No. 2 February 1972



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Contents **Vol. 55 No. 2** **February 1972**

Transactions and Communications

An investigation of some factors affecting the performance of primers for galvanised steel	91
<i>W. H. Newell</i>	
Weathering of paint films: IV. Influence of the radiation intensity on chalking of late paints	101
<i>E. Hoffmann and A. Saracz</i>	
The glycerolysis step in the production of oil-modified alkyd resins: Part V. Glycerolysis of castor oil and dehydrated castor oil	114
<i>N. A. Ghanem, M. A. El-Azmirly and Z. H. Abd El-Latif</i>	
A mathematical review and comparison of ink transfer equations	128
<i>M. Cropper</i>	
<i>Correspondence</i>	149
<i>Reviews</i>	150
<i>Student Review Paint Technology Manual Part Seven</i>	151
<i>Information Received</i>	166
<i>Section Proceedings</i>	170
<i>Notes and News</i>	179
<i>Register of Members</i>	185
<i>Forthcoming Events</i>	186

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Transactions and Communications

An investigation of some factors affecting the performance of primers for galvanised steel

By W. H. Newell

Spelthorne Metals Limited, Church Street, Rickmansworth, Herts., WD3 15Q

Summary

Paint systems applied to hot-dip galvanised steel have been studied to examine the effect of weathering of the zinc prior to paint application, type of binder, pigment composition and volume concentration. Adhesion has been assessed both by a cross-hatch test and torque-wrench measurement of the pull-off force. Little correlation appears to exist between the two methods of test, and doubt may be cast on the validity of the cross-hatch test for this type of system. Metallic lead is shown to bring about considerable improvement in adhesion.

Keywords

Types and classes of surface
galvanised steel

Types and classes of coating
primer

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

Process and methods primarily associated with analysis, measurement and testing
cross hatch adhesion test
torque wrench adhesion test

Une investigation de certains facteurs qui influent le rendement des primaires pour tôle galvanisée

Résumé

On a étudié des systèmes de peintures appliqués à tôle galvanisée par immersion dans le zinc fondu, afin d'apprécier les effets que produisent, le vieillissement du zinc avant l'application de la peinture, la nature du liant, la composition et la concentration par volume du pigment. On a apprécié l'adhérence par l'essai à égratinures croisées et par la mesure de la force de détachement effectuée au moyen d'un clé de torsion. Il paraît qu'il n'existe peu de corrélation entre les deux méthodes d'essai et on pourrait mettre en doute la validité de l'essai à égratinures croisées en ce qui concerne des systèmes de ce genre. On démontre que la présence de plomb sous forme métallique met en évidence une amélioration importante au point de vue de l'adhérence.

Eine Untersuchung der die Leistung von Primern für Verzinktes Eisenblech Beeinflussenden Faktoren

Zusammenfassung

Es wurden Anstrichsysteme auf durch Heisstauchen galvanisiertem Eisenblech untersucht, um die Wirkung von Bewitterung auf's Zink vor dem Anstrich, Art des Bindemittels, Pigmentzusammensetzung und Volumenkonzentration zu untersuchen. Zur Haftungsprüfung wurden sowohl der Kreuz- und Querschnittstest, als auch Torsionsspanner—Messungen der zum Abziehen nötigen Kraft benutzt. Zwischen beiden Prüfmethoden scheint wenig Korrelation zu bestehen, und der Wert des Kreuz- und Querschnittstests für ein System dieser Art darf bezweifelt werden. Es wird aufgezeigt, dass Gegenwart von metallischem Blei die Haftung wesentlich verbessert.

Исследование некоторых факторов влияющих на рабочие характеристики грунтовок для оцинкованной стали

Резюме

Изучались красочные системы прилагаемые к оцинкованной стали горячего погружения, для определения влияния выветривания цинка до применения грунтовки, типа связующего вещества, состава пигмента и объемной концентрации. Адгезия определялась путем испытания решетчатым надрезом и измерением крутильного срыва оттяжной силы. Наблюдается лишь мало корреляции между этими двумя методами испытания и есть основания сомневаться в надежности испытания решетчатым надрезом для такой системы. Найдено что металлическая медь значительно улучшает качества сцепления.

Introduction

The problem of securing satisfactory adhesion of organic protective coatings to metallic zinc has been recognised for many years, and considerable effort expended in obtaining satisfactory performance of such systems. Chemical conversion processes now available show remarkable upgrading of durability and adhesion. These systems, however, are applicable specifically to factory processing, primarily on a continuous basis. They have contributed much less to the problem of *in situ* protection of zinc-coated steel, and in particular of hot-dip galvanised structural and other elements.

The earliest recommendations for site painting of galvanised steel involved the use of mordant solutions, generally based on acid/metal salt combinations; the value of these, however, is now largely discounted. Various primers formulated specifically for use on zinc have been put forward over the years, but no one type has, so far, gained general acceptance as giving reliable performance under all circumstances.

This may be due in great part to inability to lay down with any certainty the effect of variation in application conditions in the widest sense. There is, however, a history over many years of wide-spread use of metallic lead primers on zinc surfaces, in general with extremely satisfactory results. The present investigation is intended to delineate more accurately the effect on performance of variations in both primer composition and application conditions. It is thus hoped to establish a procedure by which the protective value of a coating system on zinc may be upgraded, and greater certainty of the results ensured.

Experimental

Series I

Part I: A number of primers based on various media, all containing approximately 40 per cent metallic lead (by weight of the total pigment) were applied to panels six days after galvanising. Exposure was made at Dagenham, commencing December 1968, and adhesion examined subsequently by cross-hatch adhesion test, in triplicate where feasible. Results were assessed visually on a scale of 10 (perfect adhesion) to zero (complete loss of adhesion). The adhesion after 2½ years' exposure was also measured by means of a torque wrench test. Results are shown in Table 1, and the primer types used, together with their reference numbers, are given in the appendix.

Table 1
Results of exposure tests, series 1, part 1

Primer	System	Exposure period											
		3 months			6 months			2½ years					
		Cross-hatch	Torque (lb in)		Cross-hatch	Torque (lb in)		Cross-hatch	Torque (lb in)				
"KM"	1 P	10	10	10	9	9	9	9	9	9	51	50	64
	2 P	10	9	8	8	9	9	9	9	9	83	47	47
	1 P + 1 F	9	9	9	9	0	0	0	0	0	47	48	49
"KB"	1 P	10	4	0	0	6	3	7	7	7	10	55	58
	2 P	10	10	10	8	0	0	0	0	0	56	35	38
	1 P + 1 F	10	9	10	9	0	0	0	0	0	68	55	89
"KS"	1 P	9	0	0	0	10	10	10	10	10	61	54	42
	2 P	9	9	10	9	0	0	0	0	0	30	75	70
	1 P + 1 F	2	5	5	6	0	0	0	0	0	51	48	55
"105"	1 P	7	0	0	0	6	5	10	10	10	70	75	70
	2 P	9	2	9	9	0	0	0	0	0	114	88	90
	1 P + 1 F	3	2	2	2	0	0	0	0	0	66	42	35
"240"	1 P	9	8	0	3	9	9	9	9	9	121	118	97
	2 P	6	9	9	8	0	0	0	0	0	85	81	64
	1 P + 1 F	7	9	2	9	4	9	1	1	1	87	103	55
"95"	1 P	10	7	4	4	5	10	10	10	10	79	104	102
	2 P	9	0	9	10	0	0	0	0	0	120	112	101
	1 P + 1 F	9	9	7	9	7	5	5	5	5	45	88	120
"275"	1 P	9	8	3	5	10	0	10	10	10	82	82	95
	2 P	8	9	8	8	0	0	0	0	0	112	114	86
	1 P + 1 F	8	7	7	5	0	0	0	0	0	98	102	106
"149"	1 P	9	4	9	8	5	9	9	9	9	59	75	95
	2 P	10	10	10	10	10	10	9	9	9	88	95	68
	1 P + 1 F	9	9	9	9	10	9	10	10	10	44	88	100
"76"	1 P	7	7	9	9	10	10	10	10	10	69	52	40
	2 P	0	0	0	0	0	0	0	0	0	49	27	51
	1 P + 1 F	5	0	2	6	10	7	10	10	10	85	84	84

P = Primer. F = Finish (alkyd gloss) 1 P = 1 coat of primer. 2 P = 2 coats of primer. 1 P + 1 F = 1 coat of primer + 1 coat of finish (alkyd gloss).

The following table shows average figures for each material, system, and period of test.

If the cross-hatch figures in Table 2 are used as a basis for assessment, it appears that, for both the two-coat systems 2 P and 1 P + 1 F, adhesion gradually falls over the period under consideration. The one-coat tests, however, indicate that, after an initial substantial loss of adhesion, a significant improvement occurs. This may possibly be attributed to continued leaching removing water-solubles from the interface.

Table 2
Average values from Table 1

Primer	System	3 months	6 months	2½ years	2½ years
		Cross-hatch	Cross-hatch	Cross-hatch	Torque (lb in)
	1 P	9.0	4.5	8.1	72
	2 P	8.0	7.4	2.0	75
	1 P + 1 F	7.0	6.5	3.2	72
"KM" ..	—	9.7	9.0	6.0	54
"KB" ..	—	10.0	6.7	1.8	52
"KS" 1 ..	—	6.7	5.0	3.3	54
"105" ..	—	6.3	3.0	2.3	73
"240" ..	—	7.3	6.3	4.7	90
"95" ..	—	9.3	7.3	4.7	97
"275" ..	—	8.3	6.7	2.2	95
"149" ..	—	9.3	8.7	9.0	79
"76" ..	—	4.0	3.7	6.3	60

If, however, the results of torque adhesion force measurements are considered, there is considerable doubt as to the validity of the cross-hatch test. For example, a cross-hatch test may show complete film detachment, rating zero, whilst torque adhesion force figures on the same system may be high. This is exemplified in Table 1 by the "275" figures at 2½ years, where the adhesion forces measured are extremely high, but once rupture by cross-hatch has occurred, film removal is complete. Another possible source of error is the occurrence of "worse than zero" adhesion, i.e. removal of the film not only at the cross hatch, but beyond the damaged area.

Statistical examination of the results shows practically no correlation between the two methods of assessment, either absolutely or for order of merit.

Part 2: A similar series of tests commenced in February 1969 covering not only metallic lead, but also other types of primer. The results obtained are shown in Table 3.

This second series would appear to confirm the time effect of a decrease in adhesion, followed by an increase, in the case of single-coated systems. Although, in this instance, there would appear at first sight to be rather better correlation between the cross-hatch figures and the adhesion force, the significance of this is not high, because of the rather limited number of tests, and a proportionately somewhat larger experimental error.

Table 3
Results of exposure tests, series 1, part 2

Primer	System	Exposure period									
		1 month	4 months			2 years		2 years			
		Cross-hatch	Cross-hatch			Cross-hatch		Torque (lb in)			
Ca plumbate	1 P	10	10	10	10	10	10	91	74	70	
	2 P	8	7	4	9	10	10	10	77	76	72
	1 P + 1 F	8	3	3	3	3	2	8	58	54	63
Red lead ..	1 P	3	8	3	3	9	9	9	51	50	42
	2 P	3	2	2	3	7	8	9	50	43	34
	1 P + 1 F	2	0	0	0	0	0	0	39	45	20
"K" ..	1 P	10	7	5	5	10	10	10	57	69	42
	2 P	10	5	7	0	6	8	7	61	46	61
	1 P + 1 F	10	10	9	9	2	1	9	41	42	49
"95" ..	1 P	9	9	8	9	8	8	9	62	60	57
	2 P	10	10	10	10	8	7	8	54	57	35
	1 P + 1 F	8	9	9	9	10	9	10	88	71	58
"263" ..	1 P	8	10	10	10	10	10	10	60	42	38
	2 P	9	6	9	9	4	8	9	65	72	59
	1 P + 1 F	9	7	8	9	9	8	9	77	77	60

The average values are summarised in Table 4.

Table 4
Average values from Table 3

Primer	System	1 month	4 months	2 years	2 years
		Cross-hatch	Cross-hatch	Cross-hatch	Torque (lb in)
Ca plum- bate ..	1 P	8.0	7.8	9.5	58
	2 P	8.0	6.2	7.4	57
	1 P + 1 F	7.4	5.9	5.3	56
Red lead ..	—	8.7	6.6	8.1	70
"K" ..	—	2.7	2.3	5.7	42
"K" ..	—	10.0	6.3	7.0	52
"95" ..	—	9.0	9.2	7.7	60
"263" ..	—	8.7	8.7	8.5	61

Series 2

Further investigation of the problems of adhesion on galvanised steel was directed towards an examination of the following factors:

- metallic lead content,
- pigment volume concentration,
- type of medium,
- condition of the surface at the time of first priming.

These factors were varied as follows:

- metallic lead content 10 per cent, 20 per cent, 40 per cent by weight of the total pigment,
- PVC 35 per cent, 40 per cent, 45 per cent,
- media, long oil alkyd (LOA), linseed oil blend (oil), vinyl/toluene alkyd (VTA),
- galvanised panels as received (six days old); after one month's weathering; after three months' weathering.

Tables 6, 7, 8 show in detail the results obtained in cross-hatch tests after various periods of exposure at Dagenham, and also torque wrench adhesion values after the longest period of exposure. The average values are summarised in Table 5.

Table 5
Average values from Tables 6, 7 and 8

<i>Six days after galvanising</i>								
	Cross-hatch	Torque (lb in)		Cross-hatch	Torque (lb in)	Cross-hatch	Torque (lb in)	
10% Pb	0.1	44	35% PVC	5.9	47	LOA	5.2	56
20% Pb	4.6	52	40% PVC	4.2	54	Oil	5.5	47
40% Pb	8.4	57	45% PVC	3.2	51	VTA	2.6	62
						Ca plumbate	1.6	23
<i>Primed after one month's exposure</i>								
10% Pb	1.0	30	35% PVC	2.2	38	LOA	4.3	38
20% Pb	4.8	42	40% PVC	4.0	43	OIL	4.1	32
40% Pb	5.1	50	45% PVC	4.7	43	VTA	2.5	53
						Ca plumbate	0.5	52
<i>Primed after three months' exposure</i>								
10% Pb	1.0	35	35% PVC	3.8	46	LOA	3.2	46
20% Pb	3.3	44	40% PVC	3.9	46	Oil	3.0	36
40% Pb	6.4	58	45% PVC	3.0	44	VTA	4.5	54
						Ca plumbate	1.0	41

Table 6

Adhesion values obtained with no pre-weathering

	10% Pb			20% Pb			40% Pb											
	Cross-hatch	Torque (lb in)		Cross-hatch	Torque (lb in)		Cross-hatch	Torque (lb in)										
<i>Long oil alkyd</i>																		
35% PVC	1 month	0	0	0	0	1	1	10	9	2								
	2 month	0	0	0	0	1	2	9	8	9								
	4 month	0	0	0	35	35	37	0	0	0	42	48	43	5	5	3	46	64
40% PVC	1 "	0	0	0	3	2	0	9	1	2								
	2 "	0	0	0	10	0	1	2	2	2								
	4 "	0	0	0	40	50	42	0	1	1	72	65	68	0	1	1	75	75
45% PVC	1 "	0	1	1	6	8	1	1	0	3								
	2 "	0	0	1	3	2	1	4	0	4								
	4 "	0	0	0	52	62	57	0	0	0	62	78	63	0	0	2	28	63
<i>Oil</i>																		
35% PVC	1 "	0	0	0	6	7	3	8	9	7								
	2 "	0	0	0	0	0	3	5	3	1								
	4 "	0	0	0	20	25	27	0	0	0	30	32	30	0	0	0	45	40
40% PVC	1 "	0	0	0	8	8	9	7	4	7								
	2 "	0	0	0	0	0	4	0	1	5								
	4 "	0	0	0	25	23	25	0	0	0	30	27	42	0	0	4	36	39
45% PVC	1 "	0	0	0	2	2	1	8	7	9								
	2 "	0	0	0	1	0	1	1	2	1								
	4 "	0	0	0	25	26	23	0	0	0	33	31	31	2	1	1	49	52
<i>VT alkyd</i>																		
35% PVC	1 "	0	0	2	0	0	0	10	8	2								
	2 "	0	0	1	0	0	0	8	3	5								
	4 "	0	0	0	57	54	57	0	0	0	82	76	50	1	1	0	36	54
40% PVC	1 "	0	0	0	5	7	5	0	0	1								
	2 "	0	0	0	0	0	0	0	0	1								
	4 "	0	0	0	56	57	58	0	0	0	82	66	67	0	0	0	67	84
45% PVC	1 "	1	0	0	2	3	4	0	0	1								
	2 "	1	0	0	0	0	0	0	0	0								
	4 "	0	0	0	82	82	45	0	0	0	42	60	46	0	0	0	58	55
<i>Ca plumbate</i>																		
	1 "	5	5	4	—	—	—	—	—	—								
	2 "	0	0	0	—	—	—	—	—	—								
	4 "	0	0	0	27	22	20	—	—	—								

Table 7

Adhesion values obtained with one month's pre-weathering

	10% Pb		20% Pb		40% Pb	
	Cross-hatch	Torque (lb in)	Cross-hatch	Torque (lb in)	Cross-hatch	Torque (lb in)
<i>Long oil alkyd</i>						
35% PVC 1 month	0 0 0		0 2 2		9 2 0	
2 "	0 0 0	15 10 15	0 0 0	27 20 35	0 1 0	50 56 55
40% PVC 1 "	2 0 0		8 4 7		6 5 8	
2 "	0 0 0	27 28 32	0 0 0	47 40 54	0 0 0	45 42 46
45% PVC 1 "	6 1 0		8 6 7		9 10 10	
2 "	0 0 0	23 40 49	0 0 0	50 54 40	1 1 0	43 37 52
<i>Oil</i>						
35% PVC 1 "	1 3 1		9 8 4		2 2 2	
2 "	0 0 0	15 25 18	0 0 0	30 25 20	0 0 0	48 46 45
40% PVC 1 "	0 0 0		6 5 8		8 5 4	
2 "	0 0 0	22 20 10	0 0 0	35 33 35	0 5 1	38 52 48
45% PVC 1 "	0 0 1		7 8 7		6 4 5	
2 "	0 0 0	24 27 20	0 0 0	36 30 32	0 5 1	38 52 48
<i>VT alkyd</i>						
35% PVC 1 "	0 0 0		2 3 0		3 2 2	
2 "	0 0 0	68 38 38	0 0 0	62 58 57	0 0 0	31 74 40
40% PVC 1 "	4 4 2		3 0 0		0 0 8	
2 "	0 0 0	56 48 43	2 8 0	71 68 35	0 0 0	62 70 50
45% PVC 1 "	0 0 1		0 2 4		2 3 3	
2 "	0 0 0	33 36 34	0 0 0	60 72 40	6 2 1	80 80 20
<i>Ca plumbate</i>						
1 "	0 1 2	—	—	—	—	—
2 "	0 0 0	58 42 57	—	—	—	—

Conclusions

The effect of the variation of the metallic lead content is marked. For future work, it is proposed that 40 per cent be adopted as a minimum standard; this level corresponds to that established over years of commercial usage on steel.

The effect of variation in PVC is barely significant over the period of exposure. Taking into account not only the present results, but also other factors involved, such as flow, drying time, hold-out, etc., a level of 35/40 per cent PVC would appear to be a satisfactory compromise.

Table 8
Adhesion values obtained with three months' pre-weathering

	10% Pb			20% Pb			40% Pb		
	Cross-hatch	Torque (lb in)		Cross-hatch	Torque (lb in)		Cross-hatch	Torque (lb in)	
<i>Long oil alkyd</i>									
35% PVC 1 month	0 0 0	10 10 10	6 2 0	40 55 45	10 10 9	90 75 60			
40% PVC 1 "	0 0 0	48 45 47	1 0 0	58 25 15	7 8 5	63 63 55			
45% PVC 1 "	0 0 0	50 52 45	2 1 0	27 38 62	9 8 8	58 50 47			
<i>Oil</i>									
35% PVC 1 "	0 0 0	22 32 25	0 0 0	35 30 37	10 8 8	45 45 45			
40% PVC 1 "	0 1 0	35 32 30	2 2 5	38 31 35	9 9 8	45 46 46			
45% PVC 1 "	1 0 0	22 22 25	8 2 8	48 40 35	1 0 0	43 50 45			
<i>VT alkyd</i>									
35% PVC 1 ,	2 0 0	30 43 23	9 6 2	73 67 48	10 9 2	85 82 84			
40% PVC 1 "	6 8 0	78 35 32	5 2 3	52 55 67	6 8 10	63 55 50			
45% PVC 1 "	2 1 8	57 50 30	9 8 6	54 70 15	0 0 0	55 55 55			
<i>Ca plumbate</i>									
1 "	2 1 0	39 41 44	—	—	—	—			

Conclusions regarding the relative performance of the three media can only be drawn relative to the condition of the zinc surface at the time of painting. In this respect the VT alkyd appears very much less affected than the long oil alkyd or the oil blend, both of which appear to be adversely affected by reaction with soluble salts presumably present on the zinc after weathering. Any deductions as to the relative merits of the media after long-term exposure must await examination after as long a further period as may be feasible.

Discussion

During this work, a number of factors have emerged whose discussion is not entirely pointless at this stage.

In the first instance, there are apparently no absolute laboratory criteria as to the standard of performance which may be regarded as satisfactory for a galvanised steel/paint system. The cross-hatch test appears to be insufficiently discriminatory for this purpose, as it tends to be of a pass or fail nature. It is notable that, of 198 cross-hatch tests carried out in the above programme, 83 were ranked 10 or 9 and 52 at zero; it is apparent that no reliable grading of performance is achieved. On the other hand, 81 torque adhesion tests were spread over a range of 0-130lb in with a fair approximation to a normal distribution. It still remains difficult, however, to establish any specific level of adhesion for acceptance tests.

It may be noted that virtually all tests in this programme, when subject to re-exposure after mechanical damage (by cross-hatching), showed little or no signs of further spread of adhesion loss. This would appear to suggest that cross-hatching tends to induce loss of adhesion rather than to assess the actual adhesion forces. It should also be noted that certain panels graded as complete failures showed detachment at the cross-hatch only, whereas others showed considerable stripping from the adjacent areas. These latter tests were, in general, those which showed low torque adhesion values.

All these phenomena must be considered as establishing a complete lack of correlation between cross-hatch performance and adhesion force measurements as given by the torque wrench tests. It would seem clear that to establish a satisfactory, even if arbitrary, standard of adhesion, this incompatibility must be resolved.

The effects demonstrated for the time factor also require further elucidation. The results obtained would indicate that the adhesion of any specific paint system can suffer a drop consequent upon short-term weathering of the zinc surface, but can subsequently regain or even surpass its original level if the pre-weathering be sufficiently extended. This would appear to contradict the generally held view that performance is worst on an unweathered surface and improved by exposure of the bare metal, albeit without reference to any specific time or condition of exposure.

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Appendix

Composition of paints tested

	<i>PVC</i>	<i>Extender</i>	<i>Medium</i>
"KM"	30%	Asbestine/mica/barytes	Boiled oil/stand oil
"KB"	30%	Barytes/asbestine	Boiled oil/stand oil
"KS"	35%	Barytes/asbestine/mica	Boiled oil/stand oil
"105"	40%	Barytes/asbestine/mica	Reduced phenolic/linseed 1:2
"240"	44%	Barytes/asbestine	65% Linseed/penta alkyd
"95"	40%	Barytes/asbestine/mica	68% Linseed/penta alkyd
"275"	45%	Barytes/asbestine	VT alkyd
"149"	45%	Barytes/asbestine/mica	75% Soya/penta alkyd
"76"	40%	Barytes/talc	Chlorinated rubber
"16"	30%	Barytes/asbestine/basic Pb sulphate	Boiled oil/stand oil
"263"	45%	Barytes/asbestine	VT epoxy ester
Ca plumbate	—	Commercial product, specifically for galvanised steel	
Red lead	—	To BS 2523 Type B	

Weathering of paint films: IV. Influence of the radiation intensity on chalking of latex paints

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Summary

Chalking of paint films has been carried out at different levels of the intensity of radiation. Paints formulated with four different latex resins and pigmented with either zinc oxide or anatase titanium dioxide have been investigated. The degree of chalking, measured by the quantity of pigment set free, has not been found proportional to the intensity. Therefore, it is not advisable to accelerate weathering tests on paint films by increasing the radiation intensity above that which would be found under natural conditions.

Keywords

Binders, resins, etc.
emulsion resin

Prime pigments and dyes
anatase titanium dioxide
zinc oxide

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

*Processes and methods
primarily associated with:*
accelerated weathering

*Equipment primarily
associated with:*
analysis measurement and testing
xenon arc weatherometer

Le vieillissement des feuil de peintures

IV^{ème}. Partie: L'influence qu'exerce l'intensité de radiation sur le farinage des peintures-émulsions

Résumé

On a provoqué le farinage des feuil de peintures aux différents niveaux de l'intensité de radiation. On a examiné des peintures basées respectivement sur quatre latices et pigmentées avec de l'oxyde de zinc ou du dioxyde de titane du type anatase. Le degré de farinage, dosé par la masse de pigment dégagé, ne se démontrait pas proportionnelle à l'intensité. Ainsi on ne conseille pas de faire accélérer les essais de vieillissement sur les feuil de peintures en augmentant l'intensité de radiation au delà du niveau que l'on trouverait au naturel.

Bewitterung von Lackfilmen IV.

Einfluss der Bestrahlungsintensität auf Abkreiden von Latexfarben

Zusammenfassung

Abkreidungsversuche an Farbfilmen wurden mit verschiedenen starken Bestrahlungsintensitäten durchgeführt. Dabei wurden Farben, welche vier verschiedene Latexharze enthielten und entweder mit Zinkoxid oder anatas Titandioxid pigmentiert worden waren, untersucht. Es wurde nicht festgestellt, dass das Ausmass des Abkreidens, gemessen je nach Quantität freigesetzten Pigments, der Intensität proportional war. Es ist daher unratsam Bewitterungsprüfungen von Anstrichfilmen durch Erhöhung der Bestrahlungsintensität über die unter natürlichen Bedingungen vorkommende hinaus zu beschleunigen.

Выветривание красочных пленок Влияние интенсивности излучения на известкование латексоподобных красок

Резюме

Проводилось известкование красочных пленок на различных уровнях интенсивности излучения. Анализировались краски формулированные на четырех различных латексных смолах и пигментированные окисью цинка или анатазом двуокиси титана. Найдено что степень известкования, измеренная по количеству освобожденного пигмента, не пропорциональна интенсивности. Поэтому не советуется ускорять испытания на выветривание красочных пленок, путем увеличения интенсивности излучения выше интенсивности наблюдаемой в натуральных условиях.

Introduction

It has been pointed out^{1, 2, 3} that, for the development of an accelerated test method, it is necessary to know a great deal about the mechanism of the changes which take place, or at least to know which variables influence these changes and the degree to which they do so.

The weathering of paint films will presumably be influenced by humidity^{1, 2}, wavelength of radiation³, temperature of the paint film³, and the intensity of radiation. This paper deals with the influence of the latter.

Materials

Pigments

Anatase titanium dioxide and a zinc oxide made by the indirect process.

Resins

1. Vinyl acetate/acrylate copolymer (15 per cent acrylate)
2. Vinyl acetate polymer plasticised with dibutyl phthalate
3. Pure acrylate copolymer
4. Vinyl acetate/fumarate copolymer (18 per cent fumarate)

Determination of chalking

The procedure used in this investigation was as follows. Weighed stainless steel panels 62.5×75.0 mm (2.5×3 in) were painted and dried to constant weight at 38°C . After exposure the panels were kept at 38°C for 24h and then reweighed before and after removing the chalk with a dry cloth.

Procedure

Experiments were carried out in the xenon arc weatherometer at 65-70 per cent relative humidity and an air temperature of 40°C . In order to change the intensity of the radiation falling on the paint film, the painted panels, which are usually placed parallel to the wall of the rotating drum, were inclined to it. The total intensity at each position was measured with a Kipp-Zonen pyranometer, and by making additional measurements with suitable light filters it could be established that the energy distribution remained unchanged. The type of filters used and the energy distribution of the light from the xenon arc has been given in a previous paper³.

Discussion

The effect of the radiation was judged by the quantity of pigment set free, and this was determined by weighing the sample before and after removal of the chalk. In a previous paper³ reasons were given for the assumption that no chalk is lost by falling off the panels. Analysis of the chalk for carbon showed that it consists almost entirely of pigment. From the quantity of carbon the amount of resin still present can be calculated³, and the values are given in Table 1. Of the eight samples analysed only two contained more than 5 per cent

Table 1
Residual resin in chalk (PVC 40 per cent)

Resin	Pigment	Carbon content of chalk (%)	Residual resin in chalk (%)
Vinyl acetate/acrylate copolymer	Anatase titanium dioxide	2.31	9.4
Vinyl acetate polymer	do.	2.09	8.5
Acrylate copolymer ..	do.	0.76	3.1
Vinyl acetate/fumarate copolymer	do.	0.72	2.9
Vinyl acetate/acrylate copolymer	Zinc oxide	0.24	1.4
Vinyl acetate polymer	do.	0.32	1.9
Acrylate copolymer ..	do.	0.8	4.6
Vinyl acetate/fumarate copolymer	do.	0.38	2.2

resin still combined with the chalk (9.4 and 8.5 per cent respectively); the rest were well below this value*.

The intensity of the radiation falling on the panels was in the proportion 4.3: 1 in the case of paints pigmented with anatase titanium dioxide and 3.1: 1 for those formulated with zinc oxide. With the exception of the first paint system, in which the quantity of totally decomposed resins was approximately proportional to the two energy levels, there was a considerable deviation from proportionality, as can be seen from Table 2.

*From the amount of pigment set free (chalk) the quantity of resin previously combined with it was evaluated. Where the chalk contains no carbon, this value represents the totally decomposed resin. In this paper the expression chalk and total decomposition are used interchangeably as the results can be expressed validly in both ways.

Table 2
Weight ratio of totally decomposed resin at various times of exposure* at two energy levels

Anatase titanium dioxide pigment†				Zinc oxide pigment‡							
Vinyl acetate/acrylate copolymer		Vinyl acetate polymer		Acrylate copolymer		Vinyl acetate/fumarate copolymer		Vinyl acetate/acrylate copolymer		Vinyl acetate polymer	
Exposure (h)	Ratio of weights	Exposure (h)	Ratio of weights	Exposure (h)	Ratio of weights	Exposure (h)	Ratio of weights	Exposure (h)	Ratio of weights	Exposure (h)	Ratio of weights
416	5 : 1	163	9 : 1	163	2 : 1	163	3.5 : 1	115	1.7 : 1	115	2.3 : 1
728	3.8 : 1	461	2.1 : 1	461	1.8 : 1	461	2.2 : 1	266	2.4 : 1	266	3.2 : 1
1,432	3.6 : 1	785	2.8 : 1	728	2.2 : 1	728	2.8 : 1	411	3 : 1	411	5.7 : 1
1,679	4 : 1	1,109	2.6 : 1	1,109	2.1 : 1	1,109	2.4 : 1	529	3.3 : 1	675	4.3 : 1
1,951	3.9 : 1	1,431	2.6 : 1	1,432	2.5 : 1	1,432	2.8 : 1	675	2.8 : 1	837	3.8 : 1
2,284	3.8 : 1	1,679	2.7 : 1	1,629	2.4 : 1	1,629	3.2 : 1	837	2.3 : 1	1,002	2.8 : 1
2,612	3.9 : 1	—	—	1,951	2.1 : 1	1,951	3.2 : 1	1,002	2.2 : 1	1,143	3.4 : 1
2,907	4.3 : 1	—	—	2,284	2.1 : 1	2,184	2.7 : 1	1,143	2 : 1	1,293	2.5 : 1
—	—	—	—	2,612	1.9 : 1	2,612	2.9 : 1	1,294	1.8 : 1	1,454	2.3 : 1
—	—	—	—	2,907	1.8 : 1	2,907	2.2 : 1	—	—	—	—
Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5	Fig. 6						

*Weatherometer exposure: air temperature 40°C; relative humidity 65-70%; PVC 40%.

†Energy levels 4.3 : 1.

‡Energy levels 3.1 : 1

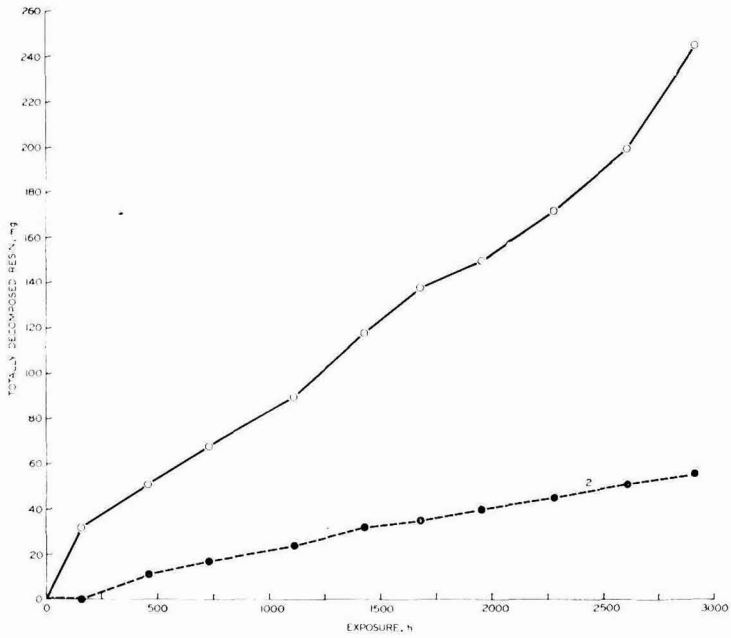


Fig. 1. Amount of totally decomposed resin in relation to time of exposure

Resin: Vinyl acetate/acrylate copolymer

Pigment: Anatase titanium dioxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

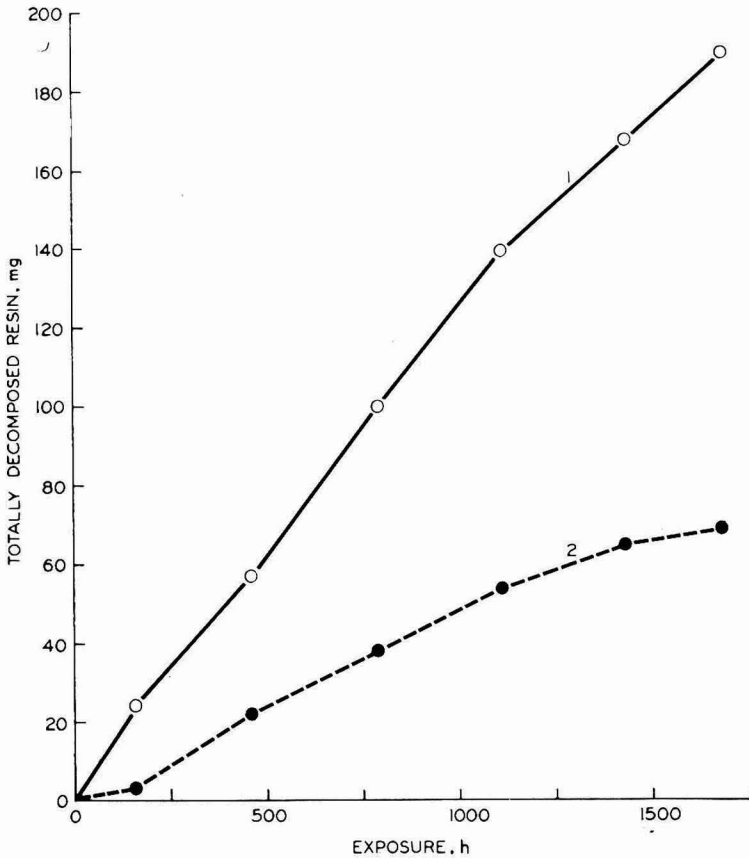


Fig. 2. Amount of totally decomposed resin in relation to time of exposure

Resin: Vinyl acetate polymer

Pigment: Anatase titanium dioxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

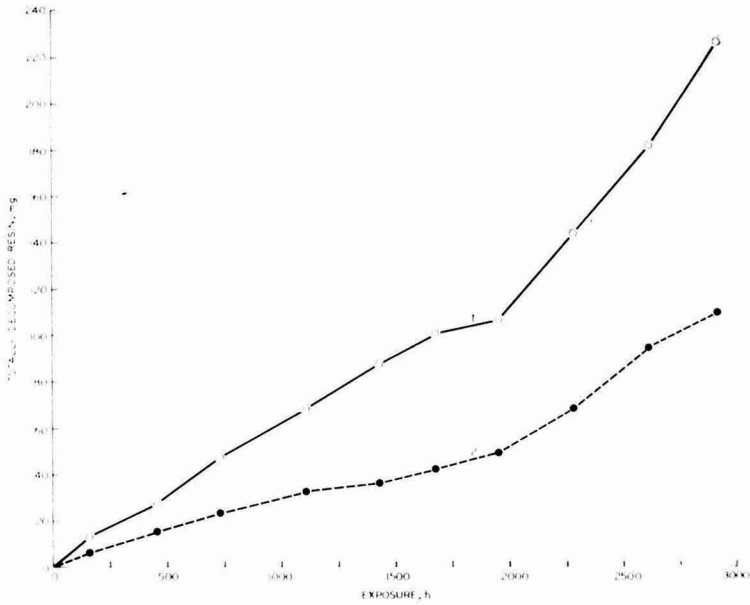


Fig. 3. Amount of totally decomposed resin in relation to time of exposure

Resin: Acrylate copolymer

Pigment: Anatase titanium dioxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

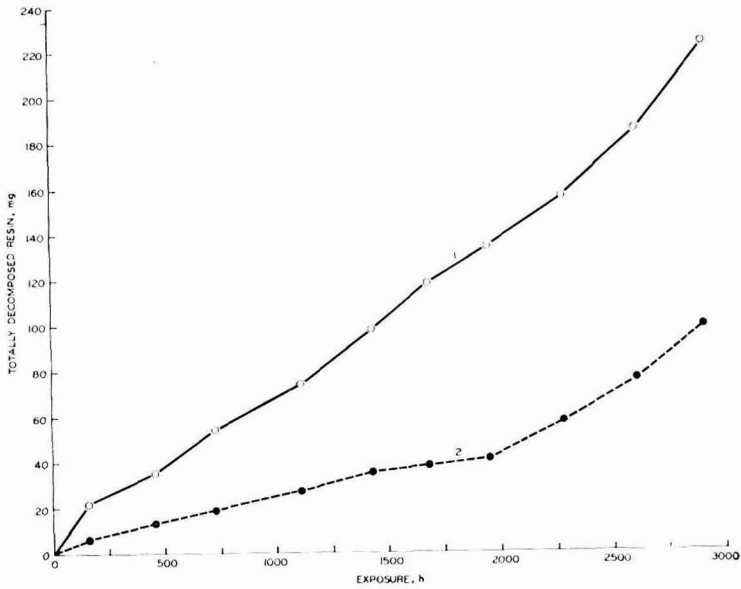


Fig. 4. Amount of totally decomposed resin in relation to time of exposure

Resin: Vinyl acetate/fumarate copolymer

Pigment: Anatase titanium dioxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

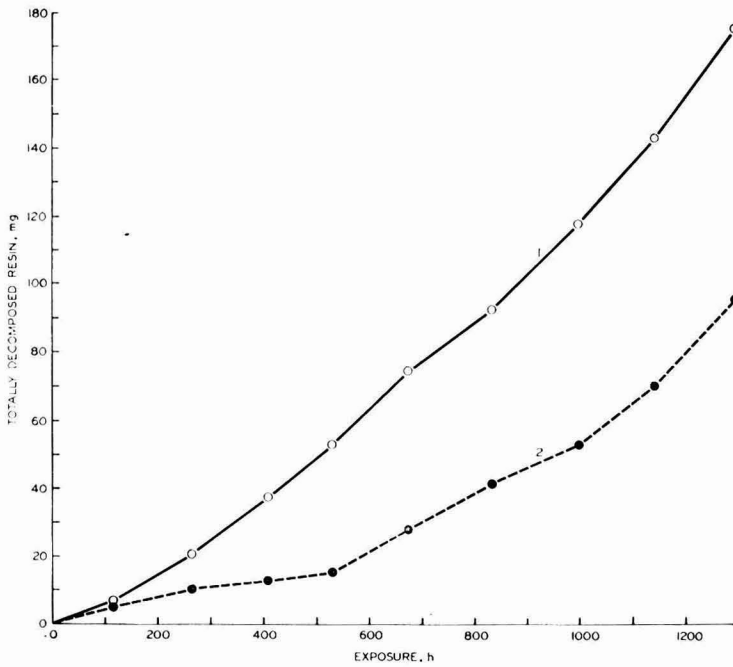


Fig. 5. Amount of totally decomposed resin in relation to time of exposure

Resin: Vinyl acetate/acrylate copolymer

Pigment: Zinc oxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

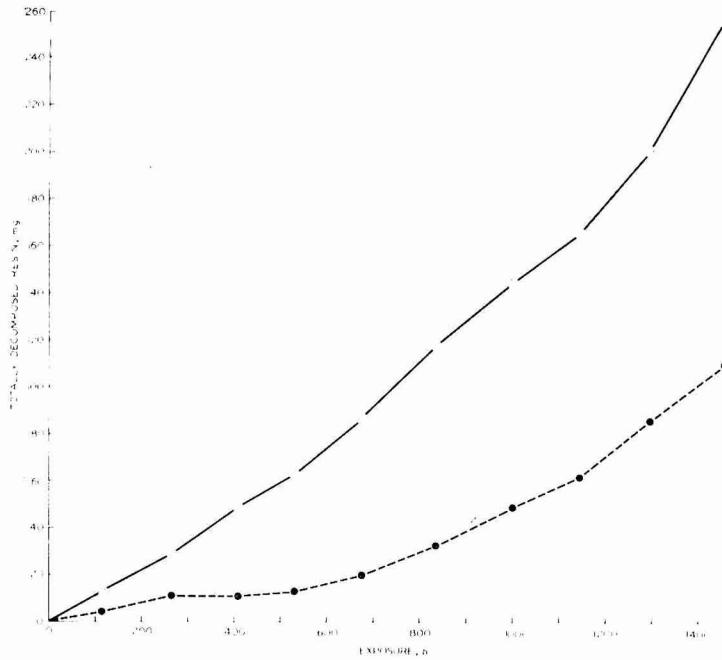


Fig. 6. Amount of totally decomposed resin in relation to time of exposure

Resin: Vinyl acetate polymer

Pigment: Zinc oxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

The systems based on acrylate copolymer and the vinyl acetate/fumarate copolymer (Fig. 7 and 8) are of special interest in that very little or no chalk is formed on the panels exposed at the lower energy level.

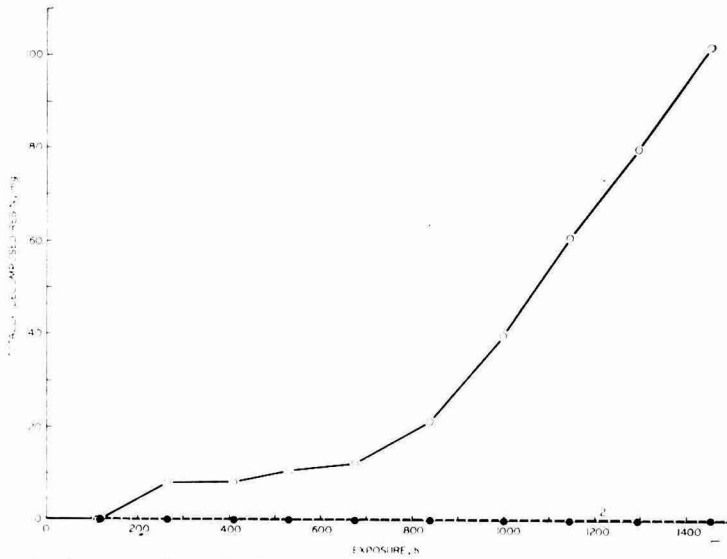


Fig. 7. Amount of totally decomposed resin in relation to time of exposure

Resin: Acrylate copolymer

Pigment: Zinc oxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

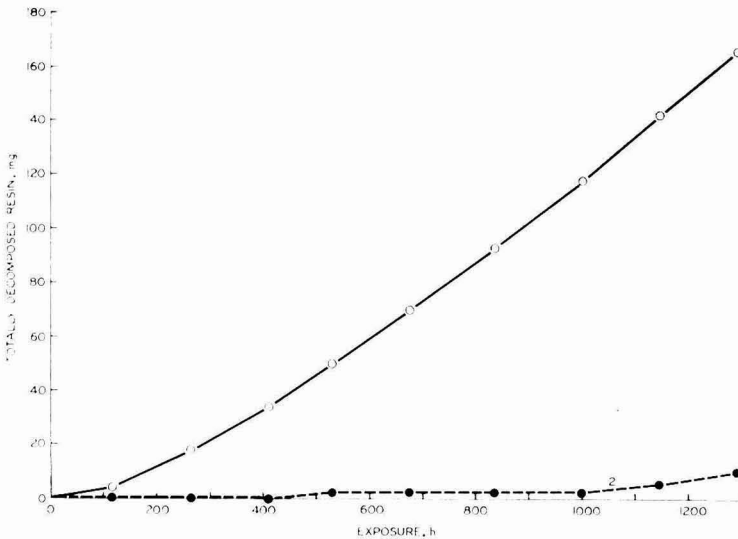


Fig. 8. Amount of totally decomposed resin in relation to time of exposure

Resin: Vinyl acetate/fumarate copolymer

Pigment: Zinc oxide

PVC: 40 per cent

Conditions: Air temperature 40°C at 65-70 per cent R.H.

Curve 1: High intensity radiation

Curve 2: Low intensity radiation

The examples given here show that the effect of the radiation (measured by the quantity of chalk formed) is not proportional to its intensity. The system in which the effect comes nearest to proportionality is the one formulated with vinyl acetate/acrylate copolymer pigmented with anatase titanium dioxide.

The most interesting cases are those in which the paints are formulated with the acrylate copolymer and vinyl acetate/fumarate copolymer pigmented with zinc oxide. At the lower energy level, there is no chalking on the acrylate copolymer formulation and only very little chalking on the other. However, there is still a weight loss before removing the chalk, which has been interpreted³ as being due to partial oxidation of the binder. In other words, at the lower level, different reactions occur which do not lead to the total decomposition of the binder resin and therefore do not set free any pigment.

It may be worthwhile to point out the difference in behaviour between a paint film and an unpigmented plastic, such as unstabilised polyvinylchloride, where the rate of photo-oxidation is directly proportional to the intensity of the xenon arc radiation⁴ and independent of the relative humidity.

In a previous paper³ a reaction mechanism was proposed to explain the role of the relative humidity on the total decomposition of the resin. This suggested a photo-catalysed reaction between the water and oxygen molecules adsorbed on the surface of the pigment, which in turn oxidised the resin molecules. It will be clear that the effect of the radiation will not only be determined by its intensity, but also by the diffusibility of oxygen and water molecules to the surface of the pigment, and this explains why direct proportionality will be the exception rather than the rule.

This explanation obviously cannot hold for the formulations with the vinyl acetate/fumarate and acrylate copolymers pigmented with zinc oxide, in which the absence of chalking must be sought in something other than the diffusibility of the reactants. The behaviour may be explained as follows. If a comparatively small number of hydrogen peroxide molecules is formed, the partially oxidised resin molecules may have time to recombine to form new polymer molecules, but if a great number of hydrogen peroxide molecules is generated then a single resin molecule may be attacked by more than one molecule of hydrogen peroxide and the opportunity to react with another polymer molecule may be missed. As the paints formulated with the same resins but pigmented with anatase titanium dioxide also chalk at the lower energy level, it must be assumed that, in the paints formulated with zinc oxide, the polymer in the binder can move more freely than in the case of the coating formulated with anatase. At the moment, this is speculation for which there is no proof except that it fits the observations.

Because the effect of radiation does not appear to be proportional to its intensity, it is not considered advisable to attempt to accelerate the rate of weathering by increasing the intensity.

Construction of the weatherometer

The investigations have so far studied the influence of humidity^{1, 2}, the effect of water and simultaneous irradiation* on the paint film, the air temperature³,

*Unpublished results. A wet paint film irradiated will chalk to a much greater extent than one at very high humidities (>90 per cent).

the wavelength³ and intensity of the incident radiation. The relative humidity and wetness appear to be the most important of these variables.

In the xenon arc weatherometer being used at the Division, it is virtually impossible to keep the relative humidity above 65-70 per cent for any length of time, and this is the value at which the effect of increasing humidity begins to show most strongly². Higher humidities are difficult to obtain because of the large amount of heat developed by the xenon arc. The lamps draw approximately 5000W and barely 20 per cent of the radiation has any influence on the weathering process³. The large amount of heat generated has to be removed by cooling, which is done partly by air, and this makes it difficult to achieve a high relative humidity. It would be much better if the active radiation could be generated by other light sources that have approximately the same intensity and spectral distributions as those found in sunlight under 450nm. Any necessary heating could be done by ordinary heating coils.

It may be pointed out that the xenon arc weatherometer is suitable for plastics because the humidity has very little influence on their weathering.

Conditions in the weatherometer

Accelerated tests are generally applied in two ways. First, the specimen is subjected to the worst conditions likely to be encountered in normal use. This would mean a very high relative humidity (say > 90 per cent), the highest intensity of ultraviolet light, the highest air temperature, and the longest time the paint film is likely to be wet with radiation falling upon it. Any paint judged to be satisfactory after exposure under these conditions for (say) two years would last much longer under less demanding circumstances.

Secondly, the values of the important variables in the weathering process of the coating can be established for the site and the weatherometer can then be programmed to correspond to these values. These would be the air temperature, relative humidity, ultraviolet radiation at different times of the day, the time during which a paint film remains wet with dew in the morning, the time for which it is wet by rain and also the average time during which it is irradiated whilst wet. Because the effect of radiation is not proportional to its intensity, it would be advisable to run the accelerated test so that the specimen is under three different intensity levels during 24h. This can be easily achieved by inclining the panels at suitable angles to the vertical.

The first type of test is very unsatisfactory because it cannot give an indication how long the paint will last under different conditions. The second type of test takes much longer but is likely to give much more accurate results.

Conclusions

It is not advisable to attempt to accelerate weathering tests on paint films by a considerable increase in the intensity of radiation above that which occurs naturally.

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The glycerolysis step in the production of oil-modified alkyd resins: Part V. Glycerolysis of castor oil and dehydrated castor oil

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Summary

Castor oil (CO) and dehydrated castor oil (DCO) were subjected to glycerolysis under normal pressure in the manner usually employed in alkyd resin production. The reaction proceeded at a higher rate and produced a higher equilibrium content in the order $\text{LiOH} > \text{CaO} > \text{PbO}$ when these compounds were used as catalysts. At the same catalyst concentration and with similar time/temperature schedules, the amount of α -monoglycerides formed was increased when the glycerol:oil ratio was raised from 2:1 to 3:1. Traces of water decrease the rate and extent of monoglyceride formation from castor oil triglycerides.

Keywords

Raw materials used in the manufacture of ingredients for coatings

castor oil
castor oil dehydrated

Processes and methods primarily associated with manufacturing or synthesis

glycerolysis

L'étape glycérolytique dans la fabrication des résines alkydes modifiées à l'huile :

Vème. Partie: La glycérolyse de l'huile de ricin et de l'huile de ricin déshydratée

Résumé

L'huile de ricin (C.O.) et l'huile de ricin déshydratée étaient soumises à la glycérolyse, sous la pression ambiante, au moyens du procédé classique pour préparer les résines alkydes. La réaction allait à une allure plus élevée, et elle rendait une teneur d'équilibre plus importante au fur et à mesure de l'ordre suivant $\text{LiOH} > \text{CaO} > \text{PbO}$, dans le cas où on utilise ces composés en tant que catalyseurs. Aux concentrations pareilles de catalyseurs et aux cotes durée/température semblables, la quantité des α monoglycérides produites était augmentée où le rapport glycérol:huile était haussée de 2:1 à 3:1. Les traces d'eau diminuent le taux de formation de la monoglycéride ainsi que la quantité de celle-ci produite à partir des triglycérides de l'huile de ricin.

Die Glycerolyse-Stufe in der Herstellung Ölmodifizierter Alkydharze Teil V. Glycerolyse von Rizinusöl und dehydratisiertem Rizinusöl

Zusammenfassung

Rizinusöl (C.O.) und dehydratisiertes Rizinusöl (D.C.O.) wurden unter normalem Druck in der bei der Alkydharzfabrikation üblichen Weise der Glycerolyse unterworfen. Die Reaktion verlief schneller, und die Bestandteile waren ausgeglichener, wenn in folgender Anordnung die Verbindungen $\text{LiOH} > \text{CaO} > \text{PbO}$ als Katalysatoren angewandt wurden. Bei gleicher Konzentration der Katalysatoren und ähnlichen Zeit/Temperatur-Exponierungen bildete sich mehr α -Monoglycerid, wenn das Verhältnis Glycerin: Öl von 2:1 auf 3:1 erhöht wurde. Spuren von Wasser vermindern die Geschwindigkeit und das Ausmass der Monoglyceridbildung von Rizinusöltriglyceriden.

Стадия глицеролиза в производстве алкидных смол модифицированных маслом.

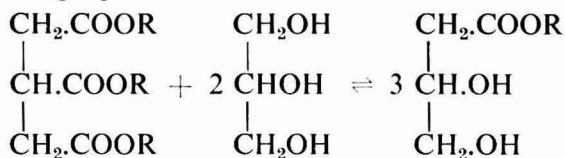
Часть. Глицеролиз касторового масла и дегидрированного касторового масла.

Резюме

Касторовое масло и дегидрированное касторовое масло подвергались глицеролизу при нормальном давлении, методом обычно применяемым в производстве алкидных смол. Реакция протекала с большей скоростью с выявлением более высокого равновесного содержания в порядке $\text{Li OH} > \text{CaO} > \text{PbO}$, когда соединения применялись в качестве катализаторов. При той же концентрации катализаторов и при сходных температурно/временных режимах, количество образующихся α -моноглицеридов увеличилось когда отношение глицерина к маслу было повышено с 2:1 до 3:1. Следы воды понижают скорость и степень образования моноглицеридов из триглицеридов касторового масла.

Introduction

The production of alkyd resins modified with oils for surface coatings is usually preceded by conversion of the oil into its monoglycerides. This process is termed glycerolysis, since the oil is split by glycerol to give, in the simplest case, the following equilibrium mixture:



where R is a fatty acid chain.

The hydroxyl functionality of the oil in the mixture is thus raised from zero to a value which depends on the extent of the reaction but never exceeds two. Hence, it is possible to proceed to the completion of oil-modified alkyd resin preparation without too much risk of premature cross-linking and gel formation.

The trend to the preparation of alkyds via the monoglyceride step is justified by the rapidity of the glycerolysis reaction and because, commercially, the vegetable oils required are normally cheaper than the equivalent quantities of fatty acid and glycerol¹. It is therefore of importance to gain as much insight as possible of the nature of the glycerolysis reaction and the factors which influence monoglyceride formation, since an improperly formed monoglyceride mixture would undoubtedly be reflected in the final physical and chemical properties of the alkyd resin produced¹.

The glycerolysis of cottonseed and linseed mixed triglycerides has been intensively studied²⁻⁵. When LiOH, CaO or PbO was used as a catalyst, the reaction with linseed mixed triglycerides proceeded at about twice the rate and produced a yield of about 17 per cent more monoglyceride than with the cottonseed triglycerides. Activation energies were found to be in the range of 20-32 Kcal mole⁻¹, and the formation of monoglyceride was found to follow zero order reaction³. The influence of some of the initial constants of the oils on the rate and extent of monoglyceride formation was also examined; it was found that the reaction of oils with higher iodine values proceeded at a higher rate and gave a higher equilibrium content of monoglycerides⁴. It was also found that, with cottonseed and linseed mixed triglycerides, the reaction

rate did not increase to any appreciable extent upon increasing the molar concentration of glycerine and that the reaction time was almost doubled when the glycerolysis was carried out in absence of a blanket of inert gas, that is, oxygen retards the glycerolysis reaction⁵.

It was thought important to extend the above studies to CO and DCO for various fundamental and technological reasons. A study of DCO would provide an opportunity to examine the effect of conjugation on the glycerolysis reaction; a parameter which has not, to the best of the authors' knowledge, hitherto been investigated, and CO would allow a study of the effect of the hydroxyl group in its molecule on the reaction. Technologically, CO can be used directly in alkyd manufacture by virtue of the compatibility caused by the hydroxyl groups present. The product may serve as a drying or a non-drying alkyd depending on whether or not dehydration of the oil is allowed to take place during the reaction. But as the dehydration process is liable to yield a mixture of the conjugated and non-conjugated dienes, it would be expected that a higher ratio of the more useful conjugated dienes would be obtained when the dehydration is carried out separately under well controlled conditions⁶. In the latter case, the DCO so obtained should then be converted to glycerides before incorporating it into the alkyd structure.

Most of the work carried out on the glycerolysis of castor oil employed high pressure. Thus, refined castor oil and glycerol were heated in an autoclave with CO₂ at 200 psi and 250°C for two hours and then gradually cooled to give a product containing about 91 per cent monoglycerides⁷. The use of high pressure increased the equilibrium monoglyceride concentration, whilst the rate of monoglyceride formation and the concentration at equilibrium increased with temperature up to 250°C⁸. A fractionation method has recently been proposed⁹, by which the castor oil monoglyceride content could be enriched by partitioning the mixture between aqueous ethyl alcohol and *n*-hexane; this may provide an alternative to the high pressure technique. The importance of the high pressure or fractionation techniques for improving the yield of monoglycerides lies in the fact that the monoglycerides of castor oil, in particular, are usually intended for end uses as plasticisers, detergents or lubricants.

In this investigation, the course of glycerolysis of castor oil and DCO under normal pressure was followed by quantitative analysis and qualitative tests, and the effects of some of the factors influencing the reaction, such as the catalyst, temperature, oil:glycerol ratio and prolonged reaction time, were examined.

Materials, methods and analytical techniques

Materials

Castor oil: An Egyptian product manufactured by cold pressing of the seed in Abu-Saada Mill, Alexandria; its analytical constants have been given previously⁶. Acid value 0.72mg KOH/g. Moisture was completely removed by adding benzene and distilling off the azeotropic mixture.

Glycerol: A local product obtained from Salt & Soda Company. Glycerol content not less than 99 per cent.

Dehydrated castor oil: Obtained by dehydrating castor oil. Its specification has been given previously¹⁰. Acid value 4.23mg KOH/g.

Glycerolysis catalysts: LiOH, CaO and PbO, all of analytical reagent grade.

Dehydration catalyst: The ion exchange resin Dowex-50, (Sulphonated polystyrene/divinyl benzene) was used. Sieve analysis 82 per cent by weight between 62 and 125 microns¹⁰.

Periodic acid: Prepared from potassium periodate¹¹ for use in determining the monoglyceride content.

Preparative methods

Glycerolysis: 50g portions of oil and the calculated amount of glycerol were heated in a specially constructed apparatus⁶ which permits uninterrupted sampling. The charge was heated initially under reduced pressure to remove dissolved air, and thereafter was protected from oxidation by blanketing with oxygen-free dry nitrogen. When the desired temperature was reached, the weighed catalyst was added. The time of addition was taken as zero reaction time. The temperature was maintained within $\pm 1^\circ\text{C}$. Continuous moderate stirring was maintained throughout the reaction. At the end of the reaction the mixture was cooled rapidly.

Dehydration: Dehydration of castor oil was carried out at 270°C under reduced pressure using Dowex-50 as catalyst¹⁰.

Analytical techniques

Testing of DCO: The acid, iodine and diene values were determined using standard methods. Viscosity was measured using the bubble tube method¹³ and the colour using the Gardner 1933 standards.

Determination of the extent of glycerolysis: The glycerolysis product usually contains free glycerol, α -monoglyceride, β -monoglyceride, α : γ - and α : β -diglycerides. The most important of the above constituents is the α -monoglyceride. The latter is qualitatively determined by the tolerance test in methanol¹⁴ and quantitatively by the periodic acid method.

Methanol tolerance test: This is based on assessing the solubility of a portion of the glycerolysis reaction mixture in 2.5 times its volume of methyl alcohol; absolute MeOH in case of DCO and 90 per cent MeOH in water in case of CO. Alternatively, titration of a given sample of the glycerolysis mixture with methanol to a faint but persistent turbidity was also used.

Periodic acid method: Small samples were introduced into small weighed conical flasks. The partition technique of separating the monoglycerides from unreacted glycerol was applied, as it is claimed to give more precise results¹⁵. The analysis was performed according to the method of Pohle and Mehlenbacher¹⁶ which depends upon the preferential oxidation of adjacent OH groups with periodic acid. The equilibrium of the α - and β -monoglycerides was considered to be entirely in favour of the α -form¹⁷, especially in the range of the reaction temperatures used¹⁸, thus

$$\% \alpha\text{-monoglyceride} = \frac{(x - y) \cdot N \cdot M \cdot 100}{W \cdot 1000}$$

where

x = ml $\text{Na}_2\text{S}_2\text{O}_3$ solution required for blank.

y = ml $\text{Na}_2\text{S}_2\text{O}_3$ to titrate sample.

N = Normality of $\text{Na}_2\text{S}_2\text{O}_3$ solution.

M = Molecular weight of monoglyceride.

W = Weight of sample in g.

Results and discussion

Glycerolysis of castor oil

A series of experiments was performed to evaluate the relative efficiency of the exchange catalyst on a weight basis, and to examine the effect of temperature on the reaction rate. The reactions were followed qualitatively by determining the turbidity temperatures, and by titration with methanol, and quantitatively by the periodic acid method. A typical example of the course of the reaction as followed by the above methods is shown graphically in Fig. 1a. The glycerolysis reaction proceeds quite rapidly but, as with normal fatty triglycerides, the extent of monoglyceride formation does not exceed a certain equilibrium value under the conditions used. However, in contrast to normal triglycerides, the turbidity temperature at the equilibrium content was not observable unless the mixture was immersed in a cooling mixture well below

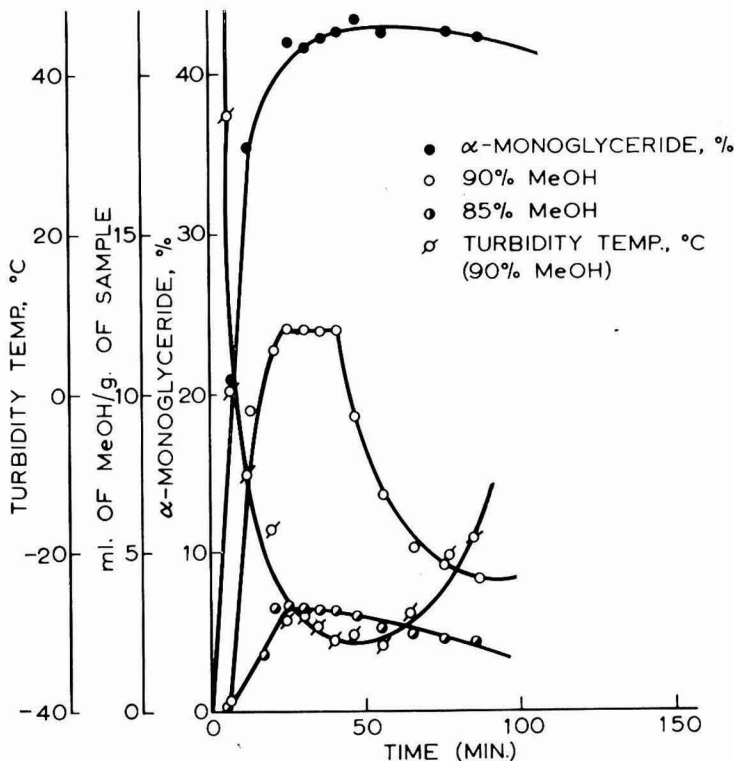


Fig. 1a. The glycerolysis of CO catalysed by 0.04 per cent LiOH at 240°C

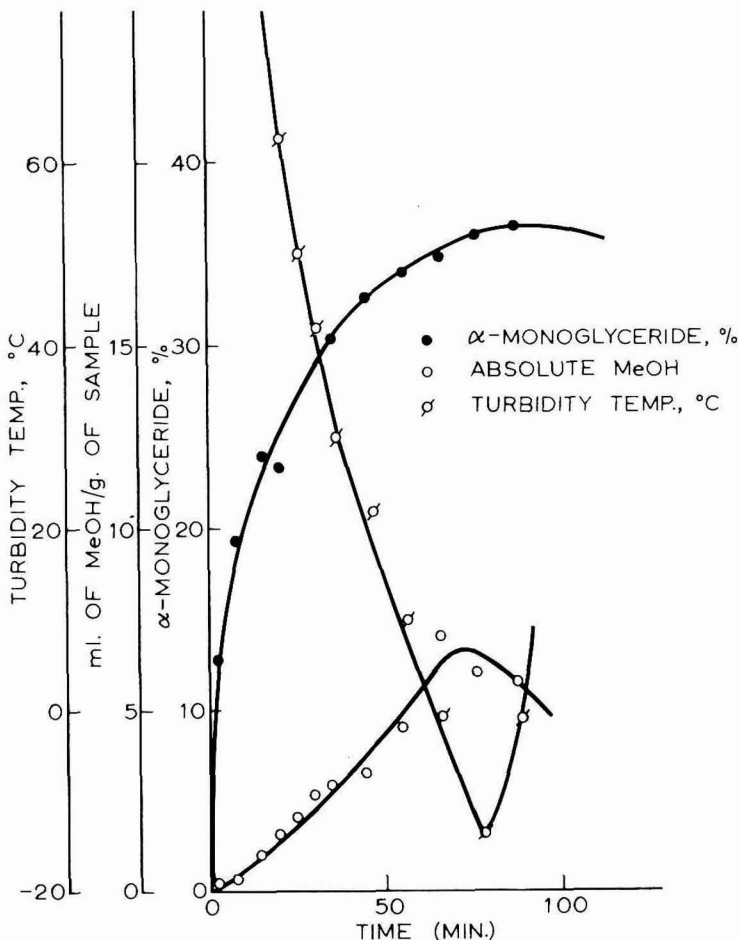


Fig. 1b. The glycerolysis of DCO catalysed by 0.04 per cent LiOH at 240°C

0°C. An interesting observation was that titration with 90 per cent methanol after the equilibrium time has been reached gives a decreased titre, whereas with 85 per cent methanol the decrease is only slight. In the quantitative determination, only a slight decrease in the monoglyceride content was generally observed when the time was prolonged beyond the equilibrium point. These findings will be commented upon later. The type and amount of catalyst and temperature have a great influence on the rate and extent of the glycerolysis of castor oil. At 220 °C and a fixed concentration of 0.04 per cent of catalyst, the reaction proceeds at a higher rate and produces a higher equilibrium content of α -monoglyceride in the order $\text{LiOH} > \text{CaO} > \text{PbO}$ (see Fig. 2) which is in agreement with previous findings on other oils³.

Within a certain range of catalyst concentration, the rate and the extent of monoglyceride formation increase with the increase of the catalyst concentration. Fig. 3 shows the effect of catalyst concentration on the glycerolysis reaction at 240 °C. Fig. 4 shows the influence of temperature at a fixed concentration

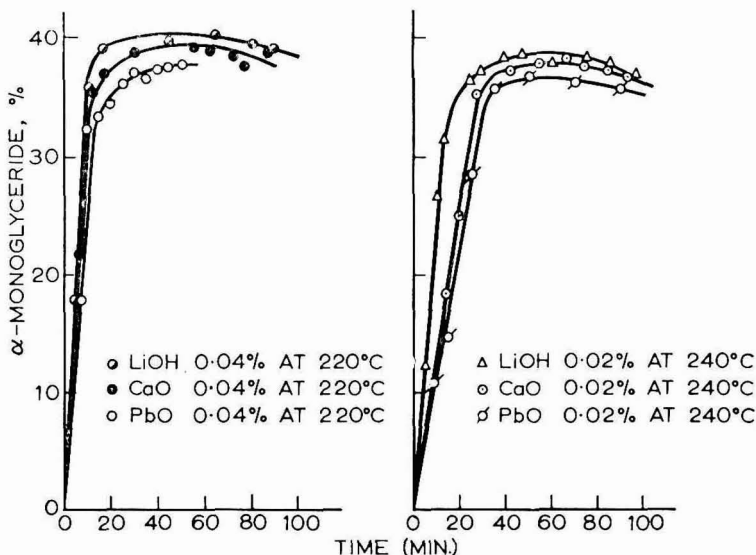


Fig. 2. The effect of different catalysts on the glycerolysis of CO

(0.04 per cent) of catalyst (LiOH); at 240°C the rate of monoacylglyceride formation is 13.8×10^{-4} mols l^{-1} sec^{-1} and the equilibrium content of α -monoacylglyceride is 42.8 per cent, and at 200°C these figures are 2.56×10^{-4} mols l^{-1} sec^{-1} and 41.6 per cent. The conversion/time curves vary with temperature near the equilibrium point; at high temperatures the equilibrium is reached quite suddenly, showing a sharp inflection in the curve, whilst at low temperatures some sluggishness is observed as the equilibrium is approached.

It has been suggested¹⁹ that the presence of water affects the rate and extent of the glycerolysis process. This effect was investigated for CO at a fixed temperature and catalyst concentration; the results are shown diagrammatically in Fig. 5. The rate and extent of monoacylglyceride formation are higher in the absence of water.

Glycerolysis of dehydrated castor oil

The course of glycerolysis of DCO, as followed by the three methods described above, is shown graphically in Fig. 1b. Although DCO differs widely in its hydroxyl value and conjugation from CO, the curves show essentially the same features: monoacylglyceride formation proceeds linearly with time until very near the equilibrium point. Its lower rate of formation is probably due to its initially higher acid value⁴. The turbidity temperature rises and the titre with MeOH falls when the reaction time is prolonged beyond the equilibrium point. These last two determinations do not represent a decrease in the monoacylglyceride content owing to the back reaction as much as a change in the composition of the mixture owing to side reactions. This can be illustrated from the quantitative monoacylglyceride curves in Figs. 1a and 1b, where the monoacylglycerides isolated from the mixture decrease only slightly upon prolonged heating. On the other hand, longer heating of the glycerolysis mixture, especially in presence

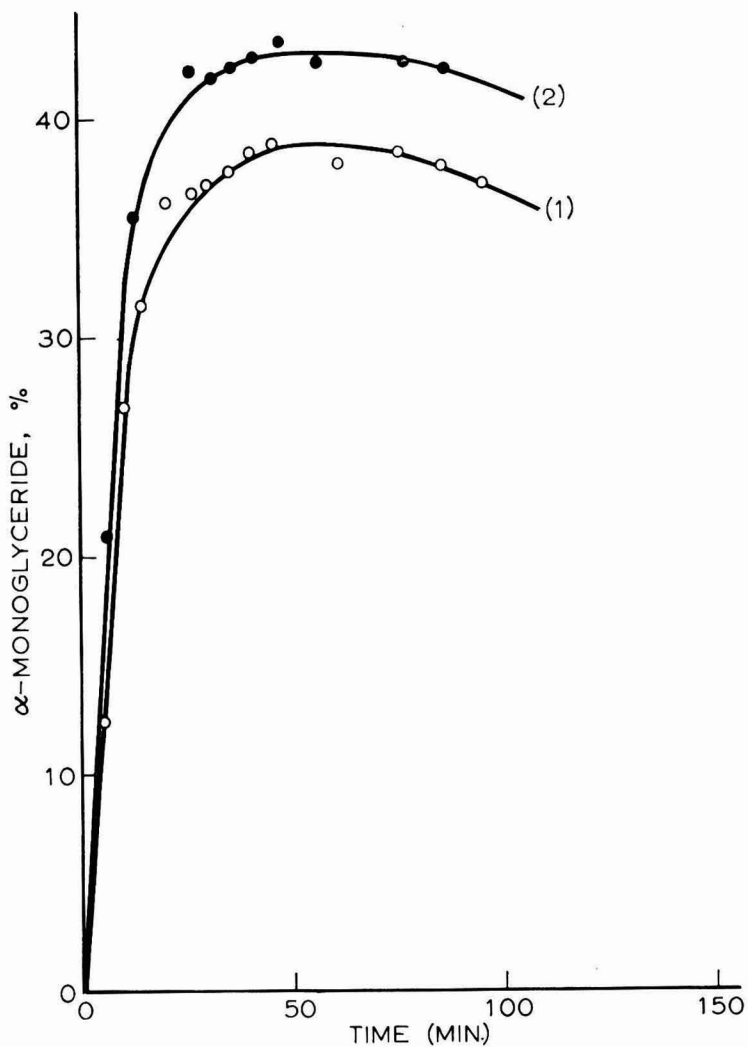


Fig. 3. The increase of the glycerolysis rate and the monoglyceride content for CO with the increase of catalyst concentration at 240°C: (1) 0.02 per cent LiOH; (2) 0.04 per cent LiOH

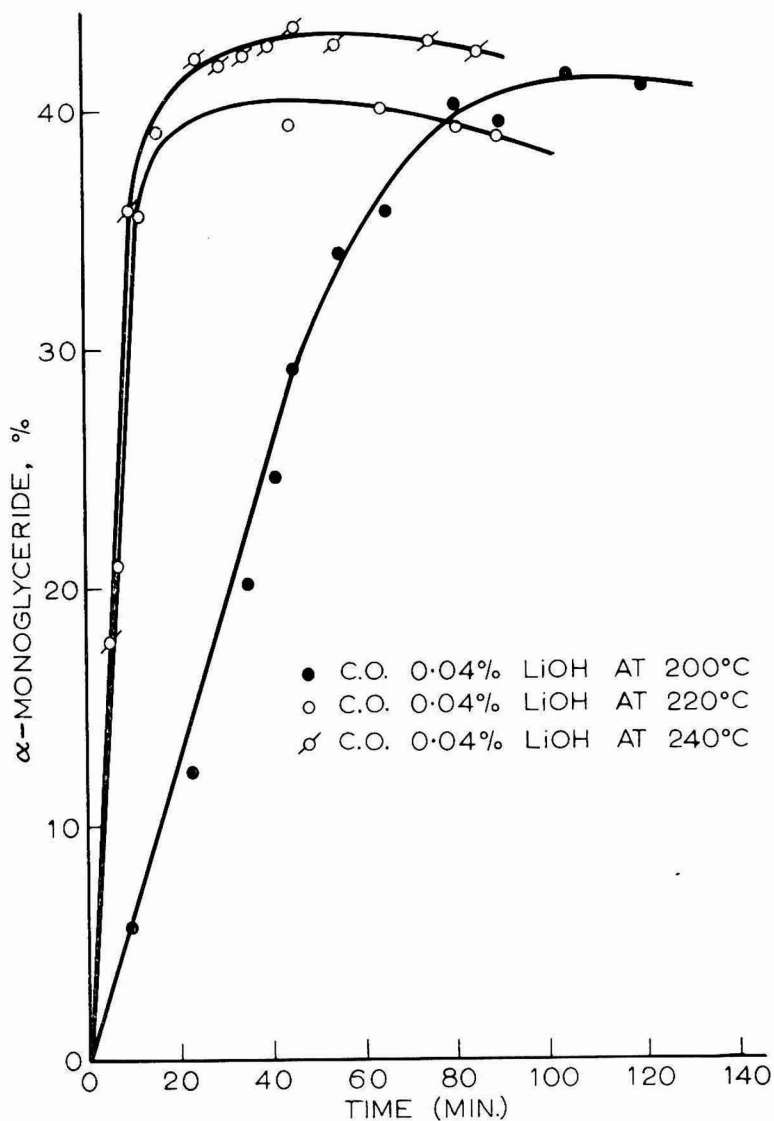


Fig. 4. The influence of temperature on the glycerolysis of CO catalysed by 0.04 per cent LiOH

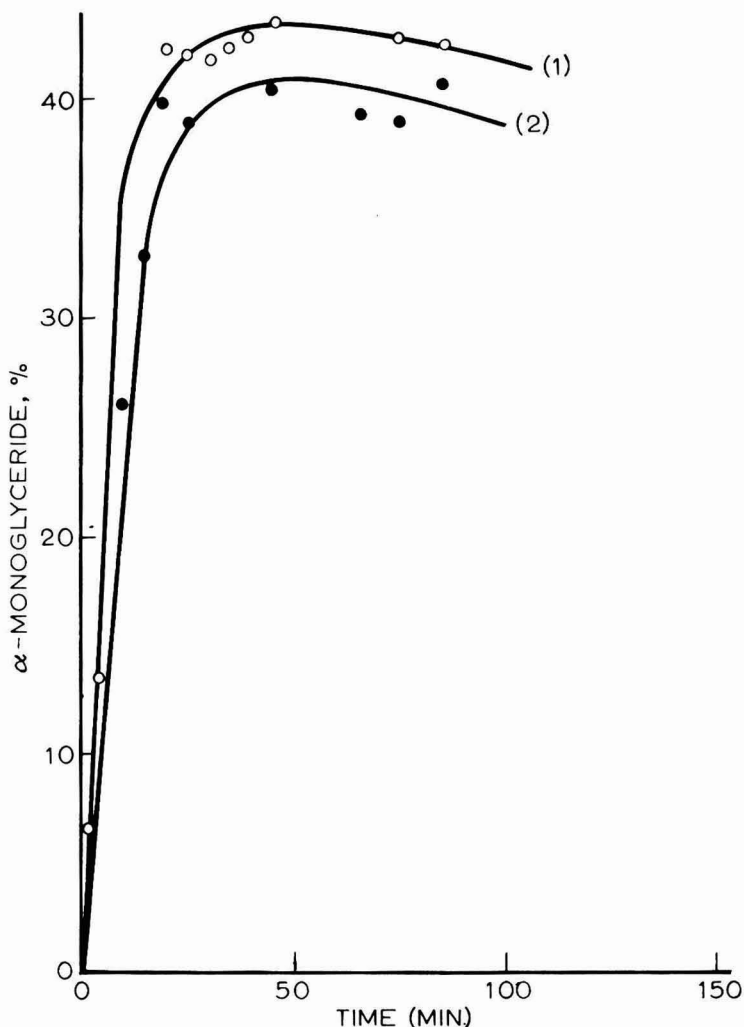
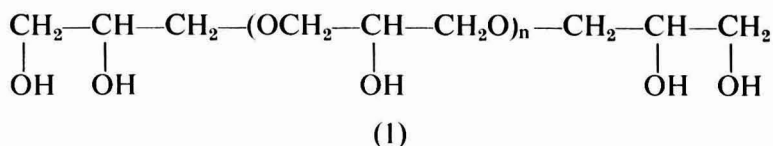


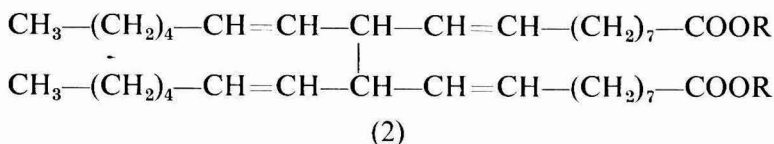
Fig. 5. The effect of water on the rate and extent of the glycerolysis of CO: (1) 0.04 per cent LiOH, 240°C; (2) 0.04 per cent LiOH, 240°C, 2 per cent H₂O

of the glycerolysis catalyst, promotes etherification of glycerol to give polyglycerols²⁰ of the type:



Etherification might also occur in the case of CO owing to its hydroxyl groups, and polymerisation is also feasible²⁰ in the case of DCO, by way of the double bonds, with the formation of compounds such as (2). These side

reactions result in a decreased polarity of the mixture and hence in decreased tolerance in polar methyl alcohol.



The side reactions are naturally much slower than the glycerolysis reaction and therefore become competitive only at high temperatures and after longer times. As shown in Fig. 6, increasing the reaction temperature causes a rapid increase in the rate of monoglyceride formation, but the equilibrium α -monoglyceride content tends to be lower. In order to assess the effects of temperature and time on the equilibrium monoglyceride contents, reactions

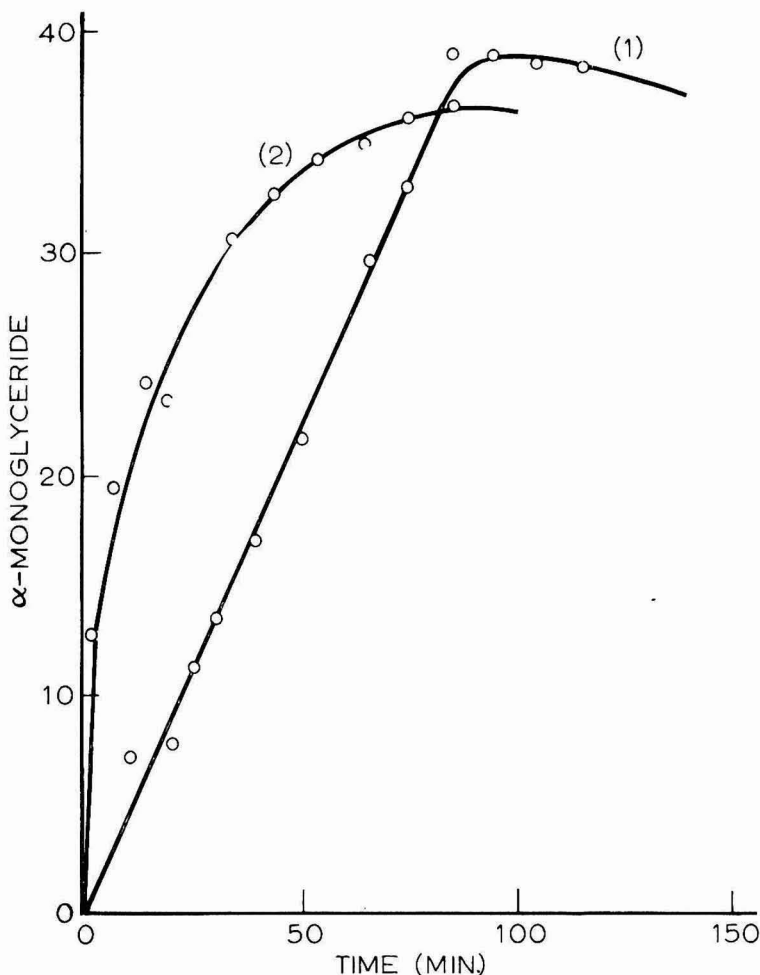


Fig. 6. Glycerolysis at high temperature: (1) 0.04 per cent LiOH at 220°C; (2) 0.04 per cent LiOH at 240°C

were performed with different catalyst concentrations and the monoglyceride contents were determined after the mixture had been heated for fixed times. Some of the results are graphically illustrated in Fig. 7; prolonged heating, particularly in presence of a relatively high concentration of catalyst (0.2 per cent), causes a rapid fall in the equilibrium α -monoglyceride content.

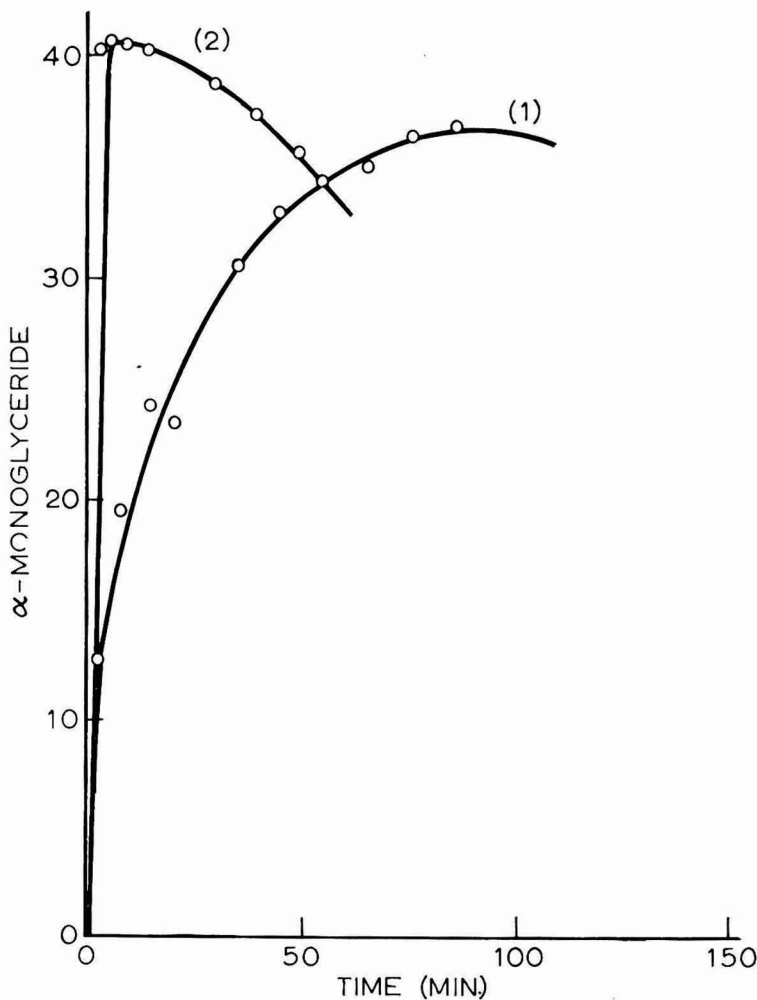


Fig. 7. Effect of prolonged heating of the monoglyceride mixture: (1) 0.04 per cent LiOH at 240°C; (2) 0.2 per cent LiOH at 240°C

Reactions were performed under two different conditions of temperature; at 240°C initially and then at 280°C, or at 280°C throughout. Two molar ratios of oil:glycerol, namely, 1:2 and 1:3, were used.

The results are summarised in Table 1.

At the same catalyst concentration and for similar time/temperature schedules, the amount of α -monoglyceride is higher the higher the glycerol:oil ratio. This does not contradict previous findings that excess glycerol has no appreci-

Table 1

Variation of the α -monoglyceride content with the conditions of the glycerolysis of DCO and its further heating

Catalyst %	Temperature °C	Time hours	Glycerol:oil = 2:1		Glycerol:oil = 3:1	
			α -MG %	decrease in MG %	α -MG %	decrease in MG %
0.04 LiOH	240	1.5	39.05	—	46.19	—
	280	0.5	31.61	19.05	39.91	13.60
	280	1.0	28.79	26.27	36.95	20
0.04 LiOH	280	0.5	40.62	—	45.22	—
	280	1.0	37.68	7.24	44.65	1.26
0.1 LiOH	240	0.5	41.16	—	47.67	—
	280	0.5	31.01	24.66	—	—
	280	1.0	22.95	44.2	36.12	24.20
0.1 LiOH	280	0.5	35.13	—	48.26	—
	280	1.0	24.72	29.6	43.32	10.20
0.1 KOH	240	0.5	—	—	45.61	—
	280	0.5	—	—	39.38	13.70
	280	1.0	—	—	36.33	20.40
0.1 KOH	280	0.5	—	—	44.44	—
	280	1.0	—	—	43.25	2.70

able effect on the rate or extent of the glycerolysis reaction^{2,5}. The higher monoglyceride content obtained at higher glycerol:oil ratio can be explained by the existence of the side reactions, especially the etherification reaction by which hydroxyl groups are consumed (see formula 1). This would seriously affect the 2:1 mixture, since the concentration of the OH groups will fall below the stoichiometric ratio, but it will not do so in the 3:1 mixture where the OH groups are present in 50 per cent excess. Again, in view of the relatively higher acid value of DCO and its lower capacity to dissolve glycerol⁴, the conditions favour a slower glycerolysis (see Fig. 1b) but do not affect the simultaneous side reactions; a situation which results in lower monoglyceride content at low glycerol:oil ratios.

When the reaction time is prolonged, losses in the monoglyceride content occur. The loss is greater in the 2:1 mixture than in the 3:1 mixture because of the consumption of the reactants by side reactions, and hence the tendency of the equilibrium to shift towards the left hand side of the equation¹. The loss is also greater in the runs performed initially at 240°C and for a longer reaction time than in the runs performed directly at 280°C and for a shorter reaction time, indicating that the side reactions are slower than the glycerolysis reaction. Using high catalyst concentrations under these conditions does not produce any appreciable increase in the monoglyceride content and, moreover, increases the losses upon prolonged heating, which means that the glycerolysis catalysts also catalyse the formation of side-reaction products.

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A mathematical review and comparison of ink transfer equations*

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Summary

Several equations have been published in the past concerning the transfer of printing ink from plate to substrate. This paper accepts these equations at their mathematical face value, makes comparisons and finds several similarities amongst them. The coefficients in these transfer equations have only limited correlation with ink, paper and machine characteristics. Further investigation is required to ascertain the optimum number of coefficients in order to equilibrate the highest degree of accuracy with a workable mathematical formula.

A simple graphical method is proposed which enables the position of the peak in the familiar "percentage transfer curve" to be obtained rapidly from the "transfer curve".

Keywords

Types and classes of coating printing ink

Process and methods primarily associated with application of coatings ink transfer

Une analyse mathématique et une comparaison des équations a l'égard du transfert d'encre d'imprimerie

Résumé

Plusieurs équations ont été publiées déjà pour élucider le transfert d'encres d'imprimerie à partir du cliché au support. Cet exposé accepte ces équations à leur valeur mathématique apparente, il fait des comparaisons et trouve plusieurs similarités entre elles. Les coefficients postulés par ces équations ne possèdent que d'une corrélation limitée aux caractéristiques de l'encre, du papier, et de la presse. Il faut que l'on fasse d'études supplémentaires afin de déterminer le nombre optimal de coefficients nécessaires à faire accorder le degré de précision le plus élevé à une formule mathématique praticable.

On propose une méthode graphique simple qui permet la détermination rapide de l'emplacement de l'apogée de la bien connue "courbe de transfert en pourcentage" à partir de la "courbe de transfert."

Mathematisches Betrachten und Vergleichen von Druckfarben-Umdruckgleichungen

Zusammenfassung

Seither wurden verschiedene Gleichungen veröffentlicht, welche sich mit der Übertragung der Druckfarbe von Platte zum Substrat befassen. In der vorliegenden Arbeit werden die Werte dieser Gleichungen als mathematisch richtig übernommen, auch werden Vergleiche gezogen, und dabei einige Ähnlichkeiten gefunden. Die Koeffizienten in diesen Umdruckgleichungen stehen nur in beschränktem Masse in Korrelation mit Druckfarben-, Papier- und Maschinencharakteristika. Um die optimale Anzahl von Koeffizienten mit Sicherheit

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festzustellen, müssen weitere Untersuchungen vorgenommen werden, um höchste Genauigkeit mit einer praktisch brauchbaren mathematischen Formel ins Gleichgewicht zu bringen.

Eine einfache grafische Methode wird vorgeschlagen, mit Hilfe derer die Lage der Spitze in der vertrauten "Prozentsatz Transferkurve" aus der "Transferkurve" schnellstens auffindbar ist.

Математический обзор и сравнение уравнений для переноса печатных красок.

Резюме

Ряд уравнений был опубликован за последнее время, описывающих перевод типографских красок от пластинки на субстрат. Настоящая статья анализирует эти уравнения с их математической точки зрения, сравнивает их и находит среди них ряд сходств. Коэффициенты этих переносных уравнений обладают лишь ограниченной степенью корреляции с краской, бумагой и машиной. Необходимы дальнейшие исследования для определения оптимального числа коэффициентов, для того чтобы согласовать максимальную степень точности с практически применимой математической формулой.

Предлагается простой графический метод, позволяющий быстро определить положение пика на «процентной переходной кривой» из «кривой переноса».

Introduction

The transfer of printing inks from plate to paper has been the subject of world-wide study. This paper discusses eight transfer equations attributed to the following sources: American Newspaper Publishers Association⁸ (1953), Walker-Fetsko¹ (1955), Central Laboratory parameters⁷ (Ginman 1957), Rupp-Rieche² (1959), Wultsch-Schubert⁵ (1959), Laraignou⁶ (1960), Ichikawa-Sato-Ito¹⁰ (1962) and Joyce-Fuchs⁹ (1966). Unfortunately, each researcher has tended to use his own individual terms of reference, a fact which necessarily complicates a comparative approach. This paper attempts to survey and interrelate some of the more significant findings, accepting the equations at their mathematical face value and making the adjustments necessitated by divergent units of measurement. The approach is purely theoretical and does not attempt to evaluate the practical significance of the various equations. Hence it has been possible to make the following comparisons:

Walker-Fetsko with Rupp-Rieche

Laraignou with Walker-Fetsko

Ginman with Walker-Fetsko

ANPA with Walker-Fetsko

ANPA with Joyce-Fuchs

Ichikawa-Sato-Ito with Walker-Fetsko

Ink transfer

The traditional methods of printing (letterpress, litho, gravure, screen, flexography) require pressure to transfer the inked image from the plate surface to the material to be printed. The manner in which the ink is transferred depends on many factors, such as: the nature of the surfaces, the pressure, quantity of ink available for transfer, printing speed, ink rheology, etc. The conventional study of ink transfer relates the quantity of ink transferred (expressed as a percentage) to the quantity of ink available for transfer. If these parameters

are recorded on a graph with per cent transference along the vertical axis, a characteristic curve is obtained which increases to a peak and then falls to about the 50 per cent level as the quantity of ink available for transfer increases. By changing the printing speed, ink viscosity, pressure, or printed material, a number of families of curves can be obtained. Mathematical relationships have been proposed by the workers discussed here which relate the amount of ink transferred (y) to the amount of ink on the plate before impression (x). These equations involve between two and six coefficients which may be related to the factors already mentioned influencing ink transfer.

It is clear that one particular equation may fit the empirical results more closely than another. An initial appraisal of the equations, however, enables their relative flexibilities to be assessed. Moreover, if a number of equations have been shown to be sufficiently flexible, i.e. incorporating enough coefficients to fit most observed results, comparisons of this kind are legitimate and useful.

The first point of confusion occurs when the units of measurement are investigated. It has already been stated that the ink transfer curve relates percentage ink transference to original ink quantity on the plate. In the interest of clarity, such a curve should be called a "percentage ink transfer curve". Ink transfer may also be recorded as a plot of the quantity of transferred ink against the original ink quantity on the plate. Such a curve is shown in Fig. 1, which should be compared with the (quite different) percentage transfer curve in Fig. 3.

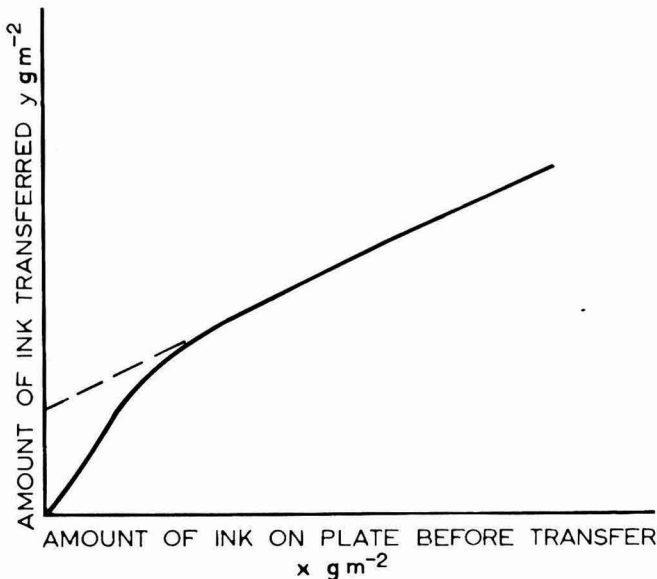


Fig. 1. Amount of ink transferred in relation to amount of original ink on plate

It should be noted, however, that an ink transfer equation invariably relates the quantity of ink transferred (y) to the quantity of ink originally on the plate (x), but care should be taken to make sure whether y and x are measured in microns, grams or grams per square metre.

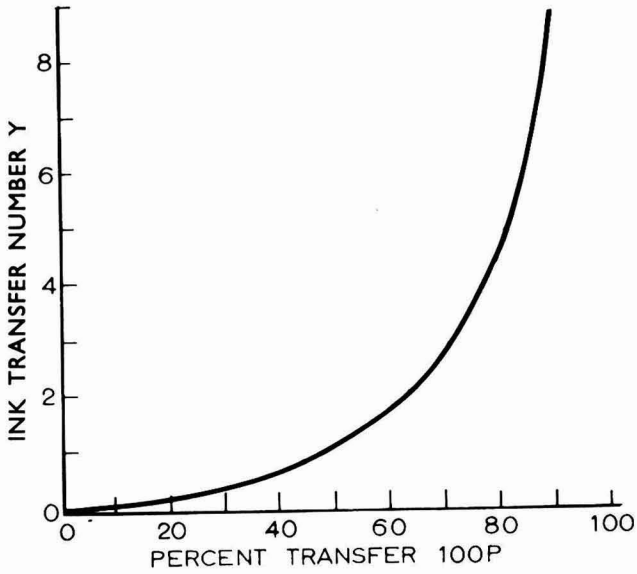


Fig. 2. Ink transfer number (Y) versus per cent transfer (100P)

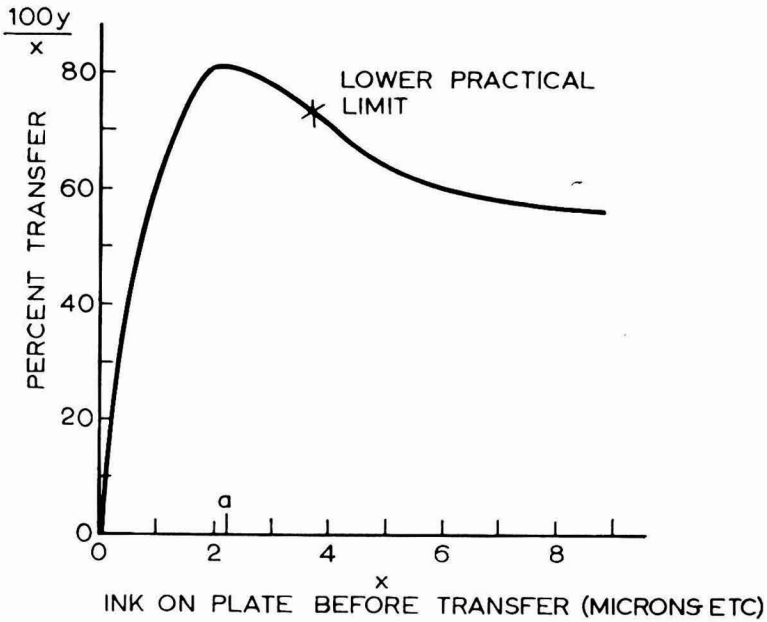


Fig. 3. Per cent transfer

The Walker-Fetsko equation

One of the most significant contributions to the study of ink transfer is the Walker-Fetsko equation¹:

$$y = (1 - e^{-kx})\{b(1 - e^{-x/b}) + f[x - b(1 - e^{-x/b})]\} \dots\dots\dots (1)$$

- where y = amount of ink transferred to paper
- x = amount of ink on plate before transfer
- b = amount of ink immobilised on the paper
- f = film splitting constant
- k = smoothness factor

This equation contains three coefficients, b , f and k , generally related to the ink, paper and printing conditions. Even in the work of the originators, x is sometimes measured in microns and sometimes in grams per square metre. Weight per unit area is easy to measure because this involves a simple weighing operation on a sample of known size. Measurement of ink film thickness is subject to larger errors.

On the other hand, film thickness would appear to be more appropriate than film weight when investigating the mechanics of film splitting. It would therefore be of greater fundamental significance to measure x , y and b in length units, e.g. microns. If, however, areal weight units are selected (g m^{-2}), b will also be in g m^{-2} units, f will be dimensionless and k will be in $(\text{g m}^{-2})^{-1}$ units. The equation will, of course, hold for measurement in either microns or g m^{-2} provided consistency is maintained.

If y is plotted against x , a curve similar to that shown in Fig. 1 is obtained. Walker and Fetsko observed that, at heavier ink film weights, the curve approaches a straight line. In this case, the exponential components in the equation have approached zero and the equation now approximates to:

$$y = b + f(x - b) \dots\dots\dots (2)$$

This graph is used to obtain f (the value of the slope) and b (intercept of extrapolated straight portion of the graph on the y axis divided by $(1 - f)$). More complicated procedures are required to determine k , which is usually achieved by considering the thin film region of the curve.

Fortunately for the study of ink transfer, as already indicated, the convention has been established that transfer should be recorded as per cent transference:

$$\text{Per cent transfer} = \frac{100y}{x} \dots\dots\dots (3)$$

where x and y are measured in identical units.

A typical per cent transference curve is shown in Fig. 3. This graph has been computed from the transfer curve of Fig. 4. It shows a peak of 81 per cent at $x = 2.2$, an equilibrium level of 53 per cent and the lower practical limit (point of minimum inking and transfer for adequate printing quality) has been inserted at $x = 3.7$, which are the three aspects of the per cent transfer curve which have been given the greatest attention.

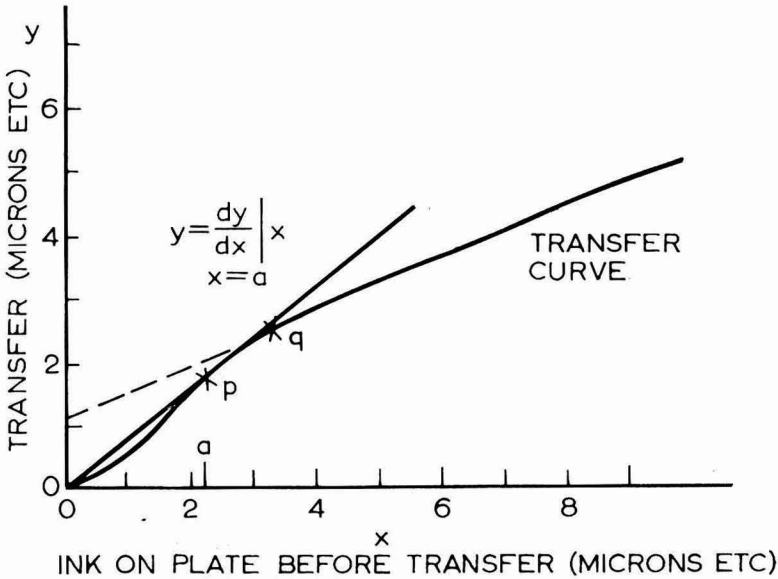


Fig. 4. Transfer curve

Comparison of the Walker-Fetsko and Rupp-Rieche equations

The alternative approach adopted by Rupp and Rieche² and by Pihl and Olsson^{3,4} was based on an ink transfer number* defined as:

$$\text{Ink transfer number, } Y = \frac{y}{x - y} \dots\dots\dots (4)$$

A few selected values show the relationship between per cent transfer and ink transfer number:

Percentage transfer	Ink transfer number
10	1/9
25	1/3
50	1
75	3
90	9

The relationship between ink transfer number (Y) and per cent transfer (100.P) is:

$$Y = \frac{P}{1 - P} \dots\dots\dots (5)$$

This relationship is shown in Fig. 2. The graph indicates that the ink transfer number is more sensitive to a change in y above 50 per cent transference than below.

* Also called "ink distribution number"³ and "Verteilungszahl" after Rupp and Rieche².

Considering first the fractional transference y/x which will be called r . A turning point in this function (maximum or minimum) will occur at $x = a$, where

$$\frac{dr}{dx} \Big|_{x=a} = 0$$

$$\frac{dy}{dx} = \frac{y}{x} \Big|_{x=a} \dots\dots\dots (6)$$

Differentiating again,

$$\frac{d^2r}{dx^2} = \frac{d^2y}{dx^2} \cdot \frac{1}{x} - \frac{2dy}{dx} \cdot \frac{1}{x^2} + \frac{2y}{x^3}$$

Substituting from (6),

$$\frac{d^2r}{dx^2} = \frac{1}{x} \cdot \frac{d^2y}{dx^2} \text{ (at } x = a) \dots\dots\dots (7)$$

If the ink transfer number, Y , is considered a turning point in the function $y/(x - y)$ will occur at $x = a$ when:

or
$$\frac{dY}{dx} \Big|_{x=a} = 0$$

$$\frac{dy}{dx} \left(\frac{1}{x-y} \right) \Big|_{x=a} - \frac{y}{(x-y)^2} \left(1 - \frac{dy}{dx} \right) \Big|_{x=a} = 0$$

For $x \neq y$ (i.e. apart from the origin),

$$\frac{dy}{dx} = \frac{y}{x} \Big|_{x=a} \dots\dots\dots (8)$$

i.e. the same condition as in (6).

Differentiating again,

$$\frac{d^2Y}{dx^2} = \frac{d^2y}{dx^2} \cdot \frac{x}{(x-y)^2} \Big|_{x=a} \dots\dots\dots (9)$$

Therefore, d^2Y/dx^2 at the turning point has the same sign as d^2y/dx^2 .

It will be tacitly assumed that $\frac{d^2y}{dx^2} \Big|_{x=a}$ is negative and hence the turning point is a maximum. This will be substantiated later for the Laramou equation.

The condition for a maximum in either the percentage transfer or the ink transfer number is that $\frac{dy}{dx} \Big|_{x=a} = \frac{y}{x} \Big|_{x=a}$. In Fig. 4, a typical plot of y against x has been drawn and the straight portion of the graph extended to cut the y axis. The function will conform to the equation $y = b + f(x - b)$ at the point q . A straight line through the origin has been drawn to be a tangent to the function. This line touches the curve at the point p . At p , the gradient of

the curve is $\left. \frac{dy}{dx} \right|_{x=a}$. The slope of the straight line through p is also $\left. \frac{dy}{dx} \right|_{x=a}$. The equation of the straight line is $y = \left. \frac{dy}{dx} \right|_{x=a} x$. Since point p lies on the curve, its co-ordinates (x', y') satisfy equation (1). Therefore, the gradient of the tangent through (x', y') is $\left. \frac{y}{x} \right|_{x=a}$. Hence a maximum value of either the percentage transfer $100y/x$ or the ink transfer number $y/x - y$ will occur when $x = a$. This analysis holds provided the function $y = f(x)$ is monotonic increasing for $x > a$.

It can be noted that p and q cannot coincide unless the intercept is zero. If the intercept is zero, $b(1 - f) = 0$. As $f < 1$ and $b = 0$, such a case could occur when printing on non-absorbent plastic foil. Generally, p and q will not coincide and it follows that the point p must lie on the curved part of the graph. An analysis of the point p can be made only by using the full form of the transfer equation.

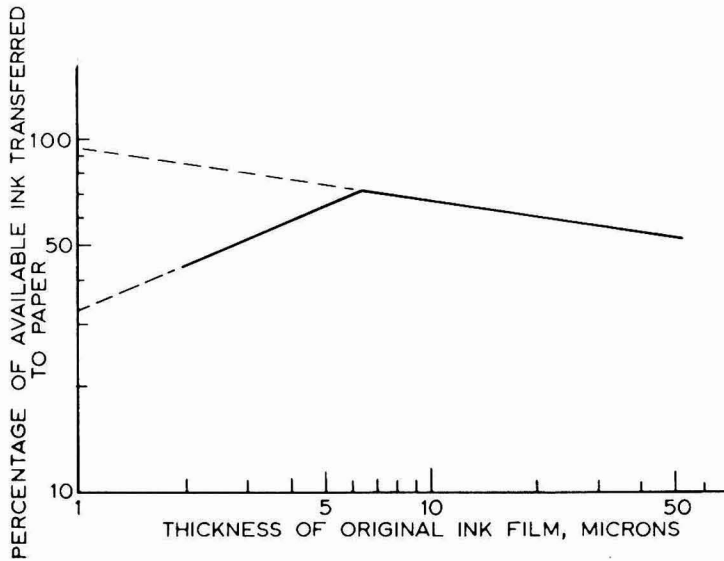


Fig. 5a. Per cent transfer curve using ANPA equation

This graphical approach enables the investigator to ascertain the position of the peak very rapidly from the transfer curve. As indicated in Fig. 2, the ink transfer number is more sensitive than the percent (or fractional) transference to changes in y greater than 50 per cent transference. The ink transfer number is therefore preferred when analysing the peak value. Such an approach will also assist in comparing ink transfer and percentage ink transference data.

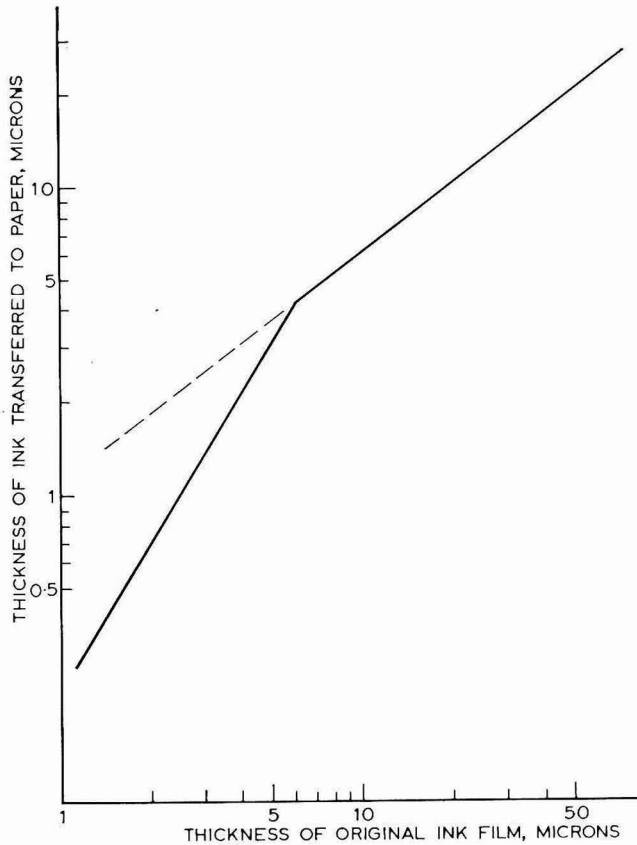


Fig. 5b. Ink transfer curve using ANPA equation

The Walker-Fetsko equation (1) will only become $y = b + f(x - b)$ when $e^{-kx} = 0$, i.e. $kx = \infty$ and $e^{-x/b} = 0$, i.e. $x/b = \infty$. As k and b are required to be finite, the equation only tends to be that of a straight line as x tends to infinity. In practice, it is found that the curve approximates to a straight line for finite values of x . It must therefore be assumed either that the equation is inaccurate or that it is accurate to (say) 5 per cent. The values of x that in both cases will give 95 per cent of unity of the functions $(1 - e^{-kx})$ and $(1 - e^{-x/b})$ for specified values of k and b can be calculated. From the work of Fetsko and Walker, typical values of k and b might be $2 \text{ (g m}^{-2}\text{)}^{-1}$ and 5 g m^{-2} respectively. Fig. 7 shows the plot of $p = (1 - e^{-q})$. For an accuracy of 95 per cent, the required value of the exponent is given by:

$$(1 - e^{-q}) = 0.95$$

$$e^{-q} = 0.05$$

$$q = 3$$

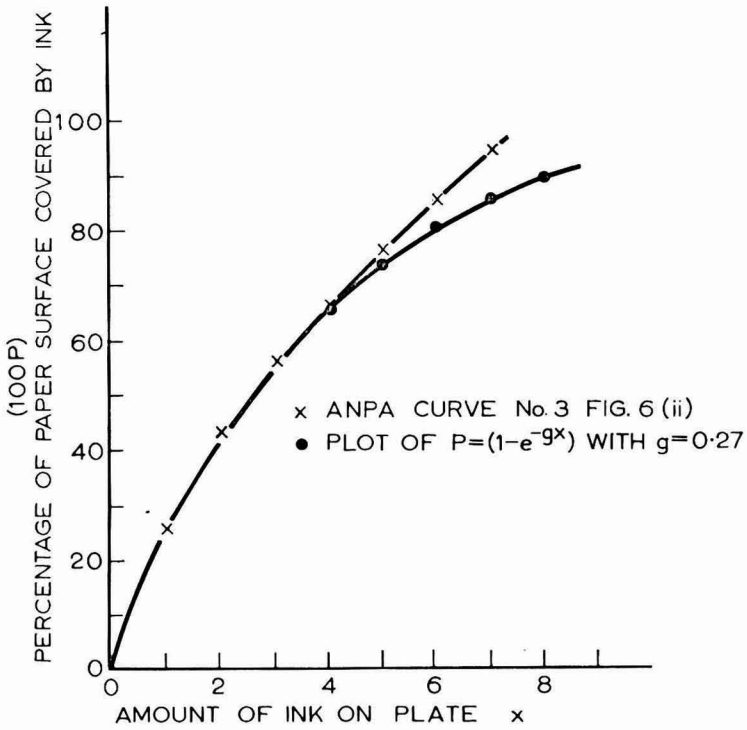


Fig. 6. Calculated percentage of nominal paper surface covered by ink versus amount of ink on plate before transfer compared to the function $P = (1 - e^{-gx})$

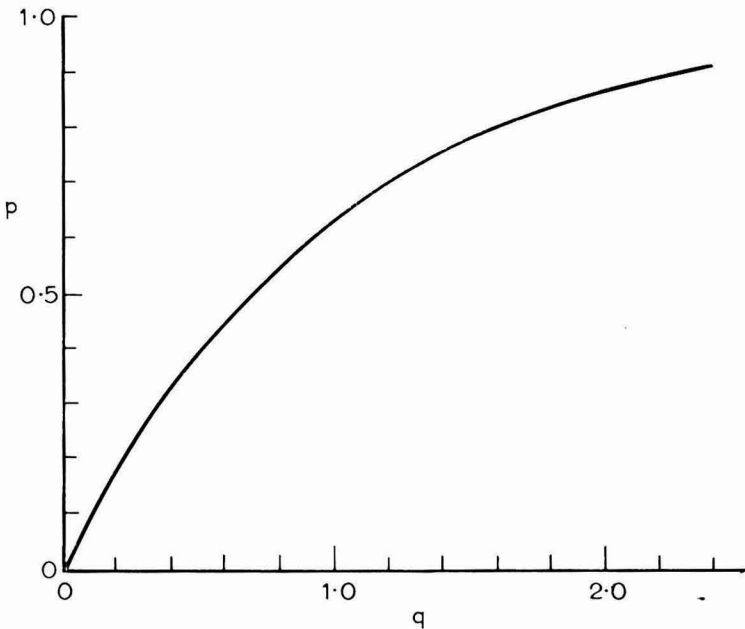


Fig. 7. Plot of function $p = (1 - e^{-q})$

In the case of the function $(1 - e^{-kx})$, it approximates unity to 95 per cent at the value of $x = q/k = 1.5g \text{ m}^{-2}$.

With the second function $(1 - e^{-x/b})$, this will approximate unity to 95 per cent at the value of $x = bq = 15g \text{ m}^{-2}$.

If second order errors are ignored, a significant approximation to a linear plot is obtained for values of $x > 15$.

Rupp and Rieche² found the function $(1 - e^{-x/b})$ to fit their results satisfactorily. However, they derived a smoothing factor $(1 - e^{-a^2/x^2})$ by assuming that the increase in the fractional ink coverage was proportional to the fraction of paper not covered and the amount of ink on the plate before printing. The coefficient a was related to paper smoothness in a similar manner to k . If D is the fraction of ink coverage when x is small, and by choosing the constant of proportionality as $2a^2$,

$$\frac{dD}{dx} = 2a^2x(1 - D)$$

$$\frac{1}{(1 - D)} dD = 2a^2x dx$$

Integrating,

$$- \ln(1 - D) = a^2x^2$$

$$1 - D = e^{-a^2x^2}$$

$$D = (1 - e^{-a^2x^2})$$

They therefore proposed the following equation:

$$y = (1 - e^{-a^2x^2}) \{ b(1 - e^{-x/b}) + f[x - b(1 - e^{-x/b})] \} \dots \dots \dots (10)$$

(bearing in mind that their original symbols have had to be transposed for the sake of consistency).

The basis for proposing an equation in the form of (10) was similar to that of Walker and Fetsko (1), viz.:

- initial incomplete contact of paper with ink (as above),
- acceptance of ink up to a maximum capacity,
- split of excess ink in any constant percentage.

It is seen that Rupp and Rieche's a^2 is similar to Walker and Fetsko's k/x , which is non-restricting as k and x are always positive. The difference between equations (10) and (1) is the exponent within in the first bracket. The Rupp and Rieche exponent has an x^2 term compared to the x term of Walker and Fetsko. The difference is best shown graphically as in Fig. 8. Curve 1 shows the plot of the Walker-Fetsko function with $k = 2$, which can be compared with the Rupp and Rieche function with $a^2 = 2$. Curve 3 has been drawn to coincide at the average value $p = \frac{1}{2}$.

At this point,

$$e^{-2q} = \frac{1}{2}$$

$$q = 0.35$$

$$(1 - e^{-a^2q^2}) = 0.5 \text{ at } q = 0.35$$

$$e^{-a^2q^2} = 0.5$$

$$a^2q^2 = 0.7$$

$$a = 2.4 \text{ (} a^2 \approx 6 \text{)}$$

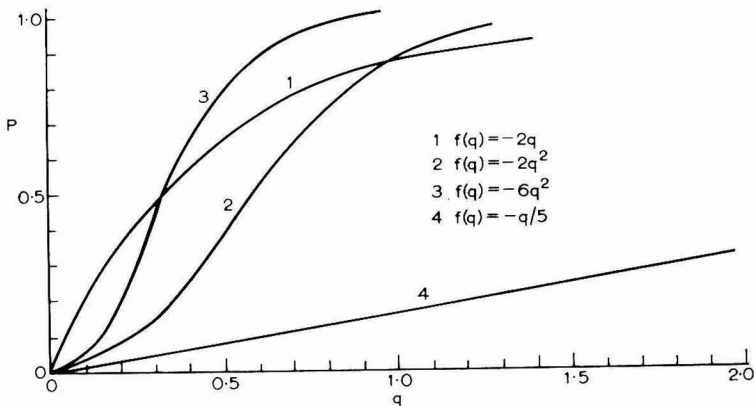


Fig. 8. Plots of $p = (1 - e^{f(q)})$

It can be seen that a^2 has to be approximately three times the value of k to give the same effective smoothing in the middle of the range. The values of k used in practice by Walker and Fetsko were between 1 and 10 $(\text{g m}^{-2})^{-1}$. The values of a according to Rupp and Rieche were much lower, namely about 0.15 to 1.0. If higher values of a had been used by Rupp and Rieche, the plot of the theoretical trace would be further to the left of the graph (smaller values of x) and hence closer to the observed results. But clearly a compromise is reached as the peak value is inclined to be increased. As the theoretical trace conforms well to the observed results, a value close to the optimum has been selected. An alternative approach might be to explore an exponent with a power of x between 1 and 2. This, in fact, forms the basis of the work by Wulsch and Schubert⁵. They found a better fit was obtained with the factor $(1 - e^{-(kx)^{2/3}})$ compared to either the Fetsko-Walker or the Rupp and Rieche expressions.

In Fig. 8, curve 4, the trace of $(1 - e^{f(q)})$ has also been plotted with $f(q) = -q/b$ and $b = 5$, which is a typical value from the Walker-Fetsko data. This curve shows the pronounced difference in the smoothing factors $(1 - e^{-2q})$ and $(1 - e^{-q/5})$. In the range $1.5 < q < 15$, the $(1 - e^{-2q})$ factor can be ignored as it is within 5 per cent of unity.

Rupp and Rieche have shown their preference for concentrating on the peak areas at the expense of the very thin film region where measurement is difficult. Despite this fact, it is surprising that the values of a as recorded are so low compared to the Walker-Fetsko values. The actual value of y is dependent on the product of the two smoothing factors. By selecting low values of k and b , the net change in y need not necessarily be very large. This may account for the differences in the values of k and a selected by the two groups of investigators.

It has been shown in this comparison that the ink transfer number after Rupp and Rieche and the per cent ink transference after Walker and Fetsko are similar. Peak values occur for both at the same value of x . This common value of x may be determined from the transfer curve (see Fig. 4) by drawing a tangent to the curve passing through the origin.

The Laraignou equation

It has already been seen that $(1 - e^{-kx}) \approx 1$ for $x > 1.5$ and typical values of k . The Walker-Fetsko equation may be written in the approximate form:

$$y = \bar{b}(1 - e^{-x/\bar{b}}) + f[x - b(1 - e^{-x/b})] \text{ for } x > 1.5 \dots\dots\dots (11)$$

The turning point occurs in the region $0 < x < 1.5$ and this equation cannot be used to analyse the value of x at which the peak in the percentage transfer curve occurs. It is possible, however, to compare the modified equation with Laraignou's equation,⁶ which may be written:

$$y = (1 + c^2/x^2)^{-1} \cdot [fx + b(1 - f)] \dots\dots\dots(12)$$

or
$$y = b(1 + c^2/x^2)^{-1} + f[x(1 + c^2/x^2)^{-1} - b(1 + c^2/x^2)^{-1}]$$

The coefficient c is associated with the smoothness of the paper and could be shown to be proportional to E (see Ginman⁷).

The similarity between the functions $(1 - e^{-x/b})$ and $(1 + c^2/x^2)^{-1}$ is most striking. Fig. 9 shows the two curves taking $b = 6.25$ and $c = 5$. The two

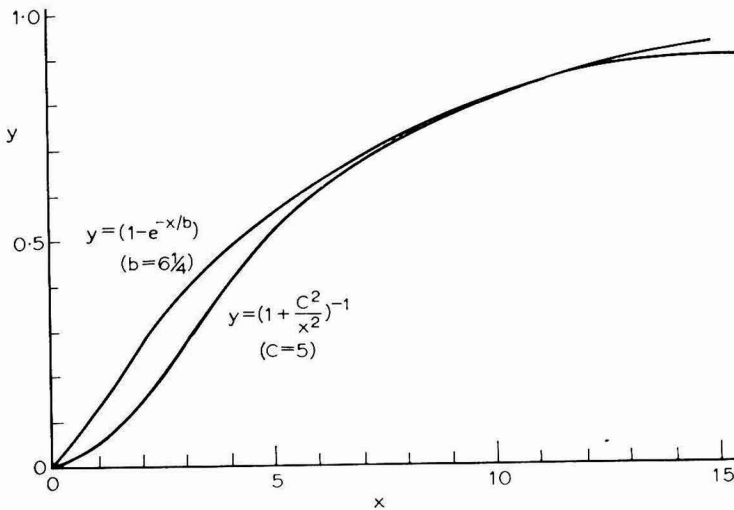


Fig. 9. Plots of $y = (1 - e^{-x/b})$ and $y = (1 + c^2/x^2)^{-1}$

curves can be made to fit at any one point. If the functions are equated, the relationship derived is:

$$(x^2 + c^2) e^{-x/b} = c^2$$

or
$$b = \frac{x}{\ln\left(\frac{x^2 + c^2}{c^2}\right)} \dots\dots\dots(13)$$

If a typical value of x (say $x = 10$) is taken with $c = 5$, then $b = 10/1.61 = 6.25$. As shown in Fig. 9, the functions are equally valued at $x = 10$.

An advantage of the Laraignou equation is that differentiation is relatively simple:

$$y = (1 + c^2/x^2)^{-1} [fx + b(1 - f)]$$

$$\frac{dy}{dx} = \frac{fx^2}{x^2 + c^2} + \frac{2xc^2[fx + b(1 - f)]}{(x^2 + c^2)^2}$$

$$\frac{dy}{dx} = \frac{y}{x} \text{ at } x = a$$

when

$$\left. \frac{x^2[fx + b(1 - f)]}{(x^2 + c^2)} \right|_{x=a} = \frac{fx^3}{x^2 + c^2} + \frac{2x^2c^2}{(x^2 + c^2)^2} \{fx + b(1 - f)\}$$

$$x^2b(1 - f) - 2fxc^2 - c^2b(1 - f) \Big|_{x=a} = 0 \dots\dots\dots(14)$$

By inserting particular values in (14) the position of the peak value can be obtained. For example, with $f = 0.5, b = 9, c = 5$ there is a turning point at $x = 8.8$. By using these values and differentiating again it can be shown that d^2y/dx^2 is negative. This means the turning point is a maximum.

Central Laboratory parameters

The Central Laboratory⁷ parameters E and H were proposed by Ginman and associates of the Finnish Pulp and Paper Research Institute. E is the amount of ink in microns* on the printing plate prior to printing at which 50 per cent transfer occurs in the thin film region. In this area where $x < x_{max}$, E is largely determined by the function $(1 - e^{-kx})$ and is related to k , the printing smoothness. H , also in microns, is the ink transferred in excess of 50 per cent at the peak of the curve. (From the original work of Ginman⁷ it appears that E and H may have been expressed in $g\ m^{-2}, q.v.$)

In Fig. 10a a typical y versus x curve is plotted with a tangent to the curve through the origin, thus locating the point and its x co-ordinate, OR , at which maximum per cent ink transference occurs (Fig. 10b). The point A is the point at which $y = x/2$ in the thin film region. If the x co-ordinate of point A has a value OS , distance OS is the parameter E as shown. The line $y = x/2$ has been drawn which passes through A and cuts BR in C . The length BC is H . In Fig. 10b, OT is E .

Percentage transfer = $\frac{100y}{x}$; $y = \frac{x}{100}$. (per cent transfer).

If p is the peak transfer per cent, y_{peak} is given by $OR\ p/100$.

From the above definition

$$H = y_{(x = OR)} - \frac{OR}{2}$$

If M is in per cent as shown in Fig. 10b,

$$H = \frac{M \cdot OR}{100} \dots\dots\dots(15)$$

*According to Fetsko, *Tappi*, 1958, (2), 51.

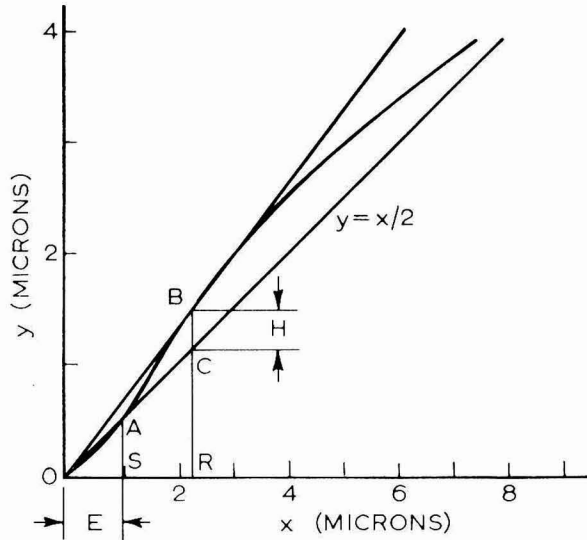


Fig. 10a. Transfer curve

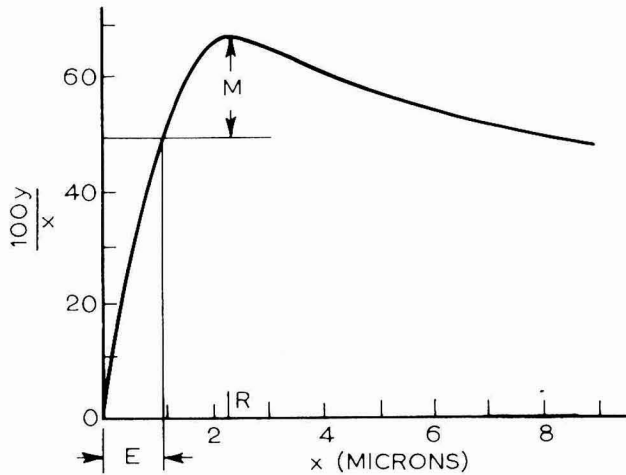


Fig. 10b. Per cent transfer

The importance of units has already been mentioned when comparing data. Ginman's parameters are usually expressed in microns which can be converted to g m^{-2} using the relationship $1 \text{ micron (micrometer)} = \rho \text{ g m}^{-2}$, where ρ is the ink specific gravity (in g ml^{-1}). To obtain the thickness of the film in microns ($1 \text{ micron} = 10^{-4} \text{ cm}$), the areal weight in g m^2 is divided by the density in g ml^{-1} .

Comparison of ANPA and Walker-Fetsko formulae

As early as 1953, the American Newspaper Publishers Association⁸ had put forward the premise that the total non-absorbed ink divides equally between the substrate and the plate. Their equation

$$T = \frac{1}{A} \left\{ a + \frac{A - a}{2} \right\} \dots \dots \dots (16)$$

relates T , the fraction of available ink transferred to the total available ink A , and a , the ink absorbed on the paper surface. A and a are in weight per unit area units and T is dimensionless. This equation forms the basis of the Walker-Fetsko equation (1) published in 1955. Two smoothing factors $(1 - e^{-kx})$ and $(1 - e^{-x/b})$ have been introduced into the Walker-Fetsko equation, and they tend to unity at larger values of x . The Walker-Fetsko equation for thick films then becomes

$$y = b + f(x - b).$$

If y , x and b are measured in g m^{-2} we see that:

$$\begin{aligned} y/x &= T \\ x &= A \\ f &= \frac{1}{2} \\ b &= a \end{aligned}$$

and the equations are seen to be identical.

A greater number of coefficients have been introduced into the Walker-Fetsko equation that depend on ink, paper and printing conditions. It is important to emphasise that the f in the Walker-Fetsko equation is a constant for an ink/paper/conditions arrangement and does not stand for "function of" as is widely used in mathematics. The coefficient f can assume values other than $\frac{1}{2}$ which is an obvious limitation of the ANPA equation. The smoothing factors $(1 - e^{-kx})$ and $(1 - e^{-x/b})$ have complete flexibility in one constant each, b and k respectively, in addition to being functions of the film thickness x . It can be argued that three approximations have been used in obtaining these functions from the observed results. Step 1: to establish an equation of the general form $(1 - e^{-z})$. Step 2: to observe that z increases proportionately with x . Step 3: to evaluate the best fitting constants k and b respectively. The functions are clearly very flexible and could even be described as "sloppy".

If the expression $b(1 - e^{-x/b})$, which is the Walker-Fetsko equivalent to the ANPA a (provided $(1 - e^{-kz}) = 1$), is inspected, it is seen that b occurs in two positions. It is therefore possible to approximate this expression to the observed results by adjusting b either to give a larger or smaller value or to approach the quantity of immobilised ink at thicker or thinner ink films. Fortunately, papers and ink combinations possessing large values of b have their peak percentage transfer values at greater film thicknesses. Hence an increase in b will effect a change in the two directions most commonly required in practice.

There is little point in working with the ANPA equation as this has less flexibility than the Walker-Fetsko equation. However, before totally dispensing with the ANPA approach in favour of the similar but more sophisticated methods of Walker and Fetsko, certain aspects of the work have advantages of independent merit which should not be ignored.

The ANPA emphasised a technique for obtaining the smoothing factor which is the fraction of the paper surface covered in ink. They made the

observation that logarithmic plots of both percentage transfer and film thickness transfer against original film thickness on the plate appeared to be linear in two distinct portions for the thin and the thick film regions, on either side of the peak value in the percentage transfer curve. At the intercept (break) of the two sections of the plot, some discrepancy was observed. This is the region where the one type of transfer mechanism could have been having a significant effect on the other.

On either side of the break, either:

$$\log y/x = C' - S \log x \dots\dots\dots (17a)$$

or $\log y = c' + s \log x \dots\dots\dots (17b)$

where S and s are the slopes of the two logarithmic plots and C and c are constant. (See Figs. 5a and 5b.)

These equations may be written:

$$y/x = Cx^{-S} \dots\dots\dots (17c)$$

where $C' = \log C$, and

$$y = cx^s \dots\dots\dots (17d)$$

where $c' = \log c$.

As $\log y/x = \log y - \log x$:

$$\log y = C' + (1 - S) \log x \dots\dots\dots (17e)$$

Comparing (17e) with (17b), it is seen that:

$$C' = c', (1 - S) = s, \text{ and hence } c = C.$$

From the value on the logarithm plots at the point $x = 1$, c' can be obtained. Equations (17c) and (17d) are completed by reading off the slope on one graph and computing the other as $(1 - S) = s$.

By using the technique as described by ANPA of extrapolating the thick film plots into the thin film region, the percentage of paper surface covered by ink can be obtained. These curves approximate to the function $P = (1 - e^{-gx})$, as shown in Fig. 6. Curve 3 from Fig. 6 of the work of the ANPA has been selected and approximated to $P = (1 - e^{-gx})$ with $g = 0.27$.

The transfer equation could now be written:

$$y = (1 - e^{-gx}) c x^s \dots\dots\dots (18)$$

containing three coefficients.

Comparison of ANPA and Joyce and Fuchs formulae

The ANPA technique of obtaining the smoothing factor $(1 - e^{-kx})$, also called F , can be compared with the procedure adopted by Joyce and Fuchs.⁹ By plotting $\ln(1 - F)$ against the quantity of ink available for transfer, they established the relationship $\ln(1 - F) = -(mx + c)$ where $-m$ is the slope of the observed straight line and $-c$ is the intercept. Hence F is of the form $(1 - e^{-(mx+c)})$. This introduces a fourth coefficient, c , which was found to be zero for a contact screen etch and 0.5 for a conventional etch.

The transfer equation can be written as:

$$y = F \{ \varphi(b) + f(x - \varphi(b)) \} \dots\dots\dots (19)$$

If it is assumed that $\varphi(b)$ is of the form $b(1 - e^{-x/b})$, values for this expression for the ink immobilisation can be calculated using the known values of b and f and selecting particular x values in the thin film region. Hence, values of F can be obtained for values of x from:

$$F = \frac{y}{\varphi(b) + f(x - \varphi(b))}$$

The results obtained appear to be similar to smoothing curves of the type $y = (1 - e^{-(mx+c)})$ which approach unity asymptotically.

A comparison of these two methods shows that a function $F_1 = (1 - e^{-(mx+c)})$ is obtained from the Joyce and Fuchs equation, and a function

$$F_2 = \frac{c_1 + m_1 \log x}{c_2 + m_2 \log x} \quad \text{from the work of the ANPA.}$$

The nature of F_2 is clearly seen from Fig. 5b where m_1 is the slope in the thin film region and m_2 is the slope in the thick film region; c_1 and c_2 are the intercepts on the vertical log axis.

These two functions can be expanded as follows:

$$\begin{aligned} F_1 &= 1 - e^{-c}e^{-mx} \\ &= 1 - e^{-c} \left(1 - mx + \frac{m^2x^2}{2!} - \dots\dots \right) \\ &= 1 - e^{-c} + mxe^{-c} - \frac{m^2x^2}{2!} e^{-c} + \dots\dots \end{aligned}$$

Also, if it is assumed that

$$F_2 = a_0 + a_1x + a_2x^2 + \dots\dots$$

then

$$c_1 + m_1 \log x = (c_2 + m_2 \log x) (a_0 + a_1x + a_2x^2 + \dots\dots)$$

$$\begin{aligned} c_1 + m_1x - m_1x^2/2 + m_1x^3/3 - \dots\dots &= (c_2 + m_2x - m_2x^2/2 + \dots\dots) \\ &\quad (a_0 + a_1x + a_2x^2 + \dots\dots) \end{aligned}$$

that is $a_0 = \frac{c_1}{c_2}$

and $a_0m_2 + a_1c_2 = m_1$

$$a_1 = \frac{c_2m_1 - m_2c_1}{c_2^2}$$

$$F_2 = \frac{c_1}{c_2} + \frac{m_1c_2 - m_2c_1}{c_2^2} + \dots\dots$$

Comparing these two expansions, it is seen that they are identical if

$$1 - e^{-c} = \frac{c_1}{c_2} \dots\dots\dots (20)$$

and

$$me^{-c} = \frac{m_1c_2 - m_2c_1}{c_2^2} \dots\dots\dots(21) \text{ etc.}$$

This shows a close relationship between the two approaches, although they were developed for different printing methods. The two functions appear at first sight to be quite different in nature, but, provided the units are modified, they are interchangeable. The Joyce and Fuchs function is marginally simpler to derive, but the ANPA expression is more general as it contains twice as many coefficients.

Ichikawa, Sato and Ito

Alternative functions to the exponential types hitherto mentioned have been used by the Japanese workers, Ichikawa, Sato and Ito.¹⁰ Two normal logarithmic functions with different standard deviations (σ) and means (μ) have been used in the same positions in the transfer equation as the exponential types. The logarithmic normal function is:

$$N_L(\mu\sigma^2) = \frac{\log e}{\sigma\sqrt{2\pi}} \int_0^x \frac{1}{x'} \exp \left[-\frac{(\log x' - \mu)^2}{2\sigma^2} \right] dx$$

The variables in this expression for a particular value of x are σ and μ . By inserting two such logarithmic normal functions with standard deviations σ_1 and σ_2 and means μ_1 and μ_2 into the transfer equation, the following expression is obtained:

$$y = N_L(\mu_1\sigma_1^2)\{b N_L(\mu_2\sigma_2^2) + f[x - b N_L(\mu_2\sigma_2^2)]\} \dots\dots\dots (22)$$

In this case, there are six coefficients. A trace of the logarithmic normal function is shown in Fig. 11 which is seen to be similar to the function $(1 - e^{-mx})$. Hence, a close similarity between the work of the Japanese and the other investigators already discussed in this paper is apparent.

Strong arguments have been put forward for using a logarithmic normal type of function based on the statistical distribution of pore sizes in paper. This equation has the greatest relevance to fundamental aspects of ink transfer and could form a sound basis for future studies. In view of the greater number of coefficients involved, a closer fit to observed results can be expected, although the interpretation of the significance of the constants may be more difficult.

Conclusion

A simple expression is preferable to unwieldy functions, particularly if the coefficients can be related to well defined physical properties of the ink, paper and machine. It has not been possible to do this with complete satisfaction

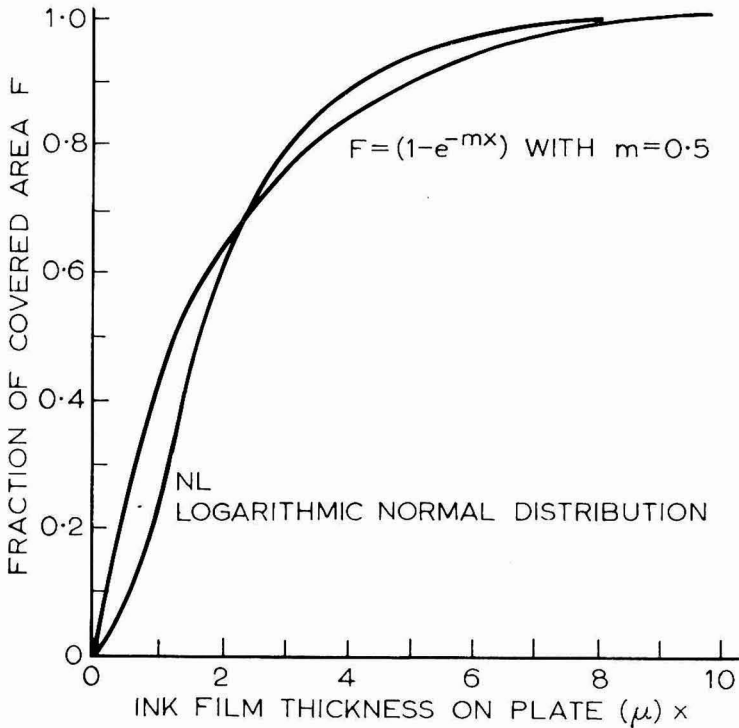


Fig. 11. Comparison of logarithmic normal distribution and exponential type function

for functions containing three coefficients (e.g. Walker-Fetsko equation). It can be concluded that three coefficients are insufficient due to interactions. Expressions containing a greater number of coefficients can be expected to match empirical results better. However, as the number of coefficients is increased, generally the divergence from an original simple hypothesis is correspondingly increased.

Ad hoc empirical equations have their place in research, but fundamental laws are mostly simple in form. The ink transfer process should be capable of explanation in simple physical laws, but in the foreseeable future more or less empirical equations will have to be used.

Every scientist welcomes new contributions, but the number of isolated investigations carried out so far in ink transfer clearly indicate that units of measurement and terms of reference have been ill-defined in the past.

Acknowledgments

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Next month's issue

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

"The blistering of paints on wood induced by moisture:

Part I The influence of some structural variables of pine wood on the blistering induced by moisture of an alkyd paint film,

Part II The influence of various treatments of pine wood on blistering caused by moisture," by C. Patteryranie and U. Ulfvarson

"Composition of dehydrated castor oil alkyds prepared by different routes," by N. A. Ghanem, M. A. El-Azmirly and Z. H. Abd El-Latif

"The Koenig and Persoz pendulum damping tests," by R. A. Fish and R. L. J. Morris

Correspondence

SIR,—I seem to recall a time when the *Journal* provided a source of information for paint chemists, as the title implies. Lately, however, I observe a tendency for the physicists and mathematicians to take over. Their contributions, however elegantly presented, and whether of any practical value or not, will remain for me eternally incomprehensible. Would it not be possible to publish the odd article specifically oriented towards the chemistry of paints and polymers, reserving these tedious pages of integrals and probability statistics for a more appropriate publication?

Yours faithfully,

E. M. Cowen.

45 Broadway, Wickham,
Newcastle upon Tyne,
19 November 1971.

Hon. Editor replies

The comments made by Mr Cowen are appreciated. However, the sources from which papers for the *Journal* are drawn were given in a reply to an earlier letter to the Editor (*JOCCA* 1971, **54**, 795).

The policy of the *Journal* for many years has been to solicit papers only under most exceptional circumstances. The papers published, because of the sources from which they are drawn, must largely reflect the broad interests of the Sections and our readers.

If suitable papers were to be presented on more chemical topics, they would certainly be given favourable consideration, but it would seem that at present little work (where publication would be permitted) is being carried out. The current trend would appear to be towards more physical and mathematical investigations.

Reviews

INTRODUCTION TO POLYMER SCIENCE

BY L. R. G. TRELOAR. London: Wykeham Publications (London) Ltd. 1970.
pp vii + 183. Price £1.50

The only fault to be found with this book is its title. Those who know Professor Treloar will not be surprised to find that he writes on the chemical physics of polymers, but the sixth-formers to whom he addresses himself may be misled into expecting some chemistry as well. There is nothing on polymer synthesis, reactions or kinetics, or on functionality theory.

The aim of the book is to inculcate a broad understanding of the relationship between structure and physical properties. This is achieved with crystal clarity and with no more demand on the reader than an A-level knowledge of science. The achievement is the more remarkable in that maths is almost entirely dispensed with: skilful verbal presentation and superb diagrams are the secrets of the author's success. If one were to read it in bed, one would be kept awake by interest rather than by the need for mental gymnastics.

A brief introduction to polymer types leads to a discussion of molecular weight, size and shape which enables the ideas of conformation and configuration to be introduced without any of the obscure jargon which so often makes these topics appear more difficult than they are. There follow chapters on rubber elasticity, the glassy state, crystallinity, fibres and fibre formation, strength and fracture, water absorption and swelling, and viscoelasticity. Each chapter builds logically on what has gone before, and ends with a half-page summary of the essential points made.

This little book may be read with profit and enjoyment by all who are interested in the why's and wherefore's of polymer properties. It provides a balanced perspective which many with specialised leanings towards polymer *chemistry* would do well to acquire.

A. R. H. TAWN

PIGMENT DISPERSION—A SELECT BIBLIOGRAPHY 2ND EDITION

BY N. L. MOORE, Hertfordshire County Council Technical Library and Information Service, Hatfield Polytechnic, Herts. pp 65 + xiii. Price 25p

The appearance of a second edition of this booklet so soon after the first (*JOCCA* 1971, **54**, p. 290) is an indication of its success. The literature coverage has been extended up to mid-1971. The general form and context of the booklet remains the same, and the reviewer is pleased to see the inclusion of 26 references to foreign language literature (mainly German), following the comments made in several reviews of the first edition. The book is well classified, and there is a combined author/subject index which is reasonably complete. By some strange chance, the present reviewer's work is indexed under Cozzens, V. T., while S. L. Cozzens' work (abstract 158) is missed.

In all, the book is to be recommended both to the student and to the advanced worker in the field as a valuable guide to the literature.

V. T. CROWL

Chapter II. Raw materials: Storage and handling

The average paint factory must store a substantial number of raw materials—some of which, by virtue of their high inflammability, are subject to legislation.

Materials handling

Whatever the size of the factory, the handling of materials warrants careful thought, as the cost of handling and losses arising from careless storage can be substantial. The number of operations involving the handling of raw materials during which losses can occur is considerable, for instance:

- (1) during transport to the factory site;
- (2) offloading from the transport;
- (3) when loading on to internal transport, conveyor etc;
- (4) unloading into the stores;
- (5) during removal from the stores weighing or measuring, and finally loading into the machine;
- (6) during removal from one machine to another for tinting, tanking, straining etc;
- (7) during filling and labelling;
- (8) when taking to warehouse or loading bay;
- (9) when loading on to transport for delivery or despatch;
- (10) during offloading at a depot or the customers receipt point.

None of the above operations is avoidable, but the list serves to illustrate the importance of materials handling and why it should never be neglected. Considerable economies in production costs may be effected by employing mechanisation where practicable. Commonsense must be applied to each of these operations, and consideration given to the frequency of occurrence of any particular operation, the quantity of material to be shifted, and so on; for example, a known requirement of 25kg of dry pigment at a certain point three times weekly would hardly warrant a conveyor system, but if the same conveyor could be used continuously in moving other goods, then its installation should soon repay the capital outlay involved. Generally, it may be reckoned that, in medium to small paint factories, movement of dry raw material is not sufficiently continuous to necessitate the installation of mechanical conveyors, and handling equipment usually comprises (a) cranes, lifts, hoists, or similar mechanical elevating or cross-moving apparatus, (b) fork lift trucks (of pedestrian operated or passenger type) capable of moving about the factory and also of raising the goods to a maximum height of 15ft, (c) electric trucks, (d) gravity roller tracks which allow goods to travel downwards to the point of use from an elevated store (usually employed from filling department to packing department), (e) pallets, (invariably made from wood or reinforced plastic) which may be

moved by (b) or (c) or by manually operated stillage trucks—whose value lies in the easy movement of up to 1,000kg at a time—and on which goods may often be stored ready for use.

It should be noted that fork lift trucks can be sub-divided into different types, each designed for a particular job: counter-balanced (forks projecting at front for lifting); outrigger or straddle (front wheels pass outside the load and can handle up to 1½ tonnes); reach (forks travel horizontally from beyond front wheels to bring load back over wheel base).

Recently, interest has been aroused in a system of bulk or semi-bulk handling for liquids and solids. The basic principle of this system is that a single container is employed from beginning to end (i.e. from raw material supplier to the point of usage), and is re-usable. These containers are designed to handle and dispense liquids or solids, and are themselves moved and stacked by means of fork-lift trucks; the general advantage is their suitability for any means of transportation. A properly thought-out lay-out using this type of system can undoubtedly assist in cutting materials handling costs. It is claimed by one American paint manufacturer that a saving of 5 per cent on raw material costs resulted when this type of system became fully operative.

Consideration of the handling equipment most suited to the unit being planned should also embrace the actual stores concerned; e.g. a fork lift truck might be employed in the stores for stacking suitable packages to a safe height, thus utilising airspace to the maximum. The same truck might also be used for handling 180 litre drums, in order to utilise its time to the maximum. It should be remembered that the same truck may also be used to handle bulk material in process and containers of finished goods produced by the unit, so that its idle time could eventually become practically negligible.

Liquid handling

Liquid handling by pipeline and pumping is frequently adopted, since in many cases the quantities to be moved warrant the capital outlay involved. If such mechanisation is not justified, then gravity discharge, simple pouring, or mobile pumps (either power or manual) are the methods usually employed. Gravity is the usual motivating force where bulk storage is of the elevated gantry type, but for ground level or underground storage tanks, the method of discharge is usually either by compressed air or pump. Compressed air is useful, and an arrangement such as that shown in Fig. 5 is employed. The compressor should be capable of generating about 350-560g cm⁻² for effective solvent movement and, provided a large enough air storage tank is installed in the system, such a scheme will handle a number of solvent storage tanks if each in turn can be connected to a number of measuring tanks; flow meters can be used in place of the measuring tanks but this is more costly. Discharge from the measuring tank may be gravitational or by pump, and the liquid is led to whatever receptacle is intended to receive it. One drawback with compressed air delivery is the need to “blow down” (i.e. release the pressure in each solvent tank) when the plant is not working. This may mean a daily operation and, when working with low boiling point solvents, losses by evaporation may become excessive.

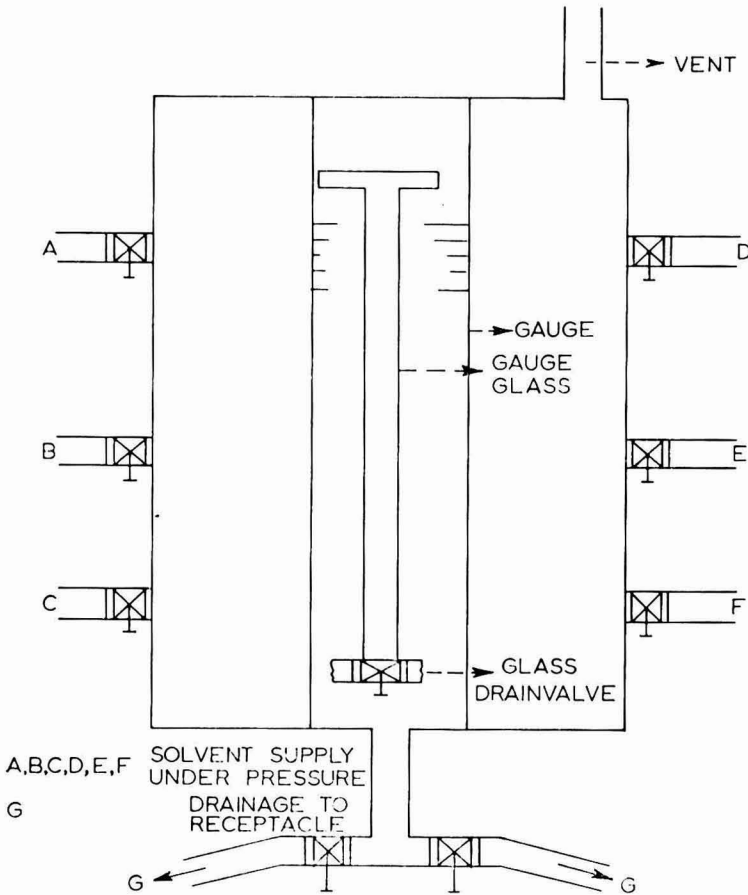


Fig. 5. Measuring tank using a solvent supply under compressed air

Pumps may be used to move practically any liquid encountered in the paint industry, but it must be realised that different types of liquid often call for different types of pump. Table 2 indicates the types of pump commonly used and gives some comments on them.

Solvents are frequently handled in bulk by the type of pump/flow meter combination commonly used for dispensing motor fuel. It is possible to employ one pump/meter unit connected to several different tanks, using independent supply pipes and cut-off valves to eliminate any risk of back contamination; it is not possible to drain the pumps and flow meters involved completely, and careful consideration must be given to the solvents linked together to any particular pump and flow meter; it would for instance be disastrous to pass a low boiling solvent through a system also dispensing white spirit, since the flash point of paints containing only the latter solvent would become lower than the statutory limit for high flash materials. Similarly, solvent sensitive products must not become diluted by even small amounts of non-solvents liable to cause precipitation of the medium. The meter installed should be of a range which will give the degree of accuracy required in the volume range

Table 2
A few simple notes about pumps

Type	General Uses	Remarks
Rotary	Viscous liquids or paste-like materials, heavy paints. Any liquid where head of pressure may vary.	Function by holding material between pump casing and either a fast moving toothed gear or a screw-type rotor. Liquid must be free from grit, abrasives etc. Usually electrically driven by universal coupling on armature shaft. May be mobile. Delivery pressures up to $140,000 \text{ g cm}^{-2}$ possible and output up to 23,000 litres per minute.
Reciprocating	Liquids of low viscosity, high volatility or flammability. Hot liquids.	Employs piston plunger or diaphragm as motivating device. May be driven by steam or electricity. Output dependent on size of pump but usually quite high.
Centrifugal	Useful for pumping solvents, oils, varnishes.	May be one or two-stage, but one is usually sufficient. Certain liquids can leak through glands with some types. The impeller may be high speed or low speed. Drive similar to rotary. Can be mobile. Output up to 14,000 litres per minute.
Displacement	Used for corrosive or abrasive liquids. Sometimes useful for moving and metering high viscosity materials.	Size of pump and type of product to be moved affect (a) output (b) power consumption (c) rate of wear.

concerned, e.g. a meter capable of metering 200 litres would not deliver accurately 0.5 litre, and so on. Another point to be considered is the delivery of liquid in bulk from tank waggons. This is most easily achieved by installing the pump house adjacent to the tank farm.

Table 2 should make it abundantly clear that the selection of the correct pump for the operation involved needs expert advice and the fullest guidance of a pump specialist should be sought before making a decision. Manufacturers will always give such advice and it is essential to make sure that sufficient information is available to them concerning the specific gravity and viscosity of liquids to be handled, the height to which the liquid is to be lifted (if any), the rate of delivery expected, what sort of operating periods are envisaged and what abrasion, corrosion or other difficult problems may be encountered. All these points are important in helping the pump manufacturer to decide what type of unit and what materials of construction should be used.

The decision as to whether to instal one or several stores will depend on the type and quantity of output of the factory under consideration. A method frequently adopted is to have a central stores for handling materials used in large quantities with a subsidiary store attached to what is often referred to as the "smalls" department.

Liquid raw material storage

Flash point below 73°F

The conditions under which these liquids are stored are governed by the Petroleum Act if the materials are of either petroleum or coal tar origin. Otherwise, no uniform control is exercised, but the local authorities may have special bye-laws. However, in the interests of safety, if low flash point solvents which are not covered by the Petroleum Act are concerned, the precautions taken should be as thorough as those set out in the Petroleum Act. When application for the petroleum licence is made, storage conditions have to be stated; and as there are always likely to be requirements for small quantities of materials in this category, the storage application should cover drums. Where the amounts of material are considerable, facilities for bulk storage should be installed.

Bulk storage: Standard tanks which comply with the construction necessary for storage of petroleum spirit are readily available in a range of sizes but, before ordering, the connections required should be carefully considered. The minimum number of these should be: a manhole of ample size for cleaning, a suction pipe for discharge, a stand pipe for filling, a vent pipe, and an opening equipped with a graduated rod for measuring the contents. Consideration should be given to possible additional connections for removal of water, an additional dip pipe for pneumatic measurement of the contents, and any other services which may be required. Once in position, access to the tank may be difficult, so that the exterior must be heavily protected by an anti-corrosive coating, and the use of a solvent resistant coating on the interior should also be considered, as some solvents can slowly attack unprotected mild steel. The usual bye-laws of the local authority may require the tanks to be below ground level; the specific requirements of an area can be obtained from the council offices. In general, however, the tank must be enclosed in a brick and concrete construction, and the space between the tank and the walls and floor may have to be filled with dry sand. (See Fig. 6)

If personnel must enter the tank to carry out cleaning operations, great care must be taken to clear all vapour before entry, or to use breathing apparatus with an external air supply. The man in the tank must have a rope attached to him for rescue purposes, and an assistant should be standing at the manhole at all times.

If a number of tanks is required, it is advantageous to group them so that a centrally situated pump house can be erected that will serve all the tanks; this allows a reduction in the number of pumps and meters required. The pumps, motors and associated gear should be of flame-proof construction, and the pumps must be fitted with by-pass valves of ample size. Accurate meters are now available, including pre-set types which deliver the quantity required automatically, and these can be sited in a measuring room adjacent to the pump house. Where a liquid is required frequently at several points in the factory, it is convenient to instal separate lines from the pump to each of these positions. A further convenience is to instal switches to operate the pumps and graduated meters near to each outlet point, in order that supplies may be-drawn as required without the necessity to send messages to the pump house. Each meter can be fitted with a recorder to register the total volume taken so that the daily

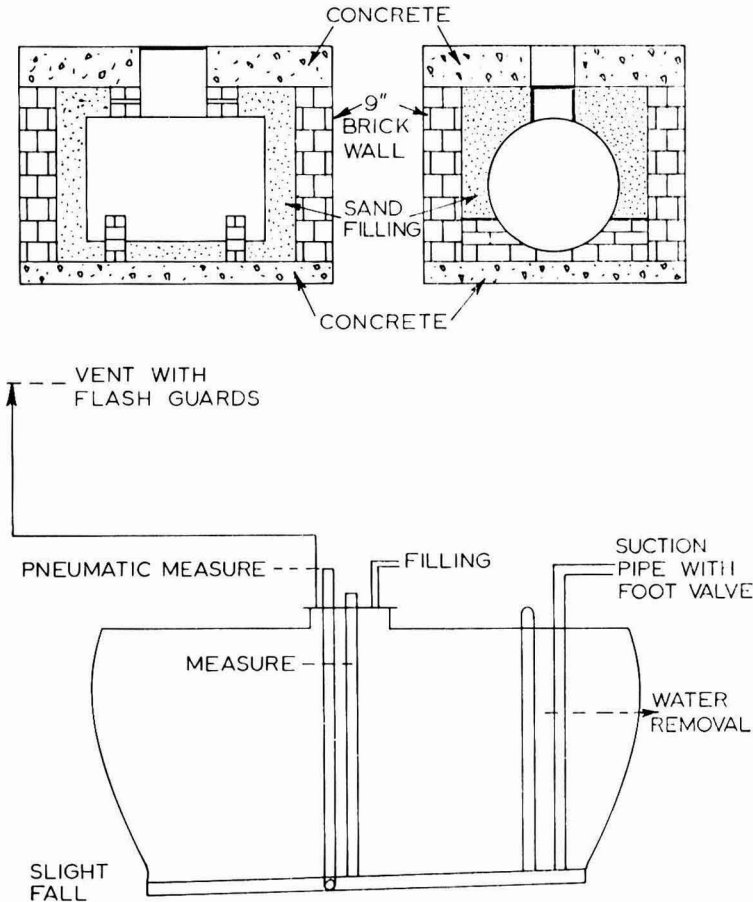


Fig. 6. Typical solvent tank installation

usage at each outlet may be ascertained. Such pipelines may be used only for one particular solvent. If long pumping lines to deliver the solvents to a process building are considered, it is essential that the petroleum inspectors and the local authorities are consulted for advice on the method to be adopted and the safety precautions to be taken. In general, however, it is better to site the tanks as near as practicable to the building they are required to serve. Bulk storage means bulk delivery, so that the siting of the tanks and buildings should allow easy access by the delivering tanker, whilst ensuring that no obstruction of the roadway takes place during delivery.

Storage in drums: If materials with a flash point below 73°F are required to be stored in drums, an outside site is essential; if possible, this should be fenced, with the access gates capable of being locked. In order to reduce corrosion risk to the packages, the floor should be adequately concreted, whilst the fencing may be of link netting. This construction is quick and easy to erect and the access gates can be arranged easily. A suggested minimum height for the fencing is 6ft. Storage space for each type of material should be marked

on the concrete, and care taken to see that the drums are used in rotation. Whenever the quantities to be used are less than complete package lots, the area should be equipped with a hand-operated drum lift device, capable of raising the drums to a reasonable height for emptying. Since these low flash point materials are generally of very low viscosity, it is suggested that, when using 180 litre standard drums, the end air vent opening should have a valve and a short length of pipe fitted into it. Using the drum lift and the valve to control the rate of flow will result in accurate measurement, safety in handling, and reduction in waste by splashing. Notices must be displayed showing that the materials stored are highly inflammable and prohibiting any naked lights or smoking. If the area is to be operated at night, adequate illumination can be achieved by overhead lighting outside the area.

Flash point above 73°F

The liquids in this category constitute the majority of paint and varnish solvents and their oil constituents. Bulk and drum storage may be used for all these materials, but careful siting of the storage for the solvents should be arranged on account of considerable fire risk.

Bulk storage: Tanks containing these solvents or oils need not be buried, and there are two methods of erection.

(i) *Storage below ground level.* An excavation is made, of sufficient plan size to accommodate all the tanks which it is proposed to use, and of such depth that the tank tops are at or near ground level. The bottom of the excavation is concreted and side walls are erected to ground level. The tanks are supported by brick or steel saddles so that they are not in contact with the ground or base and are arranged so that their under-surfaces can be inspected and maintained easily. A bridge erected over the tanks will allow for easy access to valves and dip measurement positions. The filling pipes can then be grouped at a convenient point of easy access for the road or rail tankers; suction pipes can be similarly grouped to end at a central pump house. A sump is provided in the concrete floor so that surface water can be pumped out. The sump should never be connected to the drainage system, so that no solvent or oil can accidentally reach the sewers.

This storage system has much to commend it from the point of view of safety. No materials can escape into drains or over extensive areas, and in case of fire the construction helps in the use of foam extinguishers.

(ii) *Storage at ground level.* Alternatively, the supports for the tanks can be erected at ground level on a concrete foundation area. In this case, the concreted area must have a considerable fall in its surface to allow all spillages to drain into a conveniently sited sump, but this must not be connected to the drains directly. In practice, surface water flowing from this sump passes through one or more baffle tanks to the drains; the oil and solvent thus separated can be skimmed from these tanks and disposed of. Appropriate modifications to the system must be made when dealing with liquids which are heavier than water.

In both cases, the tanks should be fitted with appropriately sized manholes, and equipped with the same series of connections as described for use with inflammable liquids, with one possible exception, that is any water accumulating

in the tank can be removed by a bottom drain at the lowest part of the tanks, which should always have a slight fall towards one end. This drain is best closed by two valves in series; as these valves are not often operated, they should be the lubricated plug type. All other connections to the tanks should be through the tank top, since this considerably reduces the risk of leakage. During cleaning, no matter what material has been stored, the precautions outlined above should be taken. The distribution and pumping arrangements may be as already described.

Storage in packages: For the storage of these liquids in drums, the fencing suggested under the storage of low flash point solvents is not necessary, but the concrete surface should, in the main, be adopted, together with the handling methods, particularly the spacing of the various materials, and the rotational use of the packages. Since there is no restriction on taking full packages into the process area, provided the normal safety precautions are taken, full drums are usually taken from the storage area. Drum supports and means of lifting the drums on to them must be provided to eliminate wasteful methods of handling. In the case of easy flowing liquids, valves fitted to the air vents are a convenient method of delivery; when viscous materials are to be used, drum spouts, the drum being on rollers attached to the stand, are satisfactory.

Use of material from drums can be wasteful if complete drainage is not obtained. All used drums should be returned to their original storage area and inspected before they are discarded. Empty drums which have contained low flash point materials should be stored in the restricted area pending return to the suppliers.

Empty raw material drums should be kept in the uncovered stores zone, and here again a little thought and care in planning the layout will save much time and probably money (returnable packages usually carry a refundable charge). Points to remember in this respect are: (a) allow sufficient ground space for the maximum number of packages likely to be on hand, or have some form of stacking, (b) have one or more notices displayed: "Make sure that all bungs or lids are properly replaced," (c) train all personnel handling empties to pack them tidily, in group according to supplier, and in such a way that rain water cannot get into the empty drum, (d) ensure that, when a delivery of full drums is being made the empties are taken away, wherever possible, by the same vehicle, otherwise work out a simple system for the regular return of the empties, (e) if empties are non-returnable, arrange for their prompt disposal through a drum reconditioning firm, the local scrap merchant, or other available means; but remember that empty drums often constitute a high fire or explosion risk.

Static electricity

When handling volatile inflammable liquids, considerable care must be taken to prevent the build-up of static electricity. If care is not taken, sparking, followed by explosion and fire, can result.

Flowing liquids may acquire a static charge, which can result in the ignition of this vapour by any sparking which may arise. Precautions must therefore be taken to ensure that all tanks, pipes, hoses and delivery vehicles shall be adequately earthed during pumping and discharging operations.

Solid raw materials

Nowadays substances such as pigments, extenders, solid resins and some additives are delivered packed in either multi-ply paper or plastic bags, or in metal containers of keg form, generally lined with paper or polyethylene. The storage conditions should be such that there will be no increase in the moisture content of the pigments, the materials must be handled so that the earliest deliveries are used first, and access for delivery and for use must be easy.

The first requirement demands control of the atmosphere in the store area, and this can be achieved by heating the area with fan heaters. If well sited, these keep the air moving as well as providing the necessary heating to reduce the relative humidity. The most careful maintenance of the roof and walls should be carried out to prevent leakage of water into the area. Considerable moisture can be absorbed from concrete floors, so that the bottom layer of all bag stacks should be insulated by the use of a false wooden floor with ample ventilation space underneath; alternatively, the stacks can be built on pallets. Moisture may also be absorbed by contact with exterior walls. In this connection, it should be realised that walls are not usually constructed so as to resist much horizontal thrust; further, old stock tends to accumulate adjacent to the wall. Consequently, bagged materials should be kept out of contact with walls. Stability can only be achieved by careful stacking, and alternate layers of bags should lie at right angles. Accurate stacking also facilitates the counting of bags during stocktaking.

The second requirement demands that the space allocated to each raw material shall be estimated and marked on the storage area floor. The estimate depends on the maximum stock of each item it is intended to carry. A stock control system will be described in a later review, but the quantities of each raw material held should never exceed a certain quantity, which fixes the overall floor space required for the material. Some additional floor space should be provided to allow for possible early or excessive deliveries. Fresh material is not ordered until a specified lower level of stock is reached. If the area covered by the maximum stock is divided into two or three separate stacks, supplies for use can be taken from one of these until it is exhausted. A second stack can then be used, and when a further delivery takes place, ample space will be available. In the meantime, the second and, if so arranged, the third original stacks can be used up, and rotational use of the stacks depending on the date of delivery can be organised. A similar system can be arranged in the case of keg packed materials but, as the contents are generally used in small quantities, there should be close supervision of the re-lidding of the kegs after use.

The third requirement deals with access for delivery and removal. Whether or not mechanical handling methods are used at the stacking area, the stacks of raw materials should be accessible from at least two opposite sides.

Mechanical handling in conjunction with pallets can often save considerable space by increasing the manageable height of the stacks, even though increased width of the passages is required to allow for the turning circle of the lifting truck. Adequate lighting of the access passages can be obtained from roof window space, which is preferable to that in vertical walls.

Further points for consideration in connection with storage of solids are shown below.

Make sure that materials are grouped to give minimum risk of contamination; thus for pigment storage, bays should be separated by light frame walls into areas for whites, extenders, colours, reds, blacks, blues etc.

The stores and the weighing section should be so constructed (solid floors, good doors) as to prevent dust dropping or drifting to mixing bays; e.g. a white undercoat being ground on an open mill can easily be ruined by helio-red drifting down on to it from an overhead store.

Ensure that adequate ancillary equipment (brooms, shovels etc.) is provided to assist in keeping the place clean and tidy. Equipment should be kept at a fixed, known point and, after being used, should be returned to that point.

If the stores acts as a combined storage area and weighing department, adequate and suitable scoops for handling dry powders should be available. Many materials delivered in bags, casks, etc. will be opened, small quantities withdrawn, and the container left until the material is needed again. Proper receptacles with lids should be installed so that the whole initial package can be put inside and kept protected, e.g. a bag of vegetable black can quite successfully be stored in an ordinary dustbin with a lid, which can be chained to the bin, and must, of course, be clearly marked. This eliminates all risk of broken bags, with consequent loss of stock, and also simplifies stores layout since a standardised receptacle can be used.

The installation of racks to utilise vertical storage space is sometimes advantageous, but requires consideration as to height, loading, and depth from front, otherwise the racks will almost certainly become receptacles for rubbish, redundant stock and so on, eventually ending up as a liability rather than an asset.

If possible, one person should be put in charge of the general running of the stores and should be held responsible for the points discussed above; this individual need not be the stock record controller but quite simply a custodian of the whole section. Good housekeeping in the raw material stores is essential for the efficient running of the factory.

The equipment for actually dispensing materials from the stores will be decided in each factory on the basis of quantity and accuracy required, and should be placed at the most strategic points. Scales or balances should be supported on rigid benches, which should have perfectly smooth tops for easy cleaning and preferably be completely clear underneath (i.e. no cupboards or shelves). It should be noted that the type of appliance installed should always be assessed in the light of possible maintenance requirements, e.g. hydraulic dial balances need proper servicing by a fully trained scale mechanic at regular intervals, so, unless such servicing can be arranged easily, their installation might not be advisable (most users of this type of apparatus have it checked every two or three months). Generally, the simplest and most robust apparatus possible, capable of giving reliable service for long periods, should be installed. Special arrangements should then be made for service engineers to visit the works at fixed intervals to keep the apparatus in good order, since inaccuracies can cause havoc with a finished product. The idea of sub-dividing the stores

into sections as shown in Fig. 7 introduces the question of the mobility of weighing equipment; if the usage is sufficient to warrant one weighing set-up for each section, then no problem arises, but if one set of instruments is to be used for the whole stores, then either the balances have to move from section to section, or alternatively, the operator must move the materials to a central weighing-out area.

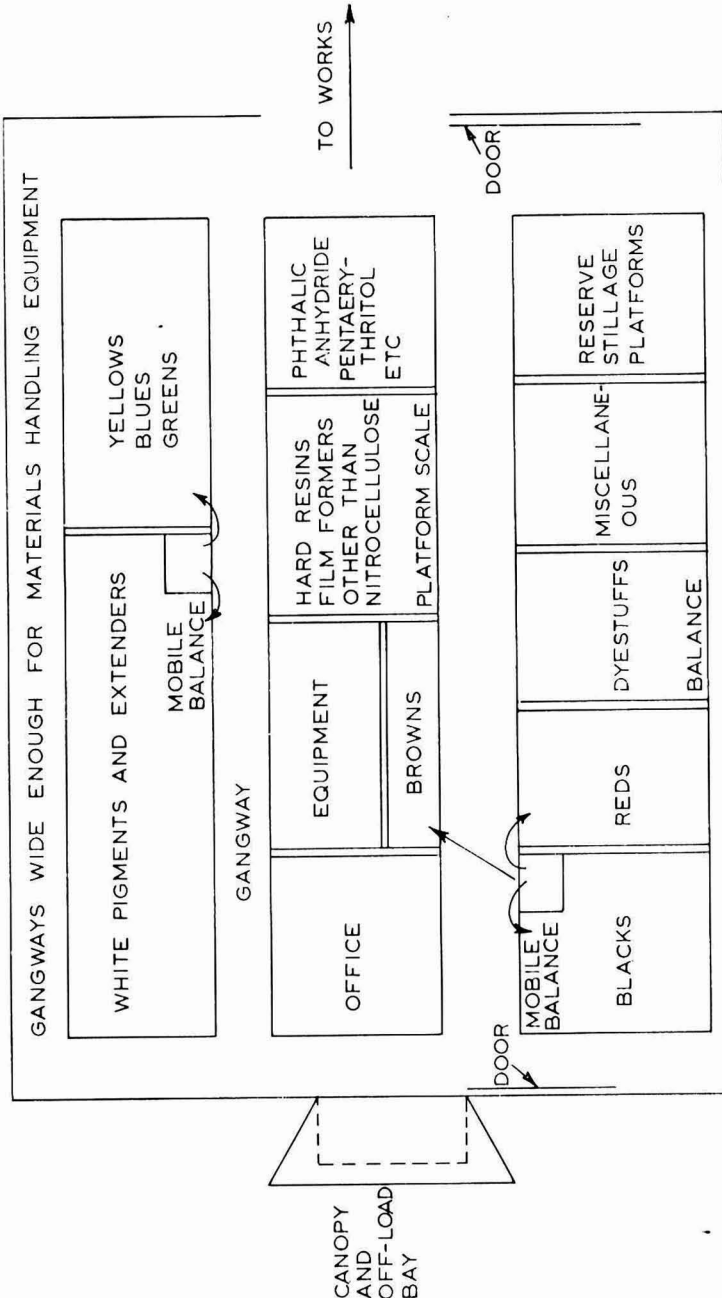


Fig. 7. Suggested arrangement of dry raw materials store

Nitrocellulose

This is a highly dangerous material which, if used in a factory, must be stored separately from other raw materials. Some differentiation is necessary between the storage of nitrocellulose and cellulose solutions. The conditions of storage and use of cellulose solution have been mentioned in Part I of these manuals on pages 96-97* and while this aspect is not entirely relevant to this section on raw materials, it may be mentioned that the Act concerned refers to all cellulose solutions, not solely to nitrocellulose and that the Act applies only to solutions having a flash point below 90°F when tested in the Abel apparatus.

The concern here is with the storage of nitrocellulose as received from the manufacturer. Dry nitrocellulose is extremely dangerous and it is always supplied damped with about 30 per cent of a non-solvent such as butanol. It is available damped with lower boiling alcohols but these are more hazardous because the damping agent is more easily lost by evaporation.

The local authorities must always be consulted regarding the storage of nitrocellulose and it must always be stored in a separate building some distance from other buildings (sometimes storage in the open air may be permitted). The store must be equipped with flameproof lighting and switches and if any motors are present they must also be flameproof. No naked lights, electric fires or smoking are permitted. All tools used for opening the drums and scoops used for weighing out must be of non-ferrous metal to avoid any risk of sparking.

To avoid loss of the damping agent, containers must be properly closed at all times, except when in actual use. Instances have been known where on long storage the top surface of the nitrocellulose has become dry in a drum which had not previously been opened, due to sinkage of the damping agent. This can be avoided by periodically rotating or reversing the drums held in store. Nitrocellulose must not be allowed to become dry after it has been weighed out for use and must be immersed at once into an appropriate liquid. Wherever possible not more than one drum of nitrocellulose should be taken into the factory at a time and any handling of it must be done in an appropriately approved, flameproofed building. Any drums taken into use must be kept closed, except when material is actually being drawn from it.

The "chip" form of nitrocellulose (pigmented and plasticised) described in Part I, page 110 of the manuals is much less hazardous, but nevertheless storage should be under conditions appropriate to nitrocellulose itself. The manufacture of nitrocellulose chips is a highly specialised operation and is not considered appropriate to this review.

Bulk storage of cellulose solutions would not be permissible in a general raw material store and it may be mentioned here that the storage of filled cellulose paints is not permissible in a general warehouse; an approved flameproof store is necessary.

Storage of containers

The container store should be sited adjacent to the filling department with the main doorway providing easy access to the delivering vehicle. The store should

*Cellulose Solution Regulations 1934 (SR + O 1934 No. 990)

be heated and ventilated, since rusting of tins may occur in a cold unheated store; furthermore, tins taken from a cold store into a warm filling section will be prone to internal condensation of atmospheric moisture, which can cause trouble with certain types of products.

It is necessary to carry stocks of relatively large numbers of empty containers to ensure fulfillment of planned production schedules. Storage of tins, particularly, can be a costly item. They are usually delivered from the manufacturer, in unit quantities either completely wrapped with paper either (e.g. 20 × 1 pints), or tied into bundles unwrapped (e.g. 10 × 1 gallon). The greatest economy in storage of these packages is achieved by methodical stacking to the maximum permissible height. Unwrapped tins should be stacked upside down to prevent the entry of atmospheric dust. Each consignment of tins should be stacked individually and the lids delivered with them should be used only for that particular consignment. It should be noted that racks are only useful for storing small quantities of tins.

Drums and kegs are best stocked on pallets, or on their sides with movable supporting posts (or Dexion framework) to the maximum convenient height.

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

Thames Valley Section

Acrylic resins

The second meeting of the Student Group of Thames Valley Section was held on 2 November 1971 at Slough College, with Miss M. Searle in the chair. A lecture entitled "Acrylic resins" was given by Mr A. R. H. Tawn of Cray Valley Products Limited.

Mr Tawn commenced by saying that acrylic resin systems were comparative newcomers in the coatings field, having been in use for only ten years. They accounted for about 10-15 per cent of total resin consumption compared with 60 per cent for alkyds.

They were derived from acrylic or methacrylic acids, Perspex being the classic example. It had reasonable abrasion resistance, water white colour, superlative clarity, slight flexibility and good weathering resistance. It could be seen that a polymer with such properties was of considerable interest to the surface coating technologist, provided it could be adapted to a solvent environment. When dissolved in a solvent it gave a lacquer of low solids and high viscosity owing to its high molecular weight, and its deposited films were also brittle and lacking in adhesion. It was a short step from the methyl to the butyl ester which made the monomer less polar and its polymer more soluble in paraffinic solvents with increased flexibility and softness and lower softening point. Mr Tawn showed the relationship between softening point and hardness in polymethyl methacrylate and he compared a branched chain and a straight chain polymer with the same number of C atoms. Branching gave decreased hardness.

He then turned to acrylate polymers and tabled the relation between brittle points and the number of C atoms in the alkyl group. Copolymerisation was the next significant step. It enabled polymer properties to be drastically modified e.g. cost was materially reduced by the inclusion of styrene or vinyl toluene monomers; adhesion was improved by the presence of carboxyl or hydroxyl materials such as maleic acid or 2-hydroxyl ethyl acrylate. Because all the basic polymers mentioned had an essentially linear structure, they retained their thermoplastic or non-convertible characteristics. By further modification they could be made to cross-link, e.g. by the inclusion of OH groups which react with melamine/formaldehyde resins; by the use of monomers containing epoxy groups, cross-linking could be achieved with amines, amides, or acids. The Tramensdorf effect was mentioned, in which conversion time could be hastened by the use of a simple artificial thickener.

Finally Mr Tawn referred to ionomers having ionic rather than covalent bonding. Mr J. D. Ping thanked Mr Tawn for a very useful and enlightening talk which was warmly acclaimed by the 27 members and visitors present.

R.E.G.
P.MCM.

Information Received

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

It has recently been announced that the firms of the **Kronos** group are following their British associate **Kronos Titanium Pigments Ltd.** by incorporating the trade name *Kronos* in their company name. As from January 1972, Titangesellschaft MBH will be known as **Kronos Titan-GmbH**. The two remaining producing units have already become **Kronos SA/NV** (Belgium) and **Kronos Titan A/S** (Norway) and the other companies in the group are now named **Kronos Titanpigment AB** (Sweden) and **Societe Industrielle du Titane SA** (France). These changes are of names only; there will be no change in the organisation or product range of the Kronos group.

An agricultural research centre is to be established at King's Lynn, Norfolk, by **Dow Chemicals**, it has recently been announced. The centre, which will be Dow's first major European research centre, will commence operations in 1972, building its programme up over the next five years.

Tioxide International Limited has issued two new booklets describing its products. "*Tioxide R-FC5* for plastics" (BTP/169) gives technical data on this general-purpose plastics pigment, and has an appendix detailing suggested formulations and processing methods. "*Tioxide* pigments in paper and paper coatings" (BTP/161) recommends grades for these end uses, and gives background data on the principles governing their most efficient use.

Two new products have recently been introduced by **Evans Electro selenium Limited**. The *EEL 251 High Sensitivity Absorptiometer* was originally developed to measure steam/water purity at power stations, and is claimed to have ten times the sensitivity of any other colorimeter on the market. The instrument covers the range 380 to 850nm, and typical sensitivities are 0.0002ppm silica, 0.004ppm iron and 0.001ppm copper, achieved by using the scale expansion facility, which extends the range of the instrument up to $\times 10$. The other product is a portable pH system based on the *Corning-EEL Model 610 Expanded Scale pH Meter*. The meter comes in a black attache case complete with a combination electrode, buffers, filling solution, beakers, shorting strap and electrode holder/stand, all positioned within the case in foam rubber mouldings in position ready for use.

EEL has also announced the acquisition of **Activation Glass Limited**, of Kinglassie, Fife, as from 2 December 1971. Activation Glass manufactures a comprehensive range of low cost pH electrodes, and the merger is claimed to strengthen the interests of both companies in pH markets.

A new service offered by **R. H. Chandler Ltd.** is the preparation of condensed translations in English of foreign language articles containing experimental work. Intended to bridge the gap between bibliographies, in which little detailed information is given, and translations of foreign language articles, which are expensive, the new publications will be 500-1,500 word condensed translations of one or more articles, including experimental figures where possible. The first in the series is entitled "Testing the curing of stoving finishes by applying dye solution," in which the experimental results and figures from articles in "Plaste und Kautschuk," "Farbe und Lack," and "Peintures, Pigments, Vernis," have been collected, and reproduced at a cost of £4.00. The company welcomes enquiries and suggestions for similar topics for treatment in this way.

It has recently been announced that **Engtime Limited**, the industrial finishing specialist that trades under the name *Pegasus*, has been acquired by the **Schubert Group** of companies. The company will continue to trade under the name of *Pegasus*, but a new image and marketing approach is planned.

Instrumental Colour Systems Ltd. has introduced a new computer-based system for colour control, measurement, correction and prediction. The *Pretema Colour Computer PCC 2000* is based on the *Pretema Spectromat FS-3A* and the *Micro 16P* minicomputer manufactured by **Digico Limited**, and is the result of three-way co-operation between Pretema, ICS and Digico.

The key to the system is the computer software, which is based on *Mathchat*, a specially designed high level programming language. A pigment mix to provide an acceptable match for a given sample is supplied in about 45 seconds, allowing 40 seconds for measurement. Pigments are chosen from a bank supplied to the computer as being available, and formulations can be made against criteria of lowest metamorphism, lowest cost, or a balance between the two.

The system is priced at £17,000, or can be leased at a cost of £75.00 per week.

It has recently been announced that **NV Allied Chemical International SA**, the wholly owned subsidiary of the American **Allied Chemical Corporation**, is to set up a branch in the United Kingdom. This step is being taken, say Allied Chemical International, to provide closer contact with the market and to enable the company to take steps leading to fuller participation in the economic expansion following the entry of the British Isles into the EEC. This will involve a change in the company's long-standing association with **Kingsley & Keith (Chemicals) Ltd.** The relationship will continue, but after 1 May 1972, will no longer be exclusive, taking the forms of sub-distribution, manufacturing and international trading.

An agreement has been reached between **Pira** and **Churchill Instrument Co. Ltd.** for the manufacture and marketing of the *Pira Ink/Water Monitor* as an attachment to lithographic presses, it was announced recently. The prototype of the instrument was first reported by Pira in October 1970; Churchill, which already handles the *Pira Ink Monitor*, will make the *Ink/Water Monitor* available after product development and field trials.

Dow Chemical Europe SA has published a new brochure giving details of the company's European activities, from chemical production sites to end-uses.

The Agreement Board has awarded a certificate to **Hardman and Holden Limited** for *Manalox 403/60.WS*, a water repellent for masonry. This product, a poly-oxo aluminium stearate dissolved in white spirit, is used on stonework after cleaning, providing a water-repellent coating and thus decreasing dirt retention.

The *Sanbri Covermeter* is the latest addition to the range of instruments marketed by **Elcometer Instruments Limited**. It is a small portable instrument that can be used to determine the position and depth of reinforcing bars in concrete, or for the detection of any ferrous metal lying beneath non-ferrous material up to a depth of 2in.

Burrell and Co. Ltd. has announced that, as from December 1971, it will cease the pigment manufacturing operations carried out in Australia by its 50 per cent owned subsidiary, **Smith Reichold Colours (Aust.) Pty. Limited**. The company was owned jointly by Burrell, through its wholly owned subsidiary **J. W. and T. A. Smith (Aust.)**

Pty. Limited, and Australian Chemical Holdings Limited. Burrell will continue to export to Australia through its sales company, **SCC Colours Limited**, but has disposed of the stocks and goodwill of the Australian company on favourable terms.

A regular series of "Bulletins on the Swedish Chemical Industry," is to be published by the British-Swedish Chamber of Commerce. The first issue was published in November 1971, and interested firms can obtain regular copies of the bulletin, which contains comprehensive marketing information, from the British-Swedish Chamber of Commerce on request.

A new thermosetting acrylamide acrylic resin has been developed by the Surface Coatings Resins Division of **Synthetic Resins Limited**. Marketed as *Scopacron 400*, the resin has been developed for use in one coat stoving applications at temperatures over 130°C, particularly where extremely hard, durable coatings are required, and is supplied in different solvents depending on the application method.

Coatings based on the resin are claimed to be extremely hard and durable, while being flexible and stain resistant and having good adhesion and colour retention. It is also suitable for modification with epoxy resins where exceptional chemical resistance is required.

The Coding and Marking Division of **Lawtons of Liverpool Ltd.** has introduced the *Lawco Can Coder*, a hand-operated can marking instrument. Operated by rubber self-inking blocks, the machine automatically prints any code proposed by the user on a series of square or cylindrical cans. Greater time savings over labelling methods are claimed.

A new grade of *Melinex* polyester film—*Opaque White X934*—is now available from the Plastics Division of **ICI Ltd.** Full details of its properties are given in "ICI Information Note MX IN 45."

ICI Paints Division has opened a new training centre at its Slough works, for personnel in the automobile refinishing industry. The new centre, which has a working area of 2,800sq.ft, will increase the number of courses in refinishing that ICI can offer to 60 per year—courses of this type have been organised by ICI for over 40 years—taking in a total of 700 trainees.

Albright & Wilson Ltd., Oldbury Division, has recently published new product sheets on several pvc stabiliser products: *Mellite 26*, a butyltin maleate, *Mellite 31* and *32*, dibutyl thiotins, *Mellite 101* and *202*, solid cadmium/barium, *Mellite 250*, food grade liquid calcium/zinc and *Mellite 831C*, and *831D*, dioctyl thiotins.

It has recently been announced that **Cabot Carbon Limited** has appointed **Kingsley and Keith (Chemicals) Limited** as distributor for *Cab-O-Sil* fumed silica in the United Kingdom and Eire.

Cabot Carbon has also announced that continued increases in manufacturing costs have necessitated an increase in prices of carbon blacks, in spite of savings from economies and improved productivity. In accordance with the CBI undertaking, the increase has been restricted to less than 5 per cent on a weighted basis. In making this announcement, which is effective from 3 January 1972, Cabot points out the good price record for British produced black: the new price for a typical grade, *Vulcan 3 N.330* in bulk being only 6 per cent more than it was ten years ago.

The **CIBA-GEIGY** group of companies has established a new educational trust, the CIBA-GEIGY Fellowship Trust, and will provide the trust funds of £20,000 per annum. The main objective of the trust is the research training at European universities of graduates of United Kingdom and Irish universities in chemistry, biochemistry, biology, chemical technology and chemical engineering.

Two classes of award are proposed: CIBA-GEIGY Fellowship awards, for recent first degree students wishing to take higher degrees at an agreed European university, and Senior CIBA-GEIGY Fellowship Awards, for graduate lecturers, senior lecturers, readers or those holding similar positions who wish to undertake special study at an agreed continental European university. Six Fellowships and four Senior Fellowships will be available each year.

Full regulations are available from CIBA-GEIGY.

A new additive to enhance gloss in gloss emulsion paints has been introduced by **Allied Colloids Manufacturing Co. Ltd.** The range of additives, trade-named *Glascal H*, is based on acrylic copolymer, and remarkable improvements in gloss are claimed when small amounts of dry latex are replaced with one of the range. Full details are available from Allied Colloids.

Section Proceedings

Bristol

Some aspects of metal pretreatment and priming

The first meeting of the Bristol Section was held on Friday 24 September at the Royal Hotel, Bristol. This was the occasion when the new Section Chairman, Mr P. L. Gollop presented the customary Chairman's Address, his paper being entitled "Some aspects of metal pretreatment and priming."

Mr Gollop began by stressing that the optimum benefits of painting of metal surfaces could only be obtained when the metal surfaces involved had been thoroughly cleaned and prepared prior to painting. Such pretreatment involved a variety of chemical and physical techniques. Degreasing with strong alkalis could alter the crystal structure of metal surfaces, resulting in the deposition of phosphate crystals on the surface during later stages of treatment. The size and shape of the phosphate crystals, which conferred improved adhesion of paint films to the metal, could be varied by the use of modifiers during the degreasing stage.

The initial cleaning stage was usually followed by thorough rinsing with deionised water—failure to carry out this step properly could lead to poor phosphating and premature breakdown of the surface coating. Controlled acid pickling and abrasive blasting were methods used to remove rust, but once steel had rusted it was extremely difficult to clean thoroughly. Mr Gollop went on to consider primers. Careful selection of additives to deactivate sulphate ions in primer formulations was extremely useful in improving the performance of the final finish.

Finally, the choice of primer systems for metal which was later to be welded was considered. Here, consideration had to be given to possible problems caused by heat breakdown, slow welding or weakness in the weld joints and also the chances of toxic fumes being emitted from the primer during the welding operation.

Following the paper several queries were dealt with by Mr Gollop and a vote of thanks was finally proposed by Mr L. J. Brooke and warmly supported by all members and visitors present.

T.I.P.

Hull

Some aspects of drying oil technology

A meeting, attended by 18 members and 12 visitors, was held at the Queens Hotel, Hull on 1 November 1971. The Section Chairman, Mr N. F. Lythgoe, introduced Mr G. H. Hutchinson, of A. B. Fleming & Co. Limited, who gave a lecture with the above title

In reviewing the constitutive aspects of drying and semi-drying oils, Mr Hutchinson indicated that the linolenic content of linseed oils was dependent upon the geographical origin and was greatest with samples from cold, wet regions. In general, properties such as the speed of polymerisation and the rate of drying and hardness of oil films correlated well with iodine value for well refined oils. The presence of anti-oxidants in the crude or poorly refined oils sometimes resulted in apparent anomalies. Two methods for contrasting the drying behaviour of different drying oil and tall oil fatty acid samples were commended by the speaker. They involved paper chromatography and the measurement of refractive index and both were carried out on films dried at slightly elevated temperature.

Mr Hutchinson discussed briefly the current theories of drying, referring to Bernstein's theory of hydrogen bonding between hydroperoxides and to Poisson and Petit's theory of polymer formation through reactions of oxidised scission aldehydes and unsaturated chains. An important difference in the behaviour of conjugated and non-conjugated systems was that the former yielded cyclic peroxides resulting ultimately in the formation of carbon/carbon linkages by a chain reaction. In support of this view Mr Hutchinson quoted the oxygen uptakes at the dry point of linseed and tung oil films as 14 per cent and 3 per cent respectively.

An interesting investigation relevant to ink odour in food packaging applications was next described. The volatile products released during the drying of a series of lithographic varnishes were sampled and analysed by gas/liquid chromatography. Saturated and unsaturated aldehydes, as well as aliphatic hydrocarbons, were identified in the chromatograms, the concentrations decreasing with increasing viscosity of the varnish.

Mr Hutchinson concluded his lecture with a survey of synthetic routes to a wide range of novel vegetable oil derived polymers, e.g. polyesteramides and unsaturated polyvinyl ethers.

A discussion period followed with contributions from Messrs. Gibson, Lythgoe, Green and Gay. The vote of thanks for an interesting and enjoyable lecture was proposed by Mr N. F. Lythgoe.

Mr Hutchinson's paper has been accepted for publication in the *Journal*, and should appear later in 1972.

J.A.H.

Irish

Powder coatings

On Friday 19 November 1971, at the Clarence Hotel, Dublin, Mr C. Lonsdale, of BJN Paints Ltd., gave a very interesting talk on "Powder coatings."

With the help of slides and a film, Mr Lonsdale covered the composition, manufacture, application, advantages and disadvantages, and possible trends in the future development and uses of powder coatings. It was mentioned that epoxy-based powder coatings were currently the most commonly used, but that development work on polyester, alkyd, acrylic and methane powders was taking place.

A lively question and answer period followed the talk, and Mr Barry proposed the vote of thanks to Mr Lonsdale on behalf of the 37 Members and visitors present.

A.R.

London

Changes in the physical characteristics of paint films in differing environments

A meeting of London Section was held on 10 November 1971 at East Ham Technical College, with Mr D. E. Eddowes in the chair. Mr R. L. J. Morris, of QAD (Mats) gave a lecture with the above title.

Mr Morris said that there were three main methods for physical testing of paint films; first, to bring the paint film to a uniform state for testing; secondly, to use a forcing environment to promote a change in the paint which could then be measured, e.g. accelerated weathering; and thirdly, to apply a localised change of environment, e.g. the use of solvents, acids, etc. to attack the film.

A film had to be conditioned to a standard environment for correlation testing in different laboratories. Mr Morris then described work which had been done jointly

for a BSI Committee, by his own organisation, the Paint Research Association, and the Greater London Council. This was concerned with the use of pendulum testing. Two instruments were in common use, the Koenig and the Persoz pendulums, and Mr Morris described them in detail.

In earlier work, a lack of correlation had been found using the Koenig pendulum, and statistical analysis had shown a positive correlation with the amount of illumination in the laboratories while the films were drying. A programme was devised to examine a series of seven paints, applied to glass plates (to avoid any possibility of flexing of metal panels). These panels were stored in two separate tanks, with forced air circulation, one of the tanks having a transparent lid and being illuminated from a fluorescent tube, and the other with an opaque black lid. The panels were examined daily, using both pendulums.

It was found that there was a significant difference resulting from the level of illumination with a gloss styrenated alkyd, a gloss medium oil alkyd, and a gloss long oil alkyd. However no effect was detected with a matt linseed oil phenolic, a matt linseed, an epoxy and a polyurethane paint. The linseed oil phenolic did not develop to a steady state, so that testing could not be done under equilibrium conditions. As a check on the pendulum hardness measurements, a Wallace indentation test was carried out. With the polyurethane film, agreement with the pendulum tests was obtained, but with the styrenated alkyd there was no difference between light and dark drying.

A comparison of two Koenig pendulums was made, one at the PRA and the other at the GLC, using a series of seven paints, tested seven days after application. Systematic discrepancies were shown and these were found to be due to minor temperature differences; the PRA tests were at 21°C, and the GLC at 19.5°C (Both temperatures were within BSI limits). When the temperature coefficients were determined, the corrected results fell on a good 45° line.

A comparison was made between the two types of pendulum, with a series of 12 paints. Both pendulums placed the paints in the same order, with the exception of three paints. It was found in this case that it was necessary to use the same pendulum for all the tests to get correlation.

In general, comparing the two pendulums, it was concluded that the Koenig pendulum was best for hard films (where the Persoz tended to slip), and had the advantage of more rapid measurement. The Persoz pendulum, with its longer damping time, discriminated better between softer paint films.

The lecture was followed by an extensive discussion, after which a vote of thanks to the speaker was proposed by Mr Aaron, a student at the college.

A paper based on the work Mr Morris described has been accepted for publication, and will appear in the March issue of the *Journal*.

V.T.C.

What's bugging your paint?

A meeting of London Section was held on 8 December 1971, at the Polytechnic of the South Bank, London, SE1, with Mr D. E. Eddowes in the chair.

Catherine E. Skinner, of the Paint Research Association, gave a lecture with the above title.

Mrs Skinner said that the microbiological problems of the paint industry fell into two distinct categories, biodeterioration of water-based paints on storage, and attack on paint films by micro-organisms. Dealing first with aqueous-based paints, Mrs Skinner said that any substance containing water was potentially subject to biological attack by micro-organisms. Bacteria could multiply rapidly; a life cycle could be as short as 20 minutes. Correct industrial hygiene was essential to minimise the occurrence

of micro-organisms in storage facilities and production equipment. Contamination could produce viscosity loss of emulsion paints, putrefaction, or gassing. The active agent was the enzyme produced by the organism; for example cellulase was active on cellulose derivatives. Even as little as 0.1ppm of cellulase could cause a 20 per cent reduction in viscosity of a latex paint. Cellulase could be deactivated by heat (20 minutes at 100°C) or by lowering the pH considerably; neither of these procedures was possible for emulsion paints, and so it was necessary to prevent its formation e.g., by choice of a suitable cellulosic thickener, followed by the use of a broad-spectrum biocide in the paint.

The breakdown of proteins in some types of paint gave rise to putrefaction, with the accompanying foul odour. A third example of breakdown was gassing, frequently caused by *aerobacter aerogenes*, which was a very widespread organism, and could be introduced at low concentrations in the water. Mrs Skinner emphasised the importance of industrial microbiological hygiene in the production and storage of water-based paints.

Deterioration of paint films could occur by mould, algal, or lichen growth. Mould growth was a serious problem in tropical climates, and also in certain environments in temperate climates, e.g., breweries or bakeries where there was high humidity and possibly inadequate ventilation. Mould growths could occur from beneath the paint film—these were present before the paint was applied—and on the film, originating from spores which were always present in the atmosphere.

The most common species of fungi found on exterior paintwork was the dark-pigmented *aureobasidium pullulans* (also known as *pullularia pullulans*). Another fungus, *cladosporium herbarum*, was frequently found on both interior and exterior paintwork. Another important fungus was *phoma violacea*, which gave rise to a pink, oil-soluble colouring matter. Most often, several species of fungus were found on one site, and unfortunately a single fungicide was often not active against all.

Tests had been developed at Teddington for wide-spectrum fungicides, in which potential compounds were screened against a series of sixteen species of fungi. This was a rapid procedure, and it was possible to screen two hundred compounds a month.

A fungal test cabinet had been developed in which paints could be tested for resistance to fungal attack. The paints, on various substrates, were subjected to controlled condensation conditions for three weeks, after being treated with sterile soil and inoculated with the test organisms. An extensive series of tropical exposure trials had been carried out, and good correlation was obtained on two years' tropical exposure and the three-week period in the cabinet. It was necessary to vary the test conditions to match those of the different climatic exposures, in particular the amount of artificial weathering given before exposure in the cabinet.

Paint films were subject to attack by terrestrial algae, which in some cases in the tropics could be an even greater problem than fungal growth. Algae needed light and water for this growth, and the test cabinet had been modified to suit these conditions by illumination with fluorescent tubes and by the passage of a stream of air with 5 per cent carbon dioxide into the cabinet.

Lichens consisted of an alga and a fungus living together in a state of symbiosis. Lichens were slow growing organisms, and could tolerate great extremes of temperature.

Mrs Skinner then considered the problem of ship fouling. The two principal marine algae were the green *enteromorpha sp.* and the brown *ectocarpus sp.* In the past, the only methods of testing potential toxicants or anti-fouling systems had been raft trials, or ships' trials involving coating strips or panels on ships' hulls. There were also

laboratory leaching rate experiments. These all had considerable disadvantages, and so techniques had now been developed at Teddington to grow these organisms in the laboratory. These methods had been very successful, and it was now possible to use these organisms to assess the activity of potential toxicants under controlled conditions in the laboratory.

Mrs Skinner concluded her lecture, which had been illustrated throughout by a very large number of coloured slides, by noting that while there were many effective biocides of very specific applications, there was a great need for the development of wide-spectrum biocides of low mammalian toxicity.

The lecture was followed by an extensive discussion, after which Mr P. Whiteley proposed a vote of thanks to Mrs Skinner for what had been a highly detailed and interesting lecture, and for her work over the years in developing soundly based laboratory techniques in this difficult and highly subjective field.

V.T.C.

Colloidal aspects of printing inks

A joint meeting of London Section and the Colloid and Surface Chemistry Group of the SCI was held on 13 December 1971 at 14 Belgrave Square, London SW1. Dr J. A. Hill took the chair for a lecture by Dr W. Carr of CIBA-GEIGY (Pigments Division), with the above title.

Dr Carr commenced with definitions of the colloid state taken from the literature. The lower limit of size of particles was taken as 1 millimicron but there was some uncertainty about the upper limit of size, definitions ranging from 0.2-1 micron. Printing inks consisted of solutions of dyestuffs or dispersions of pigments in media, which dried quickly when applied to a suitable substrate such as paper or other films.

The pigments used in printing inks consisted of powders with a wide range of sizes of aggregates and agglomerates, and a considerable energy input was necessary to disperse them in media. The ink-maker attempted to break down the sizes of the agglomerates as far as possible; in this he was only partly successful. Dr Carr listed various methods of particle size analysis, and then described the use of the ICI/Joyce Loebel disc centrifuge, which he had used for his work.

It was possible to use BET nitrogen adsorption figures to calculate the size of the primary particles of the pigments; examples quoted included a carbon black of $100\text{m}^2\text{ g}^{-1}$ surface area, equivalent to particles of $0.033\mu\text{m}$; phthalocyanine blue, $60\text{m}^2\text{ g}^{-1}$, equivalent to $0.066\mu\text{m}$; and titanium dioxide, $10\text{m}^2\text{ g}^{-1}$, equivalent to $0.15\mu\text{m}$. These, however, were the primary particles; the actual particle size distribution was much larger. In most inks (and also paints) the particle size was in the range of $0.1\text{-}1.0\mu\text{m}$. Based on the particle size distribution determined with the disc centrifuge, and the BET surface area to give the primary particle size, it was possible to calculate the efficiency of dispersion.

Dr Carr then presented results of particle size analysis of aqueous flexographic inks pigmented with Pigment Blue 1, Pigment Red 49, Pigment Blue 15, and Pigment Red 4. Some of these inks contained a considerable proportion of the pigment below $0.2\mu\text{m}$ in size, but others were considerably coarser, extending up to $1\text{-}2\mu\text{m}$ in size. On storage for 3 months, it was found that the proportion of smaller sized particles remained the same, but in the upper size ranges the inks had coarsened considerably; this had been accompanied by a weakening in colour strength, and loss of brightness and gloss. It was concluded that $0.3\mu\text{m}$ represented the upper limit for true colloidal behaviour in the inks.

It was suggested that similar effects would occur with gravure and oil based inks such as letterpress and lithographic inks. Dr Carr described a method of constructing a master curve for each pigment, relating colour strength to particle size. From these

curves it was possible to estimate the 50 per cent diameter from colour measurements of tints of the inks with a white base, and it became clear that with the majority of inks a substantial portion of the pigment was in the colloidal range. Unfortunately, it was not possible to apply directly the principles of colloidal dispersion theory to inks with a high pigment concentration (e.g. up to 40 per cent in litho inks).

It had been found that, on dilution of some inks, a slight decrease in the mean particle size of the inks occurred. This took place with two of the flexographic inks and some lithographic inks, and indicated an improvement in dispersion. These inks had also been examined on the Ferranti-Shirley viscometer. At low pigment concentrations, the viscosity was independent of particle size, up to a certain limit. At higher concentrations a reduction in particle size resulted in a marked increase in viscosity. It was concluded that, in addition to the effects due to pigment concentration and level of dispersion, a further factor influenced the flow properties, that of adsorption of the resin on the pigments.

A number of points were raised in the extensive discussion which followed the paper, including the effects of particle size on adsorption, and the effect of particle shape on flow properties, which Dr Carr did not consider to be important in the systems studied. The relevance of relating the degree of dispersion to measurements of nitrogen adsorption was questioned; the nitrogen molecules were very small, and it might be more realistic to use adsorption from solution of some larger adsorbate molecules.

After the discussion, Dr V. T. Crowl proposed a vote of thanks to Dr Carr for a very interesting and stimulating lecture.

V.T.C.

Manchester

Management of human resources

On Friday 12 November 1971, some 90 Members and guests attended at the Manchester Literary and Philosophical Society lecture hall to hear Mr J. Munro Fraser, of the University of Aston-in-Birmingham, give a paper entitled "Management of human resources."

Mr Fraser gave a witty and professional lecture. Starting with "motivation," he described some of the simple experiments with animals and proceeded to define some of the basic motivations of human beings, pointing out that in simple societies this was food and drink, whereas in a complicated society these basic needs were translated into money. Once these needs were satisfied, he suggested further social needs came into play, "The need to belong to a group and also status within the group." Again, in modern society he suggested that there were a plurality of groups to which an individual would belong, home, work, and local pub being a few of these.

He went on to say that if needs were not fulfilled then frustration was the result, and anti-social behaviour could often be traced to this cause.

Concentrating on the work group he defined two types—a flexible primary in which the individual was involved and the inflexible authoritarian secondary in which the individual had only a limited and restricted role. He suggested that the "family tree" chart of works organisation very often indicated the "secondary type" of group organisation, with the result that shop floor workers tended to form their own primary groupings, and loyalty would be towards the more attractive primary.

Mr Fraser concluded by quoting a number of examples from his experience which he felt supported his ideas.

A lively question time followed, with Mr Fraser expanding various points made during his lecture.

The vote of thanks was proposed by Mr H. Cook, and accepted with acclamation.

A. MCW

Midlands

Electrokinetics in electrodeposition

The 153rd meeting of the Midlands Section was held at the Birmingham Chamber of Commerce on Friday 15 October 1971 with the Section Chairman, Mr H. J. Griffiths, in the chair. The minutes of the 152nd meeting were taken as read and signed. A small but enthusiastic audience of 16 members and guests listened to a lecture entitled "Electrokinetics in electrodeposition" by Professor G. D. Parfitt of Tioxide International Ltd.

Professor Parfitt began by discussing the fundamental processes involved in electrodeposition: electrophoresis, electro-osmosis, electrolysis and electro-coagulation. The first two were electrokinetic. After an explanation of the distribution of charge on various particles and the potential gradients surrounding them, equations were set up to describe the electrophoretic velocity of paint particles in a typical electrodeposition bath. Earlier values were said to be much in error owing to an approximation having been made to a classic condition of high electrolyte concentration in aqueous solution.

Similarly, some doubts were raised concerning the claim that electrophoretic mobilities were high enough to maintain a plentiful supply of material in the anode vicinity. Calculations showed that electrophoresis might be a rate controlling factor.

The deposition stage was covered in some detail, discussing electrolysis of water causing a pH drop at the anode and compaction by electro-osmosis. The subject was treated in terms of colloid stability with a graphical representation of the potential energy distribution and the energy hump to be overcome for coagulation to take place.

Professor Parfitt answered questions raised by the audience and a vote of thanks was proposed by Mr R. J. King before the Chairman closed the meeting.

R.J.K.

Oil-free alkyds

A meeting of the Midlands Section was held on Friday 19 November 1971 at the Birmingham Chamber of Commerce, with the Section Chairman, Mr H. J. Griffiths, in the chair. A total of 41 members and guests assembled to hear Mr A. G. North, of Cray Valley Products Ltd., give a lecture entitled "Oil-free alkyds."

Mr North began by outlining the differences in chemical structure between a variety of commercial alkyd and polyester resins. He then invited audience participation in a short quiz in which it was asked, "Which are the oil-free?"

pelargonic/phthalic/glycerol alkyd (7 said oil-free)

dimer acid alkyd (nil)

olefin oxide/pentaerythritol adduct alkyd (30)

terephthalic/glycol polyester (40)

Since the dimer acid alkyd was oil-free, this served to illustrate Mr North's point that there was considerable confusion in terminology, whereupon he proceeded to enlighten the assembled gathering.

In considering the merits of the dimer acid based alkyds, attention was drawn to the comparatively narrow molecular weight distribution of these mainly linear poly-

mers. This was illustrated graphically and with regard to the polydispersity D for which the following values were quoted:

dimer acid alkyd	2.21
linear polyester	2.26
coconut alkyd	5.69
Cardura alkyd	4.53

The commercial value of these systems had increased on the emergence of a suitable amino resin to cross-link them, ie the HMMM type. These fully etherified aminos offered the advantage of full participation in cross-linking with the alkyd molecules. Certain problems of cissing and crawling in the stove with such systems were attributed to the comparatively large surface tension difference between the oil-free alkyd and the amino resin. It was possible to bridge the gap with a few percent of a normal u/f resin, CAB, or a suitable silicone.

A comparison of performances of the oil-free alkyds against coconut alkyds and acrylics was impressive with the exception of alkali resistance. Uses for these materials were expected to be mostly in the area of coil coating, possibly later in powder coatings.

After a lively discussion period, a vote of thanks was proposed by Mr R. J. King and the Chairman closed the meeting.

R.J.K.

Midlands

Trent Valley Branch

Chromate and phosphate pigments in anti-corrosive primers

A meeting of the Trent Valley Branch was held on Thursday 11 November, at the British Rail School of Transport, Derby, with 26 members and guests present. The Chairman, Mr E. Hare, introduced Mr H. F. Clay and Mr J. H. Cox of SCC Colours Ltd., who gave a talk on the above-mentioned topic.

As both speakers had a wide experience in the anti-corrosive pigment field, the lecture was a very informative one and a wide variety of test pieces amply illustrated the main theme.

The final period set aside for discussion proved to be very lively, but the lecturers dealt most capably with the wide range of questions fired at them.

A vote of thanks was proposed by Mr J. R. Kitchen for a most interesting and enlightening paper which it is hoped will be published in full in a later issue of *JOCCA*.

D.F.G.

Scottish

Personalised marketing

The first meeting of the 1971/72 session was held on Wednesday 13 October 1971 at St. Enoch Hotel, Glasgow. Mr W. A. Cooms of International Life Assurance Co. (UK) Ltd., addressed the members and friends on the topic "Personalised marketing", which he treated in a highly controversial manner. This naturally led to lively discussion and comment from the audience, indicating that Mr Cooms' views had certainly proved interesting, if not acceptable, to all present.

H.A.M.

Amino resins—their use in the surface coatings and paper industries

The November meeting of the Scottish Section took the form of a joint meeting with the British Paper and Board Makers Association. This was held at St. Enoch Hotel,

Glasgow, on 11 November 1971, when Mr R. McD. Barrett of BIP Chemicals Ltd. addressed a large assembled company on the subject "Amino resins—their use in the surface coatings and paper industries".

Mr Barrett traced the development and the use of amino resins since the 1930s, and indicated the wide range of products in which they found application, particularly in the coatings and paper industries. The continued development of these products was also treated in some detail.

A lively question and discussion period followed, indicating how well the paper had been received by both sections of industry.

H.A.M.

Eastern Branch

Water based acrylic primers for bare wood

The first ordinary meeting of the session was held in the Carlton Hotel, Edinburgh, on Wednesday 20 October with Mr R. Webster in the chair, when Mr J. H. Sparrow of Lennig Chemicals Ltd. spoke on "Water based acrylic primers for bare wood". Thanks are due to Mr Sparrow for taking over this lecture at short notice after the sudden death of Mr Becalick.

Mr Sparrow's talk covered work carried out in the USA, comparing acrylic primers with oleoresinous primers and conventional emulsion primers. This type of coating had to perform two functions, to protect the bare wood while giving satisfactory adhesion, flexibility, and blister resistance, and to provide a satisfactory surface to receive a top coat. Mr Sparrow showed many slides of test panels illustrating the exposure effects of the various primers.

The results showed that the acrylic primers compared very favourably with the other types, in many instances giving improved properties. Also, for maximum adhesion there should be an excess of vehicle to pigment demand, and a maximum PVC of 35 per cent was quoted. It was found that adhesion promotion of a standard emulsion depended on the emulsion polymerisation technique and not on the chemical type. This was found to be true for pva maleates, mixed and straight acrylics.

J.H.S.

West Riding

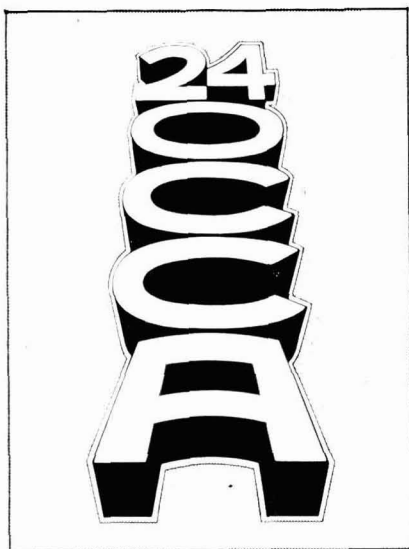
The fibre optics colorimeter and its application for industrial colour control

A meeting of the West Riding Section was held at the Griffin Hotel, Leeds, on Tuesday 9 November 1971. In introducing the speaker, Mr D. Irish of the Paint Research Association, the Chairman of the Section, Mrs K. Driver, expressed thanks to him for presenting his talk at very short notice in place of the scheduled lecture.

Mr Irish briefly presented the contents of the original paper by Dr I. G. H. Ishak which appeared in *JOCCA* 1971, 54, 129. He then described some of the practical trials which had been carried out since the original paper was published. These included the monitoring of an actual production run on a batch of paint on a member firm's premises and use of the equipment for the control of the anodising of aluminium. Colour control of plastics and the strip coating of metal were also being examined. For the future, it was hoped to work towards in-line computer control of tinting using the fibre optics colorimeter.

Following a lively question and answer period, the vote of thanks was proposed by Mr D. Gray.

R.A.C.



Technical Exhibition

17-21 April 1972

Lord Ironside to open 24 OCCA

Arrangements for 24 OCCA, the 24th Technical Exhibition organised by the Oil and Colour Chemists' Association, to be held at the Empire Hall, Olympia, from 17-21 April 1972, are well in hand, and the Exhibition Committee is pleased to announce that Lord Ironside has accepted the invitation to be the Guest of Honour at the Exhibition Luncheon, and to reply to the Address of Welcome given by the President.

Lord Ironside the second Baron of Archangel and of Ironside, is a vice-president of the Parliamentary and Scientific Committee, and is deeply involved in the electronics industry, having been associated with Marconi and English Electric Ltd. before joining the International Research and Development Co. Ltd. (then Cryosystems Ltd.) in 1963.

Principal officers of other scientific bodies, industrial research associations and organisations representing the interests of suppliers and consumers have been invited by the Committee to attend the luncheon, which is to be held at the Savoy Hotel, London WC2 on Monday 17 April, at 12.45 p.m. Copies of the *Official Guide* containing forms of

application for tickets for the luncheon, which are priced at £4.00, will be circulated to Members of the Association and scientists and technologists in the surface coatings and allied industries throughout Europe later this month; any interested person can obtain a copy on application in writing to the Association's offices.

Following the luncheon, Lord Ironside will open the Exhibition at Olympia at 3.00 p.m.

Copies of the information leaflet in six languages have been distributed to paint manufacturing companies in Europe and, with the assistance of Embassies and Chambers of Commerce abroad, to other parts of the world. Anyone wishing to send invitation cards to colleagues overseas should apply to the Association's offices.

As the number of overseas visitors has increased over the years, arrangements have been made with various hotel groups in London for hotel accommodation during the period of the Exhibition, and details will be published in the *Official Guide*. A leaflet giving details of the accommodation offered by Grand Metropolitan Hotels has already been circulated to interested parties overseas.

Professional Grade for Ordinary Members

Members will have been interested to see the first list of names of Ordinary Members admitted to the Professional Grade in the January issue of the *Journal* and the second list will be published in the March issue. It is felt that Members may like to have information on the number of applications considered for each grade by the end of 1971, together with their distribution by the Committee through the various grades, as follows:

takes some months to complete.

Non-members of the Association interested in the professional grade should first read the regulations printed in the September issue pp. 916-921 and should then make application to become Student or Ordinary Members of the Association, since it will be seen from the regulations that it is necessary to have been an Ordinary Member (or Student in certain cases) for a specified

Applications considered by Professional Grade Committee by 31 December 1971

	Applications received	Applications transferred between grades	Successful, as first list in January 1972 Journal	Awaiting fulfilment of regulations	Not accepted
1. Fellowship ..	74	<i>less</i> 13	57	—	4
2. Associateship ..	46	<i>add less</i> 13 1	44	9	5
3. Licentiatehip ..	7	<i>add</i> 1	2	6	—
	127		103	15	9

Ordinary Members are reminded that sponsors will not be required until October 1972, but those intending to make application for admission to the professional grade should do so without delay since, of necessity, the procedure

period of time before application can be considered for admission to the Professional Grade. Re-prints of the regulations and forms of application for Membership of the Association's offices.

Jordan Award

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

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

The rules of the Award are:

1. The Award will be made for the best contribution to the science or technology

of surface coating by a member of any nationality working in either the academic or industrial field who is under the age of 35 at the date of application.

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

3. The selection of the recipient of the

Award will be made by a Committee under the chairmanship of the Association's Hon. Research and Development Officer.

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

evidence of the candidate's own contribution will be required if a paper is offered under joint authorship.

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

The two previous awards were made in 1969 and 1971. In 1969 it was made jointly to Mr M. J. B. Franklin, for his paper "The effect of zeta potential on the optical properties of paints" (*JOCCA* 1968, 51, 499), and Mr R. J. King, by recommendation of a superior for work which could not be published for reasons of commercial secrecy; in 1971 the recipient was Mr J. R. Groom, for his paper "Milling—a printing ink variable" (*JOCCA* 1971, 54, 266).

Association Dinner and Dance 1972

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

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

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

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

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

News of Members

D. T. Long, an Ordinary Member attached to the Irish Section, has recently been appointed Chairman of the Institute for Industrial Research and Standards in Ireland.

Mr R. S. Robinson, an Ordinary Member attached to the Manchester Section, was elected Vice-President of the BRMA, and Mr S. H. A. Hirsch, an Ordinary Member attached to the London Section, was elected to the Executive Committee.

Mr C. H. Morris, an Ordinary Member attached to the Midlands Section, and a Vice-President of the Association, has been re-elected Chairman of the British Resin Manufacturers' Association.

Mr K. A. J. Sugars, an Ordinary Member attached to the London Section, has been appointed Group Sales Controller of Tioxide International Ltd. Mr Sugars was previously Assistant Group Sales Controller.

Irish Section



Back row Irish Section Dinner Dance (left to right) Messrs J. Corrigan, D. Sharpe, L. H. Silver, J. Smethhurst, M. Hanlon
Front row (left to right) Mrs Corrigan, Mrs A. English, Mrs Sharpe, Mrs J. Kershaw, Mrs Silver

Dinner Dance

The Annual Dinner Dance of the Irish Section was held on Friday 29 October 1971 at the Tara Towers Hotel, Blackrock, Co. Dublin. Some 130 members, guests and ladies were present, but regrettably, the President, Mr A. W. Blenkinsop, was unable to attend.

Mr L. H. Silver, a Vice-President of

the Association, proposed the toast to the Irish Section, and the Chairman, Mr D. Sharpe, replied and proposed the toast to the guests. Mr J. Smethhurst spoke on behalf of the guests.

Mr G. F. Jones, to musical accompaniment, proposed a toast to the ladies and Mrs M. Grainger replied on their behalf.

A.R.

London Section

Ladies' Night

The London Section Ladies' Night was held on 19 November 1971, at a new venue, the Strand Palace Hotel, London, WC2, which provided very pleasant and modern surroundings for a very enjoyable occasion. It was necessary to limit the numbers attending to 250, by reason of space, and unfortunately this meant that some late applications had to be refused.

After a very good dinner, the President, Mr A. W. Blenkinsop, proposed the

toast to the London Section. He referred to the breadth of activities of the Section, such as the European Exchange lectures with some continental societies; maybe in some years' time OCCA might itself have closer ties with the European societies as a whole. London Section had had a great success with their half-day symposia, and he congratulated the Section on its vigorous approach to present-day problems.

In replying to the toast, the Chairman of London Section, Mr D. E. Eddowes,



At the London Section Ladies Night: The President (Mr A. W. Blenkinsop) and Mrs Blenkinsop (left) and Mr D. E. Eddowes (Chairman, London Section) and Mrs Eddowes

thanked the President for his words of praise for the Section. OCCA was at present going through a phase of transition, following the "forward thinking" exercise initiated by Dr Bell; for example the introduction of professional grades of membership. He wished particularly to ask members to encourage their younger colleagues to join in the Licentiate grade, and then to progress to the Associate grade with further experience of the industries served. He then welcomed "the wise, the willing and the winsome." Among the wise he included the President, Mr A. W. Blenkinsop and Mrs Blenkinsop, Mr and Mrs A. A. Duell, from Newcastle Section, Mr and Mrs P. L. Gollop, from Bristol Section, Mr and Mrs B. A. Richardson from Southern Branch, Mr and Mrs B. Jacob from Thames Valley Section, and of course Mr R. H. Hamblin the Director & Secretary. He was also glad to welcome two past-presidents, and

several former chairmen of London Section.

The willing were his fellow committee members, and in particular the Hon. Secretary, Mr R. H. E. Munn, upon whom fell the task of organising the evening's entertainment. Finally came the winsome—the ladies.

Replying on behalf of the guests and ladies, Mrs L. Thompson thanked the committee for the gift of a pot plant to each of the ladies and proceeded to give a very amusing account of her horticultural experiences.

After the dinner came the excitement of the tombola, and then dancing commenced and continued until 1 a.m. to the music of Billy Wells' band. Rex Campbell was the toastmaster.

Manchester Section

Symposium: Paint performance and the microbiological environment

The Manchester Section is planning a Symposium to be held at the University of Manchester Institute of Science and Technology (UMIST) on 19-20 September 1972.

The subject, "Paint performance and the microbiological environment", is considered to be of vital and increasing interest to scientists working in the surface coatings industry, to civil engineers, and to others concerned with the protection of surfaces and structures in general.

This Symposium will be the third such event organised by the Manchester Section; the previous Symposia in 1966 and 1969 each attracted wide support in

that 300-400 delegates from the UK and Western Europe attended.

A dinner (optional) will be held on the evening of 19 September and overnight accommodation in a Hall of Residence will be available at moderate cost as required.

The technical programme is at present being consolidated following the excellent response from academic and industrial contributors.

Advanced information on the programme and arrangements for the Symposium may be obtained from:

Dr F. Dalton,
c/o CIBA-GEIGY (UK) Ltd.,
Pigments Division,
Wythenshawe,
Manchester M23 9ND.

Electrostatics; fundamentals, applications and hazards

The Institute of Physics is to organise a seminar with the above title on 18-19 April 1972 at the University of Southampton. Electrostatic methods of coating will form a major part of the application study section of the seminar, and electrostatic hazards will be treated in some detail.

It is planned to limit the attendance to about 50 participants, the selection being by the organisers, The Institute of Physics, 47 Belgrave Square, London SW1X 8QX, to whom all inquiries should be addressed. Closing date for applications is 20 March 1972.

Colour 73

Colour 73, the second congress of the International Colour Association, is to be held at the University of York from

2-6 July 1973. Accommodation will be mainly on campus, but a very small amount of hotel accommodation has been reserved in the centre of York. The call for papers will be circulated early in 1972, and all inquiries should be addressed to Professor W. D. Wright (AIC Colour 73), Applied Optics Section, Imperial College, London SW7 2BZ.

European Resins Conference

A conference of European resin manufacturers, sponsored by the British Resin Manufacturers Association, will be held at the Carlton Towers Hotel, London, on 5-6 June 1972. Programmes for the conference, which is intended to bring together resin manufacturers and users for all European countries to discuss the effect on the industry of the enlarged EEC, may be obtained from the Society of the BRMA, Alembic House, 93 Albert Embankment, London SE1 7TU.

Register of Members

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

Ordinary Members

- AARON, MICHAEL NISSIM, 30 Carlton Court, Carlton Drive, Barkingside Ilford, Essex. *(London)*
- ADAMSON, EDWARD, LRIC, 13 Denby Court, Oakworth, Keighley, Yorks. *(West Riding)*
- ARNOLD, ALAN EDWARD, 10 Ash Crescent, Kingshurst, Birmingham 37. *(Midlands)*
- BARTON, JAMES FRANCIS, 6 North Mount, High Road, London, N20 0PH. *(London)*
- BROUGHTON, COLIN MICHAEL, 46 Arrowsmith Road, Chigwell, Essex. *(London)*
- CHARLTON, PHILIP, 130 Birchwood Road, Wilmington, Kent. *(London)*
- COGGER, DERRICK ERNEST, 4 Brinds Close, Sonning Common, Reading, RG4 9SR. *(Thames Valley)*
- CONDIE, ANDREW YOUNG, 19 Lochlea, Kirkintollock, Glasgow, Scotland. *(Scottish)*
- HIGGINS, MICHAEL BRIAN, 4 Scots Close, Stanwell, Surrey. *(Thames Valley)*
- HICKSON, DAVID JOSEPH, Zinkaflex Ltd., Dumers Lane, Bury, Lancs. *(Manchester)*
- IRWIN, TERENCE, ARIC, 12 North Grove, Wetherby, Yorks. *(West Riding)*
- KAYE, DENNIS D., LRIC, 28 Buntingbridge Road, Ilford, Essex. *(London)*
- MCCLAREN, ALASTAIR MCINTOSH, 4 Rosevale Terrace, Edinburgh, Scotland, EH6 8AN. *(Scottish)*
- MOHAMMED, SHAKIR, Sissons Paint (WI) Ltd., Princess Margaret Highway, Chaguanas, Trinidad, West Indies. *(General Overseas)*
- MORRISON, WILLIAM ESPIE, 27 Garsdale Road, Whitley Bay, Northumberland. *(Newcastle)*
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- RIDDOCH, DUNCAN WILLIAM, 166 Amersham Way, Little Chalfont, Amersham, Bucks. *(Thames Valley)*

Associate Members

- BALL, DONALD, 5/4 Christian Crescent, Edinburgh 15, Scotland. *(Scottish)*
- HANFREY, PETER, 57 Pauls Croft, Cricklade, Wilts, SN6 6AJ. *(Bristol)*

Students

- BUNCE, JAMES ALEXANDER, 30 Burnside, Road, Gorebridge, Midlothian. *(Scottish)*
- DAVIE, ALEXANDER KNIGHT, 19 Bollinwood Close, Wilmslow Park, Wilmslow, Cheshire. *(Manchester)*
- DOVE, WILLIAM, 9 Great Junction Street, Edinburgh, EH6 5HX. *(Scottish)*
- FIELD, PETER, 49 Kenrick Croft, Castle Vale, Birmingham 35. *(Midlands)*
- HURST, ANDREW JOHN, 29 Schoolfields Road, Shenstone, Near Lichfield, Staffs. *(Midlands)*
- O'DONNELL, DENIS, 140 Magdalene Drive, Edinburgh, Scotland. *(Scottish)*
- PATON, LINDA ANGELA, 24 Ryehill Avenue, Edinburgh, Scotland. *(Scottish)*
- MACLEAN, RODERICK IAN, 4 Woodilee Cottages, Lenzie, Kirkintollock. *(Scottish)*

Forthcoming Events

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

Thursday 3 February

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

Friday 4 February

Scottish Section—Eastern Branch: Burns Supper, to be held at the Queen's Suite, Royal Mile Centre, Edinburgh at 7.30 p.m.

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

Monday 7 February

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

Please note new venue.

Tuesday 8 February

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

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

Wednesday 9 February

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

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

Thursday 10 February

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

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

Friday 11 February

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

Saturday 12 February

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

Tuesday 15 February

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

Wednesday 16 February

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

Friday 18 February

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

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

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

Midlands Section—Trent Valley Branch: Buffet Social, to be held at the Yew Lodge, Kegworth, at 8.00 p.m.

Thursday 24 February

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

Friday 25 February

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

Thursday 2 March

Newcastle Section: "Inorganic zinc rich primers" by Mr D. S. Newton and Mr M. Rendu of Imperial Smelting Corporation (Alloys) Ltd., to be held at Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne at 6.30 p.m.

Monday 6 March

Hull Section—Ladies Evening: "A conducted tour of the Hull Art Gallery" by the Director, Mr Bradshaw.

Wednesday 8 March

London Section: "Statistical evaluation of colour difference formulae" by Mr K. McLaren of ICI Ltd., Organics Division, to be held at the South Bank Polytechnic, Borough Road, London, SE1, at 7.00 p.m.

Newcastle Section—Student Group: Film show, to be held at the Newcastle Polytechnic, Ellison Place, Newcastle upon Tyne at 3.00 p.m.

Thursday 9 March

Manchester Section: Joint meeting with North Western Branch of the Institute of Printing. "Future trends in the printing and communication industries in the Seventies" by Mr H. Sander of the Bonnier Group, to be held at the Royal Institution, Liverpool at 6.30 p.m.

Midlands Section—Trent Valley Branch: "Examination of paint systems using the scanning electron microscope" by Mr H. Wells of the Quality Assurance Directorate, to be held at the British Rail School of Transport, London Road, Derby, at 7.00 p.m.

Scottish Section: "Some aspects of managing a new town development corporation" by Mr G. B. Young of the East Kilbride Development Corporation, to be held at the St. Enoch Hotel, Glasgow at 6.00 p.m.

Saturday 11 March

Scottish Section—Student Group: Annual General Meeting followed by a general knowledge quiz, to be held at the St. Enoch Hotel, Glasgow at 10.00 a.m.

Tuesday 14 March

London Section—Southern Branch: "Zinc phosphate—its history and development" by Mr M. Rendu of Imperial Smelting Corporation (Alloys) Ltd., to be held at the Pendragon Hotel, Southsea at 7.00 p.m.

Thames Valley Section—Student Group: "Titanium dioxide—manufacture and treatment" by a speaker from Laporte Industries Ltd., to be held at the Main Lecture Theatre, Slough College at 4.00 p.m.

West Riding Section: "Industrial espionage," to be held at the Griffin Hotel, Boar Lane, Leeds, at 7.30 p.m.

Friday 17 March

Midlands Section: Annual J. Newton Friend Lecture: "Antiques" by Mrs D. I. Bamber of J. and D. I. Bamber Ltd., to be held at the Chamber of

Commerce, 75 Harborne Road, Birmingham, at 7.30 p.m.

Wednesday 22 March

Scottish Section—Eastern Branch: Film by Hoechst UK Ltd., to be held at the Carlton Hotel, North Bridge, Edinburgh at 7.30 p.m.

Thursday 23 March

Thames Valley Section: "Powder coatings" by Dr O. Brussman of BASF AG, to be held at the Beech Tree Hotel, Maxwell Road, Beaconsfield, Bucks at 7.00 p.m.

Bristol Section: Annual Dinner Dance to be held at the Mayfair Suite of the Bristol Entertainments Centre.

Friday 24 March

Irish Section: "Solvents" by Mr D. H. Scharer of Shell Research Ltd., to be held at the Clarence Hotel, Wellington Quay, Dublin at 8.00 p.m.

Wednesday 29 March

Manchester Section—Student Group: "Modern applications of polyurethanes" by Mr A. C. Jolly (Synthetic Resins Ltd.) to be held at the Manchester Literary and Philosophical Society at 4.30 p.m.

Friday 31 March

Bristol Section: "Industrial relations in the surface coatings industries" by Mr J. L. Thomas of the University of Bristol, Department of Extra Mural Studies, to be held at the Royal Hotel, Bristol at 7.15 p.m.

Newcastle Section

Ladies' Night

The Newcastle Section Ladies' Night Dinner Dance will be held at the Five Bridges Hotel, Gateshead, on 18 February 1972. Tickets, price £2.50, are available from:

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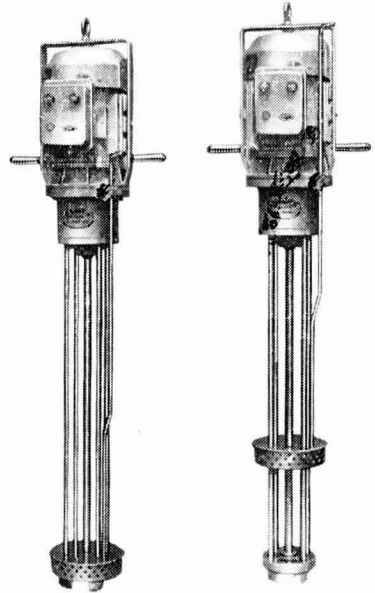
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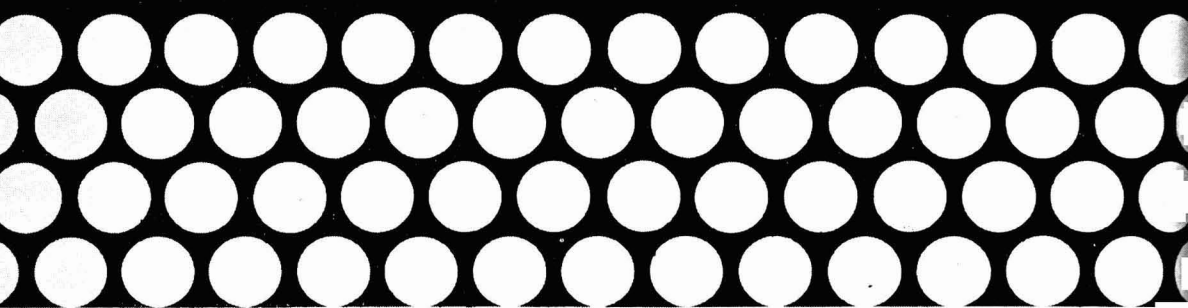


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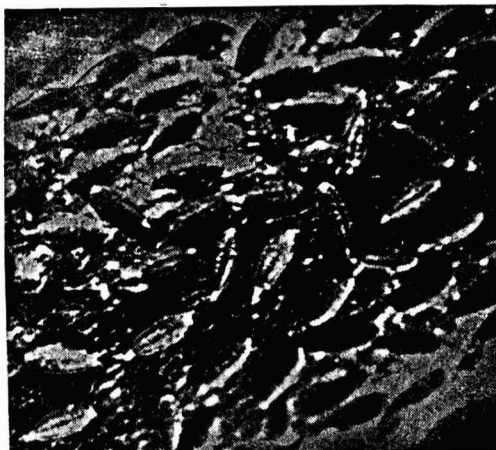
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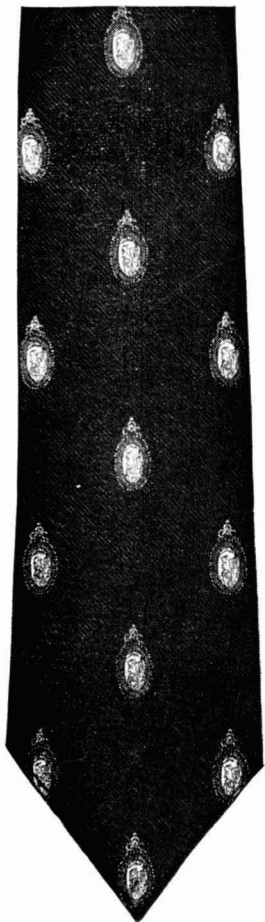
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