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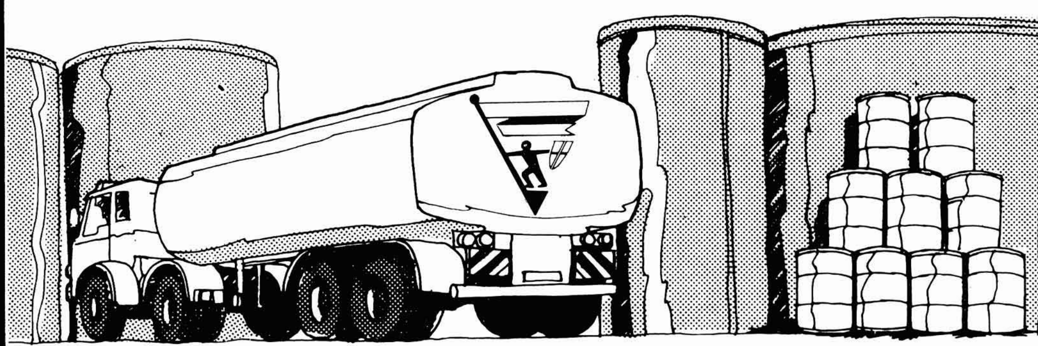

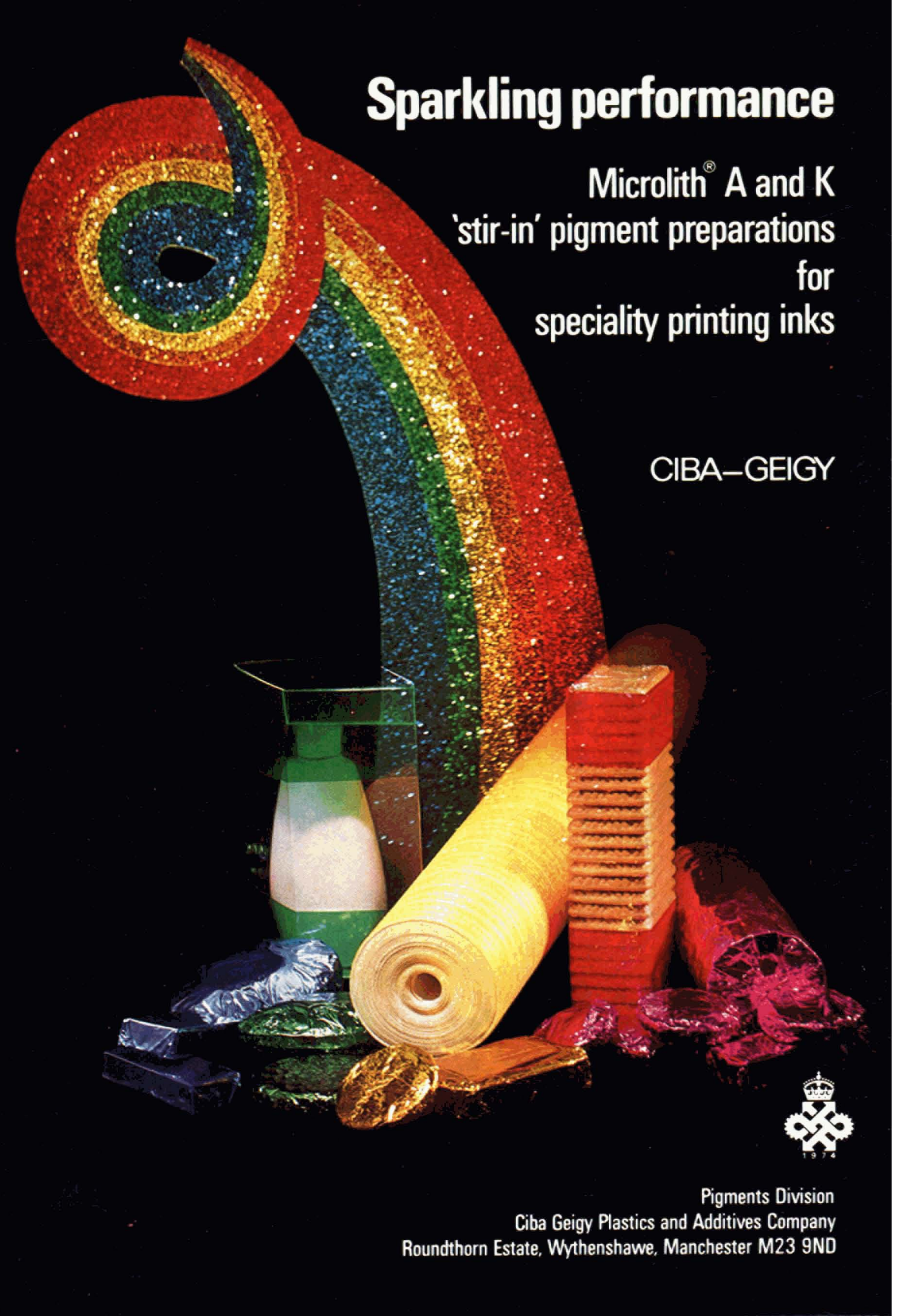
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Transactions and Communications

Microvoid coatings: material and energy savers?*

By J. A. Seiner

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Summary

Evidence is presented to show that poorly insulated structures or tanks will operate at lower temperatures during the summer if high reflectance coatings are used. However, a clear case is also presented to show that appreciable energy savings do not result when reasonably well insulated structures are involved.

Calculations and measurements are presented to show that synergistic hiding effects, obtained in coatings containing both microvoids and titanium dioxide, are actually attributable to normal low levels of flocculation or agglomeration which occur during drying interacting with microvoids.

Keywords

Types and classes of coatings and allied products

microvoid coatings (bubble coatings)
reflecting paint
reflective coatings
latex paints
pigmented coatings

Properties, characteristics and conditions primarily associated with: materials in general

light scattering
insulating coatings
flocculation
hiding power
microvoids

structures of surfaces being coated

buildings
storage tanks

Revêtements contenant des microvides: offrent-ils des économies en matière et en energie?

Résumé

On présente certaine évidence qui indique que les structures et les cuves dont l'isolation thermique n'est pas efficace attiendront en été des températures moins élevées lorsqu'on utilise les revêtements de haut pouvoir reflecteur. Cependant on démontre d'une manière claire que les économies importantes ne se produisent pas dans le cas des structures bien isolées au point de vue thermique.

On présente des calculs et des observations en vue de démontrer que le pouvoir masquant assuré par l'action synergistique des microvides et de l'oxyde de titane contenant par les revêtements est dû en réalité aux faibles degrés de floculation et d'agglomération qui se produisent normalement lors du processus de séchage.

Microvoid Beschichtungen: Material- und Energiesparer?

Zusammenfassung

Beweisematerial wird vorgelegt, um zu zeigen, dass schlecht isolierte Konstruktionen oder Tanks im Sommer bei niedrigeren Temperaturen funktionieren, wenn Beschichtungsmittel von hoher Reflektion benutzt werden. Indessen wird ebenfalls ein klarer Fall vorgelegt, der aufzeigt, dass bei einigermassen gut isolierten Strukturen keine nennenswerten Energieersparnisse erzielt werden.

Berechnungen und Messresultate werden vorgelegt, um zu zeigen, dass synergistische Deckkraft-Effekte bei sowohl Microvids als auch Titaniumdioxid enthaltenden Beschichtungsmitteln in Wirklichkeit normalen niedrigen Ausflockungs- und Agglomerationsniveaux, welche beim Trocknen als Reaktion mit Microviden vorkommen, zuzuschreiben sind.

Introduction

Refs. 1-14

Previous publications in the field of microvoid coatings have mostly fallen into three categories: *A.* Theoretical light scattering calculations which usually include comparisons with titanium dioxide; *B.* Physical and/or mechanical properties of such diverse materials as corfam, millipore, nuclepore, sheet molding compound and many others[1-14] and *C.* Procedural details relating to the various techniques for generating microvoids. These include: extraction, coagulation, blushing, solvent precipitation, frothing, microcrazing, low-profile techniques, emulsification, stretching, hollow microcapsules, piercing, selective swelling and others.

The main thrusts of this publication are somewhat different. For the first time two comparisons will be drawn. Both comparisons could have considerable impact upon a world where resources of materials and energy are finite and of limited availability.

One comparison made will be between theoretical calculations of Kerker, Cooke and Ross[24] at Clarkson College in upstate New York and actual measurements on controlled microvoid containing films made by Vanderhoff and El Aasser at Lehigh University in eastern Pennsylvania. The author has had the continuing good fortune to serve as a monitor for the Paint Research Institute on the Clarkson project and to work as a collaborator from PPG Industries, sponsor of the work at Lehigh.

A second comparison will be made between the theoretical and actual energy rejection which results from painting the exteriors of structures with ultra-high reflectance microvoid containing coatings. Here the theoretical calculations were done for PPG by Dougall and Hwang at the University of Pittsburgh in western Pennsylvania and actual measurements were taken at PPG's Springdale Pennsylvania Research Laboratory field test site and a field site in Beaumont, Texas.

Primary justification for both these comparisons are almost intuitively obvious. The replacement of titanium dioxide,

*The Hon. Editor regrets that the conversion of the paper to SI units is virtually impossible. Paper presented at the Association's Biennial Conference held at the Grand Hotel, Eastbourne, Sussex from 16-19 June, 1977.

even partially, by microvoids would be potentially economical with respect to both resources and costs. Early research efforts involved preliminary measurements of heat rejection by highly reflective white coatings on inverted one gallon cans. The results were promising enough to justify scale-up to both small structures, called for lack of a better name, "dog houses", and full scale solvent storage tanks in Beaumont, Texas. The results in each case were favourable. This led to calculations to determine whether building air conditioner loads could be appreciably decreased and net energy savings demonstrated.

Heat rejection studies

Refs. 15, 16

Theoretical calculations were made based on three different types of structures. The first was a characteristic residential single family dwelling. This house is described as:

General description of characteristic house

Type: Single family detached dwelling. Two storey, 32.8ft × 27.3 ft. Fully air conditioned with all typical major appliances present.

Windows: Aluminum casement, single glazing. Total aiea 180 ft² (No windows on west wall).

Patio Door: Aluminum frame, single glazing, 40 ft² located on south wall.

Doors: Wood panel, 3, total area 60 ft², 1 north wall, 1 south wall, 1 west wall.

The floor plan is shown in Fig. 1.

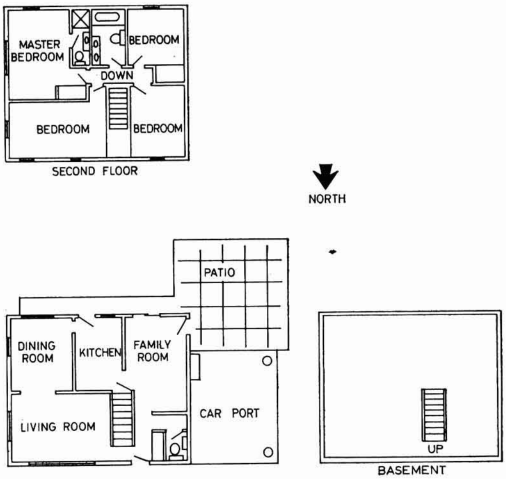

Fig. 1. Floor plan of characteristic house

Calculations were based on response factor methods of Stephenson and Mitalas[15] and by Kusuda[16]. These authors used the schematic shown in Fig. 2.

Each factor noted in the scheme is important in running the modified NBSLD program. To make these calculations data is needed upon weather tapes for each specific location, sun tracking tapes, internal load information of three types, ventilation (air turn-over) rates, heating and cooling capabilities and rates, wall and ground thermal response data and an integrating programme to combine them.

For each individual calculation a set of reasonable assumptions were necessary. In the case of the characteiistic house an average occupancy of 3.35 people was assumed as shown in Fig. 3.

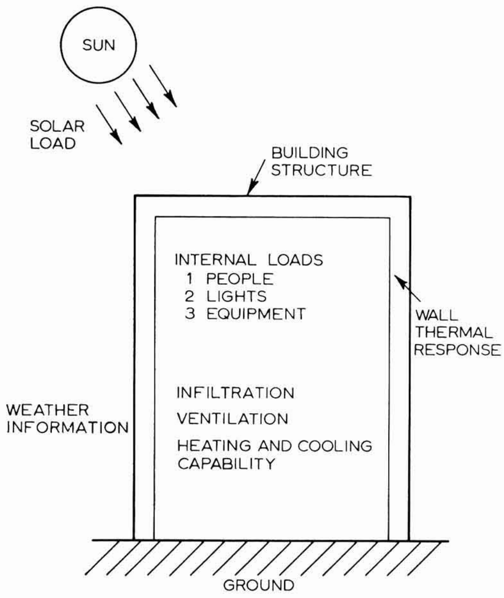

Fig. 2. Schematic representation of the important parts of the NBSLD programme

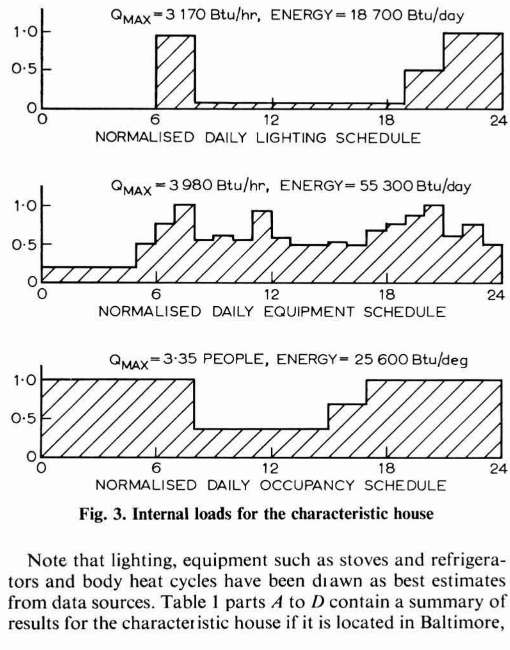

Fig. 3. Internal loads for the characteristic house

Note that lighting, equipment such as stoves and refrigerators and body heat cycles have been diawn as best estimates from data sources. Table 1 parts *A* to *D* contain a summary of results for the characteiistic house if it is located in Baltimore, Maryland, Atlanta, Georgia, or Houston, Texas. Exterior paint reflectivities of 10, 50 and 95 per cent are assumed under low and high air infiltration rate conditions. (Low being normal ASHRAE air turn-over rates and high being 150 per cent of normal).

Table 1

Summary of results for characteristic house

Part A—Maximum heating & cooling loads

City	Reflectivity	Infiltration	Maximum heating (BTU-HR)	Maximum cooling (BTU-HR)
Baltimore	0.10	High	47,255	26,159
	0.50	High	47,256	25,501
	0.95	High	47,257	24,761
	0.10	Low	35,157	21,262
	0.50	Low	35,158	20,341
	0.95	Low	35,159	19,427
Atlanta	0.10	High	48,059	25,202
	0.50	High	48,059	24,667
	0.95	High	48,059	24,066
	0.10	Low	35,484	20,457
	0.50	Low	35,484	19,922
	0.95	Low	35,484	19,321
Houston	0.10	High	38,123	31,111
	0.50	High	38,124	30,469
	0.95	High	38,126	29,746
	0.10	Low	28,306	24,193
	0.50	Low	28,307	23,551
	0.95	Low	28,309	22,827

For Baltimore, under normal (low) infiltration rates the mid-summer maximum air conditioner load is about 10 per cent higher for a dark (0.1 reflectivity house) than for a very light (0.95 reflectivity) house.

Table 1

Summary of results for characteristic house

Part B—Annual heating & cooling loads

City	Reflectivity	Infiltration	Annual loads (10^6 BTU) Heating	Cooling
Baltimore	0.10	High	73.29	29.74
	0.50	High	74.25	28.39
	0.95	High	75.35	26.89
	0.10	Low	51.92	26.81
	0.50	Low	52.83	25.42
	0.95	Low	53.89	23.89
Atlanta	0.10	High	42.48	45.49
	0.50	High	43.16	43.86
	0.95	High	43.96	42.05
	0.10	Low	29.65	39.06
	0.50	Low	30.27	37.36
	0.95	Low	31.01	35.49
Houston	0.10	High	22.88	67.77
	0.50	High	23.28	66.11
	0.95	High	23.74	64.24
	0.10	Low	15.75	56.33
	0.50	Low	16.10	54.61
	0.95	Low	16.52	52.71

Inspection of Table 1, part *B* discloses similar but not identical results. With the change from maximum loads to annual loads, differences between Baltimore, a reasonably northern warm weather city, and Houston, a far south city become obvious. Thus in Baltimore a 3 million BTU summer savings in cooling is somewhat offset by a 2 million BTU increase in winter heating load whilst for Houston the 3.6 million BTU savings is off-set by only a 0.8 million BTU increase for heating.

Table 1

Summary of results for characteristic house

Part C—Annual energy costs

City	Reflectivity	Infiltration	Heating costs* (dollars)	Cooling costs** (dollars)
Baltimore	0.10	High	209.40	148.72
	0.50	High	212.14	141.96
	0.95	High	215.23	134.44
	0.10	Low	148.34	134.04
	0.50	Low	150.94	127.12
	0.95	Low	153.98	119.44
Atlanta	0.10	High	121.34	227.44
	0.50	High	123.32	219.32
	0.95	High	125.60	210.24
	0.10	Low	84.72	195.32
	0.50	Low	86.48	186.80
	0.95	Low	88.60	177.44
Houston	0.10	High	65.38	338.84
	0.50	High	66.52	330.56
	0.95	High	67.82	321.20
	0.10	Low	45.00	281.64
	0.50	Low	46.00	273.04
	0.95	Low	47.20	263.56

*Based on gas costs of $2.00 per million Btu.
**Based on electric costs of $0.04-kw hr.

Using the assumptions of air conditioner efficiency at 8 BTU/watt-hour, an electricity cost of $0.04/kw hr, a furnace efficiency of 70 per cent and a gas cost of $2.00/million BTU's allows us to calculate the figures in Table 1 part *C*. Here annual energy costs are shown for both heating and cooling. Once again it is seen that air infiltration rate is a major factor in energy costs and that savings from cooling costs in the summer are somewhat off-set by increases in winter heating costs.

Table 1

Summary of results for characteristic house

Part D—Incremental savings in energy costs (medium reflectivity is reference)

City	Reflectivity	Infiltration	Heating savings (dollars)	Cooling savings (dollars)	Net savings (dollars)
Baltimore	0.10	High	+2.74	−6.76	−4.02
	0.50	High	—	—	—
	0.95	High	−3.14	+7.52	+4.38
	0.10	Low	+2.60	−6.92	−4.32
	0.50	Low	—	—	—
	0.95	Low	−3.04	+7.68	+4.64
Atlanta	0.10	High	+1.98	−8.12	−6.14
	0.50	High	—	—	—
	0.95	High	−2.28	+9.08	+6.80
	0.10	Low	+1.76	−8.52	−6.76
	0.50	Low	—	—	—
	0.95	Low	−2.12	+9.36	+7.24
Houston	0.10	High	+1.14	−8.28	−7.14
	0.50	High	—	—	—
	0.95	High	−1.30	+9.36	+8.06
	0.10	Low	+1.00	−8.60	−7.60
	0.50	Low	—	—	—
	0.95	Low	−1.20	+9.48	+8.28

Part *D* of Table 1 is a summary of the incremental savings in energy costs which result from varying exterior reflectance at each infiltration rate. In this case, the values for 50 per cent reflectivity have been subtracted from the 10 and 95 per cent reflectivity values. The largest net savings were noted in Houston where increased heating costs are minimised. At that location total costs vary from $327 per year for a 10 per cent reflectivity house to $311 per year for a 95 per cent reflectivity house. Thus a net savings of only $16 per year which is about

5 per cent results from painting a very dark house a very bright white. If the house has an original reflectance of 50 per cent the savings would be about half or $8 per year.

In light of these not very optimistic results, a reassessment of the situation was required. It was decided that possibly structures with different area to volume ratios and degrees of insulation might be more promising. For this reason the next structure analysed was a 93 ft × 35 ft small office or light industrial building shown in Fig. 4.

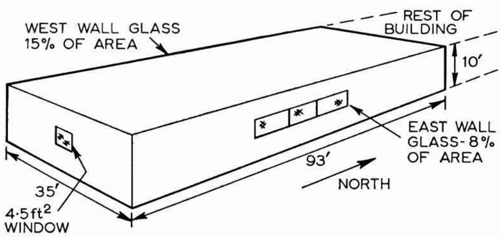

Fig. 4. Basic model for the small office building

For the small office building situation only internal load and final savings information will be given as shown in Fig. 5 and Table 2.

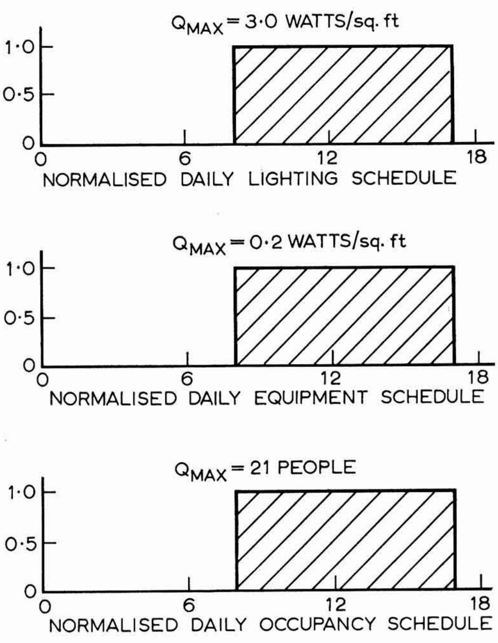

Fig. 5. Internal loads for the small office building

This small office building which is a wing of a larger building, is occupied by 21 people for 9 hours each day. In this case the Houston savings are again the largest. Cooling savings of $55 per year are reduced by increased heating costs of $18 per year to yield a net savings of $37 out of a total bill of $611. This 6 per cent saving in going from 10 per cent to 95 per cent reflectance is again cut in half if the structure's original reflectance is 50 per cent.

Table 2

Summary of results for small office building

Incremental savings in energy costs

(medium reflectivity is reference)

City	Reflectivity	Heating savings	Cooling savings (dollars)	Net savings
Chicago	0.10	+10.20	−15.00	−4.80
	0.50	—	—	
	0.90	−10.40	+14.52	+4.12
Pittsburgh	0.10	+11.80	−17.00	−5.20
	0.50	—	—	—
	0.90	−12.00	+16.00	+4.00
Houston	0.10	+9.20	−28.00	−18.80
	0.50	—	—	—
	0.90	−9.40	+27.52	+18.12

Once more, not being overwhelmed by success, it was decided that possibly an uninsulated warehouse with neither heating nor cooling capabilities could derive appreciable benefit from high reflectivity. Therefore maximum and minimum inside air temperatures were calculated under Houston's solar load for one having 3 inches, and one without, insulation. Fig. 6 shows the results of these calculations.

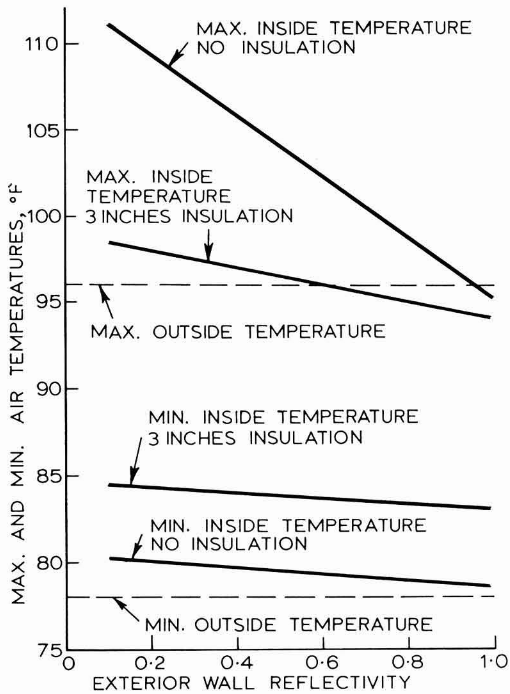

Fig. 6 Comparison of maximum and minimum inside air temperatures for an insulated and uninsulated warehouse

Note here that peak summer temperatures of 112°F are reduced to 96°F when changing from 10 per cent reflectance to 95 per cent reflectance. This 16°F drop could be appreciable under certain conditions. If this peak daytime temperature is reduced by adding insulation instead of changing reflectance, then minimum temperatures at night will be 4°F higher.

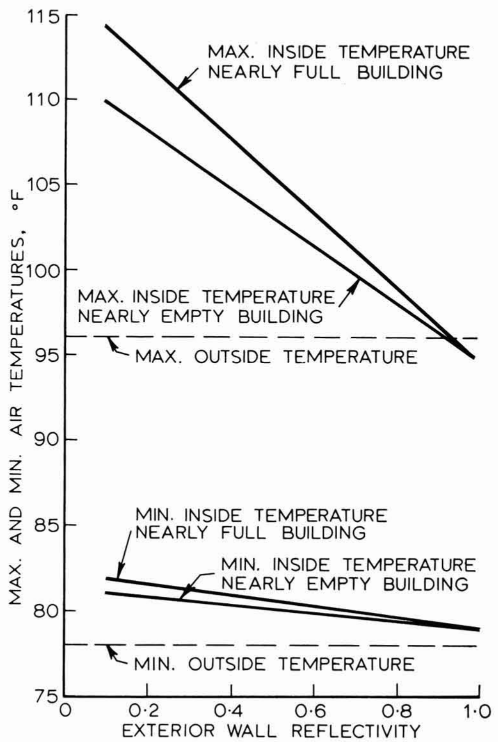

Fig. 7. Comparison of maximum and minimum inside air temperatures for a nearly full and nearly empty uninsulated warehouse

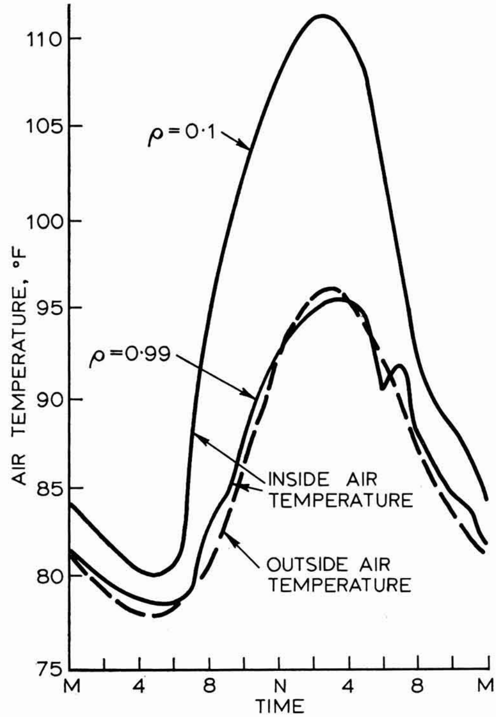

Fig. 8. 24 hour warehouse cycle

Fig. 7 indicates that by filling the warehouse the daily high temperature problem is accentuated. Instead of a 16°F reduction 19°F can be obtained or from 115°F to 96°F. This is, of course, due to the thermal masses involved.

The last figure in this sequence (Fig. 8) indicates temperature fluctuations during a 24 hour cycle for the uninsulated warehouse. Note that going from a dark to a light structure can lead to a 16°F drop in mid-afternoon (2.30 pm) temperature. Conversley, utilising Fig. 6 it can be seen that the temperature drop would only be 2–3°F in changing from an 82 per cent reflectance conventional paint to a 95+ per cent reflectance for an ultra bright microvoid paint.

Actual measurements on "super dog houses" (approximately 6 ft × 6 ft × 4 ft) shown in Fig. 9 are compared with these calculations.

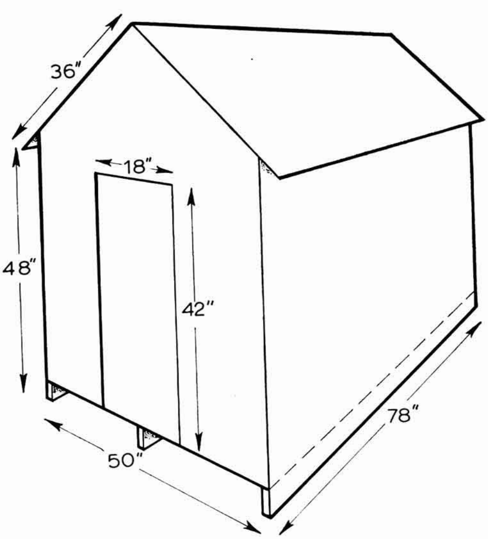

Fig. 9. Test super "dog houses"

The coatings compared in Fig. 10 were a conventional exterior white at 87.3 per cent absolute reflectance *versus* an ultra high reflectance microvoid coating at 95.7 per cent. Measurements on a sunny day in August could be typified by Fig. 10. Here a temperature difference of 7°F is seen for a difference in reflectivity of only 8.4 per cent. This difference of 7°F *vs* 2–3°F as predicted by Fig. 6 is explained by the gross differences in surface to volume ratio. Mid-winter measurements on a sunny day indicated that the high reflectance house was 3°F cooler (32°F *vs* 35°F) in February. On sunny days in mid-October this difference was still 5° to 6°F (70°F *vs* 76°F and 75°F *vs* 80°F).

A comparable set of data was also obtained from the Beaumont, Texas test facility where several large uninsulated ethylene glycol storage tanks were painted with conventional white and ultıa high reflectance microvoid coatings. Here it

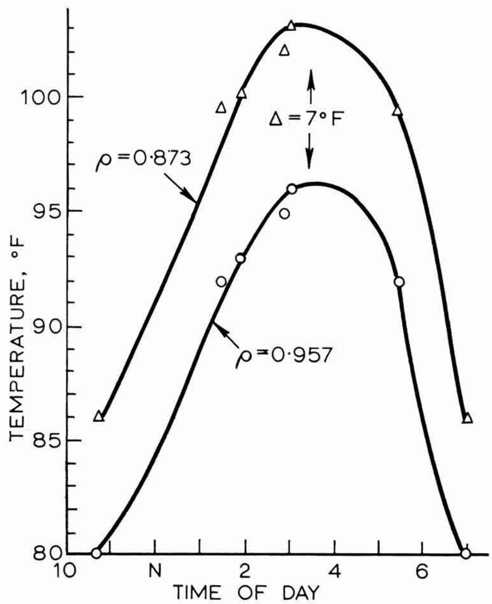

Fig. 10. August 1968 "dog house" measurements

was found that vapour space temperatures varied between 14 to 21°F lower for the high reflectance tanks as shown in Table 3.

Table 3

Tank vapour temperatures

Reflectance	Tank 1	Tank 2
0.85	100°F	110°F
0.95	86°F	89°F

Ambient temperature: 93°F
Contents: ethylene glycol

But for the advent of large in-tank floats now in use at oil refineries, these findings could have been a major factor in today's push for petroleum conservation. Possibly there are still some large petrochemical storage areas where tank reflectance improvement would be of major consequence.

Summarising the findings so far, it must be concluded that for conventional dwellings and well insulated structures, reflectivity does not appear to be an economic route to appreciable energy savings. However, for poorly insulated structures such as warehouses, storage tanks and the like, ultra-high reflectance coatings based on microvoid technology could make a major difference. This may not be an answer to every question, but it is the answer to some, if a careful choice is made.

Light scattering studies

Ref. 17-25

After investigating numerous techniques for introducing known microvoid configurations into a coatings film, it was found that the most feasible route to follow was that of El Aasser and Robertson[19] from their work in 1971 involving deposition of monodisperse latex particles from a 35 per cent sucrose solution.[17-19] By using a hard monodisperse polystryrene core particle and over-coating it with 50 to 200 Å of a soft low T_g polymer, such as polyethyl acrylate, it is possible to coalesce continuous films of an almost crystalline character containing well defined void contents and distributions. Table 4 describes the emulsions used for this part of the study.

Table 4

Seeded emulsion polymerisation of ethyl acrylate in monodisperse polystyrene latex

Recipe	Particle diameter of monodisperse polystyrene latex, μm	Calculated thickness of polyethyl acrylate layer, Å
KS-60	0.234	50
KS-61	0.234	100
KS-62	0.234	150
KS-63	0.357	50
KS-64	0.357	100
KS-65	0.357	150
KS-39	0.795	50
KS-38	0.795	120
KS-66	0.795	150
I-1	0.795	200
KS-68	1.10	150
I-2	1.10	200
KS-69	2.02*	200

*polyvinyltoluene

Fig. 11 is a photograph of model microvoid films produced by centrifugal separation of polystyrene latex particles "coated" with a thin layer of polyethyl acrylate. Films *1* and *2* contain microvoids of the same size (0.795 μm polystyrene plus 150 Å polyethyl acrylate) but are of different thickness; Films *3* and *4* are of the same film thickness (1.6 mils) but contain different void sizes (0.234 μm polystyrene plus 50 Å polyethyl acrylate and 1.10 μm polystyrene plus 150 Å polyethyl acrylate respectively).

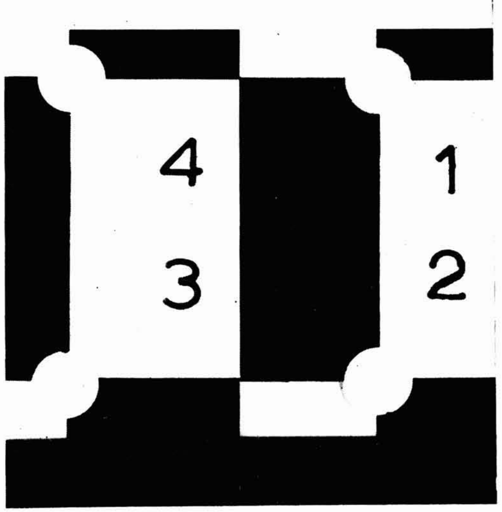

Fig. 11. Model microvoid films produced by centrifugal separation

Fig. 12 is a scanning electron microscope (SEM) photograph of a typical film.

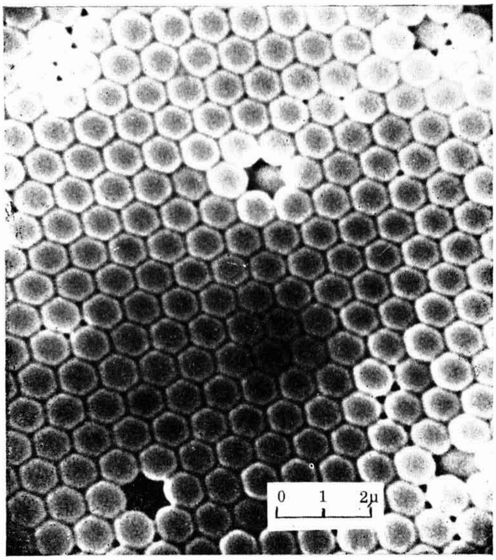

Fig. 12. Scanning electron micrograph of the surface of a model microvoid film of 0.795 μm-diameter polystyrene latex particles "coated" with 120Å-thick layer of polyethyl acrylate, showing the uniformity of packing of the latex particles in the film

Table 5

Average microvoid volume fraction of model films (Table 4)

Latex	Average volume fraction of microvoids
0.357μm PS + 100Å PEA	0.3418
0.795μm PS + 120Å PEA	0.3992
0.795μm PS + 150Å PEA	0.4142
0.795μm PS + 200Å PEA	0.4030
1.10μm PS + 150Å PEA	0.4431
1.10μm PS + 200Å PEA	0.4164

Standard packing calculations enabled the average microvoid volume fractions to be calculated. These are tabulated in Table 5.

Fig. 13 is an example of typical reflectance *vs* wavelength curves measured over white and black Vitrolite substrates, whilst Fig. 14 is a typical Kubelka-Munk plot used to determine scattering coefficients.[20]

Table 6

Scattering coefficients of model microvoid films at 560 nm

Latex	Film scattering coefficient, $mils^{-1}$	Microvoid volume fraction	Specific microvoid scattering coefficient, $mils^{-1}$ PVC^{-1}
0.357μm PS + 100Å PEA	3.025	0.3418	8.850
0.795μm PS + 120Å PEA	3.675	0.3992	9.206
0.795μm PS + 150Å PEA	3.420	0.4142	8.257
1.10μm PS + 150Å PEA	4.050	0.4431	9.140

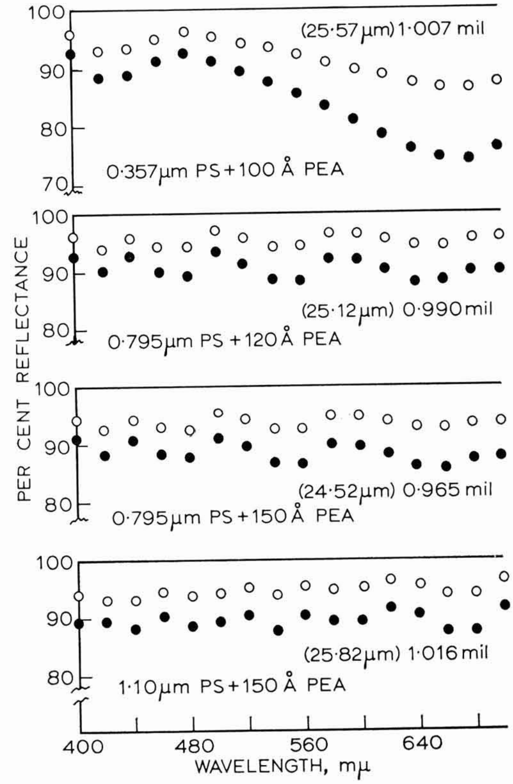

Fig. 13. Representative reflectance-wavelength curves measured over white (O) and black (●) backgrounds for four different model microvoid films of about the same thickness

More reasonable comparisons between various light-scattering materials can be made if film scattering coefficients in $mils^{-1}$ are converted to specific scattering coefficients in $mils^{-1}$ PVC^{-1}. This is accomplished as shown in Table 6 by merely dividing by microvoid volume fraction. The values attained of around 9 $mils^{-1}$ PVC^{-1} compare reasonably well with the results of Pierce, Babil[21] and Blasko 6 $mils^{-1}$ PVC^{-1} where simplified Kubelka-Munk methods were also used but the microvoids films were of random type.[21–23]

Table 7 contains calculated specific scattering coefficients calculated using the general Kubelka-Munk equation. Here the coefficients varied from about 6 to 19 $mils^{-1}$ PVC^{-1}. Fig. 14 is a plot of some of the data from Table 7 which demonstrates decreased scattering as the microvoid size is decreased, but the number is held constant.

A final series of light-scattering measurements were made at Lehigh on three films submitted by the author. These films consisted of first, a film containing only a fixed level of titanium dioxide; second a film containing only a fixed level of microvoids, but free of titanium dioxide, and third a film containing both of these. The results are shown in Fig. 15.

Note that whilst this microvoid film had a scattering coefficient of less than 0.5 mil^{-1} and the titanium dioxide containing film had a scattering coefficient of about 7 mil^{-1}, the film containing combined levels of both had a scattering coefficient of

Table 7

Specific scattering coefficient of microvoids in model films, using general Kubelka-Munk equation

	Specific Scattering Coefficient, mil^{-1} PVC^{-1}					
Wavelength, nm	0.357μm PS + 100Å PEA	0.795μm PS + 120Å PEA	0.795μm PS + 150Å PEA	0.795μm PS + 200Å PEA	1.10μm PS + 150Å PEA	1.10μm PS + 200Å PEA
400	19.028	17.264	15.461	11.702	12.057	12.809
420	15.538	15.574	14.024	11.165	12.130	12.811
440	15.154	16.773	13.962	11.061	11.204	11.962
460	17.036	13.793	12.682	10.158	12.198	12.532
480	17.736	12.922	11.832	9.663	10.819	11.682
500	15.965	16.062	14.405	10.260	11.056	11.420
520	13.933	13.715	12.608	9.884	11.299	12.015
540	12.134	11.331	10.523	8.743	9.706	10.587
560	10.687	11.127	10.202	8.381	10.833	11.389
580	9.404	13.205	11.810	8.774	9.819	10.602
600	8.280	12.535	11.533	8.987	9.498	10.341
620	7.288	10.959	10.196	8.478	10.461	11.064
640	6.517	9.828	9.175	7.844	9.643	10.452
660	6.049	9.617	8.879	7.503	8.225	9.116
680	5.954	10.461	9.524	7.503	7.984	9.407
700	6.362	10.359	9.510	7.593	9.591	10.248

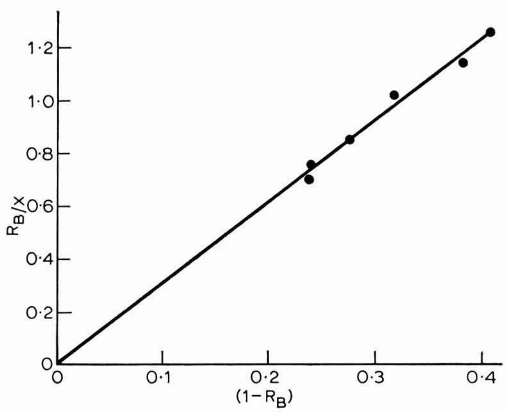

Fig. 14. Variation of the reflectance R_B at 560 nm of the model microvoid films of 0.357 μm-diameter polystyrene latex particles "coated" with a 100Å-thick layer of polyethyl acrylate over black background divided by the corresponding film thickness X with $(1 - R_B)$. Slope = film scattering coefficient = 3.025 mil^{-1}

about 13 mil^{-1}. It is this unexpected synergism which both allows the commercial possibility of microvoid films and has puzzled workers in the field for a number of years.

Summarising the results of the Lehigh measurements on microvoid films of known geometry allows a crude optimisation approximation to be made. The best hiding (highest scattering coefficients) is obtained when the microvoid size is about one-third the spacing between microvoids. So, for a spacing of 1.2 μm, it might be desirable to use regularly spaced microvoids of 0.4 μm whilst for a spacing of 0.3 μm microvoids, 0.1 μm would be more appropriate.

An answer to the synergism question referred to above appears to have resulted from the work of Kerker, Cooke and Ross[24,25]. In this case computer programmes were written to analyse theoretically the complex light scattering from the three configurations shown in Fig. 16.

Configuration *A* consists of a microvoid containing a centrally positioned titanium dioxide pigment particle, configuration *B* consists of a titanium dioxide pigment particle

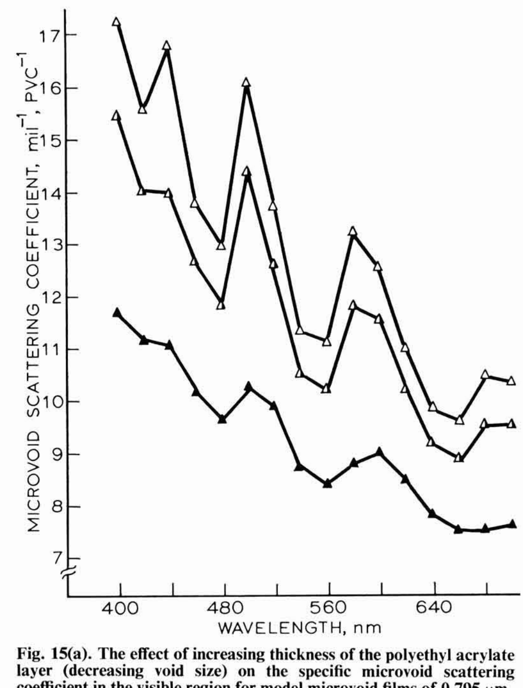

Fig. 15(a). The effect of increasing thickness of the polyethyl acrylate layer (decreasing void size) on the specific microvoid scattering coefficient in the visible region for model microvoid films of 0.795 μm-diameter polystyrene latex particles coated with the following thicknesses: (△) 120Å; (△) 150Å: (△) 200Å

containing a centrally positioned microvoid and C consists of physically separated microvoids and titanium dioxide pigment particles.

Using conventional light-scattering graphics, a convenient way to display data is by using a sizing parameter where $\alpha = 2\pi a/\lambda$. Here a is the radius in μm and λ is wavelength in μm.

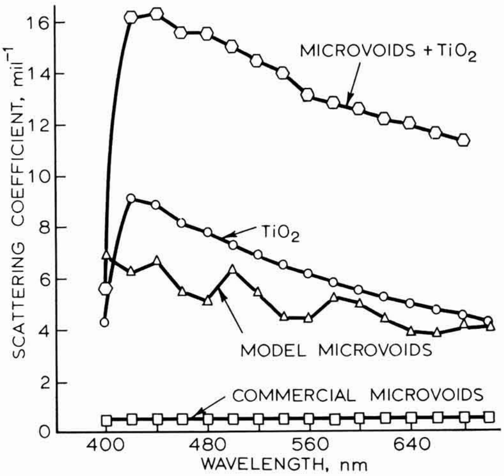

Fig. 15(b). A comparison between the film scattering coefficients in the visible region for model microvoid films of 0.695 μm-diameter polystyrene latex particles "coated" with a 120Å-thick layer of polyethyl acrylate (△), and PPG films containing only microvoids (□), only titanium dioxide (O), and microvoids plus titanium dioxide.

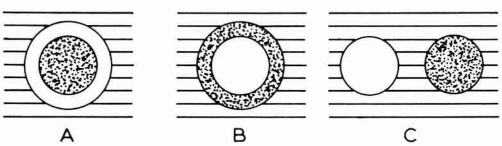

Fig. 16. Microvoid configurations

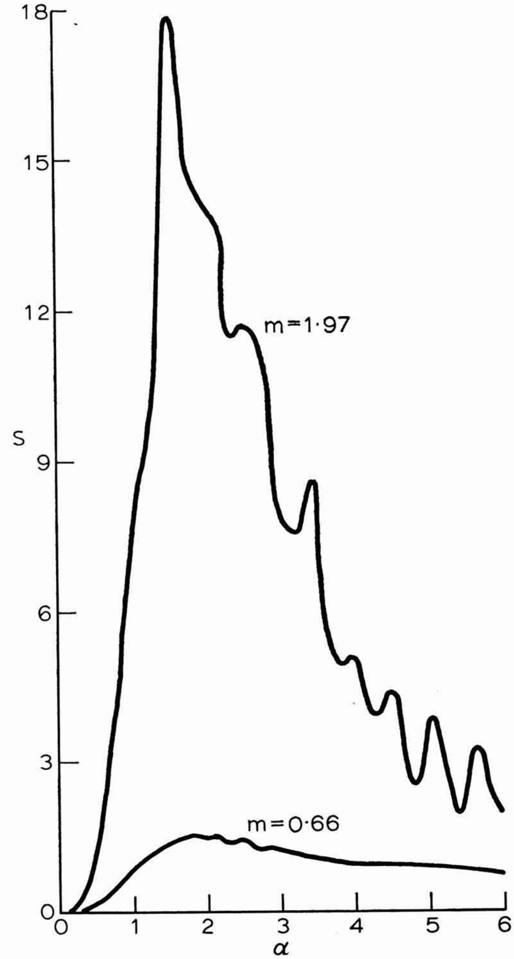

Fig. 17. Titanium dioxide and microvoid

In Fig. 17 the scattering coefficient S in mils^{-1} is plotted *vs* α for titanium dioxide whose ratio of refractive index to binders is 1.97 and for microvoids whose ratio is 0.66. It is at once obvious that alone, titanium dioxide has a scattering coefficient maximum of almost 18 mils^{-1} at $\alpha = 1.6$ whilst microvoids only reach a peak of 1.5 mils^{-1} at $\alpha = 2.0$ and that on this basis the pigment is much preferred to air. Using $\lambda = 0.546$ for the middle of the visible spectrum and $\alpha = 1.6$ as titanium dioxide's most efficient size, a is calculated to be 0.092 μm. This leads to pigment diameters of 0.184 μm which is very near to the actual size of commercial products.

In a similar manner, sizing parameters can be used for systems containing both microvoids and titanium dioxide pigment. In this case the sizing parameter ν = sizing parameter (voids + titanium dioxide) and f = fraction of ν which is titanium dioxide. (Or in simpler terms the volume fraction of pigment in combined pigment and void volumes.)

Fig. 18 graphically displays f *vs* ν at constant scattering coefficient S for configuration A. Note that for $f = 1$ and $\nu = 1.6$ the maximum hiding value for titanium dioxide alone is regenerated. Fig. 18 leads to a number of somewhat surprising results. Firstly, it was not originally anticipated that for small particles where ν is less than 0.4 and when f is about 0.4, S appears to become very small. In fact, as Fig. 19 indicates, the scattering coefficient drops to 5×10^{-6} mils^{-1} and the film becomes essentially transparent. This unexpected result, which is being explored further by Kerker and co-workers, may have commercial utility to those producing UV screens and sun tan lotions where transparency and screening are both desired.

Fig. 20 is another way of displaying data somewhat like that shown in Fig. 18, but here extended to larger values of ν. In Figs 20, 21 and 22 a plotting index factor was used to conserve space. Thus in Fig. 20 the curve marked P.I. = 2.0 is displaced upward 2 units. For $f = 1$ the actual value of S is 4.1 mils^{-1} (6.1 minus 2.0).

Fig. 20 demonstrates that for agglomerates of a size equivalent to two or three primary pigment particles, scatter-

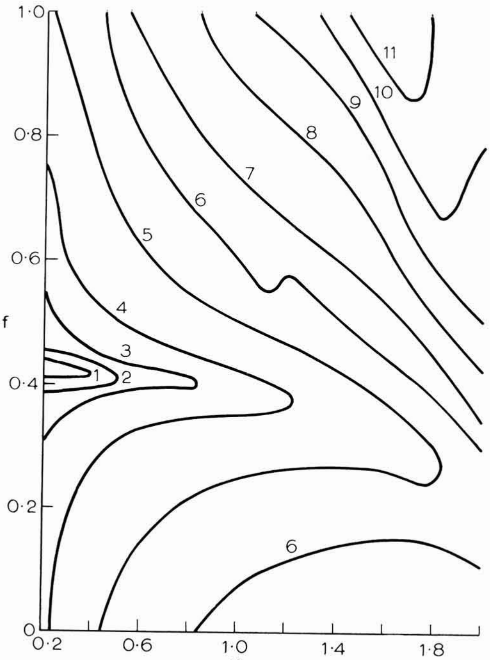

Fig. 18. Configuration A

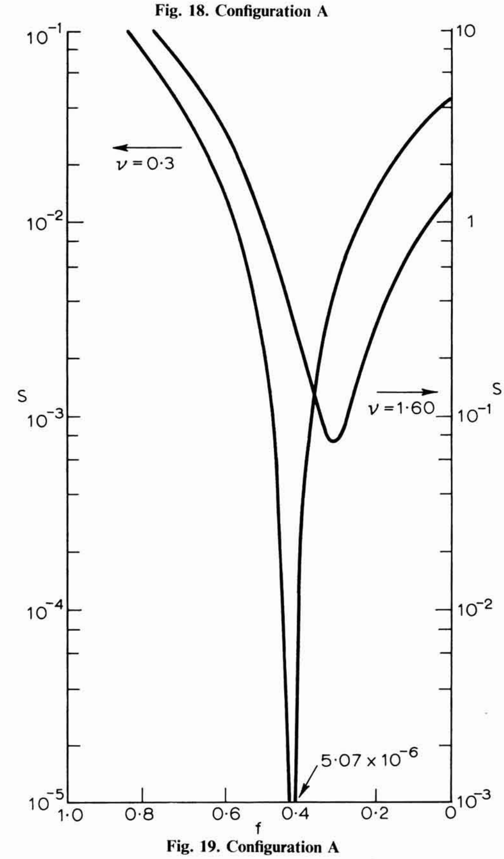

Fig. 19. Configuration A

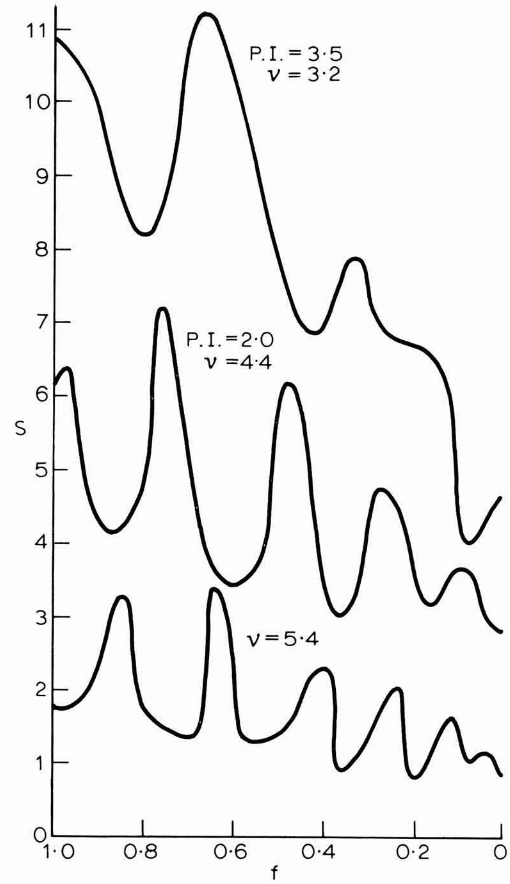

Fig. 20. Configuration A

ing coefficients for pigment fractions as low as 25 to 70 per cent are equivalent to 100 per cent pigment.

Fig. 21 describes results for configuration *B* where a void is encapsulated by titanium dioxide. Its light-scattering characteristics are intriguing. In partially flocculated paint systems, where multiple titanium dioxide particles might be enticed to form around a microvoid precursor, cases like $\nu = 5.4$ in Fig. 21 might be more practical than most formulators realise.

Here optimal hiding is attainable with major reductions in prime pigment or the alternative of equal hiding at 80 per cent pigment removal is possible. In this day of limited resources both options should be vigorously explored.

The last graph, Fig. 22, represents the real world of latex coatings, configuration *C* where titanium dioxide particles and microvoids are separate entities. Here a wide variety of combinations and alternatives are feasible. If the hypothesis is accepted that as a latex paint dries, partial flocculation occurs leading to agglomerates the size of two to four pigment particles, then it must be recognised that the spectacular blip in Fig. 22 for $\nu = 4.8$ that occurs at $f = 0.76$ is of major significance. It is, in fact, most likely that this type synergism is the explanation for results shown in Fig. 15. It is also noteworthy that when pigment and void are separate, as long as at least partial agglomeration exists ($\nu = 3.2$), at least 50 per

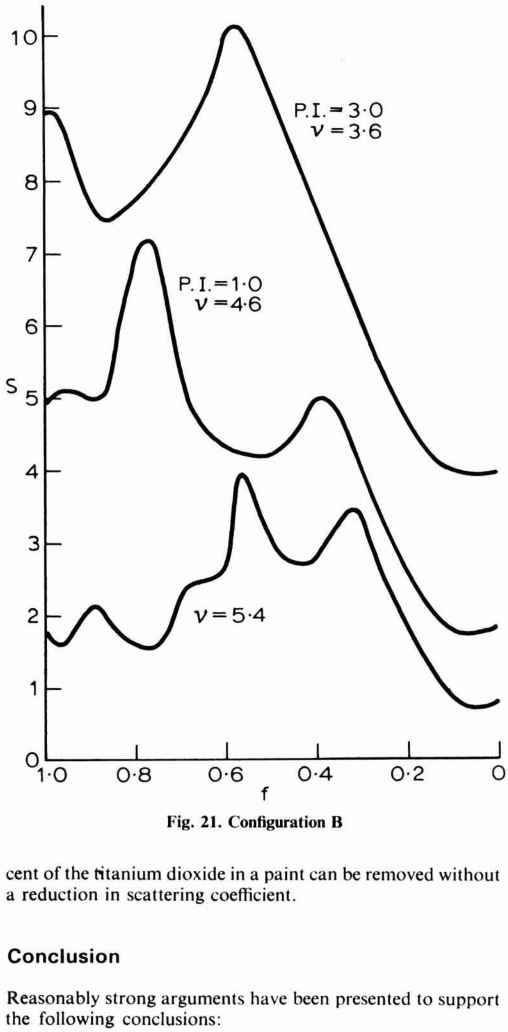

Fig. 21. Configuration B

cent of the titanium dioxide in a paint can be removed without a reduction in scattering coefficient.

Conclusion

Reasonably strong arguments have been presented to support the following conclusions:

1. For conventional, fairly well insulated structures appreciable savings in air-conditioning energy requirements are not attainable by increasing the reflectance of exterior paints.

2. For poorly insulated structures or tanks appreciable internal temperature reductions are possible by increasing external reflectance.

3. For pigment free microvoid systems of perfectly uniform geometry, optimised scattering is attained when microvoid size is about one third the spacing between microvoids.

4. For systems containing microvoids with internal titanium dioxide particles, geometries and levels exist where optically transparent, yet UV absorbing, coatings can be formulated.

5. For systems containing separated microvoids and titanium dioxide particles and where, at least, partial flocullation or agglomeration exists, formulators are given the option of either remarkably improving hiding or major reductions in prime pigment content.

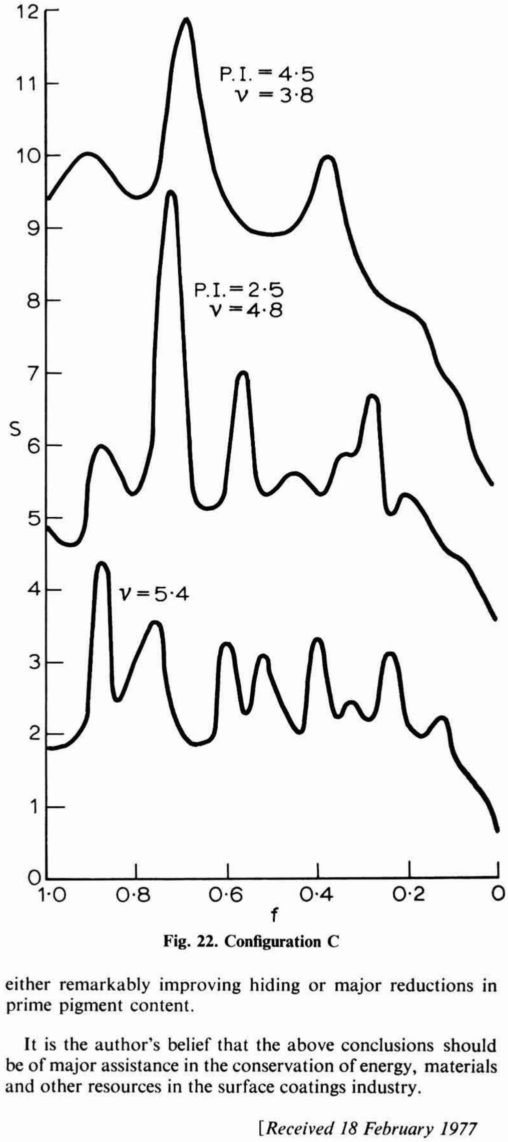

Fig. 22. Configuration C

It is the author's belief that the above conclusions should be of major assistance in the conservation of energy, materials and other resources in the surface coatings industry.

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Discussion at Eastbourne Conference

Dr G. D. Parfitt asked what effects the microvoids in the paint film had on the other characteristics of the paint, such as strength and durability which were, of course, very important. He also asked whether the difference between the model microvoids and the commercial microvoids in Figure 15(b) was purely a function of particle size uniformity, and whether the comparison between curves of microvoid plus TiO_2 and TiO_2 alone was a fair comparison. He pointed out that if the TiO_2 alone provided any dry hiding this would affect the curve.

Mr Seiner replied that one of the advantages of the techniques he had described was that they created closed cell microvoids. When this was compared with other methods of incorporating air into films, which involved going up to high levels of PVC, the voids in the film were generated in an interconnected manner; these were usually related to pigment interfaces and there was, generally, a much more rapid degradation in properties by increasing PVC than there was in incorporating isolated closed cells of air into the film. With a very high microvoid content, the film properties would obviously degrade. However, in general, it was found, as a result of about eight years work, that coatings could be made which had all the properties possessed by their predecessors in addition to microvoids and the benefits gained from them. This process was being used commercially in the US on a large scale.

In Figure 15(b) the differences were not simply due to the microvoids, although these were present, but also in the distribution—in a paint film there appeared to be a diminished number of microvoids near the surface and a larger number further down in the film. Secondly, the level of microvoids had been chosen to give an insignificant scattering coefficient and yet when it was used in combination with titanium dioxide the increased hiding power was evident and the films were of reasonably comparable quality.

Dr L. A. O'Neill asked if any progress was being made in the use of microvoids or of combined microvoids/titanium systems in ultraviolet radiation curing coatings as it seemed a very obvious field where the advantages would be greatest.

Mr Seiner said that microvoid UV cured products were now commercially available. Among the obvious advantages were the ability to cure whilst the film was still transparent, and thus allow the ultraviolet energy to be transmitted through the film and effect the curing and finally to generate the opacity which would otherwise reflect and scatter the UV. Thermoplastic, thermoset and UV curing in a variety of microvoid products were actually being developed.

Prof. W. Funke suggested that some of the heat effects of the microvoid film, whilst not being very large, could be caused by the insulating effect of encapsulating air in the film and thus preventing heat transfer through a film.

Mr Seiner stated that other characteristics which could be obtained from microvoids, such as the possibility of heat insulation or acoustic benefits, had actually been investigated, but it turned out that in most of their commercial systems the amount of air incorporated into the film was too low, being less than the volume of pigments in the film and normally much lower than 10 per cent.

The thickness of the films applied was normally too thin for either of these properties to be noticeable, but if a thickness of 10 or 15 mm was applied then it was possible that both acoustic and heat insulation benefits might become noticeable.

Dr M. L. Ellinger stated that when Mr Seiner had mentioned the use of microvoid coatings on large storage tanks he had stated that some companies preferred to use floats in the tanks and she asked whether the reasons for this were that the microvoid coating was more expensive or less durable than standard paints and so did not reduce the cost of preventing evaporation.

Mr Seiner replied that the cost of the microvoid coating was clearly lower than the cost of a comparable high reflectance coating without microvoids. Durability was obviously a key question and, in common with all paints, the microvoid paints had to be replaced after a period of a few years. The main advantage of using a float in tanks rather than a microvoid coating was that once the float was in position it did not have to be replaced, and many large petroleum companies also used such floats as an advertising means by putting the company's symbol on it.

Dr G. D. Parfitt said that the uniformity of the electron micrograph intrigued him because Mr Seiner had showed earlier some particles that were doublets. He asked if this was just an artifact of the electron microscope.

Mr Seiner replied that it was.

Dr Parfitt pointed out that normally, when showing polystyrene latices, about 1000 were shown on a photograph, so it would be possible to see how uniform they were, but that in this case there were only a few (with one or two missing).

Mr Seiner said that he could not increase the concentration because, rather than having a monodisperse polystyrene, he had an overcoat of a coalescible polymer with a low Tg (the Tg of ethylacrylate was about —22°C) and therefore, if he had raised the concentration to show 1000, he would have had a lump.

Dr Parfitt asked whether he had experimental curves showing the scattering coefficient plotted against wavelength, which would indicate the way in which the fine structure varied as the f factor changed and whether this agreed with his and Kerker's calculations.

Mr Seiner replied that he had.

Dr Parfitt questioned the accuracy of the curves, but Mr Seiner asserted that they were correct. Mr Seiner said that the actual curves had been published in the first two patents relating to the solvent precipitation process, and that the light scatterihg difference versus wavelength difference for microvoid compositions would be very useful to a formulator.

Prof. W. Funke asked if the method of preparation of the polystyrene emulsions particles could be explained further. He asked if they were crosslinked particles which were grafted as an outer layer.

Mr Seiner said he believed they were initially produced as a monodispersion by the method used by Pearce and Kreeger at Case Western Reserve and these were merely used as seed polymers, not really grafted, and the added monomer polymerised on the outside of them. Whether it was actually chemically grafted he was not sure.

Prof. Funke asked if they were produced by emulsion polymerisation.

Mr Seiner said they were.

J. Oil Col. Chem. Assoc. 1977, 60, 348-353

Recent developments in antifoulings*

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International Marine Coatings, R & D Laboratory, Stoneygate Lane, Felling, Gateshead, Tyne & Wear NE10 0JY

Summary

Largely as a result of vastly increased fuel costs, the problem of controlling the growth of fouling on the underwater hulls of ships has recently been subjected to detailed investigation. The biology of fouling organisms has been studied in considerable depth and there is now a much better understanding, particularly of algal fouling.

Fouling is an extreme aspect of the general problem of hull roughness which develops as a consequence of the traditional approaches to underwater hull maintenance. It is suggested that the practice of cleaning and repainting at frequent intervals using traditional materials, does not supply the ideal answer either in terms of fouling control or long term control of roughness. The more recent approaches of diffusion control by hydrophilic varnishes, the introduction of scrubbable coatings and self-polishing copolymer antifouling systems give an indication of the effort that the marine coatings industry has made towards providing improved ship performance.

Keywords

Types and classes of coatings or allied products
anti-fouling coating

Types and classes of structures or surfaces to be coated
ship bottom paint

Processes and methods primarily associated with:
manufacturing or synthesis
leaching

Raw materials for coatings:
prime pigments and dyes
antifouling pigment
copper oxide

paint additives:
biologically active ingredients
organo tin
microbiological agent

Développements récents dans le domaine de peintures "antifouling"

Résumé

En raison largement de la forte augmentation des prix de combustibles, le problème du contrôle de la croissance de salissures marines sur les coques de navires a été récemment l'objet d'une investigation détaillée. On a étudié très profondement la biologie des organismes qui provoquent les salissures marines et il existe actuellement une connaissance beaucoup mieux surtout des salissures algales.

La formation des salissures marines est un aspect à outrance du problème général de la rugosité qui se produit sur la coque en conséquence des techniques traditionnelles employées pour la maintenance de la partie submergée de la coque. On suggère que la technique de nettoyage et de repeindre par fréquents intervalles et en utilisant les matériaux traditionnels n'assure par la solution idéale ni au point de vue du contrôle de la formation de salissures ni du contrôle à long terme de la rugosité. Les tentatives plus récentes de contrôler la diffusion au moyen des vernis hydrophiles, de l'introduction des revêtements capables d'être nettoyés par frottement, et des systèmes "antifouling" à base de copolymères autoluisables donnent une indication des efforts qu'a fait l'industrie de revêtements marins en vue d'assurer une augmentation du rendement des navires.

Neuere Entwicklungen auf dem Antifoulingsgebiet

Zusammenfassung

Hauptsächlich als Folge der enorm gestiegenen Brennstoffkosten wird seit kurzem das Problem des Ansetzens von Anwuchs (Fouling) an den unter Wasser befindlichen Schiffshüllen mehr ins einzelne gehend untersucht. Die Biologie der Anwuchsorganismen wurde in beträchtlicher Tiefe erforscht, sodass man jetzt insbesondere das Fouling durch Algen viel besser versteht.

Das Anwachsen ist ein extremer Gesichtspunkt im Hauptproblem der Rauhheit von Hüllen, die sich als Folge der traditionellen Instandhaltungsmethoden von Unterwasserhüllen entwickelt. Es wird nahegelegt, dass die in häufigen Zwischenräumen und mit althergebrachten Materialien benutzte Methode von Reinigung und Anstricherneuerung weder bezüglich Foulingkontrolle noch langfristiger Kontrolle der Rauheit eine ideale Lösung ist. Aus den neu eingeschlagenen Wegen der Diffusionskontrolle durch hydrophile Lacke, die Einführung scheuerbeständiger Beschichtungsmittel und selbstpolierender kopolymerer Antifouling Systeme kann man sich ein Bild von den Bemühungen der Schiffsfarbenindustrie zur Verbesserung der Leistungsfähigkeit von Schiffen machen.

Introduction

Although the problem of fouling on the underwater surfaces of ships has occupied the attention of mankind since the first vessels put to sea, it is only comparatively recently that the problem has been subjected to sophisticated scientific scrutiny. The main reason for the current level of interest in antifouling research is the increased cost of fuel oil, which in recent years has risen to a level such that fuel is now a major item in the operational budget of a ship. A very large crude oil carrier (VLCC) operating at 15 knots will be burning fuel at a rate of 170 tons/day at a cost of £2 $\times$ 10^6 in a 300 day operational year; for a fast container ship the fuel bill will be approaching twice that for the VLCC! In economic terms it is therefore easy to appreciate that the growth of fouling on the underwater hull of any vessel will impose a severe financial penalty. To put the problem in perspective the current mercantile marine fleet totals some 4,700 vessels with a deadweight exceeding 500 million tons and even moderate fouling on a tanker can increase the fuel consumption required to maintain speed by 30 per cent. It is not surprising, therefore, that considerable research effort is currently being directed towards improving our ability to control this recalcitrant problem of the growth of marine plants and animals on ships' hulls. Since the ultimate aim of antifouling research is conservation of fuel, a paper on recent

*Paper presented at the Association's Biennial Conference held at the Grand Hotel, Eastbourne, Sussex from 16-19 June 1977.

developments in this subject is particularly pertinent to the theme of this Conference.

Fouling problem on ships

The fouling encountered on ships originates from the plant and animal communities which inhabit the seas. Although the sea is populated by a vast diversity of life, only a relatively small number of species give rise to the practical problem of ship fouling. This is because the ships themselves provide a rather specialised environment and those forms which are adapted to tolerate wide fluctuations in environmental conditions, such as temperature and salinity, tend to dominate as ship-bottom foulers. Other attributes that characterise the successful marine fouling forms found on ships are an ability to attach quickly and firmly to surfaces, a capacity for very rapid initial growth and vast reproductive potential. Although fouling is generally broken down into the two major types, "grass" and "shell", it is certainly true to say that "grass" fouling is the more intractable problem and, unfortunately, the mode of operation of modern shipping predisposes these vessels to colonisation by algae. This can readily be shown by a glance at Table 1 which gives a comparison of the types of fouling encountered on cargo vessels pre-1950 and a group of oil tankers in the mid-sixties.

Table 1

Frequency of occurrence of various forms in ship fouling

131 Cargo Ships pre 1950		20 Oil Tankers 1965	
Barnacles	190	Algae	54
Hydroids	99	Green	37
Algae	91	Brown	15
Bryozoans	74	Red	2
Molluscs	68		
Annelids	15		

The reason for this complete swing from an animal dominated problem to the specific problem of fouling by marine algae is largely dependent on the change that has taken place in vessel operation. Modern requirements for fast transport and efficient ship operation result in stationary periods being very much reduced; containerisation and methods of modern tanker operation reduce the stationary time to periods usually less than 48 hours, followed by lengthy voyage periods, such that the time spent actively under way is usually of the order of 80 per cent or greater. If this is considered in relation to the biology of the fouling plants and animals it is not surprising that there has been such a swing in favour of the plants. Shore-dwelling marine animals reproduce themselves by releasing their young as small free-swimming larvae, the length of time these larvae remain free-swimming is variable and may range from about six weeks in the case of barnacle larvae to a matter of a few hours in the case of the larvae of tubeworms and hydroids. However, if the case of the larvae of the barnacle is taken as an example, the settling stage does not in the least resemble a typical barnacle. Indeed, on attaching to its preferred site the barnacle larva has to undergo metamorphosis, to change from a flea-like creature to the miniature fully shelled adult type. This remarkable metamorphosis takes some 48 hours to accomplish and while the animal is undergoing these changes the present day vessel is underway, giving the barnacle little chance of making a successful start in life. In this situation, animal fouling is not particularly serious on high activity vessels. Unfortunately, as frequently happens, the operational pattern is disrupted and the ever present barnacle can then produce a serious fouling problem. It is the practice of a number of tanker operators to leave the vast, dark flat-bottoms of their vessels with no antifouling protection because the lack of light precludes algal fouling, but the short term economy of saving the cost of a coat of antifouling paint on this area can very often lead to a considerable cost in terms of increased fuel, premature drydocking and the additional cost of removing the accumulated fouling.

Algal fouling on ships

Refs. 1, 2

As already suggested, however, by far the more serious fouling problem on modern vessels is that caused by algal fouling and a study of the biology of a typical fouling alga *Enteromorpha* soon indicates why this is the case. The adult plants which are morphologically identical may be of three types: the sporophyte or vegetative plant which produce motile zoospores when fertile and either male or female gametophyte plants which produce motile male or female gametes. The organisation of *Enteromorpha* is a collection of individual cells forming a flattened tube encased in a cellulose matrix and attached to the substrate by a basal root system. Each cell is capable of independent existence and obtains its requirements for growth directly from the surrounding water. The basal root system in seaweeds provides only an attachment function; there is no system for the absorption of nutrients through the roots as in the case of land plants. Indeed, the plant has no differentiated tissue; if a filament of *Enteromorpha* in sea water is removed and cut into small sections, each section will very quickly regenerate a root system at the basal end and reattach to the container in which it is placed! As a result, it can be appreciated that once *Enteromorpha* starts to grow on a surface, there is very little chance of subsequent control. The initiation of growth of *Enteromorpha* is by means of the flagellated spores, zoospores are particularly responsive to surface contact (thigmotaxis) and if given a roughened surface are capable of attaching to it within seconds.[1] The next two hours sees a remarkable reorganisation take place and the production of a relatively thick protective cell wall.[2] The first cell division takes place within a few hours of attachment and in a matter of days the small erect filaments are already well established and growing rapidly away from the surface to which they are attached. Since the only requirements for growth are a supply of light and nutrients, both readily available in the environment of the ship's side, it is hardly surprising that extended control of weed fouling on service vessels presents a very severe challenge to the marine paint manufacturer.

Underwater hull roughness

Refs. 3, 4, 5

It is not difficult to appreciate that accumulations of plant or animal growths on ships' hulls will give rise to increased drag during vessel operation, since they cause a very large increase in surface roughness and hence in turbulence. However, there is another insidious contribution to hull roughness which arises directly from the traditional approach to ship maintenance. Ships drydock at regular intervals to be inspected, repaired, cleaned and painted. Normally, after 18 months to 2 years in service, a vessel will receive at least an additional two coats of paint and in areas of damage as many as five coats. Depending on the condition of the existing paint system, the quality of cleaning and the quality of painting, the acquisition of hull roughness commences and continues during the lifetime of the vessel. The consequences of this type of physical roughness can be seen in Fig. 1, which shows the SFI data[3] relating surface roughness

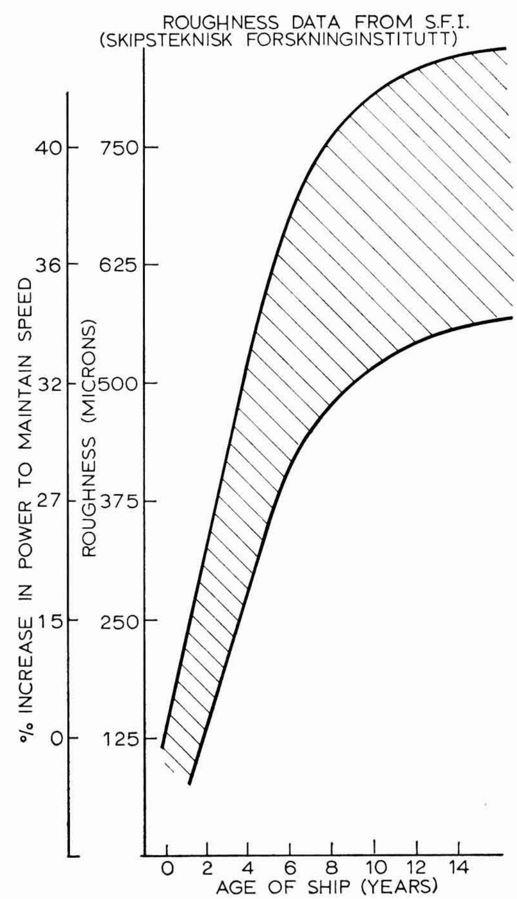

Figure 1. Roughness data from SFI. The shaded area gives the distribution of roughness found on ships of varying ages maintained in a traditional manner. The rate of acquisition of hull roughness is dependent on the quality of maintenance, but the penalty in power occasioned on even the best-maintained ships is severe.

to the power required to maintain speed. Hull roughness is defined as the maximum peak to trough height, expressed[4] in microns, in any given length of 50 mm along the hull and this particular unit (mean apparent amplitude) arises from the trials on the Lucy Ashton[5], where it was shown to provide a convenient approach to correlate ship resistance with surface roughness. Going back to Fig. 1, it is apparent that not only has the antifouling chemist to control the fouling problem, he is also faced with the dilemma of trying to control or, at least, to diminish the rate at which hull roughness is acquired. On vessels, such as tankers, over 90 per cent of the total resistance through the water is dependent on the frictional component so that the requirements for the ideal antifouling are not only extended control of fouling, but also some positive contribution to the smoothness of the underwater hull.

Traditional approaches to fouling control

Traditionally, the paint chemist has endeavoured to control fouling by formulating paints designed to provide controlled leaching of a biocide (usually copper) at a level, such that the larvae of the fouling animals or spores of the fouling algae are killed before they become established on the paint surface. The literature on copper antifoulings suggests that provided the paint liberates copper above a critical rate of 10 $\mu g/cm^2/$day then the surface will remain free from fouling growths. Unfortunately, this early work was carried out when animal fouling was the dominant practical problem; all current evidence suggests that much higher levels of copper leaching are required to control weed fouling. The control that the paint chemist has over the leaching of biocides from traditional antifoulings which are physical dispersions of biocides in sea-water sensitive (rosin-based) media is not very great, and the laws of physics and chemistry dictate that these comparatively simple paints all suffer an inherent defect, namely that of exponential leaching. During the early life of the antifouling, biocide leaching starts at an excessively high level, this declines exponentially until leaching falls below the critical level required to control fouling and the system, if challenged, will fail. Inherently this is a wasteful process, not only in the logarithmic manner of the leaching behaviour, but also because the mechanism does not allow efficient release of biocide from the depths of the film. On subsequent recoating this remaining biocide is irretrievably lost in the depths of the paint system.

Traditional antifoulings suffer other defects in that by their very nature the coatings are weak and friable and it is difficult to maintain the integrity of the total paint system on subsequent overcoating. Eventually this gives rise to breakdown, delamination and progressive roughening of the underwater hull

The availability of chlorinated rubber, vinyl and epoxy resins has allowed the paint chemist to move in the direction of physically tougher antifoulings, but in order to allow efficient biocide release it is usually necessary to incorporate a proportion of rosin. Although capable of giving considerably improved antifouling performance, these more sophisticated systems are still incapable of defying the laws of diffusion, the problems of logarithmic leaching and inefficient utilisation of contained biocide.

Developments in antifoulings

1. *Novel biocides*

Refs. 6, 7

The major development since the early fifties as far as novel biocides are concerned has been the use of organotin compounds.[6] When organotins became available in quantity, it seemed that the fouling problem would surely succumb to the wit of the paint chemist. In the laboratory the toxicity of these compounds to barnacle larvae and seaweed spores seemed to offer effectivity factors of 100 times in their favour compared to cuprous oxide. Unfortunately it has not proved possible by the extension of traditional approaches to translate this *in vitro* advantage into more than perhaps a factor of two on the side of a ship, and it would be true to say that the most carefully designed traditional antifoulings based on organotins are limited in practice to a lifetime of about eighteen months.

It is a curious fact that despite the enormous numbers of organic biocides that exist, very few have found an application

in antifouling paints. One notable exception to this is DDT which shows a remarkable specificity against barnacles.[7] However, environmental considerations have now removed this material from the armoury of the paint chemist. Tetramethylthiuram disulfide (TMT), a rubber accelerator, has found some application in antifouling paints combining a measure of antifouling activity with the merit of comparative cheapness, but from the battery of herbicides, algicides and fungicides currently finding large-scale applications in other fields there has been little evidence of a material of real potential for the antifouling chemist. This, the author believes, serves further to underline the severity of the problem of long term fouling control. The problem is not the short term control of a particular biological problem, but long term continuous control against a host of different fouling organisms.

2. *Diffusion control by hydrophilic varnishes*

Refs. 8, 9, 10

One comparatively recent innovation has been the application of hydrophilic varnishes over traditional antifoulings in an effort to control the rate of biocide leaching.[8] To some extent the use of these varnishes does cut down the initial excessively high leaching rate and thereby is capable of extending antifouling life. However, the problem of exponential decline in leaching rate is not solved by this approach and difficulties are liable to occur at a later stage on overcoating such a hydrophilic layer, if it were to persist on the hull. Certain claims have been made that these hydrophilic varnishes are capable of decreasing frictional drag, but in one carefully controlled independent test[9] the claim for reduction in skin friction was not substantiated. In Milne's rotor studies[10] in the author's laboratory the conclusion has been made that frictional drag is independent of surface chemistry and that the ultimate goal must be to achieve as smooth a surface finish as possible if skin friction is to be minimised.

3. *Scrubbable antifoulings*

An approach of current interest is that of applying a relatively thick (250 μm) coat of a traditional antifouling and to endeavour to reactivate the surface by periodic brushing at intervals of 12–14 months. In theory, at least, this approach has the merit of avoiding coatings build up and also of improving the efficiency of the applied antifouling by removing the stifling layer of insoluble matrix at the surface. However, when viewed from the practical angles of the requirement for uniform application and for uniform removal of the "leached-layer" by underwater scrubbing, the approach does seem to be rather academic. It certainly does not provide micro-smoothing, but rather micro-roughening and the provision of an ecological niche ideally suited to rapid colonisation by seaweed spores. Vessels would also suffer the disadvantage of delay whilst the reactivation takes place and although the method acknowledges the difficulty of long term fouling control, it would not seem to provide a useful solution.

Self-polishing co-polymer antifoulings

Refs. 11, 12

A unique approach to fouling and roughness control on ships is that provided by self-polishing coatings. These systems rely on the flow of water past the ship to generate the polishing action and this provides not only a smoothing benefit, but also allows for the continuous renewal of the surface of the antifouling paint. This novel result is achieved by chemically combining an organotin biocide with the varnish component of the paint; in contact with seawater, biocide is released to provide the antifouling action and the property of water solubility is conferred upon the varnish. By judicious control of the varnish composition, pigmentation and the use of retarders[11], the rate at which these systems polish can be controlled. Fig. 2 shows a schematic representation of the operation of a typical polishing system. Matrix ablation proceeds from the surface of the film and the events controlling the progress of polishing are confined to the reaction zone of about 5 μm at the surface of the paint. Under dynamic conditions the paint polishes away in a controlled fashion to provide both fouling and roughness control. The advantages of these systems can be listed as:

(1) A lifetime proportional to the thickness applied (traditional antifoulings have lifetimes proportional to the logarithm of their thickness).

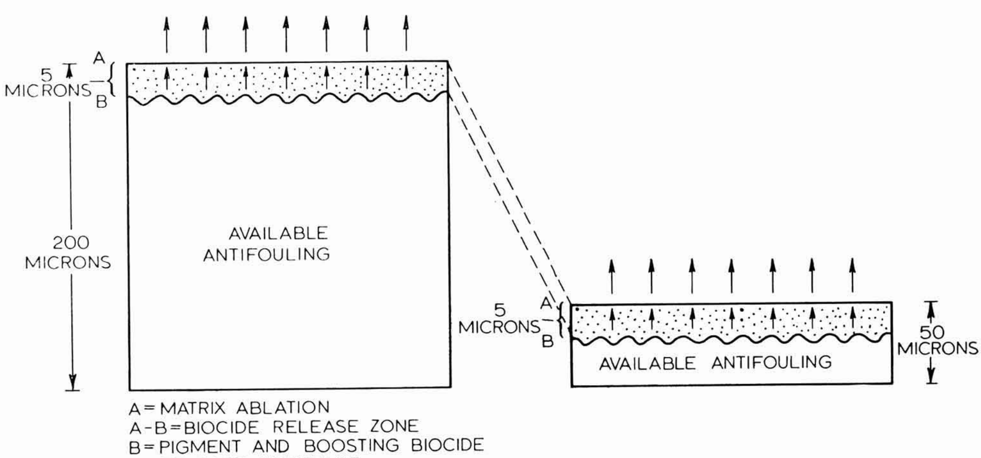

Figure 2. Schematic diagram showing the mechanism of the action of a self-polishing copolymer antifouling system. The controlling reactions are restricted to the surface 5 micron layer and the paint functions through the ablation of the surface layer under dynamic conditions. These systems can be overcoated at a later stage and avoid coatings build up since the existing antifoulings on the hull still remain available for eventual use

(2) Overcoating without loss of existing activity (any self polishing antifouling overcoated by more polishing material is still utilisable).

(3) Avoidance of coating build up on underwater hulls.

(4) Efficient utilisation of contained biocide.

(5) Continuous replacement of an active surface without requiring the inconvenience of physical scrubbing.

(6) The provision of an automatic self-smoothing action (this is readily explained since at points of localised turbulence the system is polished away at a faster rate than on sensibly smoother areas and surface smoothing results).

The list of benefits obtainable from self-polishing systems is impressive and, indeed, all these have been achieved in practical ship operation. However, it should be pointed out that it is not possible to perform miracles on the side of a ship. A self-polishing system cannot be expected to convert an old rough hull into a smooth, sleek and efficient surface. The extent of smoothing will always lie within the film thickness applied, so that once hull roughness is of the order of 300 microns the system is not to be recommended. Ideally, self-polishing systems should be applied either to new buildings or to shotblasted tonnage and in both these situations remarkable benefits in fouling and roughness control have been achieved. The proof of the efficacy of self-polishing systems lies in both the demonstration of surface smoothing in practice and also in the demonstration that there is an improvement in ship performance. The first of these requirements has already been proved in trials. Test plates attached to a ship's underwater hull conclusively demonstrated the correlation between progressive surface smoothing and decreased drag as measured in a hydrodynamic flume. Currently a large number of measurements on surface roughness are being carried out on ships coated with self-polishing systems and these investigations have already shown smoothing. Establishing the relationship with ship performance is much more difficult, but methods[12] do exist and currently several ship operators are carefully studying the performance of vessels coated with self-polishing systems. Again the evidence shows that several vessels have achieved a gain in speed and it would seem to be only a matter of time before the self-polishing approach is generally accepted as a most exciting antifouling development.

Conclusion

In this paper the author has attempted to give a picture of the difficulty of achieving extended fouling control on ships and also to provide an insight into current approaches to the problem. Antifoulings have always provided scope for the unscrupulous, who, with the aid of a few photographs, may convince the unwary of the latest revolutionary development. Claims for miracle products abound, cause amusement to the initiated and cost money to the gullible. It is wise to be cautious of products which claim to "alter critical surface tension", so that the fouling organisms find it difficult to secure good adhesion, or products which "go on smooth and stay smooth" or indeed which can "decrease the apparent viscosity of water in turbulent flow thereby increasing the speed of the vessel"! The problem of maintaining underwater hulls in a smooth fouling-free condition is one of severe difficulty; it is hoped that this paper has given some insight into the effort that the marine paint industry has made towards the conservation of energy in ship operation.

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Discussion at Eastbourne Conference

Dr L. A. O'Neill asked if it was still generally accepted that all antifouling poisons operate by a similar exponential leaching mechanism to cuprous oxide, for example the organotins, organotins built into copolymers, and organic biocides. He commented that there was not much published on this subject, but that it seemed to be assumed that they would all act in the same manner as copper.

Dr Christie said that this was perhaps one point he should have emphasised in his paper. With normal antifouling systems, whether they contain cuprous oxide, organotins or an organic biocide, the surface layers quickly become depleted of antifouling biocides and, therefore, the biocide has to percolate through the depth of the film to get to the paint surface. Thus, these systems are committed to an exponential form of leaching. With a self polishing system, however, biocide is released when the surface of the film interacts with the sea water and so the rate at which biocide enters the sea is governed, not by the depth of paint film that the antifouling has to get through to reach the surface, but rather by the rate at which the surface is polished. Therefore, in a self polishing system the active surface is continually replenished and a much closer approach to linear leaching (the optimum) is achieved.

Dr Christie said he would set the polishing systems apart from the others in this respect.

Mr H. W. M. Armstrong asked Dr Christie if he had any comments to make on the use of acrylic (using the word acrylic in its broadest sense) polymers in conjunction with organotins in antifoulings as some years ago he had come across reference to work on this in Norway.

Dr Christie replied that the self polishing system was based on tin acrylate technology. Basically, the approach is that the polymer system, a copolymer of tributyl tin methacrylate/methyl methacrylate, splits off the organotin under the influence of sea water and the remaining residual copolymer is solublised. He thought that most of the developments in tin acrylate technology came originally from M&T in the States and he was not aware of any Norwegian developments in this connection.

Mr E. A. Watson asked Dr Christie if the self polishing systems gave a satisfactory rate of leaching in the static condition when there were unscheduled delays in the turn round of a ship, and secondly if there were any basic problems of adhesion when applying a relatively thick layer of the self polishing antifouling paint of approximately 300 microns thick.

Dr Christie said that the question of leaching rate in the static condition was something of a compromise. The situation was that systems which gave a high static rate of leaching were polished too quickly in the normal running of the ship, whilst systems which polished more slowly had a lower static leaching rate. He said that with their product they had chosen a compromise which gave an acceptable rate of leaching in static condition for about three months, coupled with a practical rate of polishing when the ship was in use. He thought this was probably the best compromise obtainable.

On the question of adhesion, Dr Christie said that an initial application of 300 micron DFT was required which was thicker than most other antifouling systems used, but that if the goal of two years (or even more) freedom from fouling was required then there was no alternative. To achieve this it is necessary to apply the anticorrosive paint in a satisfactory manner on to a satisfactory substrate and he pointed out that there was no easy way to do this. Referring to one or two of the slides he had shown, he indicated that if the antifouling layer was applied correctly the most outstanding results were obtained, but that if the job was not done properly then the paint was no better than any other paint and a complete breakdown of protection was just as likely. He mentioned that it was his company's policy to emphasise the need for supervision of the initial application of the system. This is vitally important to the success of the operation.

Mr P. Jeffery asked if any progress had been made in the use of substances which break down the cement which barnacles use to adhere to a ship, thus eliminating the ecological disadvantages of toxic metal salts.

Dr Christie said that this was an area which had interested him particularly some years ago when he was working with algae, and he had found, in fact, that the glues that algal spores secreted were largely proteins and very similar in this respect to the cement secreted by barnacles. It had been found that across the spectrum of fouling organisms there is a similarity in the adhesives they initially secrete. These are largely proteinaceous and he had at one time become very excited by the prospect of using enzymes to control fouling. Experiments were carried out and initially the results were particularly good; they could expose settled algal spores to dilute solutions of a proteolytic enzyme which completely destroyed their adhesion. In the next experimental stage they repeated this experiment with enzyme inside a permeable membrane. Again success was achieved in that, on raft exposure, the membrane was kept clean, but it was never possible to repeat this experiment. It was suspected that the membranes had been immersed at a time when there were many algal spores present and there was sufficient enzyme leaching out to control the growth. He said he did not think the enzyme approach was a practical solution to fouling. He pointed out that in order to be effective the surface would have to be virtually 100 per cent active enzyme because as the spores are so small (each spore was about 10 microns) they would colonise a pinpoint defect in surface. His other point was that whilst he had only mentioned barnacles and seaweeds in his lecture, there were in fact a multitude of bacteria of different types present in the sea and he was perfectly sure that there would be several varieties which would regard proteolytic enzymes as a good source of food.

On the second point of Mr Jeffrey's question, Dr Christie stated that he thought the amount of toxic metal salts released into the sea bya polishing systemwas negligible.When it was realised that in a normal working day a ship would travel 350 miles and that in this time the antifouling system would have been worn away by less than half a micron, it is clear that the organotin released would be almost infinitely diluted.

Mr M. Goto asked for how long a self polishing system would be effective in actual service before the ships hull became fouled.

Dr Christie said that the answer to this depended upon the film thickness and the rate of polishing of the system. With the system they were presently using and a film thickness of 300 microns, they recommended a period of two years between overpainting, but in panel tests periods of 28 months clear of fouling had been obtained. Dr Christie also pointed out that if a layer of the antifouling system in excess of 300 microns could be applied satisfactorily then even longer periods between overpainting could be obtained.

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Conserving human resources through innovation*

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Summary

If man can learn how to innovate with greater frequency and effectiveness, he will be able to utilise new technology with fewer scientists or technologists than are required at present. The human resources thus saved can be directed to perform other vital functions in his evolving society.

A model for "Innovation" has been developed, which can be used to estimate the probability of innovation occurring in a given research or development project. This model is now being used as a working tool in the author's laboratories and elsewhere. The technique discussed has proved valuable in pointing out weaknesses in the organisation and execution of research and development projects and has suggested means of correcting these weaknesses.

La conservation de ressources humaines grâce à l'innovation

Résumé

Pourvu que l'homme apprenne à faire les innovations plus fréquemment et avec plus d'efficacité, il saura utiliser de nouvelles technologies en faisant appel à moins de savants et de technologues qu'il n'en a besoin actuellement. Les ressources humaines ci-épargnées peuvent être amenées à exercer d'autres fonctions essentielles à sa société en évolution.

On a mis au point un schéma pour "l'Innovation", que l'on peut utiliser pour apprécier la probabilité qu'un élément d'innovation sera produit au cours d'un particulier projet de recherche ou de développement. Ce schéma est utilisé actuellement en tant qu'outil pratique au laboratoire de l'auteur et ailleurs. La technique ci-décrite s'est démontrée effective en indiquant les faiblesses au sein de l'organisation et de l'exécution des projets de recherche et de développement et, en même temps, elle a suggéré des moyens pour rectifier ces faiblesses.

Erhaltung der für dieMenschheit wichtigen Lebensquellen durch neuen Ideen

Zusammenfassung:

Wenn die Menschheit lernen kann, wie sie neue Ideen viel häufiger und wirkungsvoller in die Tat umsetzen kann, wird sie fähig werden, neue Technologie mit weniger Wissenschaftlern und Technologen als bisher zu beherrschen. Die auf diese Weise eingesparten menschlichen Quellen könnten auf diese Weise für andere vitale Funktionen in einer sich fortentwickelnden Gesellschaft freigesetzt werden.

Ein Modell für "Innovation", wurde entwickelt, um die Aussichten für die Wahrscheinlichkeit des Vorkommens neuer Ideen in einem gegebenen Forschungs- oder Entwicklungsprogramm zu schätzen. Dieses Modell wird jetzt als Werkzeug in den Laboratorien des Autors und von anderen benutzt.

Die besprochene Methode erwies sich als wertvoll für Hinweise auf Schwächen in der Organisation und Ausführung von Forschungs- und Entwicklungsprojekten, auch legte sie Mittel zur Korrektur dieser Schwächen nahe.

Introduction

This Biennial Conference of the Oil and Colour Chemists' Association is devoted to matters of the most timely and weighty interest, "conservation of energy, materials and other resources in the surface coatings industry". This paper will relate to conserving human resources through improving the innovative performances of our scientists.

The world-wide technological community—scientists and industries—is interested in "innovation". Just what does this word mean? What are the forces which tend to inhibit such innovations? If we could find even some partial answers to these questions, it could help our countries and also make our companies grow more rapidly and become more profitable. More innovation would help the scientists and engineers in our industry to repudiate the remark that "we do not need research and development laboratories", that "the large chemical companies who are our raw material suppliers will tell us all we need to know".

Increasing the innovative potential of our laboratories by even a few percentage points will make the work of our technologists more humanly and psychologically satisfying, too. Morale and productivity would inevitably be improved. Management would be more content, perhaps even pleased, with the work of our industrial scientists. Innovation can frequently be the difference between just "working for a living" and feeling a professional, personal or mystical drive/compulsion to accomplish a goal or an ambition.

The Oxford Dictionary tells us that the word "innovate" comes from the Latin "in" plus "novare"—to make something new. Another definition can be "to change into something new", "to alter". For our purposes, it can be accepted that the definition that "to innovate" means "to make something new", or to change something old into "something new and superior". The innovation involved must have some intrinsic value—economic, scientific, or technological.

There is no secret road to "innovation". There are no magic words. When King Ptolemy of Egypt was looking for a short cut one day, Euclid is reported to have chided him with "There is no Royal Road to learning." With apologies to this great Greek mathematician and philosopher, it can also be said, "There is no Royal Road to innovation". There is honesty in how you communicate, there is hard work, there is continuing study in the various fields of chemistry and engineering, there is humility, there is a sense of humour. There is also that special sensitivity that directs one to treat each and every colleague as a fellow human being, as a person with feelings and pride, and with abilities needed to get the job done! These are some of the basic attributes and skills which one must develop in order to mature and improve our innovative abilities and thus to conserve our human resources. When our level of innovation increases, fewer technologists may be needed to perform the innovative tasks required by our industry. There are already indications that these scientists will be required to help our industries to fight the air and water pollution, to study the toxicology of the hazardous

*Paper presented at the Association's Biennial Conference held at the Grand Hotel, Eastbourne, Sussex from 16-19 June 1977

chemicals we use, and to dedicate themselves to those activities which are now vital to our survival.

Much has been written in the past several decades about idea generation by "brainstorming", about innovation by group efforts, and of technical "breakthroughs" made by the use of computers and the statistical design of experiments to meet precise, predetermined goals. There are many cases where this approach is fruitful, and it is freely used in the author's laboratories. It is my firm personal opinion, however, that most innovations are primarily the result of the efforts of one individual. Dr Henry Eyring, the distinguished Professor of Chemistry and Metallurgy at the University of Utah, is quoted as saying, "People think best alone—at least most of the time."[9] Other authorities have vouchsafed the same opinions. Am I suggesting that the so-called "team research" may at times be wasteful of human and monetary resources, and that smaller Research and Development groups could be more productive? Perhaps! It depends on the people involved! The increasingly popular "Delphi Method"—a technique better to use expert opinion in technological forecasting—tacitly recognizes this factor in "minimising group reactions by isolating the members of the group from one another." Rubenstein has concluded that, "Organisations don't make RD/I (Research and Development/Innovation) projects successful, individuals do."[25]

It should first be noted that there appears to be little correlation between innovative abilities and intelligence as measured by "IQ" in aptitude tests. In studies made on idea generation, certainly one of the important factors in innovative activities—one of the repeated complaints of R & D personnel is that "(perceived) time pressures due to current work" effectively prevent them from coming up with new ideas or innovations. In my experience, chemists who most loudly voice this say that they are always under such tremendous time pressure on their regular assignments that they have no time to generate new ideas, and rarely evolve any worthwhile innovations when they are given additional time.

Those research personnel who are habitually successful in their assigned innovation-requiring Research & Development projects are frequently the same ones who are also successful in coming up with meaningful innovations outside of their specific assignments.

At this point we must ask ourselves, "What are the factors which make some individuals highly innovative and others much less so?" Have we become so accustomed to people in our laboratories who rarely or never innovate that we accept this situation as natural? Well, it all depends upon what we consider "natural". Dr Wernher Von Braun, the famous rocket and space scientist, told a story about a man who opposed the idea of the U.S.A. spending so much money trying to land men on the moon on the grounds that "it isn't natural, we should stay on earth", he said, "and watch television like the good Lord intended"! To this man, watching television was "natural".

Perhaps I touch upon a controversial and sensitive subject, —but it seems clear to me that unless we organic coatings scientists and technologists innovate at a markedly increased rate, the organic coating industry and all of us in it, will surely suffer. Not only must we innovate more to conserve human resources, we must also do so to preserve our industry and our jobs! Innovating in organic coatings is our work, not that of our raw material suppliers and their chemists. In this coatings chemist's opinion, the role of the chemical companies who supply us with raw materials should be that of doing the more basic research. Very interesting in this regard is a statement by Utterback that, "Basic research does not seem to be significant as a direct source of innovation".[26] We should use the findings of this basic research, but we must be careful not to abdicate our responsibilities and opportunities in the vital area of coatings development.

"Experimental" Methods

Rubenstein, *et al.*[25] at Northwestern University in Evanston, Illinois, working in the area of "innovation" with support from the USA Office of National R & D Assessment of the National Science Foundation, have studied the R & D innovation process in the US industrial organisations—a continuation of studies which have been made at Northwestern University for many years. Professor Rubenstein and his colleagues identify "screens" influencing the innovative process—positively or negatively. These "screens" are related to phenomena such as those shown in Table 1.

Table 1
Some "Screens" Affecting Innovation

Barriers
Constraints
Facilitators
Incentives
Stimulants

The investigators at Northwestern University identified some of the important disciplines relating to innovation. These are shown in Table 2.

Table 2
Some disciplines involved in innovation research

Anthropology
Chemistry
Economics
Industrial Engineering
Management
Physics
Psychology
Sociology

Also studied were the so-called "environmental" factors affecting the R & D process as outlined in Tables 3, 4, 5, 6.

Table 3
Environmental factors affecting the R & D process

Macro factors
Competition
Economic*
Survival

*Human and other resources available

Table 4
Environmental factors affecting the R & D process

Organisational factors
"Climate" for R & D
Communication Processes
Decision Processes
Size
Sophistication of R & D

Table 5
Environmental factors affecting the R & D processes

Technical factors
Current Technology
New Technology
Patent Situation
State of Art

Table 6
Environmental factors affecting the R & D process

Individual Factors
Experience
Intuition
Personality Traits
Risk Propensity
Status
Technical Competence

It is obvious at this point that if the "Organisational Factors" and the "Individual Factors" are propitious—the indications for innovative success are very good indeed.

Researchers in the field of technical innovation seek to draw general theories and conclusions from empirical findings resulting from interviews and studies with researchers in various laboratories. They search for what are called "propositions". In the field of Logics, a "proposition" is defined as "an expression of anything which is capable of being believed, doubted or denied". In mathematics, "proposition" is defined as "a formal statement of truth to be demonstrated". Serious efforts are made to recognise situations which appear to recur in "innovation-positive" or "innovation-negative" environments, hoping to find sets of these "propositions" which might be generally applicable as "do's" and "don'ts" in the search for the innovation process, or for a total R & D environment generally suitable to innovation.

"Propositions" were extracted by Rubenstein and his colleagues from an impressive number of sources. These were then adapted, restated to assure a reasonable congruency and listed. In addition, these "propositions" were supplemented by Northwestern University's own field studies on this subject.

Results

From a consolidated list of variables affecting innovation compiled from these various sources, I have selected those factors which I feel to be the most significant. The "weighting" column on the right shows how I ascribe the importance of each of those factors in "score per 100 points". This data is shown in Table 7.

Table 7
Most significant factors for innovation

	Weighting
1. Effectiveness of Communications (TM, TC, TT) 10 5 5	20
2. Scientific and Technological Competence	20
3. Presence of a Champion	20
4. Recognition of Market Opportunities	15
5. Recognition of Technical Opportunities	10
6. Degree of Top Management Interest	10
7. Competitive Factors	5
8. Timing	5
Innovation potential	100

Discussion of Results

Let us now discuss the individual factors in Table 7. Innovation must be thought of as a "systems concept". Most of the dynamics of the system must be operating positively for innovation to occur. Each of the eight factors in Table 7 is a dynamic thing and will operate in varying equilibria with the other factors. For example, communications may be more effective when a "champion" is operating at high encouragement and intervention levels. Technological competence may spurt after a chemist has attended an inspirational meeting of OCCA, FATIPEC, The Japanese Society of Colour Material, The Scandinavian Paint Federation, or the Federation of Societies for Coatings Technology. The dynamics of innovation are never in balance; they must constantly be influenced in the direction of what we consider the ideal at that time. In the "innovation dynamic", one of the greatest dangers is the "equilibrium state"—that period of time when nothing seems to be happening.

For this study, I have divided the communications factor into three sub-categories as shown in Table 8.

Table 8
Sub-categories of communications important to technical innovation

a. Technical-to-Marketing (TM)
b. Technical-to-Customer (TC)
c. Technical-to-Technical (TT)

The Technical-Marketing (TM) interface is perhaps the most important communications line—it can be an important entering wedge for success or it can be a barrier. The (TM) interface must be consistent, broad and sincere. It must form an integral part of every R & D project. (TM) communications must be governed by honesty and mutual respect. They must create a climate where a person can freely admit a mistake. Young suggests that innovative product development is closely related to the art of managing the people involved.[27] Innovation is impossible if immature technical people consistently ignore the suggestions of the marketing people. Innovation is equally impossible when the marketing people involved are immature or authoritarian. Innovation is not likely to occur if the project scientists are not directly involved with the prospective customer. False pride, whether in a chemist or a marketing person, is a seductive and effective inhibitor of innovation. False pride is wasteful of human resources because it can delay, prolong, and sometimes defeat the efforts needed to complete an R & D project

All technically-oriented industries have seen the disastrous effects on innovative efforts when the technical and marketing partners on an important project are simply incompatible. In such instances, there is insufficient personal and/or professional respect in the abilities, the efforts, or the integrity of a colleague. Groups like this must be promptly separated or selectively terminated. This destructive set of circumstances is more likely to occur when there is a substantial hierarchal difference between the marketing and technical leaders involved. The very important marketing man cannot discuss the real problems involved objectively with his "lower status" technical colleague. Or, the "very important" technical man finds it personally demeaning to take suggestions from the marketing people. In the (TM) interface, the senior people directly involved should be at or near the same hierarchal level if the most effective communications are to be realised. When hierarchal or incompatibility problems exist, we often see the informal (TM) network arise—where the individuals concerned communicate constructively, but outside the prescribed channels.

A recent Industrial Research Institute study of communications between research and other departments, showed that the poorest communications were generally those between research and marketing! Undoubtedly this is a major deterrent to increased innovative success.

With this same line of thought, let me read you a short, but pertinent, item I came across a few months ago.

"It was a dark night in April, 1841, about 250 miles off the coast of Newfoundland, when the American vessel William Brown struck an iceberg and started to sink. The ship carried 65 passengers and a crew of 17. There were only two life-boats, which were quickly lowered into the icy water. The captain, the second mate, seven crewmen, and a passenger scrambled into the small jollyboat. The first mate, a man named Holmes, 32 passengers, and eight seamen stampeded the longboat. Both lifeboats were over-loaded, but they managed to pull away from the mother ship. In another hour, the William Brown went down with 31 trapped persons.

"The longboat began to leak as soon as she was launched. Only through bailing out the icy water was she kept from sinking. The sea was treacherous. The vessel could not remain afloat with so many passengers. The following night, without casting lots, the first mate, Holmes, and his crewmen began to throw some of the passengers overboard. They did not stop until 14 passengers had been cast into the sea. Eventually, the longboat with 27 survivors was rescued. Holmes was brought to trial for manslaughter. He argued that, if the 14 had not been sacrificed, all 41 would have perished. Although he was found 'guilty", he received a light prison term of six months and was later pardoned by President John Tyler."

What is our lesson here? How does it relate to communications and innovation? Simply that if we have too many R & D projects for our particular resources, our "good ship", Research and Development, will also founder and sink!! If we have too many projects and continuous discussions on which projects we should undertake, we waste human resources. This simply means that we shall "conserve human resources" if we objectively undertake only that amount of research we think we can accomplish—and accomplish well!

Laboratory managers of coatings manufacturers and their marketing peers must be aware of this hazard and must be prepared to make the very difficult decisions. Which R & D projects should remain and which should be postponed or dropped? These are among the important and difficult decisions at the Technical-Marketing interface. Without mature and successful resolution of problems of this type, the possibilities of innovation become more remote and the cost of innovations soars skywards! Technical managers must communicate promptly and honestly with their marketing managers (and sometimes with their top executives) if the R & D workload is excessive. We all know chemists who habitually take on more than they can handle successfully. These men subsequently suffer from the "DBM syndrome"—"Don't blame me for being such a failure in everything I tried to do, I had too many projects, too many . . .".

The Technical-Customer interface (TC) is a very important line of communications. From the technical view, the best way for a technical group to get information about a customer's needs is in direct discussion with the knowledgeable people in the customer's liaison group. Sometimes a marketing or sales person is reluctant to allow technical people to share customer contacts. Reasons given are, "They don't have to go, I'll tell them everything of importance that's mentioned", or "I don't want him (the technologist) present, he may say something I wouldn't approve. He's not diplomatic enough". Of course, such expressions are just excuses and they are generally invalid! No one individual, salesman or chemist, can report "everything that's mentioned" or sense all the nuances of importance expressed at a meeting. Communications theory tells us that we are all likely to comprehend something different from the very same statement.

It is accepted among experienced technical managers that perhaps the most common reasons for delay of a research or development project are improper or incomplete specifications as to what the product to be developed really must be. By encouraging a meaningful (TC) interface, we can eliminate the majority of such wasteful activities. In my firm view and experience, the senior project chemist or someone he delegates must be at customer meetings and he will probably be just as diplomatic as his sales colleague! It is psychologically and personally indefensible to tell a technical man to whom is entrusted the leadership of an important project that he cannot be trusted to speak directly to a customer!

A common reason for low chemist morale and perhaps low chemist success in innovating is that they do not have enough opportunity to visit the customers, to hear his needs in person, and to participate as closely as possible in customer evaluations and reappraisals, all the way through to the final production tests, approval or failure. Some sales personnel always want to take their chemists to the customer to confront problems, but never to hail the success of a project on which the chemist has worked long and hard. In the long run, the procedures I suggest will be effective in conserving human resources because, although my suggestions will take the technologist away from his research laboratory for a few hours, the work undertaken will nearly always be completed sooner and better. To confirm my thesis, I would cite Aram, who reports that "high complexity projects tended to be successful technically when communications between R & D and the customer on the outside were more direct, that is, less channelled through intermediaries"[1]. Happiness in one's job is also important for innovation to occur. A. J. Heschel has said, "Happiness may be defined as the certainty of being needed". When a chemist is part of a team visiting a customer, he is happier and will innovate better.

The Technical Technical interface (TT) closes the circuit of our communications network. It must be mentioned here that the "Scientific and Technological Competence" factor must exist in a high degree, or the (TT) interface cannot operate effectively. In general, the less competent technical people will not have the necessary good technical relationships with their counterparts. A competent technical man should perhaps have (TT) contacts and communications as suggested in Table 9.

Table 9. Technical—Technical aspects important for innovation

1.	Colleagues in own company
2.	Colleagues in coating industry
3.	Colleagues in the larger chemical industry
4.	Consultants
5.	Company records
6.	Patents, periodicals and journals (world wide)
7.	Libraries
8.	Participation in Technical Societies
9.	Continuing education
10.	Curiosity (self-communications)

A few brief remarks about Table 9 would seem to be in order here. Amazingly, each of the ten items in Table 9 is a method for communicating! Let us ask ourselves how many times we have observed sincere young chemists trying to literally "re-invent the wheel" when the technology they seek is readily available in his own company or elsewhere? In the year 80 B.C., Cicero said, ". . . not to know what happened before—is always to be a child". Information desired and needed may be accessible in the mind or laboratory notebooks of a senior scientist next door! Asking for help is not a sign of weakness; it's a sign of maturity! We learn in the Bible, Proverbs 27:17, that "Iron sharpens iron, and one man sharpens another". We must speak with the colleagues in our own companies first, and then with other chemists in our field and in related fields of chemistry and engineering. We must listen carefully and patiently when our colleagues speak. Sad to relate, sometimes the "available" technology is not readily retrievable and we have to re-initiate studies and complete projects which have already been done and could be available to us. There is no greater need in the (TT) interface than an effective, practical and readily available information-retrieval system.

Chemists who do not regularly read the scientific and technical journals, who do not use library services, who do not use outside consultants from time to time, who do not carefully scrutinise patents and chemical company literature—such chemists do not often innovate, despite all the other favourable factors which may exist. There are some chemists who do not have the self-motivation or self-discipline to become innovators. There are also some chemists who "talk a beautiful game" but who never actually produce the required innovations. Part of a desirable (TT) interface would include participation in technical seminars—either as participant or attendee, and regular attendance at technical society meetings. Technical curiosity, in all its manifestations, is a vital factor. Samuel Johnson has written, "Curiosity is one of the permanent and certain characteristics of a vigorous intellect".

Without scientific and technical competence, there can be little or no successful innovation. Technical competence includes the factors listed in Table 10. I have assembled these from various sources and have myself assigned "weightings" for each factor in the right hand column.

Table 10

Factors in "Technical Competence" (as they relate to innovative abilities)

	Weighting
(a) The "Intuitive Factor"	25
(b) Commitment to Hard Work	20
(c) Technical Training	10
(d) Practical Experience	10
(e) Understanding of Colleagues	10
(f) Trust in Colleagues	10
(g) Commitment to Success	10
(h) Desire to Know Consequences of His Work	5
	100

In my considered opinion, the "Intuitive Factor" is perhaps the most important characteristic of an individual as far as his innovative competence is concerned. For our purposes, intuition may be defined as "apprehension without the consciousness or intervention of any reasoning process".

Some scientists and technologists habitually innovate, others rarely or never do. Chemists give all kinds of reasons for not innovating—we've all heard them. Responsible and successful technical managers cannot accept such excuses. The "intuitive factor" has certain mystical aspects, perhaps related to some imagination or art form. Einstein has observed that "imagination is more important than knowledge". Innovative thinking is probably at its best when it's "poetry, not prose".

Robert Nisbet in his "Sociology as an Art Form" mentions "Scientism—which is science with the spirit of discovery and creation left out". Nisbet finds no conflict between science and art because, "in their psychological roots they are almost identical". This author continues, "The unity of art and science exists most luminously in the motivations, drives, rhythms, and itches which lie behind creativeness in any realm, artistic or scientific". And, there is no "conflict betwen the aesthetic and the practical or utilitarian".[21] Professor C. S. Smith of MIT writes that "Innovation and discovery require aesthetically-motivated curiosity".

The late Chaim Weizmann, great English biochemist and first President of Israel, who was responsible for the production of urgently needed acetone by fermentation during World War I, was described as "in essence, an artist, even in his science" and "his greatest work was achieved not by logical deduction, but by intuition".

Kubie has expounded on the neurotic aspects of innovation, saying "neurosis corrupts, mars, distorts, and blocks creativeness in every field". Kubie states further that ". . . creativity is a product of preconscious activity"—as distinguished from unconscious or conscious processes. Dr Kubie, a psychoanalyst and psychiatrist who has taught at Yale and Columbia Universities, writes further, ". . . the preconscious system can be the direct recipient and utiliser of informational data without requiring the slower paced interposition of conscious processes".[17] Most of us have, at one time or another, enjoyed that flash of intuitive feeling about an idea or a project—and exulted deeply in the resultant innovation. Intuition is probably related to the preconscious system, a latent but still available information retrieval system.

Intuition may be likened to the air we breathe. Pragmatic or rational thinking may be likened to the ground on which we walk. There is a flaw in being too rational. We can get this way if we neglect the intuitive or mythic element. When there is a conflict between intuition and rationality, don't try to resolve it! Always favour the intuitive approach! Emily Dickinson, the American poetess, deplores those who have only "the facts but not the phosphorescence". The great Albert Einstein put it, "The most beautiful thing we can experience is the mysterious. It is the source of all art and science". Intuitive thinking and hard work can combine to give us the types of innovation which will truly conserve the scientific resources we most cherish and need. Nisbet reminds us that, "It is a mistake to think of creativeness as some special power with which only geniuses are endowed".[21] All people, properly trained, motivated and encouraged, can create and innovate.

Most of us are familiar with the technologist who can nearly always get an R & D project 60–75 per cent completed, but who is never able to take a project to the 95–100 per cent successful completion point. I call these people "pseudo innovators". They are disastrous to a technical staff. "Pseudo-innovators" should be relieved of their R & D assignments. Put them in the analytical laboratory, in quality control, in environmental testing—but separate them from R & D work where innovation is required! Figure 1 shows how "pseud-innovators" and "real innovators" seem to me to operate.

In the chart on "Technical Competence", "commitment to hard work" and "commitment to success" are two of the absolute requirements of the successful project requiring innovation. Without commitment to hard work, there can be no success. You cannot innovate on an eight hour day, five days a week schedule! Without a deep commitment to successful innovation, there is often no innovation at all!

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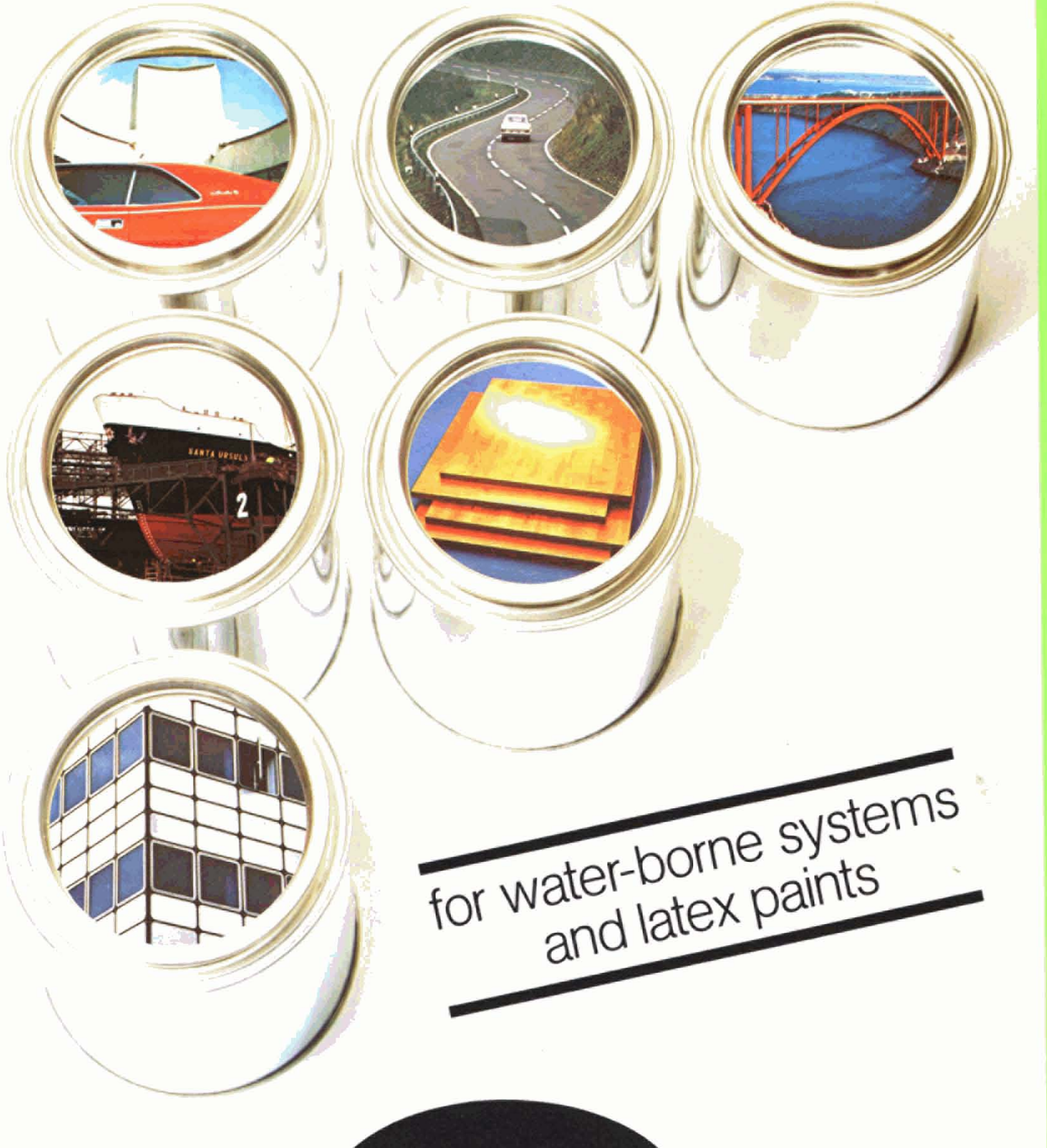

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Paint additives for aqueous surface coatings

Name	Use	Liquid	Solid	Powder	Additional Comments	Amount to be used 1)	Calculated on
Hydropalat® 1706	Pigment Dispersion Viscosity Stabilization Prevention of Sedimentation	□			Polyacrylate	0.1 – 0.5 %	pigment
Hydropalat® 1667		□			Mixture of polyacrylate & special phosphates	0.1 – 0.5 %	pigment
Texapon® P	Wetting Agent and Dispersing Agent for emulsion paints	□			Mixture of anionic and non-ionic surfactants.	0.3 %	finished paint
Disponil® 19 + 20	Wetting agents and stabilizers for emulsion paints; Emulsifiers for pigment preparations; Wetting agents for brush cleaners; Emulsifiers for alkyd resin and nitrocellulose emulsions; Emulsifiers for polymerisation	□			Low foaming wetting agents	0.1 – 0.5 %	finished paint
Disponil® 1828		□			Foam inhibiting wetting agent with synergistic interaction with Dehydran defoamers for optimum foam depressing requirements	0.1 – 0.5 %	finished paint
Disponil® 21			□			0.1 – 0.5 %	finished paint
Dehydran® C	Defoamers and foam inhibitors for emulsion paints and plastic dispersions	□			Silicone-free	0.1 – 0.7 %	finished paint
Dehydran® F		□			Silicone-free	0.1 – 0.7 %	finished paint
Dehydran® G		□			Contains small amounts of silicone	0.1 – 0.7 %	finished paint
Dehygant® B	In-can preservative for emulsion paints	□			Heterocyclic compound containing nitrogen and halogen	approx. 0.04 %	finished paint
Dehygant® LFD	Preservatives for in-can preservation of emulsion paints, emulsions, aqueous colour batches			□	Primarily chloro-acetamide	0.2 – 1.0 %	finished paint
Dehygant® LFM		□			Heterocyclic compound containing nitrogen	0.2 – 1.0 %	finished paint
Product LA 535	Anti-settling agent for water-borne systems	□			Amine neutralized polyester	0.2 – 0.6 %	finished paint

1) = in emulsion paints, 2) PVP = Polyvinylpropionate, 3) Shell Chemicals

We have taken your problems to heart and developed additives which have become recognized "trouble-shooters" in the paint world, i.e.:

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PRODUCT LA 535

Anti-settling agent for **water-borne** systems. On account of its surface active character, PRODUCT LA 535 possesses a strong affinity to the pigments. It facilitates the pigment dispersion, and mostly produces a thixotropic viscosity increase, which offers the following advantages during application of the paint:

- bodying
- reduced sagging
- moderate increase of the film thickness
- uniform film thickness
- smooth surface
- better flow
- less flooding and floating
- no pigment settling

It should be mentioned that a combination of PRODUCT LA 535 with PRODUCT VP-LA 671 for water-borne systems (based on amine-neutralized binding agents) is recommendable.

PRODUCT VP-LA 671

Defoamer for aqueous surface coatings. VP-LA 671 has a good anti-foaming effect in amine-neutralized aqueous paint systems. Systems based on alkyd resins, oil-free alkyds, polyacrylates, epoxy esters and phenol resins have been tested. Noteworthy is VP-LA 671's long-term effectiveness.

Flow improvement and a reduction in possible flooding and floating have been observed as positive side-effects.

No negative side-effects have been discovered, provided that the correct dosage of 0.2 – 1.0% is used.

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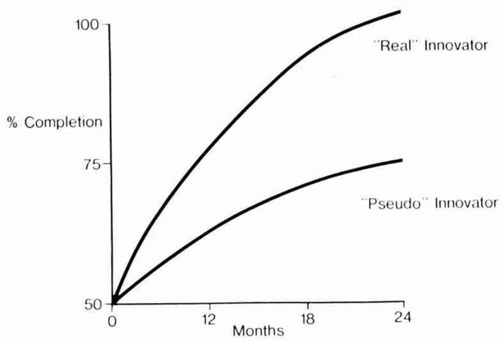

Fig 1. Progress of R & D projects

Whether it's pride, purse or personality—the successful innovator really wants to succeed. Innovation requires imaginative projection. Innovation requires total personal involvement.

Again referring to this chart, "technical training" and "practical experience" are the foundation stones of any individual or laboratory structure claiming "Technical Competence". When harnessed to "intuition" and "hard work", training and experience can and do solve many of the problems involving scientific innovation.

The item called "understanding of colleagues", in Table 10 is an important one. One cannot work constructively with one's colleagues unless there is a good measure of basic understanding. There must be understanding of strengths and weaknesses, of special skills, of personal sensitivities. We must try to understand the needs of those with whom we work, as well as our own needs. As colleagues, I include everyone involved in the success or failure of the project, from the head of R & D to the technicians; from the president of the company to the pilot plant personnel and the sales people involved. Successful innovation requires good management of people at every level. No amount of technical knowledge alone is an adequate substitute for understanding people. The process of innovation is not a comfortable one, but the entire process must be basically enjoyable for innovation to occur; enjoyable and gratifying not only for ourselves, but for our colleagues as well.

Another item in Table 10 tells us that, in addition to having an understanding of our involved colleagues, we must trust them. We must ascribe to them the same commitment and integrity we attribute to ourselves. If we do not have such trust, our path will be much more difficult. Being able to trust people with whom we work is a sign of maturity. Habitual mistrust of such people may well be neurotic.

A person who innovates has an intense desire to know the results of his work—this is the last item in Table 10. Such a person wants to know what his superior thinks of his ideas, what the sales manager thinks, and, perhaps most important of all, what the customer thinks. An innovator must have this "feed back" to survive, to improve and to overcome.

Please let me insert a caveat at this point. In my considered opinion, "one of the best ways to stifle innovative people is to burden them with excessive re-organisations, financial reports, accounting practices, technical report writing, *et al.*" I sometimes think (facetiously!) that the degree of true innovation in an R & D laboratory may be inversely proportionate to the amount of "paperwork" the staff is committed to submit regularly! Excessive "paperwork" requirements for chemists wastes human resources!

Petronius, the Roman satirist, made a pertinent comment along these lines more than two thousand years ago when he wrote, "We trained hard—but it seemed that every time we were beginning to form up into effective teams, we would be reorganised. I was to learn later in life that we tend to meet any new situation by reorganising and a wonderful method it can be for creating the illusion of progress, while producing confusion, inefficiency and demoralization". Things have not changed much in two millenia!!

Referring once more to Table 7, we have discussed the two twenty-point items in considerable detail. Let us now consider the two fifteen-point factors which are next in importance in the model we have constructed.

We use the word "Champion" here, not in the sense of a superstar in competitive games, but rather in what is perhaps the primary sense of the word "champion", "a combatant, a fighter, especially one who acts or speaks in behalf of a person or a cause: a defender" or "a fighting man; one who fights on behalf of another . . .". An R & D project "Champion", in the sense of our use here, is someone high in the organisation and outside the actual working groups—an important senior person in the company who is deeply dedicated to the successful completion of the new project. A "Champion" will encourage when things are going poorly, will chide when he thinks one of the sectors involved isn't performing properly, will try to get additional resources when these are necessary.

Above all, a "Champion" will exude quiet confidence in the ultimate success of the project, he will calm the irritated ones, try to reconcile the sometimes apparently irreconcilable views of the participants. He is always available to listen, to sympathise, to contribute high-level assistance and to try to harmonise the discordant notes. He will alleviate the hopelessness which often creeps into an R & D project. A "Champion" will be able to change hopelessness to hope—hope fortified by the willingness of all involved, including the "Champion", to work hard and to think deeply, to envelop one's self in the problems at hand. The "Champion" concept is a newly recognised one—but a vital one, indeed, as a factor in promoting innovation in Research and Development. In my experience, few important projects calling for innovation in the coatings field have succeeded without a contributing "Champion".

The "recognition of market opportunities" is also a fifteen-point factor in Table 7, and its importance is sure to be recognised by management, marketing, and technical people alike before a project is initiated. It is this factor, perhaps more often than any other, which gives birth to projects requiring innovation. Without recognised market opportunities which have a probability of success, most R & D projects in our industry would never be initiated. Marketing opportunities may arise due to the needs of a customer or an industry, as the result of a salesman's creative planning or by a technologist's insights that new scientific developments will be important to the products his company manufactures. The economic justification for expensive innovation must be that new markets can be opened and new profits realised.

Sometimes new technical knowledge, or the application of new perceptions of older scientific knowledge, will give important clues and recognition of technical opportunities. This ten-point factor may appear on the scene before or after the "market opportunities" factor, but both, somehow, must co-exist for successful innovation to occur. Curiously, recognition of technical opportunities will frequently come from people outside the technical area—just as the recognition of marketing opportunities will sometimes come from people not directly connected with marketing.

"Top management" should always be involved in important innovative work and the degree of such interest can influence the success or failure of such a project. "Top management" should receive copies of important reports and should attend periodic progress meetings which may be held. Depending upon the organisations and projects involved, "Top management" could be represented by the president, the vice president for research, development and engineering, the operations vice president, the financial officer, the general manager, the technical director, and so on. Sometimes "Top management" may even be a "Champion", but "Top management" involvement is usually too diffused for the "Champion" function. When several of the highest executives are involved, the project receives considerable extra impetus and the people involved receive very important additional encouragement. In our model, this factor carries 10 points.

"Competitive factors" are often responsible for pushing us into R & D projects requiring innovation, especially when we are in danger of losing business we already enjoy. The urgency for innovating is obvious in such situations. Competition can be an important prod to innovation.

"Timing", while frequently an imponderable, is recognised as one of the key factors in many innovative projects. We all know of R & D projects which succeeded or failed because of this factor. Timing of innovative research and development is sometimes, but not always, a crucial factor in meeting marketing needs and in fighting competition.

Now that we have studied its component parts to some extent, let us look again at Table 7, but this time with a modification. Here is introduced what I shall call the "Fatal Flaw Factor" (FFF).

Let us then discuss Table 11 for a few moments.

Table 11

Most significant factors for innovation—introducing FFF as a required percentage of major factors

	Weighting	Fatal Flaw Factor (FFF) 70%
1. Effectiveness of Communications (TM, TC, TT) 10 5 5	20	(14)
2. Scientific and Technological Competence	20	(14)
3. Presence of a Champion	15	(10.5)
4. Recognition of Market Opportunities	15	(10.5)
5. Recognition of Technical Opportunities	10	—
6. Degree of Top Management Interest	10	—
7. Competitive Factors	5	—
8. Timing	5	—
Innovation potential	100	

Although the model we have developed here may appear to be a simplistic one, I wanted to see how realistic and useful it might be in predicting the successes or failures of several research projects with which I have been and am currently associated—projects all in categories which could be designated "difficult, but possible". Before doing this, however, it seemed desirable to introduce some early-warning mechanism which would take into account any "Fatal Flaw"—i.e., some aspect in our model which would cause the project to have essentially "zero chance of success", no matter how favourable were the other elements. For example, we could theorise "top scores" for every factor but "Scientific and Technological Competence"—but if there is "zero" competence in the project field involved, it is obvious that only failure can result.

Accordingly, I introduced a "Fatal Flaw Factor" (FFF) into our model.[14] This is simply the minimum percentage which any "weighting" element must carry for the project to qualify. After much reflection, I decided to apply the (FFF) to only the first four (or most important) factors in the model, and I made this "excellence factor" a uniform 70 per cent for these four categories—Communications, S/T Competence, Champion and Market Opportunities. I suggest that only the "Innovation Index" and "Fatal Flaw" factors be considered in evaluating a project. What we are implying is that unless we have 70 per cent of total weighting for the major factors—Communications, Scientific Competence, Champion and Market Opportunities—our chances of success will be seriously endangered—perhaps fatally.

Let us now briefly study Table 12, an actual current project, and assess its evaluation three years ago for "Innovation Index" (II) and "Fatal Flaw Factor" (FFF).

Table 12

Technical project S/G—Assessment of significant factors (1974) influencing successful innovation

	Weighting	FFF (70%)
1. Communication (TM, TC, TT) 8 3 2	13*	(14)
2. S/T Competence (55 × .20)	11*	(14)
3. Champion	12	(10.5)
4. Market Opportunities	11	(10.5)
5. Technical Opportunities	7	—
6. Top Management Interest	7	—
7. Competitive Factors	2	—
8. Timing	3	—
Innovation Index (II)	66	

*early warning that these Factors may be inadequate.

From this assessment of nearly three years ago, with an Innovation Index (II) of 66 points of an Innovation Potential (IP) of 100 points, we predicted a "borderline" situation here, perhaps one which augured failure rather than success. It seemed imperative to increase the (II) and to heed the early warning of the Fatal Flaw Factor (FFF). It was apparent that the S/T competence was lower than it should be and must be improved if success were to be achieved. Communications must also be improved. Utilising our model to evaluate project S/G, which was not progressing satisfactorily, we were prompted to reinforce both the communications and the "technical competence" factors.

Table 13 shows how this was done. We improved communications with both marketing and with customers by consulting with both much more frequently and more openly. In the technical area, we replaced the project chemist and the technical supervisor involved with more competent individuals and technical management gave them better assistance in every aspect of their work. We have increased our (II) from 66 to 74, and removed the early warnings in our (FFF) evaluation. The sales and marketing efforts were also improved.

Table 13

Technical Project S/G—Assessment of significant factors influencing successful innovation (changes after 1974 assessment)

	Weighting	FFF (70%)
1. Communication (TM, TC, TT) 9 4 3	16	(14)
2. S/T Competence (80 × .20)	16	(14)
3. Champion	12	(10.5)
4. Market Opportunities	11	(10.5)
5. Technical Opportunities	7	
6. Top Management Interest	7	
7. Competitive Factors	2	
8. Timing	3	
Innovation Index (II)	74	

We can now report that these changes did result in successful innovation for project S/G. Several successful customer trials have been made, patent applications have been filed, and a highly desirable new market area may be opening for our company.

Let us examine just one more current project and examine the factors influencing successful innovation in this case, as shown in Table 14.

Table 14

Technical project WB/IC assessment of significant factors influencing successful innovation

	Weighting	FFF (70%)
1. Communications (TM, TC, TT) 8 4 4	16	(14)
2. S/T Competence (65 × .20)	13*	(14)
3. Champion	13	(10.5)
4. Market Opportunities	12	(10.5)
5. Technical Opportunities	7	
6. Top Management Interest	8	
7. Competitive Factors	5	
8. Timing	5	
Innovation Index (II)	79	

*early warning that this factor may be inadequate.

As we study the model analysis, we would say that the prognosis for successful innovation here was fairly good. However, we have an "early warning" that the S/T competence factor may be borderline. This project was so important that we were worried, and "reinforcements" were added in 1974 and early 1975 as shown in Table 15.

Table 15

Technical Project WB-IC—Assessment of significant factors influencing successful innovation (changes after 1974 & 1975 re-assessments)

	Weighting	FFF (70%)
1. Communications (TM, TC, TT) 9 4 4	17	(14)
2. S/T Competence	15	(14)
3. Champion	13	(10.5)
4. Market Opportunities	13	(10.5)
5. Technical Opportunities	7	—
6. Top Management Interest	9	—
7. Competitive Factors	5	—
8. Timing	5	—
Innovation Index (II)	84	

This project was commercialised at the end of 1975 and large commercial quantities are now being sold (in late 1976 when this was written).

Conclusions

I recognise the subjective aspects of assigning numbers to the various factors affecting technical innovation, fatal flaws, etc. However, I have analysed a sizeable number of R & D projects (both completed and those still under way) by this method. My "Innovation Index" (II) numbers almost always come out within two or three units, and I have applied this model to the same project as many as ten times in some cases. The tentative conclusion is that, using the model developed in this paper, a Critical Innovation Index (CII) of 70 or higher is necessary for innovation probability in an R & D project involving "industrial" organic coatings. Also, the Fatal Flaw Factor (FFF) should not be less than 70 per cent of the "weightings" assigned to the first four (most important) factors shown in the model. For any evaluator, the calculation of a few "control" or retrospective projects will help to establish the proper Critical Innovation Index gauge. This is the procedure I used to establish the figure of 70 as the (CII). For a respected collegue, the (CII) turns out to be 75.

We are now using this model on my own company's major projects—and with good success. Other technical managers in the coatings industry and in other segments of industry as well, have written me and reported good results from their use of this model, which was first revealed in my Mattiello Lecture in 1974.[12]

In the industrial world of rapidly shifting targets in which we work on our projects today, we coating scientists need a sense of humour, a sense of our own worthiness, and a sense of the Infinite to continue our work and to succeed occasionally. We need the "quiet of the forest" if we are to innovate better and more often. Perhaps we occasionally need the sight of a beautiful tree or flower. We need the sound of inspirational music. We need to better harmonise our inner selves with the external influences under which we work and live so as to maximise our personal contribution. In this way we can, indeed, conserve human resources through more and better innovation. I don't think that the computer or the supreme use of logic can do this for us. Again, I quote Nisbet, who wrote, "It is hard to think of anything more fatal to discovery or invention than the idea that the creative act can be generated by properly following the rules of logic."[21]

The factors working for successful innovation, as well as those militating against successful innovations, are many and exceedingly complex. This subject is currently being studied by investigators from many disciplines. More and more understanding on how successfully to encourage innovation will undoubtedly be developed by both academic scholars and industrial scientists—those of us who must either innovate or perish!

Perhaps this introduction to the requirements for innovation, and how to conserve our human resources in the innovation process, will encourage further discussion and research into this fascinating field! In the interim, I invite R & D managers everywhere to try this model in their laboratories.

As "Chemical Week" reported in its review of my model in its October 29, 1975 issue, "His approach . . . can serve a useful function if it does no more than furnish a check list, forcing management to make sure that all aspects of a program have been taken into account."[4]

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Discussion at Eastbourne Conference

Dr G. D. Parfitt said that he thought one of the main discouraging effects on innovation in this country was the relative lack of financial reward for any new advances in comparison with other countries, especially in the United States. He also mentioned that whilst he thought the technical/marketing interface was very important, he considered the marketing/customer interface to be more important as it was at this stage that the customer requirements often failed to be passed back to the technical men and so they often had to proceed with inadequate or inaccurate specifications. Dr Parfitt's final point was that he thought the modern trend of management to form tightly organised R & D groups was too rigid and also tended to inhibit innovation.

Mr Glaser answered by using a quotation from Nesbit "it's hard to think of anything more fatal to discovery or invention than the idea that the creative act can be generated by properly following the rules of logic". Mr Glaser also pointed out that logic might dictate making reports every week, but this provided some chemists with the perfect excuse for not completing their research projects.

Dr E. Inman asked Mr Glaser to comment on the assertion that analysis of the type he had described in his paper was, of itself, fatal to innovation.

Mr Glaser accepted the possibility that Dr Inman might be correct but stated that he used the model himself and had found it to be helpful. He also knew of several other people in the United States who had gained from using the model, and indeed one person at the Conference had told him that he was at that moment trying it out in his laboratory.

Dr J. E. O. Mayne said that in his opinion one of the problems of communication was that of company size. He suggested that in a small company of 10-40 people, the employees often met together and discussed their problems and so eliminated the communication difficulties. However, in a larger company, as the size of the company increased it seemed that the problems of communication also increased. He, therefore, suggested that there might be an optimum size for a company, although he was not able to suggest a way of determining this.

Mr Glaser agreed with the points Dr Mayne had raised and illustrated them by referring to his own company, which had grown from a relatively small concern, in which he had known all the chemists and technicians by name, to one with over 200 research people in eight or nine different locations. He recalled that he had had to fight to prevent the whole R & D organisation becoming too centralised and to avoid this problem of communication. Mr Glaser suggested that it was the duty of administrators to avoid the great dangers of too much centralisation.

Dr L. Valentine said he was surprised that Mr Glaser had given such a low rating to timing as a factor for innovation and he suggested that everyone would know of cases where a solution had been obtained at the wrong time, either too early or too late. He suggested, therefore, that timing should "score" more than 5 points.

Mr Glaser said that his model for innovation was not intended to be a rigid system and that it should be modified to suit individual cases. He could recall instances in his own laboratories when the time factor would have been given a rating of 20 or 30 but on average he recommended it should score about 5. One of his colleagues had suggested to him that luck was a large factor in innovation and suggested giving luck 10 or 20 points. Mr Glaser's opinion of this was that luck was, in fact, a factor in innovation, but that to a large extent luck is a result of hard work and thinking and being involved in the project.

Mr D. Buckley said that in his firm a similar system to Mr Glaser's was used, but that one question which had always intrigued him was how far to take the technical/marketing communications through the laboratory structure. He asked Mr Glaser at which point he stopped the communications; did he stop at chemists or did he go all the way down to technicians?

Mr Glaser said that everyone in the project should feel he was communicating with the top people, both on the technical and marketing sides. He had practised this for many years and found it very salutory. If a young graduate chemist or a high quality technician is given all the dirty work to do and then, when there is a Conference with the Marketing Manager, he is not consulted, he is discouraged, but if a young chemist is taken along to a Conference with a Marketing Manager or Vice President, he will have a lot of enthusiasm and vigour for the project instilled into him. Mr Glaser summed up his answer by saying that in his company any person who makes a significant contribution to a project is taken all the way as far as discussions and consultations are concerned and he felt this had a better effect on morale even than receiving an increase in salary.

Mr F. Armitage wondered whether the person Mr Glaser referred to as an "innovator" is what is otherwise known as a "paint formulator" and pointed out that in the graph that Mr Glaser used to illustrate this point, the time scale of the project was only two years, whereas many important projects last 10 or 15 years. He suggested that the concept of the pseudo innovator was totally unrealistic, since a so called "innovator" could either be 100 per cent successful or anything from 0 to 100 per cent successful. There was no reason to suppose that 50 per cent was a critical point. On the question of communications, Mr Armitage pointed out that in order to prevent people in different laboratories doing the same work and "reinventing the wheel" it was necessary for technicians or chemists to write up-to-date reports on their work and he disagreed with the suggestion that to do so hampered their research and development project. He asserted that if any chemist he employed refused to write a technical report he would throw him out.

Mr Glaser thought that perhaps he had not clarified this point well enough in his lecture and illustrated the difference between a "formulator" and an "innovator". He suggested that there were many routine "formulators" and there was nothing exceptional about these people, but that the "innovator" was capable of doing things which had not been done before or had not been economical before. As regards making reports, Mr Glaser said he was not against people making reports, as obviously this did help communications, but he was distressed by the tendency in some laboratories to write so many reports that the chemist hardly has time to do any research work and can, if he so wishes, use this as an excuse not to finish his development project. From his own point of view clearly Mr Glaser needed reports as, being a laboratory administrator, this was his only method of getting information about the progress of the work.

Mr Armitage's final point was that in the list of factors affecting innovation Mr Glaser had listed intuition first. He asked if Mr Glaser had found that women, therefore, were better innovators than men.

Mr Glaser said that in the past he had not had many women working in his laboratory and although he now had a fair proportion he had not really had time to assess their effect upon the innovation although he conceded that women may have slightly better intuition than men.

Mr M. L. Ellinger referred to Dr Parfitt's first remark and said that she agreed that there was a certain lack of reward for innovation in this country, but she thought that greater problem was that the younger people seemed to lack interest in the work they were doing, and were prepared to move to another firm if it paid 2.5p more. She said that young people did not seem interested in their particular job and suggested that some incentive was needed from a higher level.

Mr Glaser said that like Dr Ellinger he deplored some of the characteristics she had described in young people, but he thought that on the whole young people were good and more idealistic than his generation had been, and in many respects they had advantages which older people had never had. He agreed that the most important point was to try and involve the young people in a meaningful way in their work so as to bring out their good properties and suggested that one of the ways this could be achieved was through his model. He had taken young people who had not seemed interested in their work and involved them in an important project with the top people in the Company and with their top customers. As a result, very soon a man who had been working from 9 to 5 would be eager to stay on to finish his work or take his work home with him. Mr Glaser said that if young people could be involved through these psychological processes, then they would be able to take advantage of their large capabilities to the benefit of all concerned.

Mr J. Seiner said that he had listened to the list which had been given on the innovative factors, and whilst he agreed that they were all important, he considered that one had been omitted which was of vital importance, namely the ability to associate the various facts together and obtain meaningful results from them. Without this associative ability information would just be poured into people and nothing would really be achieved.

Mr Glaser said that he agreed entirely with Mr Seiner and answered by quoting from Arthur Koestler's book "The act of creation": "All decisive advances in the history of scientific thought can be described in terms of mental cross-fertilisation between different disciplines" and "based on the experiences of Copernicus, Darwin and Pasteur, at the beginning of each period stands the publication of a short preliminary note which contained the basic discovery in a nutshell; then there followed 10 to 15 years of elaboration, consolidation and clarification". Mr Glaser thought that this was probably the associative ability to which Mr Seiner had referred.

Mr D. A. Shingleton asked Mr Glaser to clarify the size of laboratory to which his studies referred. A figure of 200 was mentioned which he presumed referred to an organisation exclusively devoted to research and development. Referring to Dr Mayne's comments about the relative freedom from communication problems in a small company, he suggested that one point which had not been covered sufficiently in the paper was the aspect of timing on innovation. In his own company they cover a spectrum of activities from development and technical services to helping the factory in production with a total of nearly 200 people. They do not do basic research. One of their major problems is to give the competent innovators enough time to innovate, instead of spending all their time sorting out minor problems of the processes which they already had discovered. He asked Mr Glaser if he had any recipes for overcoming this problem.

Mr Glaser replied that he had come across the same problems and it had taken years to recognise them and do something about them. His system was to try to prevent the really good innovators getting involved in helping the factory and technical service, unless they were of crucial importance. For example, if a man has innovated something new and there is a problem in the field during the first two or three weeks, then he would be sent out to see if he could resolve the problem, but one of the most devastating things from the innovative point of view was to take innovators and get them involved in small problems, thus preventing them from continuing their primary function. Mr Glaser said that he, therefore, tried to dissociate his innovators from the day to day work although, of course, this could not be achieved completely.

Dr L. Valentine asked Mr Glaser if he had found any way of identifying creative individuals before they joined his staff.

Mr Glaser said he had found no such way, and the number of new people on his staff every year bore witness to that.

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The cost of flocculation*

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Summary

The effect of flocculation on paint film properties such as opacity, gloss, colour and durability is discussed, particularly with reference to decorative alkyd gloss paints. Indications as to the possible economic and technical benefits which could accrue from improvements in the states of dispersion of commercially available paints are discussed.

Keywords

Types and classes of coatings and allied products

gloss finish
latex coating
industrial coating

Raw materials for coatings binders (resins, etc)

titanium dioxide
alkyd resin
melamine alkyd resin
vinyl acetate resin
polyvinyl resin

Processes and methods primarily associated with

analysis, measurement or testing

accelerated weathering

Properties, characteristics and conditions primarily associated with

bulk coatings and allied products

pigment volume concentration
flocculation

dried or cured films

gloss
opacity
colour

Miscellaneous terms

raw material costs

Le prix de floculation

Résumé

On discute l'influence qu'exerce la floculation sur les caractéristiques d'un film de peinture, telles que l'opacité, le brillant, la couleur et la résistance aux intempéries. On discute les indications à l'égard des avantages eventuels et économiques et techniques qui pourraient parvenir aux améliorations dans l'état de dispersion des peintures disponibles actuellement sur le marché.

Die Kosten von Ausflockung

Zusammenfassung

Die Auswirkung von Ausflockung auf die Eigenschaften von Lackfilmen, wie Opazität, Glanz, Farbton und Dauerhaftigkeit wird besonders mit Bezug auf Maler-Alkydharzglanzemaillelacke besprochen. Besprochen werden auch die möglichen wirtschaftlichen und technischen Vorteile, welche durch Verbesserungen des Disperionszustands von im Handel verfügbaren Lackfarben erzielt werden könnten.

Introduction

Refs. 1, 2

In a previous paper,[1] an empirical, yet quantitative, technique for the determination of flocculation of titanium dioxide pigments in dry paint films was described. The technique, based on the scattering of infrared radiation, has been used successfully to determine the effect of flocculation on various paint properties. The majority of the work described in this paper is concerned with decorative alkyd gloss paints with which most experience has been gained. However, other systems, such as non-aqueous industrial finishes and both gloss and matt latex decorative paints, have also been examined and are discussed later.

Flocculation measurement

The technique used for the measurement of titanium pigment flocculation is based on the quantity of infrared radiation which is scattered by a paint film. The extent of flocculation is quantified by the flocculation gradient, a parameter which was defined and explained in the previous paper.

Previously, the meaning of a flocculation gradient, in terms of the size, number, and composition of the flocculates was not known with any precision. The most likely means of examining the problem was by the use of an electron microscope, but there are a number of difficulties associated with the preparation of representative samples. Some of these difficulties are described in a paper by Kampf *et al.*[2] in which they also outline a solution based on etching of the surfaces of paint films.

Figures 1–4 show electron micrographs of paint films in which the degree of dispersion varies from very good to very poor. In addition, the flocculation gradients of the paints are shown in order to give a visual appreciation of the meaning of the term. The surfaces of the paint films were etched by means of oxygen which was activated by micro-

*Paper presented at the Association's Biennial Conference held at the Grand Hotel, Eastbourne, Sussex from 16-19 June 1977.

wave radiation. Under these conditions, the organic binder at the surface is removed, leaving the pigment unattached but undisturbed on the top of the paint film. A layer of polyvinyl alcohol is then applied, allowed to dry, and peeled off. If pigment has become detached, it is embedded in the polyvinyl alcohol replica. If the pigment is not sufficiently loose it produces hollows in the replica. Gold/palladium and carbon are finally deposited on to the replica so that it can be examined by electron microscopy. Figures 1–4 are typical micrographs, the black areas representing pigment which has been removed and the white areas representing pigment which has protruded into the replica but not been removed from the paint. In order to enhance visual clarity, the white areas of four similar paint films have been blacked in and these show a clear progression from a very well dispersed paint to one which is severely flocculent (Figs. 5–8).

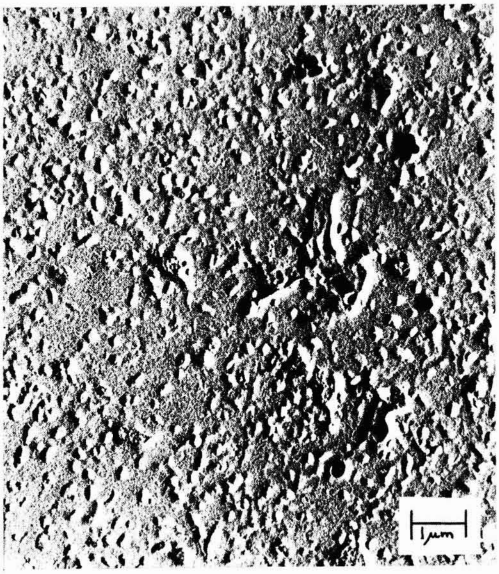

Figure 1. Electron micrograph ×20 000, flocculation gradient = 0.21

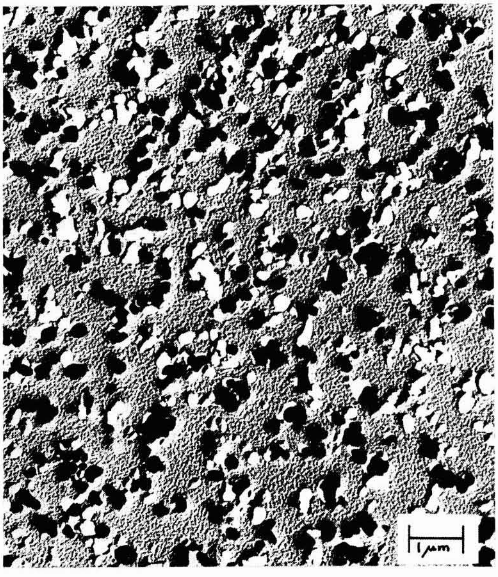

Figure 2. Electron micrograph ×20 000, flocculation gradient = 0.36

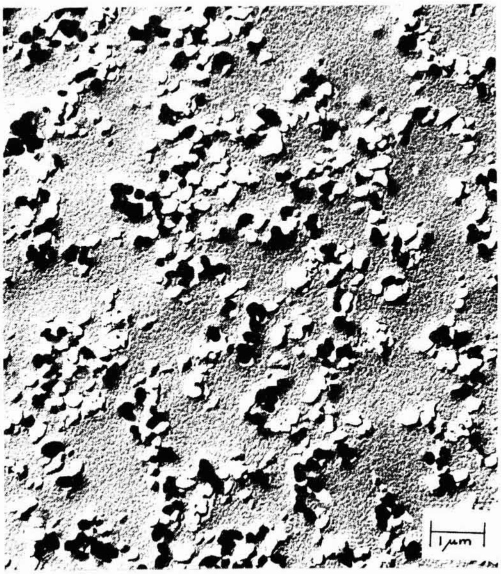

Figure 3. Electron micrograph ×20 000, flocculation gradient = 0.55

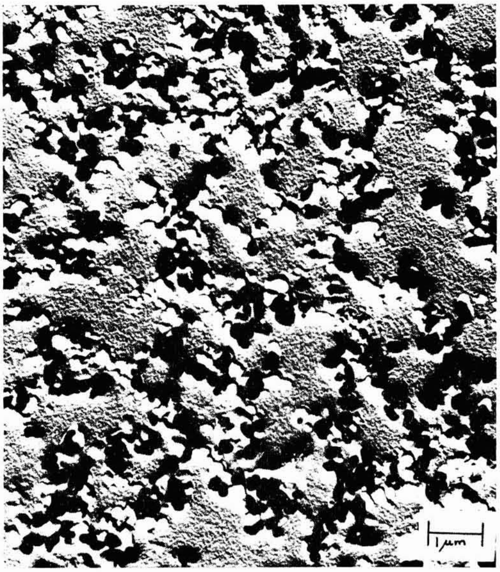

Figure 4. Electron micrograph ×20 000, flocculation gradient = 0.68

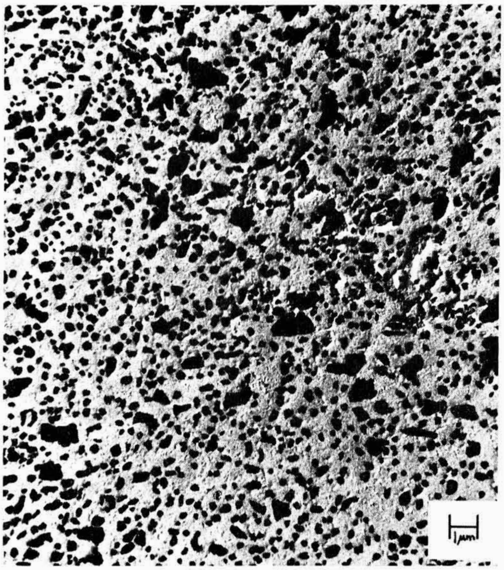

Figure 5. Electron micrograph ×10 000, flocculation gradient = 0.21

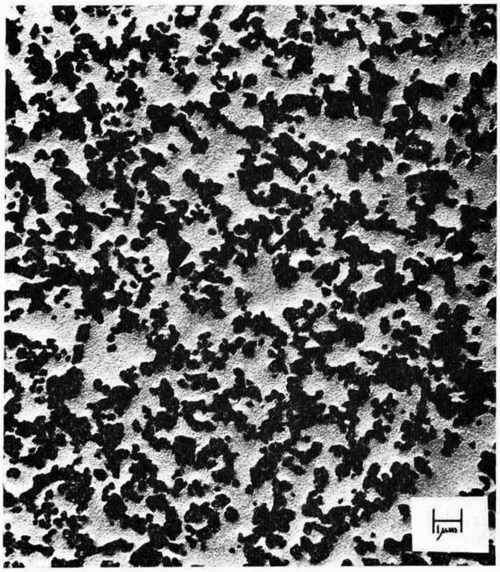

Figure 7. Electron micrograph ×10 000, flocculation gradient = 0.55

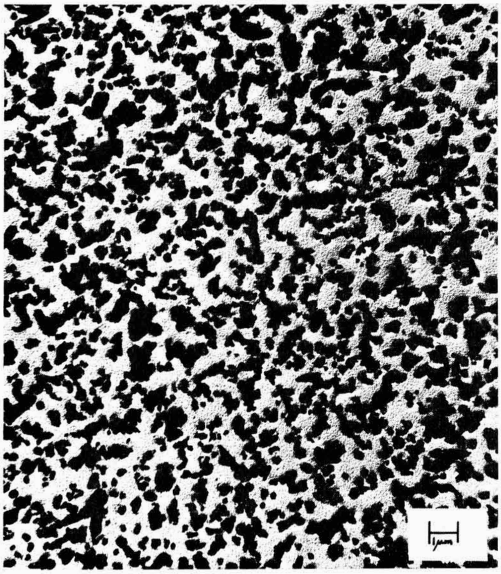

Figure 6. Electron micrograph ×10 000, flocculation gradient = 0.36

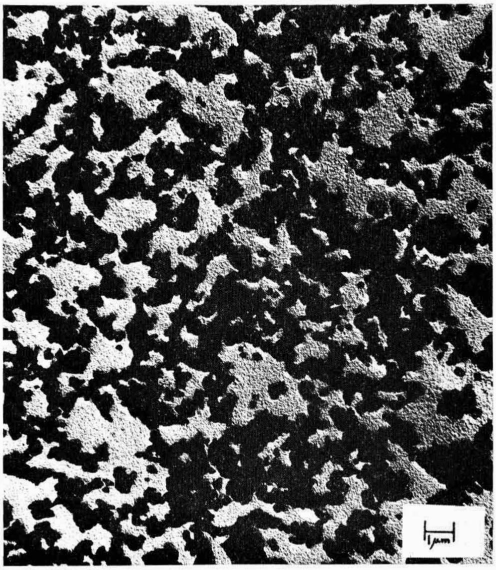

Figure 8. Electron micrograph ×10 000, flocculation gradient = 0.68

Decorative alkyd gloss paints

Refs. 3, 4

Opacity

In a flocculent system, pigment particles crowd together forming regions of high pigment concentration, in which pigment particles are unable to opacify efficiently, and lower concentration, the net effect being low opacity. This is explained in detail in the previous paper.

In order to measure the effect of flocculation on opacity, a series of paints containing a general purpose rutile grade of titanium dioxide at a PVC of 17.5 per cent in a long-oil soya alkyd was prepared. The paints varied only in the degree of flocculation which was controlled by the quantity of a flocculating agent incorporated in the paints.

Each paint was applied to polyester foil by means of wire wound applicators to give nominal wet film thicknesses of 25, 36, 50 and 60μm. The paints were allowed to dry, a square cut out of each of the drawdowns and the backscatter of radiation of 2 500 nm was measured using a Beckman DK2A Recording Spectrophotometer. The dry film thicknesses were found by stripping and weighing and using a density calculated from the formulation. Graphs of film thickness against backscatter were drawn and the gradients of the resultant straight lines calculated. These are known as flocculation gradients, the higher the value, the greater being the flocculation.

Opacity was measured by applying films in a similar manner at nominal wet film thicknesses of 50, 60, 75 and 100μm and measuring the reflectance of the dry films over standard black and white tiles using the green filter of a Colormaster Model V. Graphs of contrast ratio against wet spreading rate were drawn and the opacity taken as the contrast ratio at a spreading rate of 20 $m^2 l^{-1}$.

The effect of flocculation on opacity is expressed graphically in Fig. 9 in which it can be seen that an increase in flocculation gradient of 0.1 leads to a loss of opacity of approximately 0.4 per cent, a visually significant change.

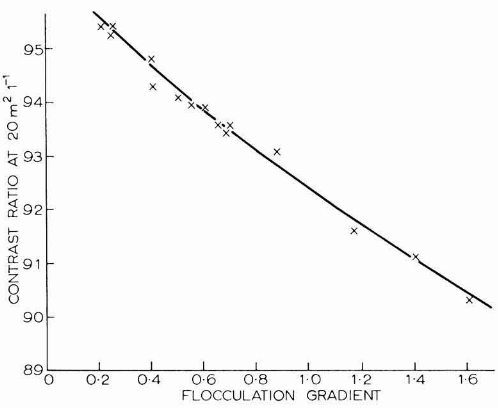

Figure 9. Effect of flocculation on opacity

A further series of well dispersed paints was prepared at various pigment concentrations, all at the same non-volatile content. Fig. 10 shows how the opacity varied with PVC. From Figs. 9 and 10 it is possible to evaluate possible reductions in pigment concentrations which could be made in flocculent systems which, if coupled with an improvement in pigment dispersion, would result in better, cheaper paints of the same opacity.

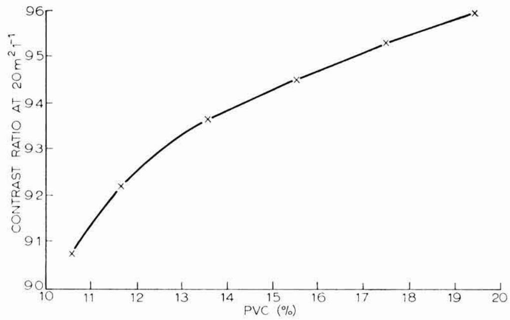

Figure 10. Effect of PVC on opacity

For example, a paint at a PVC of 17.5 per cent has a flocculation gradient of 0.8 and an opacity (from Fig. 9) of 93 per cent. If the dispersion is improved to give a flocculation gradient of, say, 0.25 the opacity would be increased to 95.3 per cent. Alternatively, if an opacity of 93 per cent is adequate, a reduction of 5 per cent in PVC (*ie* lowering the total pigment concentration by nearly 30 per cent) coupled with an improvement in dispersion could maintain the opacity of 93 per cent.

Table 1 shows reductions in PVC that could be made to paints, initially at 17.5 per cent PVC, if dispersion is improved and the same opacity maintained. An indication of possible raw material cost savings is also shown. Relative costs based on a 17.5 per cent PVC paint costing 100 units have been calculated using current (December 1976) United Kingdom raw material prices for simple formulations containing titanium pigment, soya alkyd resin, white spirit, driers and anti-skinning agent. Absolute values are not quoted as they tend to vary considerably and depend on a variety of factors. Thus, the figures quoted are approximate and should be regarded only as a guide.

Table 1

Effect of flocculation on raw material costs

Paints at 17.5% PVC			Well dispersed paints—various PVCs		
Flocculation gradient	Opacity	Relative RM cost	PVC	Opacity	Relative RM cost
0.25	95.3	100	17.5	95.3	100.0
0.50	94.2	100	14.7	94.2	95.0
0.75	93.2	100	12.8	93.2	92.5
1.00	92.3	100	11.8	92.3	90.6
1.25	91.5	100	11.0	91.5	89.3
1.50	90.7	100	10.5	90.7	88.6

In order to assess the relevance of these findings to paints which are made on a commercial basis, ten alkyd gloss paints were bought at random from local retail outlets and their flocculation gradients measured. Because of variations in the pigment concentrations, the values were adjusted such that they reflect the approximate gradients that would have been obtained had all the paints been at a PVC of 17.5 per cent. These are shown in Table 2.

Table 2
Flocculation gradients of commercially available gloss paints

	Liquid						Non-Drip			
Paint	1	2	3	4	5	6	A	B	C	D
Adjusted flocculation gradients	0.50	0.45	0.68	0.22	0.26	0.48	0.47	1.32	0.82	0.89

With the exception of two paints, all showed signs of flocculation which, in some cases was severe and which, if reduced to a satisfactory level could lead to very significant savings in raw material costs. For example, if the dispersion in Paint *B* was improved and the pigment content reduced such that the opacity was maintained, a cost saving of about 10 per cent could probably be made.

It has been noted previously[3] that thixotropic paints generally tend to exhibit greater flocculation than liquid paints and this is borne out, in particular, by the performances of Paints *B*, *C* and *D*. However, the relatively good dispersion shown by Paint *A* demonstrates that flocculation is not always severe in thixotropic paints. Overall, the results suggest that paint manufacturers might well make significant economies as well as marked improvements in quality if some attention was paid to the optimisation of pigment dispersion.

Colour

A similar series of paints was applied to white art board at a nominal wet film thickness of 100μm by means of a wire wound bar applicator. After drying, the colours of the films were measured using a tristimulus colourmeter, a Colormaster Model V. Flocculation gradients of the paints were also measured. The results are shown in Fig. 11.

$$\text{Colour indices} \left(\frac{\text{Red reflectance—Blue reflectance}}{\text{Green reflectance}} \times 100 \right)$$

were calculated, increasing values indicating greater yellowness. (Using this system a pressed sample of magnesium oxide would have a colour index of zero.)

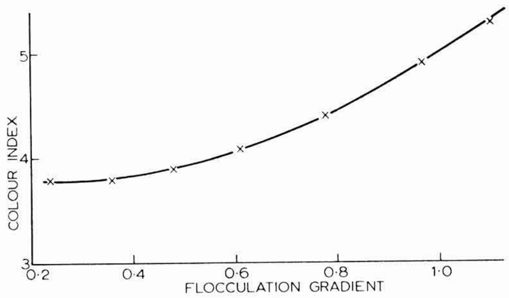

Figure 11. Effect of flocculation on colour

From experience, it is considered that a difference of about 0.3 units of colour index is perceptible, whilst one of 0.5 is visually significant. Thus, flocculation has little effect on colour in paints which are reasonably dispersed, up to flocculation gradients of about 0.6, but at higher flocculation levels, a significant increase in yellowness is apparent.

Gloss and gloss retention

The paints were also applied to glass panels by means of shims and a doctor blade. After three days the 45° specular gloss was measured according to BS 3900 Part D2 (1967) giving the results shown in Fig. 12.

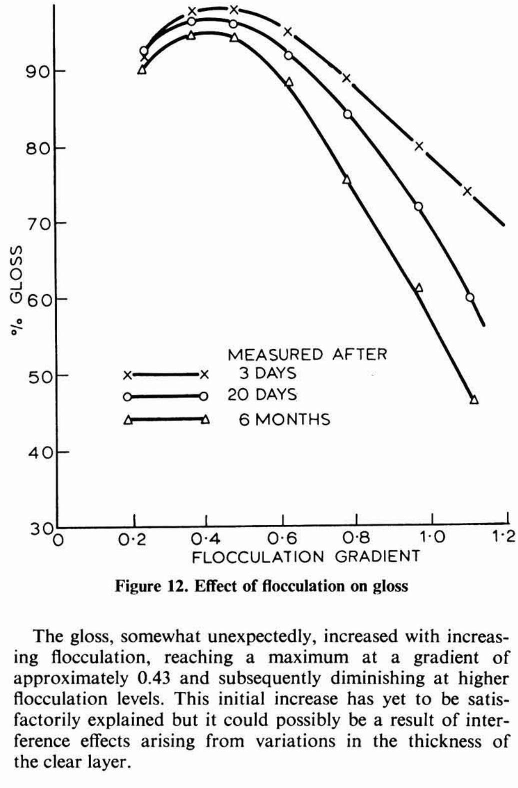

Figure 12. Effect of flocculation on gloss

The gloss, somewhat unexpectedly, increased with increasing flocculation, reaching a maximum at a gradient of approximately 0.43 and subsequently diminishing at higher flocculation levels. This initial increase has yet to be satisfactorily explained but it could possibly be a result of interference effects arising from variations in the thickness of the clear layer.

The decrease in gloss at higher flocculation levels is due to the protrusion of large flocculates through the surface of the paint film. This is demonstrated by the increase in surface roughness (Fig 13) above a gradient of approximately 0.5. The roughness, expressed as a central line average, was measured using a Talysurf according to BS 1134 Part 1 (1972).

The results expressed in Fig. 12 also show the dependence of gloss retention on the state of dispersion. The initial gloss measurements already discussed were made 3 days after application. The panels were allowed to stand in a rack in diffuse daylight and the 45° gloss measured again 20 days and 6 months after application. For well dispersed paints there was no loss of gloss after 20 days and a small loss of

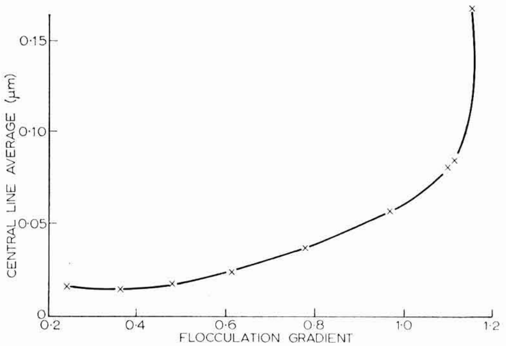

Figure 13. Effect of flocculation on surface roughness

2 units after 6 months. However, at higher levels of flocculation the rate of loss of gloss increases considerably. For example, at a gradient of 0.8 there was a gloss loss of 6 units after 20 days and 14 units after 6 months. Thus, even under the mildest of conditions, flocculation was found to have a very significant effect on the gloss retention of the paints.

Durability

It has been suggested[4] that there are two basic mechanisms operative in the degradation of paints containing titanium dioxide:

(i) *Degradation of the medium by ultraviolet light*

Ultraviolet light is absorbed by the medium, leading to reactions which, in turn, give rise to degradation of the paint film. In this case, the presence of titanium dioxide can be considered to be protective in that it absorbs ultraviolet radiation, thus leaving a much smaller proportion of the damaging radiation to destroy the binder. It is probable that the durability of a film will improve through an increase in the quantity of pigment which is able to absorb ultraviolet light. The absorption will depend, not only on the amount of pigment present, but also on the way in which the particles are distributed in the paint film, that is, on the state of dispersion.

Fig. 14 shows a very simplified model of the ultraviolet absorption at the surfaces of dispersed and flocculent paint films, the circles representing pigment particles. In the dispersed system the particles are uniformly separated from one another and are able to absorb the radiation efficiently. The flocculent paint consists of regions of high pigmentation (flocculates) and regions of low pigmentation. These regions of lower pigmentation offer reduced resistance to attack by ultraviolet light and hence can be considered as focal points for degradation to start. From the diagram, it can also be seen that the radiation penetrates further into the flocculent film than into the dispersed film, that is, it has a greater effective clear layer which might, in turn, lead to a greater initial rate of degradation. In addition, the efficiency with which the pigment can absorb is reduced in the flocculent film. In the model (Fig 14) all fourteen pigment particles are able to absorb. However, in the other system only seven of the particles are able to absorb, the remaining seven being 'hidden' from the incident radiation with a consequent loss of absorption efficiency (of 50 per cent in this idealised case). Thus, in this situation where degradation is predominantly a result of ultraviolet light attacking the medium, a greater weight loss would be anticipated the greater the pigment flocculation.

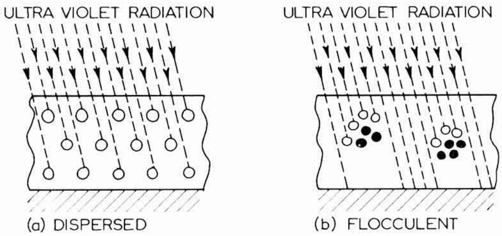

Figure 14. Schematic representation of absorption of ultraviolet light by dispersed and flocculent paint films

The rate of loss of gloss is also likely to vary, but for a slightly different reason. Fig. 15 shows steps in the degradation of dispersed and flocculent paint films. Here, the flocculates are represented as large pigment particles since they act as such.

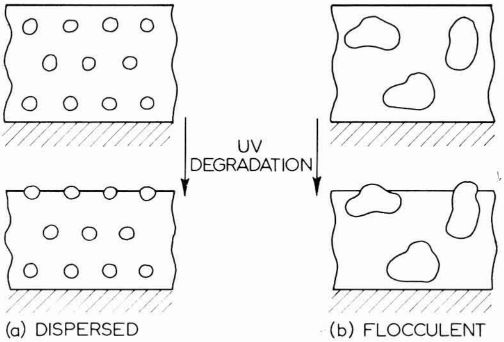

Figure 15. UV degradation of dispersed and flocculent paint films

Initially the medium is degraded uniformly across each surface. Simply, because flocculates are bigger than well dispersed particles, after initial medium degradation, they protrude through the surface quicker and to a greater extent than the smaller well dispersed particles, resulting in a greater rate of loss of gloss.

(ii) *Degradation of the medium through the photocatalytic effect of titanium dioxide*

Ultraviolet light is absorbed by titanium dioxide pigments and, it is thought, hydroxyl radicals are formed which initiate the degradation of the medium.

If this mechanism predominates, the influence of pigmentation is essentially destructive, the more pigment which is available for absorption, the greater the degradation. Thus, using the same arguments as in the previous case, it is possible that a flocculent paint may give a better durability and lower rate of weight loss than with a dispersed paint. Also, it has been reported[4] that when the photocatalytic mechanism predominates, the physical nature of the breakdown is such that loss of gloss is less severe and that weight loss measurements are more meaningful.

Thus, the purpose of the experiment was twofold. Firstly, it was designed to assess the effect on durability of flocculation using a general purpose titanium pigment in a long-oil soya alkyd medium – a typical decorative alkyd gloss paint. Secondly, it was hoped to obtain information as to which of the two mechanisms previously described, if either, predominates in this system.

A further series of paints was prepared and the flocculation gradients measured as before. In addition, the paints were applied to steel panels on a spinning table. The panels were then exposed in a single carbon arc weathering machine according to BS 3900 Part F3 (1971) for 1500 hours. Loss of gloss, measured using a 45° gloss head according to BS 3900 Part D2 (1967), and loss of weight were monitored at 250 hour intervals and the results shown in Tables 3 and 4. Interesting relationships obtained from some of the results are shown in Figs. 16–19. There was no significant chalking of any of the panels after 1 500 hours.

Overall, the weight loss after any given time of exposure is dependent on the extent to which the paint is flocculent. Fig. 16 is a graph of weight loss against flocculation gradient and clearly shows there is an increase in weight loss with increasing flocculation. However, the performance differences are not as straightforward as they might appear at first sight. Fig. 17 demonstrates that there are differences in the rate of weight loss up to an exposure time of about 250 hours but, after this initial period, the rate of weight loss is approximately the same for each paint.

This supports the theory that ultraviolet light penetrates further into the surface of a flocculent film than into a dispersed system and, initially, degrades the medium to a greater extent. The equality of performance after this initial period is more difficult to explain. The concept of the clear layer can be usefully employed to explain the phenomenon. From the shape of the curves in Fig. 17 it appears that two reactions are occurring and that up to 250 hours one of them predominates and subsequently the other becomes predominant. The first reaction is the degradation of the clear layer which, as is illustrated in Fig. 14, is effectively greater the more flocculent the paint and explains the differences in performance up to 250 hours. The second reaction is the degradation of the bulk of the film for which the rate constant was the same for each of the paints examined. This may depend on a number of factors but, because of the similar degradation rates after 250 hours, a factor which was common to all the paints, such as the diffusion rate of degradation products out of the film, is likely.

Table 3

Effect of flocculation on weight loss

Flocculation gradient	Weight loss (g) after various exposure times (h)						
	0	250	500	750	1000	1250	1500
0.29	—	0.029	0.037	0.043	0.048	0.055	0.062
0.37	—	0.030	0.039	0.045	0.051	0.057	0.064
0.50	—	0.032	0.041	0.046	0.052	0.058	0.065
0.72	—	0.034	0.042	0.048	0.054	0.061	0.068
0.89	—	0.035	0.043	0.050	0.057	0.063	0.070
0.96	—	0.036	0.044	0.050	0.057	0.064	0.070
1.06	—	0.037	0.046	0.053	0.060	0.067	0.073
1.12	—	0.037	0.046	0.053	0.059	0.066	0.073
1.21	—	0.039	0.048	0.054	0.062	0.069	0.076
1.26	—	0.038	0.047	0.054	0.061	0.068	0.075
1.26	—	0.039	0.049	0.055	0.063	0.069	0.076

Table 4

Effect of flocculation on gloss loss

Flocculation gradient	45° Gloss after various exposure times (h)						
	0	250	500	750	1000	1250	1500
0.29	89	66	55	50	39	27	13
0.37	94	60	48	46	38	29	16
0.50	92	41	30	31	28	26	19
0.72	77	14	9	10	12	15	14
0.89	64	6	4	3	4	6	7
0.96	55	4	2	1	2	4	5
1.06	45	3	2	1	2	3	4
1.12	37	3	2	1	2	3	3
1.21	34	3	2	1	2	3	3
1.26	29	3	2	1	1	3	3
1.26	30	3	2	1	1	3	3

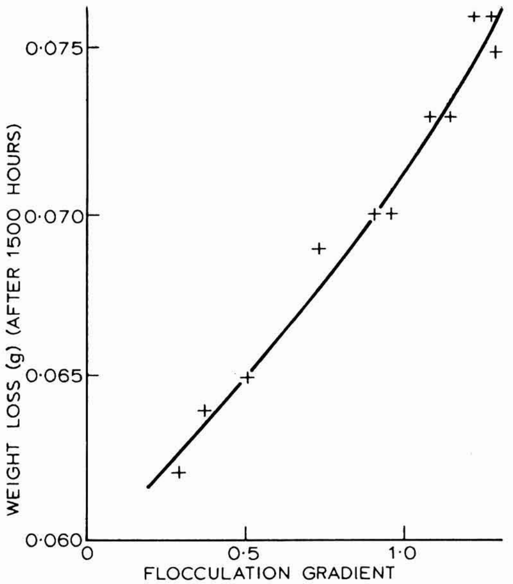

Figure 16. Relationship between flocculation and weight loss after 1500 hours exposure

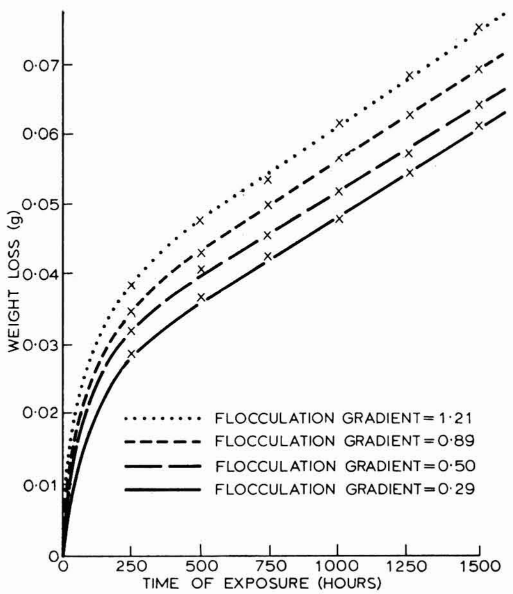

Figure 17. Effect of flocculation on weight loss

With reference to the degradation mechanisms mentioned, it appears that the predominant mechanism was due to direct attack of the medium by ultraviolet light, rather than through photocatalytic breakdown despite masking of the effect after 250 hours.

As is illustrated in Fig. 18, up to a flocculation gradient of 0.50 there was little change of initial gloss, but beyond this the gloss deteriorated rapidly. The rate of gloss loss on exposure was found to be greater for flocculent films than for dispersed films. Fig. 19 illustrates this effect and shows the loss of gloss with exposure time for three films differing in their extents of flocculation but with similar initial gloss values. Again, the differences occur during the first 250 hours, after which they tend to become constant.

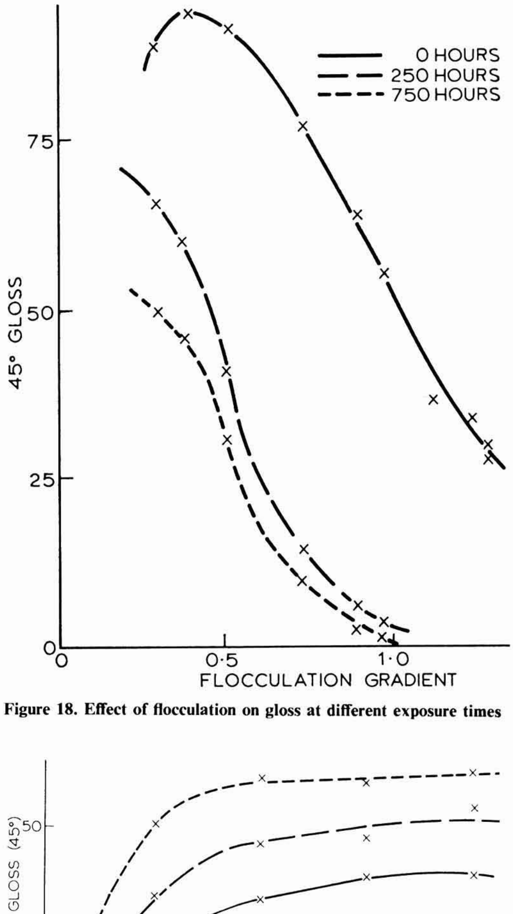

Figure 18. Effect of flocculation on gloss at different exposure times

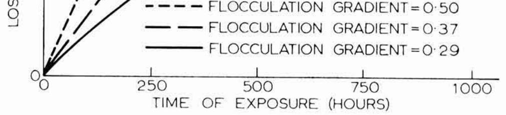

Figure 19. Effect of flocculation on rate of loss of gloss

Thus, the use of the infrared scattering technique in demonstrating the effect of pigment flocculation on optical properties and its influence on durability and the way in which film breakdown on exposure may occur has been shown. It has been demonstrated that flocculation can affect the properties of paint films very considerably and that the range of dispersion states discussed above is typical of the range of paints commercially available in the marketplace. It is thus inferred that paint companies may find massive improvements can be made to their paints in terms of both economic and technical advantages.

The above has been concerned with decorative alkyd gloss paints but the technique has been successfully used in other systems and examples of these are now described.

Alkyd amino stoving paints

In general, it appears that the effect of pigment flocculation on the film properties of most solvent based finishes is similar to that described previously. This is typified by results obtained from alkyd amino stoving finishes. Different degrees of flocculation were induced through varying the ratio of alkyd to melamine resins and by using two separate resin systems. The gloss, opacity and colour were measured as previously described excepting, of course, that the films were stoved. The results are shown in Figs. 20–22.

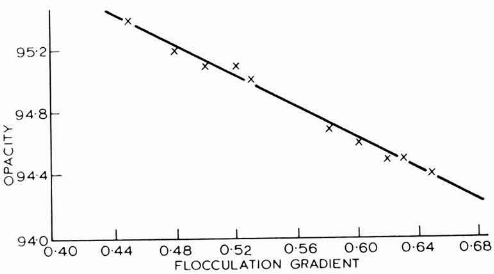

Figure 20. Effect of flocculation on opacity of alkyd melamines

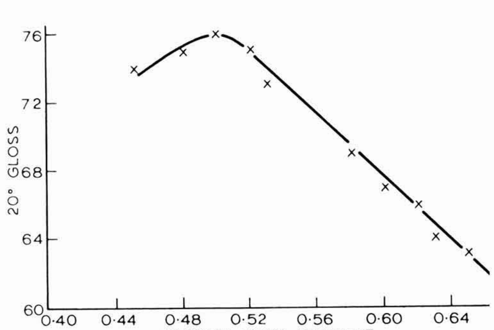

Figure 21. Effect of flocculation on gloss of alkyd melamines

The range of flocculation levels covered by the paints is much narrower than that of the decorative alkyds but it can still be seen that the effect of flocculation on paint properties is very similar. For example, an increase in gradient of 0.1 corresponds to a loss of opacity of about 0.5 per cent, which is comparable to the relationship obtained with the decorative alkyd paints at similar flocculation levels. The relationships with colour and gloss were also similar, although the maximum gloss was obtained at a slightly higher flocculation level (0.50) than with the decorative systems.

This is but one example of the use of the infrared scattering technique for the examination of industrial systems. It has been successfully employed for the solution of various pro-

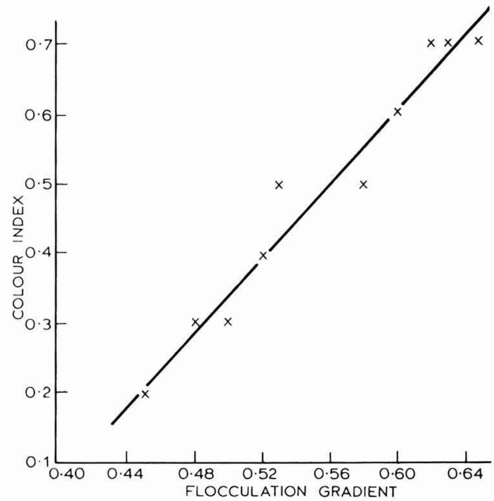

Figure 22. Effect of flocculation on colour of alkyd melamines

blems and is now regarded in the author's laboratories as a standard method for the determination of flocculation in most solvent based systems.

Water based decorative paints

Matt emulsion paints

A further example of the use of the infrared technique is concerned with the examination of the effect of extender concentration on titanium pigment flocculation in decorative emulsion paints. It has been suggested that the presence of extender particles in emulsion paints helps to keep the pigment particles separate from one another, hence improving the optical efficiency and opacity. Converse theories suggest that extenders crowd the pigment particles together in the interstices between the larger extender particles, increasing the likelihood of flocculation. Whilst the work described below tends to support the latter theory, it should be stressed it is designed to show how the flocculation measurement technique can be used in the solution of problems of this nature rather than suggest that the results are typical of those which would normally be found with emulsion paints.

A series of paints based on a vinyl acetate copolymer emulsion, a general purpose grade of titanium dioxide and whiting, was prepared. In each paint the titanium dioxide concentration in the dry film was 10 per cent and the total PVC varied between 30 per cent and 50 per cent through incorporating the appropriate amounts of whiting. The flocculation gradients and opacities were measured as before and the results are shown in Table 5 and Fig. 23.

Table 5

Effect of flocculation on opacity of matt emulsion paints

PVC	Opacity (CR at 20 $m^2 l^{-1}$)	Flocculation gradient
30	84.7	1.6
35	83.0	1.8
40	82.4	1.8
45	80.8	2.0
50	79.4	2.1

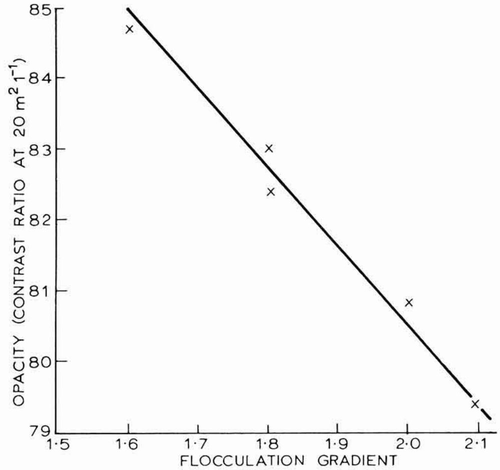

Figure 23. Effect of flocculation on opacity of matt emulsion paints

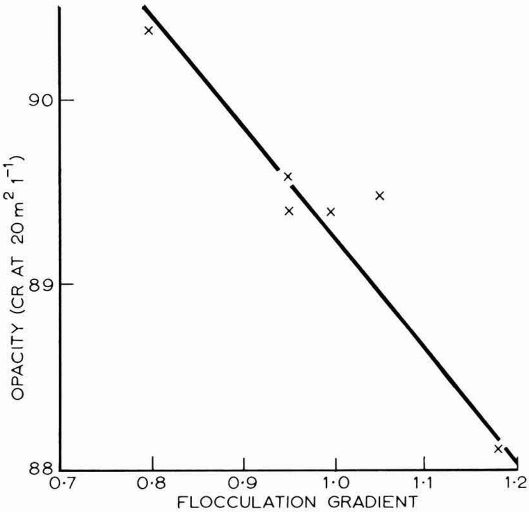

Figure 24. Effect of flocculation on opacity of gloss emulsion paints

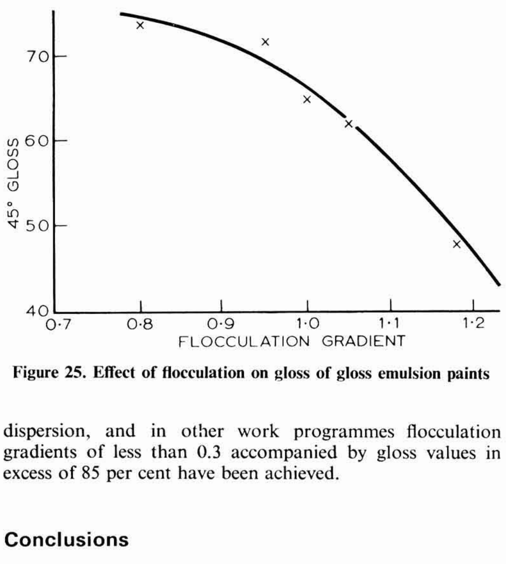

Figure 25. Effect of flocculation on gloss of gloss emulsion paints

Again a linear relationship between opacity and flocculation was found, a change of gradient of 0.1 leading to a change in opacity of about 1 per cent. Having previously established that the presence of whiting had a negligible effect on infrared scattering by examining paints extended with whiting at various concentrations in the absence of titanium dioxide, the results suggest that, in this particular situation, increasing the amount of extender has a detrimental effect on opacity as a result of flocculation. In this context the word 'flocculation' is used loosely to describe the clustering together of pigment particles, the cause of which may be steric, that is, the crowding of pigment particles into the extender interstices, or crowding due to mutually attractive forces between pigment, extender and emulsion particles. Comparing the flocculation gradients obtained from these and a number of other emulsion paints with those from other systems, it is apparent that there is considerable scope for improvement in pigment dispersion in emulsion paints and it is hoped in the future to investigate the complex interactions mentioned above with a view to improving the optical efficiency with which titanium pigments can be used in emulsion paints.

Gloss emulsion paints

A considerable amount of effort has been made in recent years to develop gloss emulsion paints. An exercise concerned with examining the effect of pigment dispersion on optical properties was carried out using the infrared scattering technique for monitoring the state of flocculation. In this experiment a range of different pigments was incorporated into a polyvinylidene dichloride emulsion and the flocculation, opacity and 45° gloss measured as before. The results are shown in Figures 24 and 25.

Figure 24 shows a relationship between opacity and flocculation, an increase in gradient of 0.1 being accompanied by a loss of opacity of approximately 0.6 per cent. In the context of attempting to produce a paint with the maximum gloss, Figure 25 illustrates the importance of flocculation on gloss. In this instance the highest gloss, 74 per cent, was achieved with a paint which gave a flocculation gradient of 0.8. In this system, however, it is possible to obtain very good dispersion, and in other work programmes flocculation gradients of less than 0.3 accompanied by gloss values in excess of 85 per cent have been achieved.

Conclusions

The work described indicates that the infrared scattering technique can be used successfully to determine the effect of flocculation on paint properties in a more quantitative fashion than has previously been possible. It has been shown that flocculation can have adverse effects on film properties and that improvements in the state of dispersion can result in better quality paints manufactured at significantly lower raw material costs. The measuring technique has been used extensively for evaluating various paints and has proved a valuable aid in the everyday solution of problems. It is hoped that the work described in this paper gives some insight into the value of the method in investigating the diverse effects of pigment flocculation in paints.

Acknowledgment

The author is grateful to the Directors of BTP Tioxide Ltd for permission to publish this paper and to his colleagues in Central Laboratories for helpful discussions.

[Received 24 March 1977

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1. Balfour, J. G. and Hird, M. J., *JOCCA,* 1975, **58,** 331
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3. Blakey, R. R., *XIth FATIPEC Congress*, 1972, 187
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Discussion at Eastbourne Conference

DR L. VALENTINE asked Mr Balfour to amplify on his explanation of why at a certain stage the gloss increased with an increased flocculation gradient and its connection with the presence of clear layers.

MR BALFOUR said that in a very well dispersed paint the pigments would be uniformly distributed throughout the paint film from the surface to the bottom, but that when some flocculation occurs there is a tendency for the flocculates to settle somewhat forming a clear layer at the surface of the film. As the flocculation proceeds beyond this point the flocculates become so large that they protrude through the surface of the film and thus the gloss once more diminishes.

MR F. ARMITAGE, referring again to the question of the clear layer on the surface of the film, queried whether anyone had tried to remove this clear layer and prove there was no titanium there and so determine its thickness. He believed that Mr Balfour had said that the clear layer in a flocculated system would be thicker than in an unflocculated system.

MR BALFOUR said that the picture of a completely clear layer was misleading, and that in actual fact, when there were large flocculates in the paint film as opposed to a finely dispersed pigment, there was more unpigmented binder available for attack by ultraviolet light and he had described this as effectively a greater clear layer.

MR ARMITAGE said that he appreciated this, but asked whether Mr Balfour had measured the difference in the clear layer in quantitative terms.

MR BALFOUR said that he had not, but he thought it was fair to say that from the micrographs of cross sections of the paint films the effects of flocculation could be seen, and there were areas clearly shown where the pigmentation was considerably lower than in the bulk of the paint film which could be described as a clear layer. He pointed out that the size of these layers, apart from any other factors, would depend upon the thickness of the paint film.

MR T. R. BULLETT said that he was quite certain that there were films which had a clear layer on the surface. In special cases where there had been Bénard cell activity in the drying paint, the pigment gets concentrated in the centre of the cell leaving a clear layer around it, but he did not think this was exactly what they were discussing. The Paint Research Association had some indirect evidence from ion beam etching work, including electron-microscopy of the surface, that there is indeed a pigment denunded region in many gloss paints which, typically, is of the order of 0.5 micron thick. This could have a major effect on the gloss of the film (it could produce a double interface). He suggested that the slight increase in gloss with a small degree of flocculation could be a result of the change in pigment concentration in that first half micron surface layer. Mr Bullett also suggested that the initial weight loss could be due to the leaching out of water soluble material which had formed during the course of the drying of the alkyd film. He complimented Mr Balfour on a most interesting technique which was giving some novel insights into the changes within paint films.

MR D. SOEN asked whether any conclusions had been reached on why such a large variation in the flocculation gradients was found when comparing commercial gloss paints.

MR BALFOUR said that what Mr Soen was really asking was what causes flocculation and this is a subject about which there is still a lot to learn. He said that only recently had they been able to measure flocculation and the precise parameters which affect it are not yet fully understood. To state the obvious, different paint manufacturers put different raw materials in their paint, and because of this they get different flocculation gradients. He did not think there was enough fundamental knowledge available yet to give a complete answer.

MR SOEN asked whether he had been able to conclude yet whether the most important factor in flocculation was the choice of the grade of titanium dioxide, the wetting agents or the type of alkyd used.

MR BALFOUR said that it was probably an interaction between all of the constituents of the paint, but beyond that it was difficult to draw any conclusions at present.

MR J. SEINER suggested that it might be interesting to perform a series of experiments on one particular paint tinted with a series of universal colourants and to look at how the different colourants affected the flocculation of the system. He was curious as to whether this technique would show different flocculation gradients for different colours.

MR BALFOUR replied that the use of this particular technique would be difficult in this case because of the way it operated. With some pigments, such as carbon black, all of the infrared radiation would be adsorbed and no reading would be obtained, whilst other pigments such as iron oxides would scatter the infrared radiation, but with some organic colours in conjunction with titanium dioxide it would be possible.

MR G. M. DEIGHTON commented that Mr Balfour tended to distinguish between photochemical attack and the photocatalytic effect of TiO_2 in his paper. Referring to figure 19 showing the loss of gloss versus time of exposure, after 250 hours constant rate of loss of gloss for paints having different flocculation gradients were obtained. He suggested that, assuming the flocculation gradient is the same throughout the paint film thickness, different gloss loss gradients should be obtained. If this was not so he suggested that this could be explained by the flocculation, in fact, reducing the photocatalytic effect by producing less active sites.

Mr Balfour said he thought that both mechanisms were probably operating within the paint film, but that for the first 250 hours the predominant effect would be the degradation of the clear surface layer. In fact, one of the reasons for carrying out the experiment was to see if this was so, and he thought it reasonable to assume that both mechanisms were operative, and that as degradation increased the relative importance of the one to the other changed.

Mr Deighton asked whether any experiments had been done on unpigmented films.

Mr Balfour said that none had been done because his experiments were investigating the effects of flocculation.

Next month's issue

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

The structure of layers of adsorbed polymers at pigment/solution interfaces and their influence on the dispersion stability of pigments in paints *by K. Hamann and G. R. Joppien*

The paint industry in a situation of diminishing availability of raw materials *by D. J. T. Howe*

Binders without environmental pollution and with good penetration properties on the basis of acrylic emulsions with very fine particle sizes *by J. L. Mondt*

The determination of zeta potentials as an aid to the pigmentation of water paints *by M. Cremer*

Correspondence

CASE awards

CASE awards (Co-operative Awards in Science and Engineering) are made by the Science Research Council (SRC) to finance PhD students to work on specific projects.

The broad objectives of these awards are to provide an opportunity for graduates to gain first hand experience of work outside the academic laboratory and to encourage the development of contacts between academic institutions and outside bodies.

Projects submitted for approval to the SRC are judged in competition and assessed by the appropriate SRC subject committee on their scientific merit, their relevance to industry, the value of the training offered, the degree of collaboration involved and the contribution of the co-operating firm.

The student must have the necessary academic qualifications, namely a First or Upper Second Class Honours degree.

The co-operating firm has to nominate a Supervisor who will be their main contact with the student and the University. It will have to agree to have the student working in its laboratories for an agreed period of time. A period of three months in the three year period of the award is the sort of time envisaged. This is to enable the student to learn the technology relating to that industry and any specialised techniques that may be necessary for his research. The firm will also be expected to make a financial contribution to cover the following

(a) The travel and accommodation costs incurred by the student when working in the firm's laboratories.

(b) A cash grant to the University towards the cost of the project, this to be not less than £300 per year.

(c) Alternatively, or in addition to the cash contribution, special materials or the provision of facilities which the University does not possess.

In return for these commitments, the co-operating firm obtains the following advantages. The full time service, for three years, of a well qualified graduate, working under the close supervision of his academic supervisor, on a basic study of a problem that is directly related to his own industry. It will receive regular reports of the work and the industrial supervisor can discuss these with the student and the academic supervisor and make suggestions to modify the future lines of work. The co-operating firm is therefore having high quality research work carried out on its behalf and has available, on tap, the services of the academic supervisor as a consultant in all matters relating to that problem. These are real and tangible benefits and the degree to which they can be exploited is limited only by the interest and enthusiasm of the firm itself. The cost of these benefits will normally be well under £1,000 per annum for three years and is therefore within the means of most industrial firms.

The purpose of this letter is to bring to the attention of firms the advantages to industry of CASE awards, as the writer has a strong suspicion that industry in general, with a few enterprising exceptions, is unaware of them.

W. CARR

Ciba-Geigy Senior Research Fellow
Department of Colour Chemistry
University of Leeds LS2 9JT

7 July 1977

Review

Raw materials safety data handbook

Paintmakers Association of Great Britain—London

Price £25

The Health and Safety at Work Act 1974 is, in due course, to provide for regulations imposing a duty on manufacturers to notify the Health and Safety Commission of the toxic or other hazardous properties of substances they propose to manufacture or import. The Council of the European Committee has issued a draft Directive setting out proposals for the notification of dangerous substances, mainly in connection with the packaging and labelling of these materials.

In the meantime the Health and Safety at Work Act 1974 imposes duties on employers for adequate care for the health and safety of their employees and for the provision of information to users of the products they manufacture.

This handbook, in loose-leaf form so that additional data sheets can be readily inserted, covers a range of chemicals now used in the paint and related industries. It provides information on over one hundred raw materials giving data on physical properties, chemical properties, fire and explosion hazards, protective measures that should be taken, the specific health hazards, first aid and firefighting measures where fire risks exist.

The information is set out in tabular form under clearly stated and simple headings on single sheets of stout paper. The materials are indexed and, where the chemical's name may not be familiar, trade names and synonyms are given.

The introduction stresses the need for knowledge of the biological hazards of raw materials and goes on to give brief, clear information on industrial hygiene. British standards on personal safety equipment are listed. There are brief, simple explanations of toxicological terms and measurements of toxicity.

In its present form it is good value at £25, and a further set of over one hundred data sheets is to be provided to subscribers at no extra cost. It is a book that should be made readily accessible to all those responsible for ensuring the safe use of chemicals and chemical products and for providing information on the hazard, to the user or operator, arising from the toxicological properties of the material.

The assembly and presentation of the information must have been a formidable task and those concerned in the preparation of the handbook have produced a commendable work, with more to come.

A. T. S. RUDRAM

Section Proceedings

Transvaal

Analytical test methods

A meeting of the Transvaal Section was held on 26 May at Shell House, Johannesburg when Mr P. Odendaal, the Head of the Physical Chemistry Division, South African Bureau of Standards, gave a lecture entitled "The Physical Chemistry Laboratory of the S.A. Bureau of Standards: its work, with special reference to paint analysis".

As distinct from other laboratories, the organisation of the Physical Chemistry laboratory is not involved in drawing up specifications for commodities. It is a service laboratory whose services are at the disposal of any other division in the Bureau, any government department or any industry that may require analyses that they cannot cope with in their own laboratories, or where they lack laboratory facilities. The service is even available to private individuals.

Analysis by means of X-ray diffraction depends on the fact that the majority of substances have definite crystalline structures. When a sample is radiated under suitable conditions by means of a monochromatic beam of X-rays, the X-rays are diffracted in a pattern which is characteristic of that substance and by which such a substance can be identified. It is therefore a convenient method for identifying compounds used as paint pigments, or for comparing compounds used in the paint industry, for example, the difference between two samples of zinc phosphate.

X-ray fluorescence is used for the determination of elements in samples. Here, use is made of the phenomenum that when a substance is radiated by a sufficiently strong beam of X-rays the sample will fluoresce. The fluorescent radiations are again X-rays, but the wave-length of these rays are now dependent on the elements that are present in the sample. By means of a suitable analyser, these rays are separated and the individual element can be determined.

Elements can be uniquely identified, and on a quantitative basis concentration can be determined, in many cases with the same or greater precision than with classical chemical methods. As it is virtually a surface phenomenon that is being dealt with, this is a useful tool for investigating surface treatment, e.g. phosphate or chromate treatment.

Emission spectroscopy using either direct reading or photographic instruments is used for analysing small samples, low concentrations, or traces of elements. It can give a rapid survey of all the elements present. As such, it is a very handy method for comparing paint samples, especially in forensic work, where only a smear of paint (as in hit and run cases) is available to be compared with the paint from a suspect vehicle.

Infrared absorption spectroscopy is another method available. It is a powerful method for identifying organic substances, and is extensively used for identifying plastics and resins, or following a reaction, such as the curing of an epoxy based paint. For determining adulteration of paint it has no rivals.

The gas chromatography laboratory is responsible for the analysis of a wide range of materials. In the paint industry, analysis of solvent retention in paint films, paint solvent analysis against specifications and fatty acid analysis in oils, etc. is carried out. Other minor facilities like differential thermal analysis are available for determining specific physical properties or carrying out corroborative tests.

Slides were shown to illustrate the various techniques and illustrate some of the work that is being done in the laboratory.

P.A.J.G.

Notes and News

Reunion Dinner for past and present members of Council

Following the successful innovation in 1973 of a Reunion Dinner for those members who have served on Council at any time, Council has decided to hold a similar event this year. The Dinner will take place on Wednesday, 12 October 1977 at the Piccadilly Hotel, London W.1. at 6.30 for 7.00 p.m. and informal dress will be worn.

The price of the ticket for the Dinner and wine will be £8.64 inclusive of VAT and a cash bar will be provided at the reception and after the Dinner. Past Presidents, Past Honorary Officers and Honorary Members have been invited as guests of the Association. All other past and present members of Council must send the necessary remittance with their completed application form. Any member with service on Council who has not received an application form and wishes to do so should write to the Director & Secretary at the Association's offices.

Mr M. A. Kerr

News of Members

Mr M. A. Kerr, an Ordinary Member attached to the Manchester Section, has been appointed Manager for Planning and Product Management of Ciba-Geigy's Pigments Division. He has taken up the position upon returning from a year's secondment to the parent company in Basle.

Dr J. B. Harrison, an Ordinary Member attached to the Manchester Section, has retired from his position as Technical Liaison Officer for the paint companies of the Lead Industries Group. Dr Harrison has been a member of OCCA for 37 years and has worked at Goodlass Wall & Co. Ltd since 1952. He does not intend to leave the anti-corrosion field, in which he was involved, but will provide a consultancy service to the industry to utilise his considerable knowledge and experience.

Dr J. B. Harrison

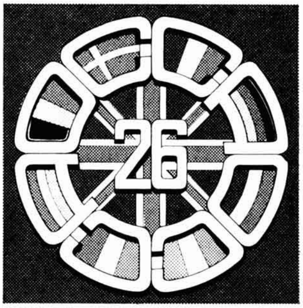
Obituary

H. R. Wood

It is with deep regret that we record the death in July of the sole surviving Founder Member of the Association, Mr H. R. Wood, at the age of 90. It is hoped that it will be possible to publish an obituary notice in a forthcoming issue of the Journal.

"The OCCA"

The annual technical exhibition of the Oil and Colour Chemists' Association (known to many simply as "The OCCA") has become the world's most important event for all those connected with the paint, printing ink, polymer, adhesive colour and allied manufacturing industries. The OCCA exhibition is held every year in London, England. The symbols for the 1974-78 exhibitions were specially designed by Robert Hamblin, Director and Secretary of the Association, to emphasise the very wide coverage which all the Association's activities attract:



The motif for OCCA-26 used the flags of the enlarged EEC converging on the British flag to symbolise the welcome extended to visitors from overseas to the Exhibitions for more than 25 years.

This theme was continued for OCCA-27 by showing the world-wide interest aroused by the Association's annual Exhibitions in London which attract visitors from all parts of the globe.

The motif for OCCA-30 uses the symbol of a moving indicator on a calendar to emphasise the importance of the continuous dialogue year by year between suppliers and manufacturers. The inward pointing letters recall the international aspect of this unique annual focal point for the surface coatings industries, which in 1977 attracted visitors from 50 countries.

The motif for OCCA-28 emphasised, that the target for 1976 was London where all the Exhibitions have been held, and continued the theme of its international aspect.

In 1977 the motif for OCCA-29 used inward pointing arrows to show the many places from which people came to the Exhibition, and these arrows formed outward pointing arrows to show the subsequent spreading of knowledge.

OCCA-30 Exhibition

Alexandra Palace, London. 18-21 April 1978

Many enquiries received from home and overseas

Closing date for applications for stand space: 1 OCTOBER 1977

Applications for stand space now being taken

Arrangements for OCCA-30

The thirtieth Annual Exhibition of raw materials, plant and equipment for the paint, printing ink, colour, adhesive, polymer and allied industries will be held at Alexandra Palace, London N.22 from 18–21 April 1978.

Whilst the Committee naturally encourages the showing of new products, it does not stipulate that a new product has to be shown each year, since it fully appreciates that there are occasions when this is not possible. Accordingly, the Committee draws attention to the fact that new technical data on existing products are regarded as acceptable subject matter.

Motif for the Exhibition

The motif, designed by Robert Hamblin, uses the symbol of a moving indicator on a calendar to emphasise the importance of the continuous dialogue year by year between suppliers and manufacturers. The inward pointing letters recall the international aspect of this unique annual focal point for the surface coatings industries which in 1977 attracted visitors from 50 countries. The colours of the motif shown on the advertisement on the back outside cover of this issue will be carried throughout the publicity leading up to the Exhibition. The two main colours of the motif, royal blue and yellow, will be incorporated on the facias of the stands and it is intended to organise complementary flower displays in the Exhibition Hall. The use of these colours will create a pleasing contrast as visitors move from corridor to corridor at the Exhibition, as the royal blue colour will be used from east to west and the yellow colour from north to south.

Invitations to Exhibit

Invitations to Exhibit at OCCA-30 were dispatched at the end of May to organisations both in the United Kingdom and abroad and already many enquiries have

The cost effective Exhibition

been received, not only from those who exhibited at OCCA-29, but from organisations which had shown at earlier Exhibitions or are considering exhibiting for the first time.

The value of showing at OCCA Exhibitions can hardly be better demonstrated than by the following quotation from an article appearing in the June issue of *Paint Manufacture*, and the Association acknowledges with thanks the kind permission of the editor to reproduce it—

> *The encouraging conclusion which may be drawn from this experience is that visitors to exhibitions are interested in new developments and an unknown company can attract attention if it brings genuine new technology to work on tasks which are important to the industry. It is a measure of the effectiveness with which the OCCA Exhibition is conceived, promoted and administered that we at Pilamec are able to regard the considerable cost of participation as an excellent investment.*

In the May issue of the *Journal*, the following quotation appeared from another Exhibitor—

> *I think you would like to know that this was without doubt the most successful Exhibition in which we have participated; the interest was absolutely enormous . . . We have simply never known anything like it.*

Another exhibitor wrote to the Association stating

> " . . . *in the four days we had over 350 'in depth' discussions with visitors* . . . ".

Visitors to OCCA-29 came from 50 countries

The Exhibition Committee was particularly pleased to see the large number of overseas companies showing at OCCA-29, both directly and through their British associates, and this emphasises the international character of the function.

The crowd puller

Visitors at OCCA-29 are known to have come from at least 50 countries and admissions of over 10,000 were recorded at the entrance. Any organisation wishing to exhibit at OCCA-30 should write immediately for details to the Director and secretary of the Association to receive a copy of the Invitation to Exhibit.

Official Guide

This unique publication contains descriptions of all companies and their exhibits at the Exhibition and is issued to each Member of the Association at home and abroad together with season admission tickets. As in 1977, several Sections will be organising coach parties to visit the Exhibition and any Members interested should contact their local Section Hon. Secretary. (Full Section Committee lists for 1978 were published in the August issue of the Journal.) It is also hoped that several parties will be organised from overseas to visit the Exhibition.

Advertising facilities

Advertising space is available in this important publication to both exhibitors and other organisations which are not able to show at the 1978 Exhibition. The Official Guide will be published early in 1978 so that visitors can obtain copies and plan the itinerary for their visits. Clearly, the Official Guide is a publication that will constantly be referred to both before and after the Exhibition and consequently any company wishing to advertise in the Guide should book space as soon as possible. Details of the advertising rates are available from Mr D. M. Sanders (Assistant Editor) at the address on the contents page. As in previous

The continuous dialogue

years the Official Guide and season admission tickets will be available several weeks in advance of the Exhibition (prepayment only) from the Association's offices but they will also be available for purchase at the entrance to the Exhibition Hall. A charge is made for both the Official Guide and the season admission tickets to the Exhibition. The policy was introduced several years ago to deter casual visitors who otherwise collected large quantities of technical literature from exhibitors stands; the policy has been welcomed by exhibitors and has in no way acted as a deterrent to bona fide visitors to the Exhibition.

Companies wishing to exhibit are reminded that application forms which were enclosed in the Invitation to Exhibit have to be lodged with the Director & Secretary of the Association **not later than 1 October 1977** and further copies can be obtained from the Association's offices at the address on the contents page.

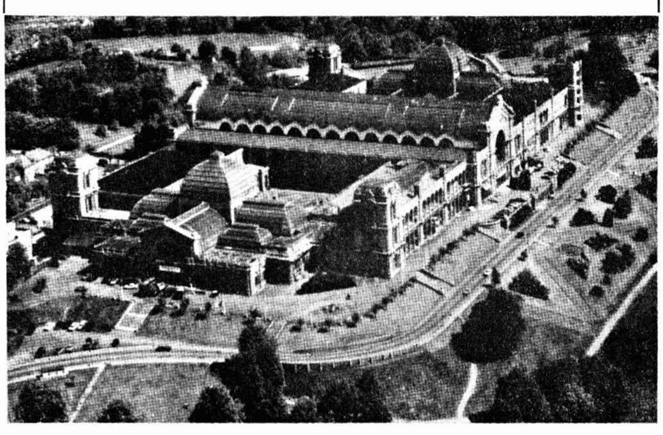
Alexandra Palace

Alexandra Palace was named after Princess Alexandra, the wife of Edward, Prince of Wales (later Edward VII). It stands high on the hills of north London giving at night time a panoramic view of the lights of the city.

The Great Hall, in which OCCA Exhibitions have been held, can be seen in the centre of the drawing above. The Palace Suite, containing the restaurants, is to the left, and at the extreme left is situated the Panorama Bar. Two bars (the West Bar and the Long Bar) in addition to a cafeteria adjoin the Great Hall and are available to visitors and exhibitors throughout the Exhibition. The Italian Gardens lie behind the Palace Suite, and in the spring time the grassy slopes in front of Alexandra Palace are gay with crocuses and daffodils. At the right of the Great Hall the British Broadcasting Corporation has for many years occupied the wing of the building and the television transmitting aerial is a landmark which can be seen for many miles. In recent years the Great Hall has been used for the degree conferment ceremony of the Open University.

For those travelling to the Exhibition by car ample free parking space is available, and recent improvements to the road system include the extension of the southbound carriagway of the M1 Motorway to the North Circular Road and the flyover on that road by the new Brent Cross Shopping Centre. By the 1978 Exhibition the extension of the Piccadilly Underground line to the Heathrow Airport Terminal will give a direct line to Turnpike Lane station from which the Association runs a free bus shuttle service to the Exhibition.

Exhibitors were allowed for the first time in 1977 to serve alcoholic refreshments on their stands and this innovation will be continued at OCCA-30. Many exhibitors expressed their appreciation of this as it allowed their personnel to remain on the stands for the whole period of the Exhibition.



All OCCA Exhibitions have been held in London, which affords excellent travel and hotel facilities for visitors from both overseas and the United Kingdom. In pursuance of the theme of the Exhibition —**The continuous dialogue**—it is felt that Exhibitors will like to know that the Exhibition Committee has also **reserved Alexandra Palace for April 1979 and will hold its annual Exhibitions there subsequently in April each year.**

It will also be appreciated that for exhibitors and visitors staying in London, the capital city offers the finest variety of entertainments for the evenings after the Exhibition.

OCCA 60th Anniversary

Celebrations

The May 1978 issue of the *Journal* will contain an article by Dr S. H. Bell, OBE (President 1965–67) on main Association events since the 50th Anniversary in May 1968. **Already many companies have reserved advertising space in this important issue in order to congratulate the Association on this achievement, and others wishing to do so can obtain full details from the Assistant Editor at the Association's offices at the address on the contents page.**

Full details of the two functions organised for the celebrations will appear in the *Journal* in due course and application forms will be sent to Members of the Association, either with an issue of the *Journal* or with a Section meeting notice.

In the meantime, Members wishing to participate should note the following important dates:

On the evening of Thursday 11 May it is planned to hold at the City Livery Hall a Commemorative Lecture followed by a Dinner to which Past Presidents, Past Honorary Officers of the Association and Honorary Members will be invited as guests. On Friday 12 May the Association's Dinner and Dance will be held at the Savoy Hotel, London WC2 and Presidents of other societies, together with their ladies, will be invited to attend.

Non-members who wish to receive application forms should write to the Director and Secretary at the Association's offices.

Report of Council Meeting

A meeting of the Council took place at 2.00 p.m. on Thursday, 7 July 1977, at the Great Northern Hotel, London N1 9AN. The President, Mr A. McLean was in the chair. There were 27 members present.

The President welcomed all members who were serving on Council for the first time or had returned after a previous period of service; there were now two ladies who were Chairmen of Sections, Miss P. Magee who was in her second year as Chairman of the Irish Section, and Mrs E. N. Harper, who had been elected Chairman of the Bristol Section in April 1977.

It was reported that the three Members elected at the Annual General Meeting were:

Mr L. H. Silver
Mr D. E. Eddowes
Mr A. C. Jolly

The dates of the Council meetings for the forthcoming session were agreed and the appointment of Members to serve on Committees of the Council and to represent the Association on other organisations was confirmed.

Reports were received on the Eastbourne Conference, the forthcoming Council Reunion Dinner, the Annual General Meeting and the arrangements for both the 1978 Exhibition and the 60th Anniversary Celebrations which would take place on 11 and 12 May, 1978.

Consideration of the format and venue of the 1979 Conference took place.

It was pointed out that the July issue of the *Journal* would contain a leaflet offering the few preprints which remained from the Eastbourne Conference at £10.00 each and the August issue would contain a leaflet listing all Association publications, with the opportunity for members to purchase the latest Decennial Index at £1.00 each.

Details of the number of members in arrears with the 1977 subscriptions were reported to the Council.

A report of the meeting of the Professional Grade Committee held earlier that day was received and it was stated that 8 Fellows and 6 Associates had been admitted and that two Licentiates had been transferred to the Associate grade.

Council were pleased to hear that papers were being presented on behalf of the Association at three forthcoming events. In September, Mr G. H. Hutchinson, who had been granted a Commendation Award at the last Council Meeting, would be presenting a paper at the OCCAA Pacific Paint Convention, Canberra. In October, Mr W. Fibiger, Chairman of the Ontario Section, would be presenting a paper on "Oil absorption of organic pigments" at the FSCT Convention in Houston, and in June 1978, Dr G. D. Parfitt would be presenting a paper on "Pigment dispersion, in principle and practice" at the FATIPEC Conference in Budapest.

As reported to the Annual General Meeting, the negotiations for the purchase of Priory House had been satisfactorily completed, without the necessity of a Bank Loan, and the Council felt that members would be pleased to learn that the Association now owned its own headquarters building.

The fee for those members of OCCAA (Australia) taking the *Journal* in 1978 on an optional basis was agreed at £15 each.

It was reported that three Sections were organising Branch activities abroad. In the Cape Section, several meetings had been held for a proposed Eastern Cape Branch around the Port Elizabeth area. The Transvaal Section had received an approach from members resident in Rhodesia for the formation of a Rhodesian Branch and members in Nigeria had approached the London Section with the suggestion that a branch be formed in Nigeria on the same lines as the successful recently launched Ontario Section.

Council extended their best wishes to the New Zealand Division for the success of their Convention at Rotorua from 28–30 July.

There being no other business, the President thanked members for their attendance and declared the meeting closed at 3.20 p.m.

Register of Members

The following elections to membership have been approved by Council. The Sections to which each new Member is attached is given in italics.

Ordinary Members

CHOW, FATT SEN, BSc, 39 Jalan Taman Seputeh, Jalan Kelang, Kuala Lumpur, Malaysia. (*General Overseas*)

DODD, KEITH, Hillcroft, Leigh Way, Weaverham, Cheshire. (*Manchester*)

ILIFFE, CHRISTOPHER JOHN, BSc, Norprint Ltd., Horncastle Road, Boston, Lincs. (*Hull*)

MITCHELL, ANDREW JOHN, BSc, 33 Lea Croft, Crowthorne, Berks. (*Thames Valley*)

TAYLOR, ALAN JAMES, Dow Corning Ltd, Barry, South Glamorgan. (*Bristol*)

Associate Members

BRIERLEY, KEITH BARNES, BASF UK Ltd., 26 High Street, Paisley. (*Scottish*)

ERIBO, GODFREY NORAGBON, 56B Erie Street, Benin City, Nigeria. (*General Overseas*)

FLORENCE, WILLIAM ALEXANDER, 10 Malmains Close, Park Langley, Beckenham, Kent. (*London*)

LOUGHER, TERENCE MALCOLM, 6 Caple Avenue, Kings Caple, Hereford. (*Bristol*)

RICHELMANN, HANS HEINRICH, Mangrove Beach Centre, Flat 510, Sointseu Street, Durban, South Africa. (*Natal*)

Information Received

Science Reference Library moves

The Bayswater Branch of the Science Reference Library is expected to move to new accommodation in the City Road, EC1 in 1979 when the lease on their present premises in Bayswater expires.

The new address will be at Companies House, 55 City Road, London EC1.

Montedison loan

The Finance Corporation for Industry (FCI) have agreed to provide a loan of £8m to ACNA (UK) Ltd, part of the Italian Montedison chemical group, to finance its share of a plant under construction at Stevenson in Scotland to produce H-acid, an intermediate for dyestuffs.

The plant is being constructed as a joint venture between Montedison and ICI Ltd, and it is expected that production will start early in 1978.

Amalgamation

Subject to the approval of the Foreign Investment Review Board, it has been announced that Westralian Sands and Tioxide Pty are to merge.

The proposed share issue would give Tioxide a 40 per cent holding in Westralian Sands, and Westralian Sands will grant Tioxide an option to increase their shareholding to 51 per cent should Westralian Sands proceed with an ilmenite beneficiation project.

CIBA-GEIGY agreement with Glaser AG

Glaser AG of Basle, Switzerland, has been appointed the sole agent for the distribution of the CIBA-GEIGY ranges of deuterated compounds, scintillators and solvents and auxiliary products for use in nuclear resonance spectroscopy.

Heat transfer fluid distributors

Issac Bentley & Co., a subsidary of Marston Lubricants, have been appointed the UK and offshore market distributors of the Santotherm range of heat transfer fluids by Monsanto.

The Santotherm heat transfer fluids have applications for indirect heating in the chemical and paint industries and operate at temperatures up to 340°C without the disadvantages associated with high pressure steam heating methods.

Gel-coats for Thunderbirds

The Thunderbird Products Corporation, a United States manufacturer of stern drive cruisers, has selected a gel-coat based on NPG glycol, a chemical intermediate marketed by Eastman Chemicals, for their new range of stern drive cruisers. The new gel coat was chosen because of its resistance to breakdown by seawater and its good colour retention and colour fastness.

The Thunderbird stern drive cruiser

New products

New sunlight tester

Raven Scientific have available the Sunlighter, a super fast sunlight tester, offering a practical and efficient testing method for the rapid evaluation of the deteriorating effects of UV in sunlight on coatings, films and plastics etc.

The new system utilizes internal reflectors and mercury vapour lamps and is designed for a 24 hour operation.

The cabinet covers up to 300-1, that is one-day exposure in the Sunlighter is equivalent to 300 days of normal sunlight exposure.

Light fastness testing

Microscal have introduced a new mark IV model fastness tester which retains the high sample capacity of 120 samples under simultaneous test, with an increased fading rate exceeding four times that given by the original instrument.

Spray booth safety

Star Chem have recently developed Starchem 600, a white spray booth coating which is designed to give rapid and safe maintenance. It has been specially formulated on a non-flammable solvent which gives the same easy application characteristics as the normal coatings without the attendant flammability problems.

New vibration sieve

Jacobson Chemical Division of R.S. Stokvis & Sons have available a new compact vibration sieve which prevents clogging when paints, inks and other liquids are being filtered during manufacture. It is designed to be connected directly on to the outlet from the tank and is powered by 0·5HP electric motor.

The use of the vibration sieve eliminates entirely the use of the scrapers, and thus the risk of puncturing the filter bag walls and, as the unit is easy to clean, colour changes may be made in a fraction of the normal time.

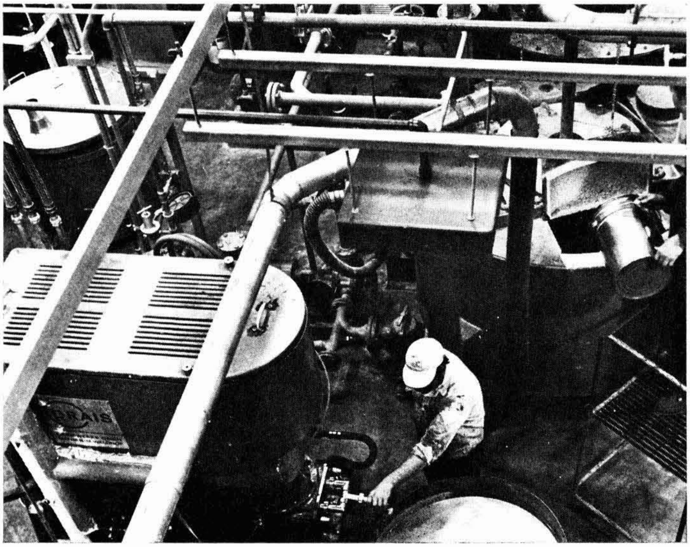
New emulsion binders

ROHM and HAAS (UK) Ltd have available a new 65 per cent solids, low Tg polymer emulsion binder that permits manufacture of plasticiser-free water-based sealants for both interior and exterior applications. Sealants based on the new plasticiser named Primal LC67 show numerous advantages when compared to caulks based on natural oils. The water-based sealant has low odour and fast drying properties and provides excellent flexibility and long-term weather resistance.

Also available is Primal AC-64, a 60 per cent solids acrylic emulsion binder for exterior paints designed to give a high level of adhesion to chalking substrates. It imparts excellent yellowing resistance and exterior durability to the formulated paint.

New Inmont plant

A new highly-automated paint manufacturing plant has recently been opened in Brantford, Ontario by the Automative Group of Inmont Canada Ltd. Situated on a 17-acre site on an industrial estate, the plant incorporates highly advanced safety and accident prevention devices and will specialise in printing inks, automobile paints and other surface coatings.



Part of the new Inmont plant in Ontario showing some of the fire sensors

New PVA copolymer

Croxton & Garry Ltd, agents for Ebnother AG of Switzerland, have a new PVA copolymer Elotex WS 45, for use in cement based compositions.

In addition to the normal PVA copolymer elasticity, ease of application and good adhesion, Elotex WS 45 also has alkali resistance, water resistance, and improved adhesion whilst still being permeable to vapours. The main applications of the new copolymer are for textured wall finishes, adhesive mortars etc.

Worsdall expansion

Following the destruction by fire of the main Thermopac heater at the Worsdall factory during last September, a new 4 million BTU heater has now been installed to heat the resin kettles with the result of an increase in production and in the range of resins offered.

A new plant has also been constructed in Guelph, Ontario, and together with the British firm and the Australian branch, Estochem Pty Ltd, a considerable improvement in the world-wide supply system is expected.

Static-free hoppers

Six hoppers are presently under construction by L.A. Plastics Ltd for Beecham Pharmaceuticals using the new 3M (UK) black Velostat electrically conductive plastic as a liner. It is hoped that the use of this lining will eliminate the build-up of static which occurs when dry chemical powders are used in hoppers and thus reduce the danger of explosions and other time-consuming problems.

Lithol Rubine 650D TD

BASF has supplemented its range of Lithol Rubine 4BS Ca lakes with Lithol Rubine 4650 TD which has excellent dispersibility, particularly in printing inks containing toluene and also in flexographic and gravure inks based on ethanol/ethyl acetate. The new Lithol Rubine is claimed to have higher colour strength, better gloss and higher transparency and is similar in shade to Lithol Rubine 4630.

Conferences, courses etc.

Printing open days

The London College of Printing will be holding its next open days at the Elephant and Castle building on 13–15 June 1978 when displays of the work conducted at the College will be on view to the public.

Computer Symposium

The John Dalton Faculty of Technology of the Manchester Polytechnic will be holding a one-day symposium on Friday

14 October on "Computer match prediction: present benefits and future developments".

Painting conference

The Process Engineering Group of the Institute of Mechanical Engineers will be holding a one-day conference at their London headquarters on Tuesday 3 October, 1978 entitled "Is the painting of process plant worth the cost?"

Literature

KRICT

The Korea Research Institute of Chemical Technology has published a booklet about the new research and development complex at Daeduk, describing the facilities which will be available and the aims and organisation of the project.

SPL booklet

The Silver Paint and Lacquer Co. Ltd has published a coloured booklet describing the growth and history of the company since its beginnings in 1947. SPL is now the largest privately owned paint company in Great Britain and the new publication gives insight into how this success has been achieved.

Propeller mixer information

Lightnin Mixers Ltd have published a series of leaflets describing their latest range of propeller mixers which are intended to be a guide to choosing and correctly installing and operating the most appropriate model for the customer's requirements.

Polyester enamels literature

A new publication from Eastman Chemical Products, Inc. discusses reactive polyester/melamine resin combinations utilising 1,4-dimethylol hexane (CMDM), a glycol intermediate. The new literature gives formulation and physical constants for two high molecular weight polyester resins based on CMDM and discusses the differences in properties resulting from the varying formulations.

Adhesives directory

A revised version of the Adhesives directory for 1977 has been published by A.S. O'Connor & Co. Ltd which contains up-dated information including a 'Who's Who' section for easy reference. The instructions on the use of the book are given in four languages.

Safety publications

Vinyl Products Ltd have recently published two leaflets giving the current safety and handling recommendations for the company's standard product range.

Forthcoming Events

Details are given of Association meetings in the United Kingdon and Ireland up to the end of the month following publication and in other parts of the world up to the end of the second following publication.

September

Wednesday 7 September

Manchester Section: Golf Tournament at Stockport Golf Club.

Thursday 8 September

Midlands Section—Trent Valley Branch: Possible speaker from Bayer Ltd. Alternative speaker from British Rail. Crest Hotel, Pastures Hill, Littleover, Derby at 7.00 p.m.

Wednesday 14 September

West Riding Section: West Riding Chairman's Golf Trophy Tournament at the Knaresborough Golf Course.

Friday 16 September

Irish Section: "New developments in azo pigments for paint and printing inks" by Mr A. Abel, Hoechst UK Ltd. Clarence Hotel, Dublin 2 at 8.00 p.m.

Midlands Section: Ladies' Night. Annual Dinner Dance to be held at the Botanical Gardens, Birmingham.

Wednesday 21 September

Ontario Section: "ED pigments—European and US experiences" by Mr K. Bruce of Worsdall Chemicals Ltd. Skyline Hotel, Toronto at 6.00 p.m.

Thursday 22 September

London Section: Chairman's Evening. "Customer's point of view" by Derek Bayliss, at the "Princess Alice", Romford Road, E7 commencing at 7.00 p.m.

Midlands Section: "Modern methods of ink drying" by D. Bissett of Coates Brothers—Joint Meeting with Printing Institute. The Calthorpe Suite, County Ground, Edgbaston, Birmingham at 6.30 p.m.

Friday 30 September

Bristol Section: "D.I.Y. adhesives" by J. Pritchard of Dunlop Semtex Ltd. The Royal Hotel, Bristol at 7.15 p.m.

October

Monday 3 October

Hull Section: "Agitation—a state of the art review" by Dr Maurice F. Edwards, Senior Lecturer at Bradford University. Joint meeting arranged by the Institution of Chemical Engineers. *Venue to be announced but taking place on the South Bank.*

Tuesday 4 October

West Riding Section: "Disposal of waste solvents" by Mr A. Molyneux of Chemstar Ltd. The Mansion Hotel, Roundhay Park, Leeds 8 at 7.30 p.m.

Thursday 6 October

Newcastle Section: "Corrosion control and sensible methods of test—at last" by Mr F. D. Timmins, British Rail, Derby. St. Mary's College, University of Durham, Elvet Hill Road, Durham.

Thames Valley Section: "Offshore painting" by a speaker from BIE Anti-Corrosion Ltd. Beaconsfield Crest Motel (White Hart), Aylesbury End, Beaconsfield, Bucks at 6.30 p.m. for 7.00 p.m.

Friday 7 October

Hull Section: Annual Dinner Dance to be held at the Willerby Manor Hotel, Willerby, Nr. Hull.

Monday 10 October

Manchester Section: "Silicone protective coatings" by J. G. Price, Dow Corning Ltd. The Woodcourt Hotel, Sale, Cheshire at 6.30 p.m.

Thursday 13 October

Midlands Section—Trent Valley Branch: "Acrylamide pigments" by R. M. W. W. Wilson of Burrell Colours. Crest Hotel, Pastures Hill, Littleover, Derby at 7.00 p.m.

Scottish Section: "The use of microvoids as pigments" by Dr N. Reeves, BTP Tioxide Ltd. Bellahouston Hotel Glasgow at 6.00 p.m.

Wednesday 19 October

Ontario Section: "Novel ink resins" by L. P. Horn of Lawter Chemicals. Skyline Hotel, Toronto at 6.00 p.m.

Thursday 20 October

London Section: "Corrosion and conservation" by Mr H. Barker, Keeper of Conservation and Technical Services, British Museum. At Rubens Hotel, Buckingham Palace Road, S.W.1 commencing at 7.00 p.m.

Friday 21 October

Irish Section: "Printing ink lecture"—*details to be announced.*

Manchester Section: Annual Dinner Dance to be held at the Piccadilly Hotel.

Scottish Section—Eastern Branch: Annual skittles match vs Scottish Section for the Newton Cup, to be held in the Murrayfield Indoor Sports Club, Roseburn Street, Edinburgh, commencing 7.00 p.m.

Thursday 27 October

Midlands Section: "Estey dynamics tunnel coating unit, a new development in powder coating plant" by Electropaint Ltd. The Calthorpe Suite, County Ground Edgbaston, Birmingham at 6.30 p.m.

Friday 28 October

Bristol Section: Ladies' evening. *Details to be announced.*

London Section: Ladies' Night to be held at the Piccadilly Hotel.

Midlands Section—Trent Valley Branch: Hallowe'en Dance at Cross Keys Inn, Turnditch.

November

Wednesday 16 November

Ontario Section: "New approaches to the developments of properties in paint films" by Prof. Schreiber of University-Polytechnic of Montreal. Skyline Hotel, Toronto at 6.00 p.m.

CLASSIFIED ADVERTISEMENTS

Classified Advertisements are charged at the rate of £3.00 per cm. Advertisements for Situations Wanted are charged at 80p per line. A box number is charged at 50p. They should be sent to D. M. Sanders, Assistant Editor, Oil & Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex HA0 2SF. JOCCA is published EVERY month and Classified Advertisements can be accepted up to at least the 12th, and in exceptional circumstances the 20th of the month preceding publication. Advertisers who wish to arrange for an extension of the copy deadline should contact the Assistant Editor, D. M. Sanders, at the address given above (telephone 01-908 1086, telex 922670 OCCA Wembley).

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Vickers Limited

Howson Algraphy Group of Vickers Limited, one of the world's leading manufacturers of lithographic printing plates, wish to recruit an experienced Formulations Chemist.

Applications are invited from those people having HNC or equivalent, with a minimum of 3 years experience of formulations in a consumer field; consideration will be given to otherwise suitably experienced applicants having ONC qualifications. This appointment offers an attractive salary together with excellent conditions of employment which include four weeks annual holiday and contributory pension scheme.

Written applications to:-
Sandra Bateson, Group Personnel Assistant

Howson-Algraphy

Howson-Algraphy Group Ring Road Seacroft Leeds LS14 1ND

An Operating Group of Vickers Ltd.

PAINT TECHNOLOGIST IRAQ

To manage production and laboratory of small paint factory in Baghdad. Good experience in all aspects of formulation and production of decorative paints, including colour matching, is essential.

Applicants should ideally be in their early thirties, preferably single, with a minimum experience of 5 years in a similar position, although an older man with outstanding experience would be considered. The position carries interesting tax free salary, housing assistance and free medical care.

Interviews will be held in London. Please write with full career details to:

Managing Director,
P.O. Box No. 3271,
BAGHDAD, IRAQ.

PRODUCTION MANAGER

The Ault & Wiborg Group have established a printing ink factory in Nigeria and require an Assistant Production Manager.

This person should be fully conversant with printing ink manufacture and laboratory control. Ideally with at least five years experience in an ink factory and be prepared to live in Nigeria on a minimum two year contract.

Remuneration is dependent upon qualifications. All the usual fringe benefits.

Apply to: Export Manager, Ault & Wiborg International Limited, 71 Standen Road, Southfields, London SW18 5TJ.

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Royal Doulton

Paint Technologist

Royal Doulton Tableware Limited is the largest manufacturer of English china and handmade full-lead crystal and has its headquarters in Stoke-on-Trent.

We are now seeking a Paint or Printing Ink Chemist for development work on Ceramic Decoration based in Stoke-on-Trent. Candidates will preferably be under 30 years of age.

This is a staff appointment offering the usual benefits associated with a progressive company, including a compulsory Pension Scheme and free Life Assurance.

Candidates, male or female, are requested to apply in writing with details of age, experience, qualifications and present salary to:

Mrs C Bennett
Personnel/Training Officer
Royal Doulton Tableware Limited
P O Box 100, London Road,
Stoke-on-Trent, Staffs. ST4 7QD

TECHNOLOGIST—R&D

We require a first-class technologist to join a small team in our Group Research and Development Laboratories located at our main factory in Sheffield.

Applicants, minimum age 25 years, should possess a degree or equivalent in Materials Science or allied discipline such as Plastics Technology. At least two years' industrial experience is desired.

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LEE steel

For application form, please contact: Peter Baker at Sheffield 387272, ext 219

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FIRA is the world's leading Research authority and technology centre within furniture manufacture and its associated materials and processes.

A scientist is required to work within the Materials Technology section of Research in a group concerned with sheet materials, finishes and adhesives. The work involves research into finishing materials and application methods, testing and fault finding both in the laboratory and in factories throughout the U.K.

The successful applicant will probably have a degree in chemistry, physics or physical chemistry and have several years' industrial experience.

Promotion prospects and conditions of employment in FIRA are very good.

Please apply in writing to:

Michael Charity
Head of Research
Furniture Industry Research Association
Maxwell Road
Stevenage
Herts SG1 2EW

SYMPOSIUM

Scottish Section

JUNIOR TECHNOLOGISTS' SYMPOSIUM

The Scottish Section of the Oil & Colour Chemists' Association have organised a Junior Technologists' Symposium, to be held on Friday, 2 December, 1977, in the Bellahouston Hotel, Glasgow.

The topic of this one day Symposium is the fundamentals of paint technology, which will serve as a good introduction for any young person who has just joined the industry, and will also help to broaden the outlook of those who are presently working in the paint, printing ink and allied industries.

For further details of this Symposium, please contact I. R. McCallum, C-Cure Coatings Ltd, Glasgow. Tel: 041-776 5480

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New paint technology: fire protective coatings, rubberised coatings, highly corrosion resistant coatings, unique paint products. Director of Research from Canada visiting UK in September.

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This key appointment is for a PROJECT LEADER to take overall responsibility for the Textiles Group within the Product Research Department of Laporte Industries Limited, located at Widnes, Cheshire.

The appointed candidate will lead a small team involved in research on the uses of peroxygen based bleaching agents in textile applications. There is also a strong link with marketing to provide a complete technical service to customers. This work is carried out on behalf of Interox—the joint Laporte/Solvay company which is concerned with the manufacture and sale of peroxygen based products worldwide.

Candidates, aged around 30, should have a good degree in a relevant field of chemistry, with several years' experience—ideally with both research and production involvement—in the wet processing of textiles.

Starting salary is negotiable; large company benefits, relocation assistance, where appropriate.

Please write, giving full career and personal details to: **The Divisional Personnel Manager,**

LAPORTE

LAPORTE INDUSTRIES LIMITED

General Chemicals Division

Moorfield Road,
Widnes, Cheshire WA8 0HE.

Ref: 491/433

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Newcastle Section Symposium 1975

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