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Report of Conference and AGM

**JOURNAL OF THE  
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SSOCIATION**

Vinyl weed-resistant antifouling: a practical approach to formulation *R. D. Mearns*

Sulfate-reducing bacteria, surface coatings and corrosion  
*M. E. Williams, R. A. King and J. D. A. Miller*

Developments in antifouling paints *J. Lorenz*

Protective coatings and wrappings for buried pipes: microbiological aspects  
*E. S. Pankhurst*

The occurrence and control of moulds and algae on paints  
*P. Whiteley*

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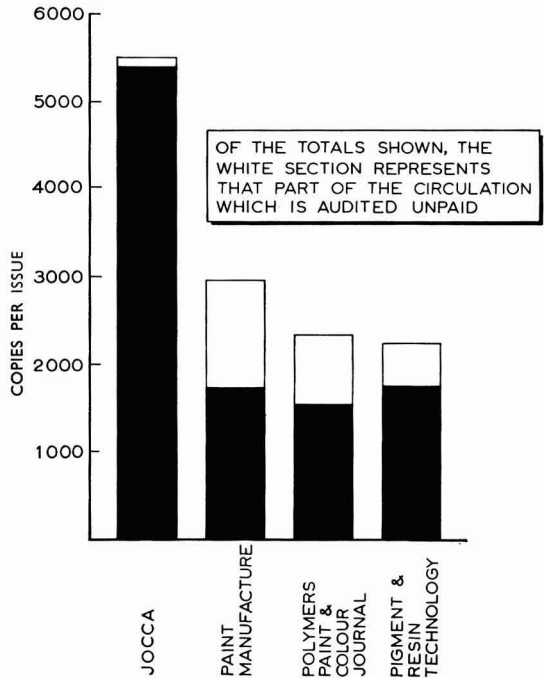
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Annual subscriptions to non-members in  
UK: £10 post free, payable in advance,  
single copies: £1 post free.

Abroad £12 (\$31) post free,  
single copies £1.25 (\$3.25) post free.

Published by

**OIL AND COLOUR CHEMISTS' ASSOCIATION**  
Priority House, 967 Harrow Road, Wembley, Middlesex, England HA0 2SF

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## Transactions and Communications

# Vinyl weed-resistant antifouling: a practical approach to laboratory formulations\*

By R. D. Mearns

Goodlass Wall & Co. Ltd., Goodlass Road, Speke, Liverpool L24 94J

### Summary

The basis for the formulation of low copper, or copper-free vinyl antifouling paints is discussed, and successful paint systems

demonstrated. Methods of test, toxicity and application problems are discussed, and future trends predicted.

### Keywords

*Types and classes of coatings and allied products*  
ship bottom paint

*Biologically active agents*  
organo-tin

*Miscellaneous*  
formulation

## Peintures vinyliques anti fouling résistant à végétation marine: un abord pratique à leur formulation au laboratoire

### Résumé

On discute la mise au point des formules de peintures antifouling sans, ou de teneur faible en cuivre, et l'on propose des systèmes de peintures efficaces. On discute les méthodes d'essai, les problèmes

de toxicité et d'application, et l'on donne des prévisions à l'égard des tendances à l'avenir.

## Vinyl-Unkrautfestes-Antifouling: Ein Praktischer weg zur Laboratoriumsrezeptierung

### Zusammenfassung

Die Grundlage zur Schaffung einer Rezeptur für Vinyl—Antifoulingfarben—von niedrigem Kupfergehalt oder kupferfrei wird

erörtert. Prüfmethode, Giftigkeit und Anwendungsprobleme werden besprochen und künftige Richtungen vorausgesagt.

## Виниловые необрастающие краски: практический подход к лабораторным формуляциям

### Резюме

Обсуждается основа для формуляции необрастающих виниловых красок с низким содержанием меди или без меди и демонстрируются успешные красочные системы. Обсуждаются

методы испытаний, токсичность и задачи применения и предсказываются будущие тенденции.

## Introduction

The demand for high performance antifouling paints is large, and the rewards to the successful paint manufacturer are significant. There has been an understandable tendency to ignore the risks arising from the toxic nature of the products which can be utilised.

The work described in this report concerns high performance antifouling paint development carried out specifically on vinyl antifouling coatings with weed-resistant properties.

The selection of the basic media, and the test methods available are discussed, together with the broader aspects of toxicology and pollution.

## Experimental

All percentages are on a volume/volume basis except where stated otherwise.

## Methods of test

The test methods available for the evaluation of antifouling paints are numerous, but each one suffers from specific drawbacks and problems, worthy of individual discussion.

The "raft trial" is the most widely used method of evaluation, since it caters for systematic formulation development with no real limit to the number of panels immersed. The choice of site is vital, however, to ensure a balanced environment, and to avoid conditions which are too static. Even so, a raft cannot simulate the moving conditions of a ship, particularly with regard to film erosion.

Although the raft area is small, the distribution of marine larvae and weed spores is not uniform, and this can lead to inaccurate comparisons being made. Peak periods of intense fouling by one or more species can result in the exclusion of other species, and erroneous conclusions can again be drawn. In particular, results must never be compared from season to

\*Presented at the symposium on "Paint performance and the microbiological environment" held by the Manchester Section, 19 and 20 September 1972.

season, and control standards and blank panels must always be exposed.

An extension of the raft trial is the "Tide test," or exposure of panels on the shore, in the "green weed" belt. This is a useful addition to raft tests, which tend to be too static due, in part, to the weight of panels involved. Enteromorpha, for instance, likes conditions where a major proportion of its life cycle is out of the water.

Ship trials or patch trials are closer to the ideal. Application over old paint surfaces is inadvisable, however, due to surface roughness and contamination by materials "bleeding" from previously applied paints. To be certain of the results, the system under test should always be applied over grit-blasted metal.

Consider the problems. First, the trade route or itinerary of the vessel must be suitable; the vessel must be new or undergoing extensive overhaul, and must be available for regular inspection. Bilge keel plates can be used, specially painted under laboratory conditions and fastened to the bilge keel. This method has much to recommend it, but today's problems increasingly concern areas near the water-line, to which this method cannot apply.

Rotor testing seems to offer promise, but involves the use of specialised equipment and copious quantities of unpolluted sea water. The panel under test is rotated at a predetermined speed in continuously replenished sea water. To be strictly relative, the speed should be similar to that of a ship, and the tests would take nine to 12 months, with an expensive power demand. As soon as higher speeds are chosen, say 40 or 60 knots, difficult problems (so far unresolved) of correlating accelerated and natural tests arise. A combination of accelerated rotor testing, and natural or laboratory fouling tests seems promising.

Laboratory spore tests, involving the germination of a species, say *Enteromorpha*, and its growth in the laboratory, offer a useful screening method, to select new products with antifouling activity and to fix limits of active concentration. As a method of testing antifouling paints, it encounters the basic problem, how artificially, and realistically to age the coating.

At Goodlass Wall, raft tests are used over a two-year period, supported by "Tide" exposures. The location is believed to be well chosen in the Menai Straits, where there is a considerable tidal flow (four to six knots). As members of Pan Marine, the company has access to raft trials in other, "all-the-year-round" polluted waters, as the next stage to a successful UK raft trial.

Patch trials are carried out wherever the opportunity arises; are found to be of limited usefulness, in that all the prerequisites are seldom met.

One of the most useful methods involves the painting of a certain semi-tropical fishing fleet, which allows regular examination since a subsidiary company is at hand to do the work.

There is, however, no real answer because only experience is conclusive. Every trial is useful, but in the final analysis reliance must be placed upon the reputation, good will and confidence of shipowners to facilitate evaluation on one or more complete ships.

## Methods of application

In all tests carried out, paints are applied by airless spray, with suitable precautions, using a system which would be recommended in practice.

The paint system used in this test sequence was:

One coat of 2-pack epoxy temporary protective primer, 25 microns.

Two coats of high performance epoxy coal tar, 250 to 300 microns.

One coat antifouling under test, 100 microns.

(Total dry film thickness 375 to 425 microns).

Film thicknesses were checked for each coating using a "Permascope" gauge.

The use of airless spray gives even, smooth films with low surface roughness and allows good control of film thickness. Surface roughness has been shown to contribute markedly to the economics of ship operation. Over a period of six to seven years the initial roughness of a high performance system doubles, and with conventional paints quadruples, leading to considerable loss of speed and, in consequence, revenue. If other methods are used, the results will suffer and performance will be reduced. There is a growing tendency for shipyard labourers to refuse to apply antifouling paints by airless spray because of their fears of toxicity.

Unless trained airless spray teams are available with the correct equipment, able to take the right precautions as advised by the manufacturer, the results in practice will vary from ship to ship, and even from area to area on the same hull. Application by roller is a very poor substitute. It cannot give the even film thickness necessary, in practice, to achieve consistent results.

Unless a suitable code of practice is established, clearly defining the toxicity of various antifouling paints and the precautions which must be taken, the refusal to use airless spray could spread, and formulations will not attain their design specification.

## Selection of toxins

It is not surprising that many of the compounds with a fatal effect on marine fauna are harmful to man. The question must, therefore, be asked "How toxic can a safe coating be?" The answer is, of course, that providing the correct precautions are taken, there is no limit to the toxicity of the products which can be used. With, for example, totally enclosed suits, an auxiliary air supply, movable overspray and wind shields, evacuation procedure, and suitable dust "clean-up" precautions, any products could be safely applied. Anyone who has seen a ship being painted will know that these precautions are considered impractical, and if these precautions were to be enforced, a paint of such toxicity would never be used. Generally, paints are applied by roller, or airless spray, in the open, with few precautions, and this must be borne in mind when deciding the degree of toxicity.

One standard practice often encountered is the "burning out" of tins or roller trays, and with some products this could be lethal! One of the major problems is that not only is the short-term toxicity important, the actual dosage producing immediate physical effect, but so too are the long-

term effects, the more insidious and difficult to trace aspects, such as the effect on the central nervous system, or the recently claimed effect of brain damage from low dosages of lead.

All these things frighten the man applying the paint. In Japan, for example, one of the foremost shipbuilding nations, the unions have banned the use of all antifouling paints containing tin, lead, antimony, arsenic, and mercury.

In this country, at the present time, no restrictive legislation exists, and it is in everyone's interest to act in a responsible manner. Responsible companies have taken the decision not to supply antifouling paints based on organic compounds of lead, arsenic or antimony at the present time.

In the work recorded here, tributyltin derivatives alone are considered, and the major emphasis is placed on the fluoride. The generally accepted LD 50 figures for albino rats are recorded in Table 1, showing compounds in use, or proposed for use in modern antifouling paints. It should be stressed that the LD 50 figures are of little direct value, and it is the chronic toxicity tests which are the most meaningful; that is, long-term results, and not the individual dosage causing death. This area is where little is known and where the danger lies.

Table 1  
LD 50 figures for albino rats

	LD 50 (mg kg <sup>-1</sup> ) 200
Triphenyllead acetate .. ..	40
Triphenylmercury acetate .. ..	125-136
Tributyltin acetate .. .. .	193
Tributyltin oxide .. .. .	78
Pentachlorophenol .. .. .	

## Discussion of experimental work

### General aspects

High-performance long-life antifoulings must be based upon a non-saponifiable resin system, which will provide a skeleton or sound framework in the exhausted film. This gives a firm, smooth basis for future coats, and greatly reduces the likelihood of detachment as the film builds up. A further advantage over conventional products is the elimination of the "barrier coat," or "anticorrosive coat" needed to seal spent conventional antifoulings and provide film strength.

The selection of a high-performance resin is important and there are five high-performance resins which could be considered: acrylic, vinyl, two-pack epoxy, or two-pack polyurethane, and chlorinated rubber. Two-pack products were not considered advisable due to problems of mixing the base and curing agent, particularly because of the low volume of the latter required per litre of paint. A further problem with an epoxy system is that tributyltin derivatives positively interfere with the curing mechanism.

Chlorinated rubber materials can show problems of instability with copper suboxide on storage. Since most new systems recommended for ships' bottoms involve the use of epoxy coal tar, adhesion of the antifouling material to the coal tar coating is important. This involves the use of complex

solvent combinations, which eliminates a further advantage of chlorinated rubber—solubility in hydrocarbon solvents.

The main choice lies between acrylic and vinyl. In this work, vinyl resins were used, mainly due to previous experience, and to these resins being extensively recommended in literature. Vinyl resins are copolymers of vinyl acetate and vinyl chloride, and the grade used was a partly hydrolysed material containing 91 per cent vinyl chloride by weight.

The leaching rate, or rate of availability of toxin at the paint surface, is controlled by the total volume of material which is soluble in seawater, by the pigment packing, and by the solubility of the constituents. The theoretical aspects are complex and beyond the scope of this paper. The grade of rosin utilised in this work was ww Portuguese rosin with a solubility of 630 mg cm<sup>-3</sup> in a pH9 borate buffer.

The initial formulations shown in this work were a result of literature surveys, and of previous work. Formulations and tabular results are recorded in the appendices for ease of assimilation, formulae being expressed as percentages of solids by volume. Additives and solvents controlling paint application and storage properties are not included as they have no direct effect on fouling aspects.

The work recorded here formed part of a much larger exercise, and the various aspects reported have been selected as being of interest.

### Comparison of tributyltin derivatives (Series 1)

Three tributyltin derivatives were selected for comparison: tributyltin fluoride (TBTF), tributyltin oxide (TBTO) and tributyltin acetate (TBTA). TBTO was used as a control at 15 per cent, and compared to the acetate and fluoride, both at concentrations of 10, 15 and 20 per cent.

The soluble pigment in the initial series was arsenious oxide and this is compared with copper suboxide in Series 2.

Two plasticisers were selected, tributyl citrate, compatible with TBTO, and glycerol because of its water solubility.

After 18 months' immersion, results could be summarised as follows:

1. There was little or no Enteromorpha (green weed) fouling, except of the control panel.
2. The best results were obtained with TBTO, followed by TBTF.
3. At least 15 per cent tin derivative was necessary.
4. Tributyltin acetate gave, generally, poor results.
5. Most of the fouling was by Ectocarpus (brown weed), barnacle and colonies of hydroids.
6. Paints tended to soften after prolonged immersion.
7. Tributyl citrate was markedly superior to glycerol.

The superiority of TBTO was no real surprise. Previous experience had shown, however, that results with TBTO-based paints tend to vary; both good, and bad results had been obtained with ships' trials, without any obvious reason.

Tributyltin oxide is a liquid and has poor compatibility with most systems. It was considered that this could lead to a variation in the distribution of toxin in the paint film,

depending on the age of the paint, and the conditions during application and drying. This could explain differences in product performance.

A further limiting factor was the fact that TBTO is a liquid, and this would limit the total volume which could be used. The fluoride is a white powder and should not be subject to the drawbacks of TBTO; it was selected as the main toxin for the remainder of this work.

For the formulations refer to Appendix 1 Table 2, for the results refer to Appendix 2 Table 8, and for the best result from Series 1, see Fig. 2, panel 72B.

#### *Replacement of arsenic by copper suboxide (Series 2)*

Arsenious oxide was selected for the initial series on the grounds of cost, but it presents problems during manufacture because of the procedures for handling a registered poison, and it had shown drawbacks in performance (Series 1). Comparing arsenious oxide with copper suboxide for significant properties, it is found that:

	Cost per litre	Sea water solubility
Arsenious oxide	£0.31	15.55 g l <sup>-1</sup>
Copper suboxide	£3.21	500 g l <sup>-1</sup>
TBTF	£3.45	3.03 g l <sup>-1</sup>

In Series 2, copper suboxide was substituted for arsenious oxide on a volume for volume basis, and the TBTO control was increased to 20 per cent. A comparison of plasticisers was made using tributyl citrate, tricresyl phosphate and dibutyl phthalate, all of which are saponifiable.

After 18 months' exposure, results could be summarised as follows:

1. After nine to 12 months, TBTO gave the best results, but after an 18-month period differences were negligible.
2. Paints based on copper suboxide gave considerably better general resistance to fouling.
3. Paint surfaces tended to discolour.
4. TBTF at 20 per cent gave good all round performance.
5. In the initial stages, tributyl citrate was superior to glycerol but the advantage was not maintained. The alternative plasticisers, tricresyl phosphate and dibutyl phthalate, were superior at the end of the 18-month period.

Surface discoloration is usually masked by the presence of red oxide, and this compound was included in later formulations.

For the formulations refer to Appendix 1 Table 9, and for the results refer to Appendix 1 Table 3.

#### *Reduction in copper suboxide content (Series 3)*

The cost per litre of copper suboxide was greater by a factor of 10 than that of arsenious oxide, and the solubility greater by a factor of 30.

Series 3 was an examination of the reduction in copper suboxide from the 45 per cent used in Series 2, to 40.5 and

38 per cent, replacing it with a combined vinyl/rosin medium (2 : 1 by volume).

A further reduction was made to 33 per cent, replacing with 5 per cent of talc, and 5 per cent of sodium fluoride. The sodium fluoride was selected being freely water soluble, and was expected to give a more porous film.

After 18 months' exposure results showed that:

1. Of the three copper suboxide levels evaluated, the best results were given by the highest copper suboxide level (40.5 per cent).
2. The 40.5 per cent copper suboxide value coincided with the highest total soluble film content.
3. Paints based on 20 per cent of TBTF were marginally superior to those based on 15 per cent, but this result could have been affected by there being a less soluble film.
4. The lowest copper suboxide level (33 per cent) coincided with the lowest total soluble film content (46 and 44.5 per cent at the 15 and 20 per cent TBTF levels, respectively).
5. In one case, at 33 per cent copper suboxide by volume, the total solubles were adjusted to 50.75 and 48.25 per cent at the 15 and 20 per cent TBTF level, using sodium fluoride. Results were poor, much more inferior than equivalent paints with the same solubles content but using 38 per cent of copper suboxide.

For the formulations refer to Appendix 1 Table 4, and for the results to Appendix 2 Table 10.

#### *Reduced copper suboxide with variable film solubles (Series 4)*

Series 3 and 4 were immersed together. In this sequence the copper suboxide level was fixed at 20 and 10 per cent, and the TBTF levels maintained at 15 and 20 per cent respectively.

The vinyl/rosin composition was changed to give ratios of 1.5 : 1, 1 : 1, and 1 : 1.5, corresponding to 44, 50 and 56 per cent total solubles at 15 per cent TBTF, and 34, 40 and 46 per cent total solubles at 20 per cent TBTF. Plasticiser was omitted from the general series, but was checked on one paint at the 1 : 1 vinyl/rosin ratio.

The general aim of the series was to decide whether lower levels of copper suboxide could be used, and what effect the rosin content had on performance.

Results after 12 months' immersion were:

1. With 15 per cent TBTF, film solubles had to be 50 per cent or greater to give adequate performance.
2. Results with 25 per cent TBTF were worse, in that fouling was more intense, indicating that the total solubles content is a decisive factor.

Results from Series 3 and 4 suggest that, providing the toxic agent is effective, the most important factor is the total content of soluble film. The question arises whether low volumes of copper suboxide contribute anything, other than solubility in seawater. It is, of course, always possible that a synergistic effect occurs, but this could only be shown by comparison with a copper-free series.

For the formulations refer to Appendix 1 Table 5, and for the results to Appendix 2 Table 12. The best result from Series 4 was with panel 11F (Fig. 3).

#### Copper-free TBTF-based paints

This sequence was formulated to evaluate fully two basic variables, the total soluble content, and level of toxic agent. The TBTF level was varied at 45, 50, 55 and 60 per cent of the non-soluble film.

The rosin content, or total film solubles content, was fixed at 25, 30, 35 and 40 per cent in turn.

Plasticiser was omitted, since it seemed to contribute little to the condition of the final film and might have tended to "clog" or hinder the release of the toxic agent. However, one paint was produced at each rosin level, for purposes of comparison.

Results after 12 months indicated:

1. At all rosin contents, the TBTF level should be a minimum of 55 per cent based on the total film non-solubles, or 40 to 45 per cent by volume.
2. The optimum value of total film solubles is 35 per cent.
3. Increasing film solubles to 40 per cent gives initially good results, but they have a tendency to become exhausted with time.
4. The expected sequence of results did not occur in every case in practice.

For the formulations refer to Appendix 1 Table 6, and for the results to Appendix 2 Table 12. The best result from Series 5 was with Panel 19F (Fig. 4).

#### Recommended formulations

The recommended formulations will depend upon product requirements. A consideration of the formulation to be adopted should include the following broad aspects:

1. Areas of usage; that is, voyages and waters where the paint is required to be effective.
2. The type of vessel for which it is designed; that is, tanker, bulk carrier, passenger or tramp.
3. The area of hull it is intended to protect.
4. The species it is required to resist.
5. The length of time it is required to be effective.
6. Cost effectiveness.

All these factors make it difficult to be specific, but assuming a high performance product is required, the broad areas of interest are outlined below for formulations both with and without copper suboxide.

#### Copper suboxide-based

The red oxide of iron content is best maintained at a uniform 5 per cent. The remaining compounds should be evaluated as follows:

Copper suboxide content	..	..	30 to 40 per cent
Tributyltin fluoride	..	..	15 to 20 per cent

WW rosin	..	..	..	..	20 to 30 per cent
VAGH resin minimum	..	..	..	..	20 per cent.

Consideration of the formulations and results given in this paper should guide the formulator.

#### Copper-free materials

Red oxide of iron again should be maintained at 5 per cent, the remaining compounds being varied as follows:

Tributyltin fluoride	..	..	55 to 60 per cent (based on non-soluble film)
WW rosin	..	..	35 to 40 per cent
Vinyl	..	..	As required

#### Future aspects

It is possible that the first million ton tanker will be built before the end of this decade. Dry docking for the application of antifouling coatings will be prohibitively costly, and both underwater cleaning and underwater paint application will become necessary.

The major problems in underwater painting concern the technical aspects of adhesion, particularly in the presence of bacterial slimes, and the provision of smooth films with low frictional resistance.

The major proportion of the surface is out of the water when the vessel is unladen, and can be treated with high performance antifouling by normal methods whilst in a wet berth.

Perhaps robot cleaners would be an answer, although this method would be expensive. There might be world-wide laws on pollution control, which would make the use of robots attractive. It might be feasible for each large tanker to have its own robot scavenger, working whilst the ship is at rest, or possibly in ballast.

Tankers can lose between 0.5 and 1 knot due to fouling problems; even with today's freight rates, which are at a low ebb, this can cause considerable loss in revenue.

The figures quoted in Table 13 were given by a large marine operator.

Table 13  
Losses due to marine fouling

Tonnage	Speed lost	Days lost	Revenue lost
250,000	½-1 knot	12-24	£60,000-£120,000
100,000	½-1 knot	12-24	£36,000- £72,000
50,000	½-1 knot	12-24	£20,500- £41,000

#### Dry docking charges

		First day	Subsequent days
250,000 tons	..	£3,500	£2,500
100,000 tons	..	£1,000	£800
50,000 tons	..	£1,000	£600

It should be noted that even a small rise in the presently depressed freight rates (considered inevitable in the not too distant future) could double, or even treble lost revenue. Dry docking charges vary widely in different parts of the world, but the figures given are considered to be average. With these costs in mind, a mechanical solution to the problem seems feasible, although there is evidence that mechanical cleaning is a short-term solution only.

The development of new organic biocides with the correct seawater solubilities is a distinct possibility. Many of these could be specific for particular species. Manufacturers of biocides tend to concentrate on the major market of the agricultural and pharmaceutical industries, the volume of potential marine requirements being very small in comparison. Research and development could certainly find a solution, but it is questionable whether the cost could be justified by sales.

There is, of course, the chance of an "offshoot" from the more lucrative fields of research, giving a product with marine antifouling activity, but to identify it will involve the paint manufacturers' testing numerous compounds with a small chance of success. Screening tests, and the organisations capable of carrying them out, become of prime importance from this consideration.

Testing methods will certainly improve, and accelerated rotor testing will be established, and correlated with practical results. It will still be limited by environmental conditions and by the number of test panels that can be economically evaluated.

A method is being evaluated at present that involves the use of a duplicate of the paint under test with varying percentages of the water soluble content replaced by a material of high water solubility.

For example, if there is 40 per cent copper suboxide and 20 per cent rosin in a particular product, this could be replaced by sodium fluoride and glycerol, at 67, 70 and 80 per cent of the total.

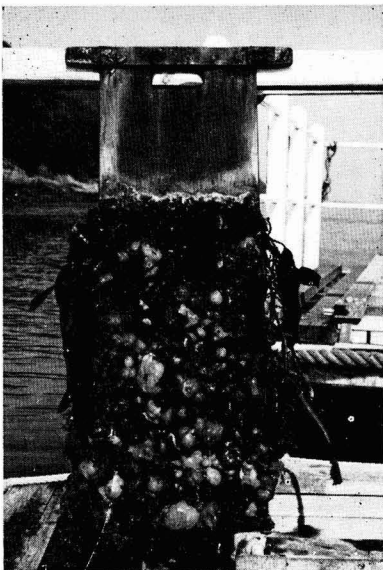


Fig. 1. Control panel 139F

For an antifouling applied at the normal film thickness of 100 microns, a 50 micron film could be overcoated by a 50 micron film of the soluble coat. It is hoped that this will give an accelerated picture of fouling patterns. The method could be useful because it could be coupled with normal raft testing procedure, and give some acceleration.

### Conclusions

The most satisfactory tributyltin compound for antifouling paints is the fluoride.

White arsenious oxide is not preferred as the soluble pigment in the series.

Paints can be produced at a variety of copper suboxide levels, with TBTF levels up to 25 per cent by volume. The actual formulation depends on the performance required.

Suggested starting formulations are outlined for copper suboxide/TBTF-based products, the actual composition depending on product requirements and raw material costs.

Copper-free TBTF-based antifouling paints give good performance, depending upon the level of TBTF and the total volume of soluble film.

Suggested starting formulations are outlined for TBTF copper-free antifouling. Actual composition is dependent on product performance requirements and raw material costs.

### Acknowledgments

The author would like to thank the directors of Goodlass Wall and Co Ltd for the permission to publish this paper. Acknowledgments are due to D. Eager and J. Harrison, of the Marine Development Laboratory of Goodlass Wall and Co Ltd, who carried out much of the experimental work. The author would particularly like to record his appreciation of the many valuable discussions with B. Partington of ROSCM.

[Received 26 January 1973]

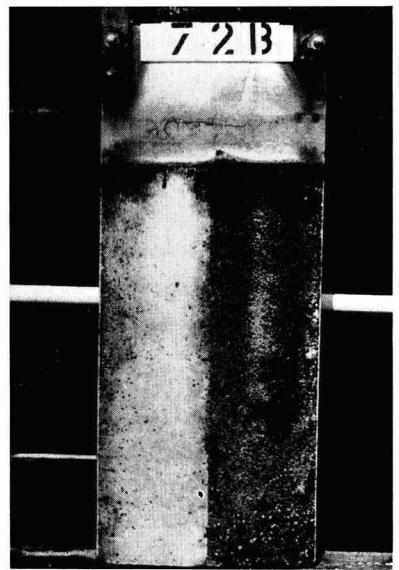


Fig. 2. Series I panel 72B





Table 4  
Series 3 formulations

Constituents	Experimental formulations series 3; per cent solids by volume															
	JH183	JH184	JH185	JH186	JH187	JH188	JH189	JH190	JH191	JH192	JH193	JH194	JH195	JH196	JH197	JH198
Copper suboxide .. ..	38	38	38	38	40.5	40.50	40.5	40.5	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3
Red oxide .. ..	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75
Talc .. ..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sodium fluoride .. ..	—	—	—	—	—	—	—	—	4.75	4.75	4.75	4.75	—	—	—	—
Vinyl VAGH .. ..	25.40	25.40	22.40	22.40	23.85	23.85	20.60	20.60	25.50	22.30	22.30	22.30	25.50	25.50	22.30	22.30
Rosin .. ..	12.85	12.85	11.10	11.10	11.90	11.90	10.40	10.40	12.70	12.70	11.15	11.15	12.70	12.70	11.15	11.15
TBTF .. ..	14.25	14.25	19.00	19.00	14.25	14.25	19.00	19.00	14.25	14.25	19.00	19.00	14.25	14.25	19.00	19.00
Tricresyl phosphate .. ..	4.75	—	4.75	—	4.75	—	4.75	—	4.75	—	4.75	—	4.75	—	4.75	—
Glycerol .. ..	—	4.75	—	4.75	—	4.75	—	4.75	—	4.75	—	4.75	—	4.75	—	4.75
Total .. ..	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Panel number .. ..	61FL	61FR	61BL	61BR	69FL	69FR	69BL	69BR	71FL	71FR	71BL	71BR	73FL	73FR	73BL	73BR
Dry film thickness (microns)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total solubles pigment and rosin .. ..	50.85	50.85	49.10	49.10	52.4	52.4	50.9	50.90	46	46	44.5	44.5	46	46	44.5	44.5

Table 5  
Series 4 formulations

Constituents	JH300	JH301	JH302	JH303	JH304	JH305	JH306	7H307
Copper suboxide .. ..	20	20	20	20	10	10	10	10
Red oxide .. ..	5	5	5	5	5	5	5	5
TBTF .. ..	15	15	15	15	25	25	25	25
Vinyl VAGH .. ..	30	36	24	27.5	30	36	24	27.5
Rosin .. ..	30	24	36	27.5	30	24	36	27.5
TCP .. ..	—	—	—	5	—	—	—	5
Total .. ..	100	100	100	100	100	100	100	100
Panel number .. ..	10FL	10FR	11FL	11FR	12FL	12FR	13FL	13FR
Dry film thickness (microns)	100	100	100	100	100	100	100	100
Total solubles pigment and rosin ..	50	44	56	47.5	40	34	46	37.5

Table 6  
Series 5 formulations

Constituents	Experimental formulations series 5; per cent solids by volume									
	JH309	JH310	JH311	JH308	JH313	JH314	JH315	JH312	JH317	JH318
Red oxide .. ..	5	5	5	5	5	5	5	5	5	5
TBTF .. ..	33.75	37.50	41.25	45.00	31.50	35.00	38.50	42.00	29.25	32.50
Vinyl VAGH .. ..	36.25	32.50	28.75	25.00	33.50	30.00	26.50	23.00	30.75	27.50
Rosin .. ..	25	25	25	25	30	30	30	30	35	35
Total volume .. ..	100	100	100	100	100	100	100	100	100	100
Panel number .. ..	14FR	15FL	15FR	14FL	16FR	17FL	17FR	16FL	18FR	19FL
Dry film thickness (microns)	100	100	100	100	100	100	100	100	100	100
Total TBTF level on non-soluble .. ..	45%	50%	55%	60%	45%	50%	55%	60%	45%	50%

Table 7  
Series 5 formulations

Constituents	JH319	JH316	JH321	JH322	JH323	JH320	JH324	JH325	JH326	JH327
Red oxide .. .. .	5	5	5	5	5	5	5	5	5	5
TBTF .. .. .	35.75	39.00	27.00	30.00	33.00	36.00	33.75	35.00	35.75	36.00
Vinyl VAGH .. .. .	24.25	21.00	28.00	25.00	22.00	19.00	31.25	25.00	19.25	14.00
Rosin .. .. .	35	35	40	40	40	40	25	30	35	40
Tricresyl phosphate .. .. .	—	—	—	—	—	—	5	5	5	5
Total volume .. .. .	100	100	100	100	100	100	100	100	100	100
Panel number .. .. .	19FL	18FL	51BR	53FL	53FR	51BL	55FL	55FR	67FL	67FR
Dry film thickness (microns)	100	100	100	100	100	100	100	100	100	100
Total TBTF level on non-solubles .. .. .	55%	60%	45%	50%	55%	60%	45%	50%	55%	60%

Appendix 2

Results

Panels were graded as follows:

- 0—Fouling absent
- 1—Trace deposits
- 2—Slight deposits
- 3—Moderate
- 4—Severe
- 5—Very severe

The method of assessment is a modification of that published in *Paint Technology*, March 1963, 26.

Table 8  
Series 1

Panel no.	Intensity	Species
72FL	2-3	Ectocarpus, young barnacle (1-2mm) latter at lower end of panel, shrimp
72FR	2-3	Ectocarpus and shrimp
72BL	1	Edge effects only
72BR	4	Ectocarpus, and young barnacle (1-2mm) shrimp
77FL	1-2	Ectocarpus and slime, leading edge of panel only
77FR	4	Ectocarpus barnacle (1-2mm) hydroid and shrimp
77BL	1	Ectocarpus, mainly edge effects
77BR	3	Ectocarpus barnacle (1-2mm) trace of Enteromorpha (waterline only), shrimp
85FL	4	Ectocarpus, barnacle (2-3mm) hydroids, shrimps
85FR	5	Similar to 85FL
85BL	4	Ectocarpus and barnacle (2-3mm) hydroids and shrimp
85BR	5	Similar to 85BL
93FL	5	Ectocarpus barnacle and hydroids
93FR	5	Similar to 93FL

Table 9  
Series 2

Panel no.	Intensity	Species
97FL	3	Stunted Ectocarpus (0.5in) slime, hydroid growth at edges only, shrimp
97FR	3	Similar to 97FL
97BL	3	Similar to 97FL
97BR	3	Similar to 97FL
131FL	3	Stunted Ectocarpus (0.5in) slime, shrimp
131FR	3	Similar to 131FL
131BL	3	Similar to 131FL
131BR	3	Similar to 131FL
132FL	1	Stunted Ectocarpus bottom of panel only
132FR	1	As 132FL

Table 10  
Series 3

Panel no.	Intensity	Species
61FL	2	Stunted Ectocarpus, slime, and shrimp
FR	2	Similar to 61FL
BL	2	Similar to 61FL
BR	2-3	Similar to 61FL
69FL	2-3	Stunted Ectocarpus slime and shrimp
69FR	2-3	Similar to 69FL
69BL	1	Stunted Ectocarpus, bottom of panel only
69BR	1	Similar to 69BL
71FL	4	Ectocarpus (2in), Enteromorpha, barnacle (1-2mm), shrimp and slime
71FR	3	Ectocarpus (1in), shrimp and slime
71BL	2	Stunted Ectocarpus (0.5in) shrimp
71BR	1	Similar to 71BL
73FL	3	Ectocarpus (1in), slime and shrimp
73FR	3	Similar to 71FL
73BL	3	Similar to 71FL
73BR	3	Similar to 71FL

Table 11  
Series 4

Panel no.	Intensity	Species
10FL	1-2	Slime, trace of Enteromorpha at waterline
10FR	2-3	Stunted Ectocarpus, slime, and shrimp
11FL	0-1	Slime
11FR	2	Stunted Ectocarpus and shrimp
12FL	1	Patch of stunted Ectocarpus (4in square)
12FR	1	Similar to 12FL
13FL	3	Stunted Ectocarpus (1in) shrimp
13FR	4	Ectocarpus (4in)

Table 12  
Series 5

Panel no.	Intensity	Species
14FR	5	Ectocarpus, trace Enteromorpha, barnacle (2-3mm), shrimp and slime
15FL	1	Slime, some shrimp
15FR	1	Slime, shrimp
14FL	2	Stunted Ectocarpus, slime, and shrimp
16FR	2-3	Stunted Ectocarpus, slime, and shrimp
17FL	3	Ectocarpus, Enteromorpha, shrimp
17FR	2	Stunted Ectocarpus, slime, and shrimp
16FL	0-1	Slime only
18FR	5	Ectocarpus (6in) shrimp, barnacle (0.1mm)
19FL	0-1	Slime only
19FR	0-1	Slime only
18FL	1	Ectocarpus
51FR	4	Ectocarpus, slime shrimp
53FL	1	Stunted Ectocarpus and slime
53FR	1	Stunted Ectocarpus and slime
51BL	0-1	Slime only

# Sulfate-reducing bacteria, surface coatings and corrosion\*

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## Summary

The mode of action of sulfate-reducing bacteria causing corrosion in buried steel structures and pipes is reviewed. The most reliable test method is underground exposure at a suitable site, but this can take up to ten years to complete.

A semi-continuous technique involving gradual replacement of the growth medium is described. Visual examination of the exposed

samples was supplemented by potentiokinetic tests, which consisted of measurements of the current flowing at various levels of applied potential and after various times. It was shown that some correlation exists between the weight loss of the samples and the plot of the current against time, but that none exists between the weight loss and the plot of potential against log current.

## Keywords

*Raw materials: biologically active agents*  
bacteriocide

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

*Miscellaneous*  
anaerobic organism

## Les bactéries capables de réduire les sulfates; des revêtements superficiels; et la corrosion

### Résumé

On passe en revue le mode par lequel les bactéries capables de réduire les sulfates provoquent la corrosion des structures et de la tuyauterie enterrées. La méthode d'essai la plus fiable c'est l'exposition souterraine à un emplacement convenable, mais elle pourrait exiger jusqu'à dix ans pour son accomplissement.

On décrit une technique semi continue où il s'agit de la lente renouvellement du milieu de culture. L'examen visuel des échantil-

lons exposés était supplémente par les essais potentiocinétiques, qui entraînaient le dosage du courant qui coule aux divers niveaux du potentiel appliqué et après diverses intervalles de temps. On a démontré qu'il existait une certaine corrélation entre la perte du poids des échantillons et la courbe du courant contre temps, mais qu'il n'en existait point entre la perte de poids et la courbe du potentiel contre le logarithme du courant.

## Sulfatreduzierende Bakterien, Anstrichmittel und Korrosion

### Zusammenfassung

Die Art und Weise, in welcher sulfatreduzierende Bakterien an in der Erde befindlichen Stahlkonstruktionen und Rohrleitungen Korrosion verursachen, wird einer Betrachtung unterzogen.

Die verlässlichste Prüfmethode ist die unterirdische Exponierung an einer sich hierzu eignenden Stelle; bis zur vollständigen Prüfung können jedoch zehn Jahre vergehen.

Es wird eine halb- fortlaufende Technik beschrieben, in welcher

das Wachstumsmedium fortschreitend ersetzt wird. Prüfung der exponierten Proben durch Augenschein wurde durch potentiocinétique Tests, welche aus Messungen des in verschiedener Höhe und in verschiedenen Zeitabständen vorgenommen angewandten Potentials, bestehen, ergänzt. Es wurde demonstriert, das zwischen dem Gewichtsverlust der Proben und der Strom/Zeit Kurve eine gewisse Korrelation bestand, nicht aber zwischen Gewichtsverlust und der Kurve von Potential/log Strom.

## Сульфатные бактерии, поверхностные покрытия и коррозия

### Резюме

Осматривается механизм действия противосульфатных бактерий, вызывающих коррозию в подземных стальных структурах и трубах. Наиболее надежным методом испытания является подземное выветривание в подходящей среде, но это может занять до десяти лет для полного выполнения.

Описывается полупостоянная техника с постепенной заменой окружающей среды роста бактерий. Визуальные наблюдения

ветренных образцов дополнялись потенциально-кинетическими испытаниями, состоящими из измерения тока проходящего при различных уровнях прилагаемого напряжения и после различных периодов времени. Показано что существует известная корреляция между потерей веса образцов и зависимостью тока от времени, но такая корреляция отсутствует между потерей веса и зависимостью напряжения от логарифма тока.

\*Presented at the Symposium on "Paint performance and the microbiological environment" held by the Manchester Section, 19 and 20 September 1972.

## Introduction

### The role of the sulfate-reducing bacteria in metallic corrosion

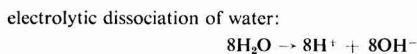
Sulfate-reducing bacteria are of concern to technology because they cause corrosion of ferrous metals in the absence of oxygen. There is considerable evidence for the implication of sulfate-reducing bacteria in the corrosion of underground pipes<sup>1-3</sup>, oil well installations<sup>4</sup>, aircraft fuel tanks<sup>5</sup>, cooling towers<sup>6</sup>, central heating systems<sup>7</sup>, sewage works and ship's plate in polluted estuarine conditions<sup>8, 9</sup>. The most thoroughly documented cases concern the corrosion of underground pipes. Vernon<sup>10</sup> estimated in 1956 that the annual cost of replacing and maintaining underground pipelines in the UK was £20 million. Booth<sup>2</sup> considered that of this total, perhaps 50 per cent or more could be attributed to the activities of sulfate-reducing bacteria. Characteristic of this type of corrosion is the occurrence of pitting: cast iron pipes of 0.25in wall thickness have occasionally been perforated within one year of installation<sup>1</sup>.

Typically, these bacteria are vibrios (curved rod-shaped organisms) approximately 0.5–1µm by 3–5µm; they are often motile. Their harmful nature is due to their unique ability to utilise sulfate ions as terminal electron acceptors in respiration. This type of anaerobic respiration is known as "dissimilatory sulfate reduction"; the electron donor may be an organic substance or gaseous hydrogen. In the latter case the overall equation may be represented:



The end-product, sulfide, is toxic to most other living organisms. The sulfate-reducing bacteria are strict anaerobes: they are incapable of utilising gaseous oxygen as a terminal electron acceptor and its presence inhibits the reaction shown above.

Many years ago Von Wolzogen Kühr and Van der Vlugt<sup>11</sup> observed rapid corrosion of iron pipes laid in the water-logged clay soils of Holland—situations of near-neutral pH and absence of oxygen, in which only low corrosion rates would be expected because of the polarisation of cathodic zones of the metal surface. The already known ability of the sulfate-reducing bacteria to utilise hydrogen for sulfate reduction led Von Wolzogen Kühr and Van der Vlugt to postulate that the bacteria caused corrosion of ferrous metals by removal of the hydrogen from the surface; that is, by cathodic depolarisation<sup>11</sup>. The reaction mechanism they proposed was:



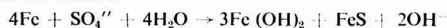
cathodic depolarisation by the sulfate-reducing bacteria:



formation of corrosion products:



overall reaction:



Booth and co-workers<sup>12</sup>, using polarisation techniques with batch cultures of these organisms, obtained results

suggesting that the ability of the bacteria to utilise hydrogen, for whatever purpose, was the criterion for anaerobic corrosion of ferrous metals, and that this depolarising activity need not be linked to sulfate reduction. Thus they considered that the formation of sulfide ions was not necessary for the corrosion process. However, more recent experiments using semi-continuous and continuous culture techniques, and using hydrogen-utilising bacteria other than sulfate reducers, have failed to confirm these conclusions<sup>1, 13</sup>.

The corrosion product, ferrous sulfide, formed by the reaction of ferrous ions from the anodic areas or the soil with biogenic sulfide is itself now known to be highly corrosive<sup>14, 15</sup>. Present knowledge of corrosion by the sulfate-reducing bacteria suggests that two main mechanisms are operating: (a) utilisation of cathodic hydrogen by the bacteria; (b) corrosion due either to this cathodic depolarisation or to galvanic cell action by the biogenic ferrous sulphide, or perhaps both. King and Miller<sup>16</sup> consider that ferrous sulfide behaves as a cathode (though not a permanent one) when in electronic and ionic contact with mild steel, and that the sulfate-reducing bacteria are able to depolarise and reactivate the ferrous sulfide, thus bringing about further corrosion.

### Protection against bacterial corrosion by surface coatings

Since the potential corrosion hazard to underground pipes by sulfate-reducing bacteria is so difficult to assess (for a review of this topic see Ref. 1), the most practicable method available for protecting pipes is the universal use of surface coatings. Nevertheless, little research appears to have been done on the effect of sulfate-reducing bacteria on surface coatings, apart from actual burial trials. These probably constitute the most reliable test method, but take up to ten years to complete. The authors have attempted to simulate in the laboratory the conditions under which corrosion by sulfate-reducing bacteria occurs, and to devise a more rapid method for determining the effect of the bacteria on a protective coating and the actual mechanism of coating failure. Their particular interest was the incorporation of biocides and corrosion inhibitors in the protective coatings since this seemed to offer the most effective method of combating the problem. This paper reports the effectiveness of several biocides in reducing corrosion; it also describes an attempt to determine why certain biocides are more effective than others in controlling the bacterial corrosion by employing potential time and potentiokinetic methods.

Surface coatings cannot be expected to give perfect protection against corrosion. Mayne<sup>17</sup> showed that surface coatings were permeable to water, oxygen and ions. In normal circumstances and with normal film thicknesses of the order of 20 to 100µm, he concluded that the passage of water and oxygen were not limiting to the corrosion process. The limiting process was regarded as being the passage of ions through the coating. In the case of very thick coatings, it is not certain which process is limiting. In the experiments reported here, a thin film of ferrous sulfide corrosion product was found beneath the surface coatings (described below). The sulfide might have passed through the surface coating in the form of dissolved H<sub>2</sub>S and/or HS<sup>-</sup> ions.

## Experimental

In view of the above considerations, it was decided to use as a basis a polyamide cured pitch-epoxy system, similar to coatings used in the field; the epoxy component is included

to give improved adhesion, temperature stability and chemical resistance. In the field, film thicknesses of up to 500µm are used; a thickness of 50µm was used in the experimental work, however, in order to obtain more rapid results. Certain workers, notably Harris<sup>18</sup>, have reported failures of this type of coating; work is at present in hand to investigate any possible utilisation of coal tar pitch by sulfate-reducing bacteria.

Nineteen biocides were selected for incorporation into the standard coating; details are given in Table 1. The semi-continuous culturing technique was used. The principle of the semi-continuous technique of growing bacteria is the drawing off, at regular intervals, of a portion of the bacterial culture with replacement by an equal volume of fresh sterile growth medium. The bacteria are thus either maintained in an active state of growth or regularly "rejuvenated." The bacterium used was *Desulfovibrio vulgaris* strain Hildenborough (National Collection of Industrial Bacteria No. 8303): a single and well-known strain was used for the sake of reproducibility. Every effort was made to prevent infection by other micro-organisms throughout the experiment.

When the test panels were coated, small "windows" were left uncoated. These were approximately 2 by 12mm in area, and were intended to simulate "holidays" in the coating and provide a means of assessment of the protective action, or otherwise, of the biocides on the bare metal exposed by the windows.

The weighed, coated and sterilized mild steel panels were introduced into the culture vessels before inoculation with bacterial culture. Coated mild steel panels suspended in sterile growth medium served as controls. Following the

Table 2

Reduction in the corrosion of mild steel brought about by additives to a pitch-epoxy coating

Additive	Corrosion (mg dm <sup>-2</sup> )		Corrosion relative to that with standard coating, in culture of sulfate-reducing bacteria
	in culture of sulfate-reducing bacteria	in sterile medium	
Panacide .. ..	26.5	2.7	30
Zinc chromate* ..	29.9	3.4	33
Hibitane .. ..	35.0	3.2	39
Crodazoline O ..	43.3	4.0	48
Morpan CW .. ..	44.2	4.0	51
Morpan TPB .. ..	44.9	4.1	51
TBTO + Arquad B.100	46.3	4.7	54
Duomeen O .. ..	48.2	2.7	54
Armohib 25 .. ..	49.5	3.8	57
Arquad 2C 50 ..	49.6	3.4	57
Triphenyl lead acetate	52.0	3.5	60
Busan 11-M1* ..	56.0	1.4	65
Zinc chromate ..	59.1	2.8	66
CTAB .. ..	61.0	3.2	69
Arquad 2C 75 ..	61.5	2.6	69
Phelam .. ..	62.7	3.7	72
TBTO .. ..	63.6	3.5	72
Arquad B.100 ..	63.8	0.1	72
Duomeen TDO ..	64.1	4.4	72
Duomeen C .. ..	68.8	3.9	78
Busan 11-M1 ..	73.9	3.6	87
Acticide APA ..	81.0	3.5	93
Pentachlorophenol	85.1	2.1	96
None .. ..	87.9	4.0	100

\*Tested in a coating system consisting of hot applied coal tar pitch with glass fibre reinforcement to give a total film thickness of approximately 1mm.

Table 1  
Biocides used in coal tar pitch/epoxy coating

Name	Type	Concentration in coating (per cent wt/wt)
Phelam	Organic mercury compound	1
Pentachlorophenol	Phenol derivative	5
Hibitane	Phenol derivative	0.5
Panacide	Phenol derivative	1
Zinc chromate	Chromate	20
Busan 11-M1	Borate	20
Acticide APA	Fluorinated sulfonamide	2
TBTO	Organic tin compound	5
Triphenyl lead acetate	Organic lead compound	1
CTAB	Quaternary ammonium compound	1
Arquad B.100	" " "	1
Morpan TPB	" " "	1
Morpan CW	" " "	1
Arquad T2C-50	" " "	1
Armohib 25	" " "	1
Duomeen TDO	" " "	1
Duomeen C	" " "	1
Duomeen O	" " "	1
Crodazoline O	" " "	1

tests, the surfaces of the coatings were examined using an electron microscope to detect any signs of attack by sulfate-reducing bacteria. None was found. Weight-loss determinations were made on the panels after removal of the coating in solvent and removal of corrosion products by use of inhibited hydrochloric acid; the results are reported in Table 2. It can be seen that the presence of certain biocides in the coating had a marked effect in reducing bacterial corrosion. The outstanding examples were Panacide and zinc chromate, which caused a reduction in corrosion 30 and 33 per cent respectively of that for the control panels without

additive. Hibitane, giving 39 per cent of the corrosion on the control panels, performed well. On a cost/effectiveness basis, Crodazoline O, Morpan CW and Morpan TPB could prove of interest.

As an extension of the above work, the most promising of the biocide-containing coatings from the weight-loss experiment were tested by a potentiokinetic technique. A schematic illustration of the apparatus is shown in Fig. 1. The coated panel with window was used as the working electrode of the corrosion cell which contained an actively

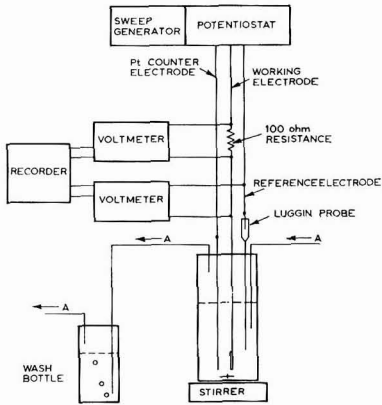


Fig. 1. Schematic diagram of apparatus for potentiokinetic experiments

growing culture of sulfate-reducing bacteria. In the potentiokinetic technique, the applied potential is varied over a given range and the corrosion current generated at the electrode is measured. In the present experiment anodic polarisation was studied. Graphs were plotted of potential ( $E$ ) against the log of the current ( $i$ ). Before each potentiokinetic run was started, the rest potential of the system was determined by allowing the system to equilibrate with its environment of either sterile medium (the control) or actively growing bacterial culture; the process was usually completed in four hours. The stable rest potential provided a base line from which the potentiokinetic run could commence.

A unified theoretical background for much of the electrochemistry has been provided by Pourbaix<sup>19</sup>. Fig. 2 provides

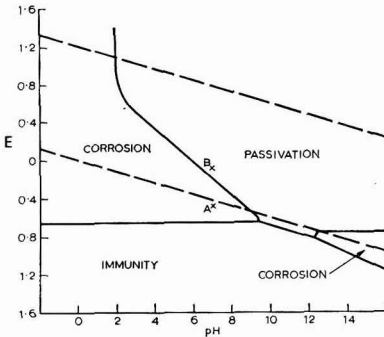


Fig. 2. Theoretical conditions of corrosion, immunity and passivation (after Pourbaix)

a simplified picture of the domains of corrosion, immunity and passivation under various conditions of pH and electrode potential. Low corrosion rates in iron are due to the presence of a passive film of oxide; but such films are normally formed only when either the pH of the surrounding solution or its oxidizing characteristics are such that the thermodynamic state of iron is in the passive region. Fig. 3, the graph of potential against log of the current using an uncoated mild steel electrode in sterile medium, provides a good illustration of the passivation process. Passivation is indicated by a sudden reduction in current after an initial rise. In the con-

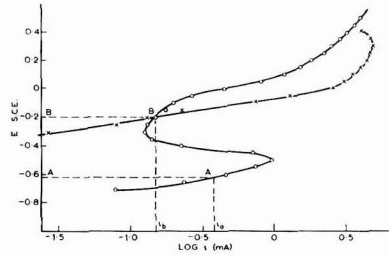


Fig. 3. Graph of potential against log current for mild steel in sterile medium (O) and in a culture of sulfate-reducing bacteria (X)

ditions prevailing in the soil, the corrosion of ferrous metals is, generally, cathodically controlled because of cathodic polarisation; hence the prevalence of pitting attack when a small, almost unpolarised anode is linked to a large though highly polarised cathodic site. If passivation can be achieved, then the reaction is stifled owing to passive film formation.

In the strongly reducing conditions provided by the culture of sulfate-reducing bacteria, it is unlikely that passive films could be developed or maintained except when assisted by a corrosion inhibitor. This is again well illustrated by Fig. 3. The action of anodic inhibitors (for example, oxidising agents such as chromates) is to raise the potential of iron into the passive region and to reinforce the protective oxide film. Line  $A$  in Fig. 3 represents the potential of the system, and the corrosion rate is proportional to  $i_A$ . If a passive film is formed, owing to the presence of an oxidising agent, the potential shifts to  $B$  and the corrosion rate is now proportional to  $i_B$ . Similarly, Fig 2 shows that by increasing the potential of the metal from  $A$  to  $B$ , the metal moves into the passive state. There is a danger in the use of these inhibitors: if the oxidising action is insufficient, there is a generalised increase in corrosion, and, moreover, pitting may occur at weak points in the oxide film.

An examination of the potential against time curve, Fig. 4, for the various coatings in sterile medium, shows that the coating incorporating zinc chromate was initially the most promising, being the only curve to remain close to the theoretical passivation potential. It later fell but remained at a higher level than the other systems. On the basis of maintaining electrochemical passivity, the descending order of effectiveness of the other systems was the coating incorporating B 100, that incorporating Panacide, the standard coating, and uncoated mild steel. The presence of a pre-existing oxide layer on the panels was indicated in each case by the initially higher potential value, quickly falling as the oxide layer disappeared.

Fig. 4, which, in addition, gives the potential/time curves for the various coatings in cultures of sulfate-reducing bacteria, shows that in these strongly reducing conditions the pre-existing oxide layer disappeared almost immediately. The coating incorporating zinc chromate was the only one to approach the theoretical passivation potential, and could be considered a borderline passivator. The standard coating, the coating incorporating Panacide and that incorporating B.100 all gave approximately equal values for potential; uncoated mild steel gave the lowest value.

Fig. 5 shows the potential/log of current for the various coatings in sterile medium. As previously mentioned, mild steel without a coating shows a definite passivation potential. Passivation potentials are also shown by the standard coating and the coating incorporating B.100. No passivation potential



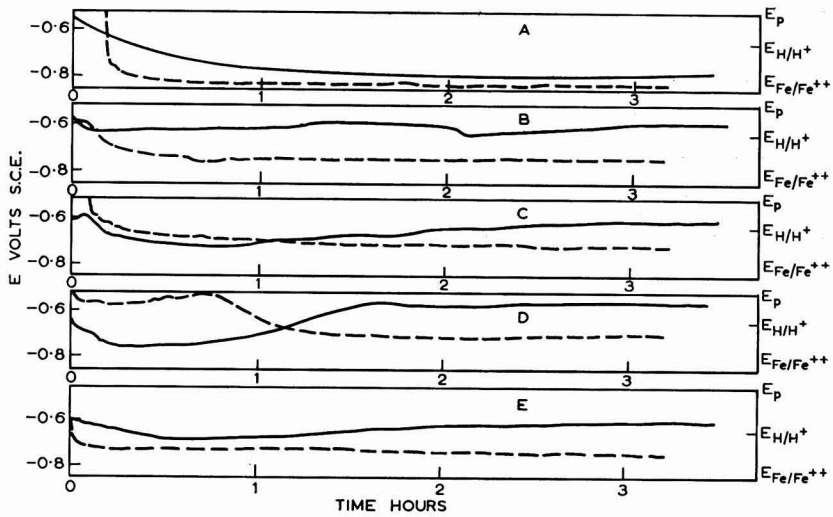


Fig. 4. Graph of potential against time for various coatings in sterile medium (---) and in cultures of sulfate-reducing bacteria (—), A: no coating, B: coating present; no additives, C: coating + B.100, D: coating + zinc chromate, E: coating + Panacide

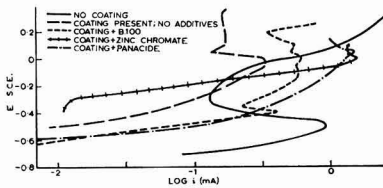


Fig. 5. Graph of potential against log current for various coatings in sterile medium

is shown by the coating incorporating Panacide. The curves for the coating incorporating zinc chromate lead the authors to suspect that the passivation is less than reliable, confirming the danger of this type of passivator.

Fig. 6 shows the potential/log of current for the various coatings in cultures of sulfate-reducing bacteria. The coating incorporating B.100 was the only system giving a passivation potential, this being somewhat lower than the passivation potential of the standard coating in sterile medium, but considerably higher than the passivation potential for the coating incorporating B.100 in sterile medium. These results probably reflect the ability of this strongly adsorbing quater-

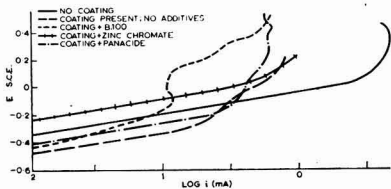


Fig. 6. Graph of potential against log current for various coatings in cultures of sulfate-reducing bacteria

nary ammonium compound to diminish the effect of corrosion on the exposed metal in the window.

**Conclusions**

Potentiokinetic and potential/time techniques appear to be valid methods for improving knowledge of some of the fundamental aspects of the corrosion of coated mild steel. At present, however, these techniques are not reliable as means of predicting results of longer-term weight-loss experiments in the laboratory: a reasonable correlation exists between the potential/time curves and the weight-loss results, but none for the potential/current curves.

Panacide, zinc chromate and Hibitane merit further study, although the authors' experiments suggest that zinc chromate, despite its apparent suitability, may be a dangerous material to use. Highly adsorbable materials, such as Arquad B.100, require more study because they offer potentially effective and safe protection.

**Acknowledgments**

The authors are indebted to Dr C. Rivers for valuable suggestions and discussions, and to the Science Research Council for a Research Grant in support of this work.

[Received 26 January 1973]

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# Developments in antifouling paints\*

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## Summary

The effectiveness of tributyltin oxide (TBTO), tributyltin tetrachlorophthalate (541) and triphenyllead acetate (TPLA) are compared with cuprous oxide. It is shown that cuprous oxide and TPLA are effective only in media containing a high proportion of rosin. The solubility of a biocide in the medium used in the paint is the factor controlling the effectiveness of an antifouling agent.

## Keywords

### Raw materials:

#### binders

rosin adduct  
vinyl resin

TPLA, but none of the other biocides, is effective against the growth of algae.

Suggested formulations are given for antifouling paints based on a vinyl-rosin medium and containing cuprous oxide and TBTO, and on all vinyl medium containing TBTO and TPLA.

### biologically active agents

bactericide  
tributyltin oxide

## Développements dans le domaine des peintures antifouling

### Résumé

On fait comparer l'efficacité de l'oxyde de stanbutyle (TBTO), le tétrachlorophthalate de stanbutyle (541) et l'acétate de plombtriphenylique (TPLA) auprès de celle de l'oxyde cuivreux. On montre que l'oxyde cuivreux et le TPLA sont efficace seulement en milieux qui contiennent une quantité importante de colophane. La solubilité d'un biocide à l'égard du milieu de la peinture c'est le facteur qui détermine l'efficacité d'un agent anti fouling.

Le TPLA, mais pas un d'autres biocides est efficace contre la croissance des algues.

On propose des formulations de peintures anti fouling à base soit d'un milieu vinylique—colophane contenant de l'oxyde cuivreux et du TBTO, soit d'un milieu entièrement vinylique contenant du TBTO et du TPLA.

## Entwicklungen auf dem Antifouling Gebiet

### Zusammenfassung

Die Wirksamkeit von Bistributylzinnoxid (TBTO), Bistributylzinn-tetrachlorphthalat (541) und Triphenylbleiacetat (TPLA) wird mit der von Kupfer—I—Oxid verglichen.

Es wird gezeigt, dass Kupfer—I—Oxid und TPLA nur in Bindemitteln wirksam sind, welche einen hohen Kolophoniumgehalt besitzen. Die Löslichkeit eines Bioxides im für die Farbe benutzten Bindemittel ist der massgebliche Faktor für die Wirksamkeit eines Antifoulingmittels.

TPLA ist—jedoch keines der anderen Bioxide—gegen Algenanwuchs wirksam.

Rezepte für Antifoulingfarben, welche auf Vinyl—Kolophoniumbindemitteln beruhen und Kupfer—I—Oxid und TBTO enthalten, werden angegeben, ebenso für solche mit nur Vinylbindemittel und TBTO sowie TPLA.

## Необрастающие краски и их развитие

### Резюме

Эффективность окиси трибутила олова (TBTO), тетрахлофталата трибутила олова (541) и ацетата трифенила свинца (TPLA), сравнивается с закисью меди. Показано что закись меди и (TPLA) являются эффективными только в средах содержащих высокую пропорцию смолы. Растворимость биоцида в среде применяемой в краске является фактором контролирующим эффективность необрастающего агента.

TPLA, но не другие биоциды, является эффективным против зарастания водорослями.

Предлагаются формуляции для необрастающих красок основанных на винило-смольной среде и содержащих закись меди и TBTO и на сплошной виниловой среде содержащей TBTO и TPLA.

## Experimental

When investigations into organo-metallic antifouling agents were started some years ago, the work was of necessity mainly on an empirical basis. Since that time the results, which could be considered only on a positive or negative basis, have been checked and found to be reproducible.

Table 1 gives the results which were reported at an earlier symposium<sup>1</sup> and upon which it is now possible to give a fuller interpretation.

The antifouling agents used were bis-tributyl tin oxide (TBTO), bis-tributyltin tetrachlorophthalate (451) and triphenyl lead acetate (TPLA), with cuprous oxide for comparative purposes.

\* Presented at the symposium on "Paint performance and the microbiological environment" held by the Manchester Section, 19 and 20 September 1972.

Table 1  
Antifouling action of some organo-metallic agents

Antifouling agent Cu <sub>2</sub> O	Antifouling agent			First growth period			Second growth period			Third growth period			Effectiveness against algae		
	TBTO	541	TPLA	A	B	C	A	B	C	A	B	C	A	B	C
40	—	—	—	0	0	10	—	—	9/4	—	—	9	—	—	—
—	40	—	—	10	10	10	9/3	9/6	9/0	0/8	8	—	—	—	—
—	—	40	—	10	4/0	10	10	—	10	—	—	—	—	—	—
—	—	—	40	0	0	0	—	—	—	—	—	—	—	—	—
20	20	—	—	10	10	10	6	2	10	8	—	10	—	—	—
20	—	20	—	0	6/0	10	—	—	10	—	—	—	—	—	—
20	—	—	20	(9)	0	7	—	—	—	—	—	—	—	(+)	—
—	20	—	—	10	10	9	9	10	9/7	9	9	4/5	+	+	—

The ratings are on a 0 to 10 basis, where 10 means free from any fouling, 9 means free from fouling, except for one or two barnacles on the surface, and 0 means completely covered with fouling. Where two figures are given the ratings are for the two sides of the panel. Panels showing a rating of 8 or less were discontinued. Immersion tests were made at Cuxhaven<sup>2</sup>.

These agents were tested in three different paint systems: (a) chlorinated rubber, (b) vinyl and (c) rosin-vinyl (80 per cent rosin by weight).

All the paints were formulated to have the composition:

	Parts by volume	Percentage by volume
Binder .. .. .	60	43
Filler plus pigment ..	40	28.5
Antifouling additive ..	40	28.5

The details of the formulations used are given in Table 2.

Table 2  
Composition of antifouling paints

	Parts by volume		
	A	B	C
Chlorinated rubber (type 40) ..	288	—	—
Vinyl (90VC, 5V Ac, 5VA) ..	—	292	53
Rosin WW .. .. .	—	—	210
Clophen A-60 .. .. .	18	—	—
Reofos .. .. .	—	18	30
Irgarol SA 39 .. .. .	18	18	4
Red iron oxide .. .. .	270	268	282
Talc .. .. .	158	156	163
	1,000	1,000	1,000
Shellsol A .. .. .	•	•	—
Butyl oleate .. .. .	•	—	—
Xylene .. .. .	•	•	•
Methyl isobutyl ketone .. .. .	—	•	—

The solvents present are given qualitatively. The additives used are not shown.

It can be seen from Table 1 that:

1. Cuprous oxide is effective only when rosin is present in the binder.
2. TBTO is highly effective for one growth period only.
3. 541 gives an excellent result with chlorinated rubber and with the rosin-vinyl binder but not with the vinyl alone.
4. TPLA is not effective alone.

5. TBTO and 541 are effective in combination with cuprous oxide only in the medium rich in rosin.

6. TBTO and TPLA when combined give a long lasting effect in systems formulated on binders free from rosin.

## Discussion

It is not surprising to find that cuprous oxide is effective only in the presence of rosin. The results confirm earlier work<sup>3</sup>. Thus, it would be expected that cuprous oxide is effective in combination with organo-metallic biocides, especially with medium C, but why not in combination with TPLA?

When the results with TBTO (40 per cent) and 541 (40 per cent) are compared, they are similar only with media A and C for the first period, in spite of their both being tributyltin compounds. In combination with cuprous oxide both products differ during the first period, but seem to be identical during the second and third periods. Table 3 compares the properties of the two compounds.

If it is assumed that the tributyltin content is responsible for the antifouling effect, then TBTO should be the more effective, because of its higher tin content, but the opposite is the case. A possible explanation is that 541 is comparable with a phthalate and these are plasticisers, but TBTO is comparable with an ether. Ethers are not plasticisers but are more or less good solvents. If 40 parts by volume of TBTO are added to a paint of 40 per cent PVC a good film is obtained after drying, but if the PVC is reduced to 20 or 0 per cent keeping the amount of TBTO constant, the film becomes sticky and wet. This does not occur with 541 which gives dry films irrespective of the PVC.

TBTO behaves like a solvent and migrates from the film; thus it is highly effective in the first period, but not enough is left in the film for it to be effective in the second period. On the other hand, 541 behaves as a plasticiser and the smaller rate of loss keeps it effective over a longer period.

In combination with cuprous oxide, TBTO is effective in paints free from rosin as it migrates from the film in large amounts, but the system fails after one period because of the lack of TBTO and the ineffectiveness of cuprous oxide in the absence of rosin. Paint C, which contains much rosin, continues to have some biocide in the film to act in the third period. On the other hand, 541 at 20 parts by volume contains

Table 3  
Properties of TBTO and 541

TBTO		541
$\begin{array}{c} \text{C}_4\text{H}_9 \\   \\ \text{C}_4\text{H}_9-\text{Sn}-\text{O}-\text{Sn}-\text{C}_4\text{H}_9 \\   \quad \quad   \\ \text{C}_4\text{H}_9 \quad \quad \text{C}_4\text{H}_9 \end{array}$		
$\text{C}_{24}\text{H}_{34}\text{Sn}_2\text{O}$	Formula	$\text{C}_{32}\text{H}_{44}\text{Cl}_4\text{Sn}_2\text{O}_4$
595	Molecular weight	881
40 per cent	Tin content	27 per cent
1.18	Specific gravity	1.38
47	Tin content g per 100 ml compound	37
Fluid	State at normal temperature and pressure	Solid

too little biocide to give the desired effect. It is only in combination with cuprous oxide and in paint C that a lasting effect is obtained.

Paints containing 541 at 40 parts by volume, made using a binder similar to C but containing 25, 50 and 75 per cent of rosin, showed that 541 is ineffective in a binder which does not contain rosin. Clear lacquers containing a constant amount of 541 but with a varying ratio of vinyl to rosin clearly showed that rosin acts as a solubiliser for 541 and that at least 20 per cent of rosin is necessary to dissolve 541 completely. If the 541 is not completely in solution, it tends to crystallise and is rapidly removed from the surface and subsequent diffusion from the lower parts of the film is too slow to be effective. As has been observed with TBTO, if the antifouling additive is miscible with the medium, the compatibility must be high to prevent loss of the active ingredient.

Recognition of the importance of solubility allows an interpretation of the results obtained with TPLA. The rather peculiar solubility characteristics (Table 4) of this compound explain its ineffectiveness when used alone or in combination with an equal volume of cuprous oxide, but in combination with TBTO it is excellent.

Table 4  
Solubility of TPLA<sup>1</sup> (gm<sup>-1</sup>)

Water	.. ..	0.15
Ethanol	.. ..	5.2
Tetrahydrofurane	.. ..	35
Diethyl ether	.. ..	0.7
Acetone	.. ..	6
Chloroform	.. ..	48
Benzene	.. ..	4.5
Hexane	.. ..	0.4

In the presence of acid, triphenyl-lead compounds are decomposed to diphenyl-lead derivatives<sup>5</sup>, and the acids present in rosin may be the explanation for the failure of TPLA in media containing rosin. TBTO and cuprous oxide

are able to prevent this decomposition to some extent, but paints containing TPLA need greater amounts of this compound to off-set the loss by decomposition in acid media.

### Practical use

The conclusions reached from the work described can be summarised as:

Organo-metallic compounds derived from tributyltin and triphenyl-lead are feasible biocides for use in long lasting antifouling paints.

The solubility of the compounds in the medium used is a most important factor in the performance of an antifouling paint.

Cuprous oxide is not an essential component, and this fact allows the formulation of water resistant media free from rosin.

It is well known that fouling is more severe at the "boot top" areas of ships than at their bottoms and it is in the first named areas, where there is intermittent exposure to the atmosphere, that paint systems based on cuprous oxide and rosin fail both as coatings and as biocides.

The last column of Table 1 gives the results of some tests against algae, and here TPLA is effective when used in conjunction with TBTO in the absence of cuprous oxide and in media which do not contain rosin.

This paper has dealt solely with the biocidal properties of the paints described, but it should be realised that these top coatings may have some effect on the anticorrosive and other properties of the underlying paint. It is of interest to study the suggested antifouling paints with respect to corrosion and so forth irrespective of the substrate to which they are applied.

Two suggested formulations are:

	Based on system B	Based on system C
Vinyl (90 VC, 5 VAc, 5 VA) ..	234	131
Rosin WW .. .. .	—	33
Redfos 65 .. .. .	14	19
Irgarol SA 39 .. .. .	14	2
Talc. .. .. .	125	102
Red iron oxide .. .. .	215	175
Barytes .. .. .	196	160
Cuprous oxide .. .. .	—	316
TBTO .. .. .	77	62
TPLA .. .. .	125	—
	1,000	1,000
Shellsol A .. .. .	175	—
Xylene .. .. .	430	175
Methyl isobutyl ketone .. .. .	430	120

These paints were applied directly to sand blasted steel panels; after ten days they were cross-cut and immersed in artificial sea water. After six weeks' immersion the panels were removed, rinsed with clean water and inspected. The panel painted with system C showed large blisters and

extensive rusting, but system B was as intact as when first immersed and was free from rust. This test stresses the importance of a high build anticorrosive coating under any anti-fouling paint containing cuprous oxide and TBTO in a medium rich in rosin.

[Received 26 January 1973]

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# Protective coatings and wrappings for buried pipes: microbiological aspects\*

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## Summary

The various types of protective coatings and wrappings used on gas mains and services are defined, and tests for assessing their susceptibility to attack by soil micro-organisms are described.

Results of short-term growth tests showed that many simple coatings or wrappings based on coal tar epoxy resins and polyethylene did not support microbial growth, and were sometimes inhibitory towards micro-organisms. More complex wrappings

(containing for example plasticised pvc, acrylic or styrene resins, or bitumen) encouraged growth, which indicated that they might be susceptible to attack. This was confirmed by the results of observations on the condition of wrapping and coating systems buried for some time in soil environments. The importance of using protective materials that are immune to microbial attack in the soil is stressed.

## Keywords

*Types and classes of coatings and allied products*

pipe coating

*Miscellaneous*

anaerobic organism  
biodegradation

## Les aspects microbiologiques de revêtements et d'enveloppes protecteurs pour tuyaux enterrés

### Résumé

On définit les divers types de revêtements et d'enveloppes protecteurs utilisés sur les canalisations de gaz et sur d'autres réseaux de distribution, et l'on décrit des essais pour apprécier leur susceptibilité aux attaques par les micro-organismes du sol.

Les résultats à partir des essais de courte durée ont démontré que plusieurs revêtements ou enveloppes peu compliqués et basés sur goudron d'houille, résines époxydes ou polyéthylène ne supportaient pas la croissance de micro-organismes, et quelquefois la

inhibaient. Les enveloppes plus complexes (contenant, par exemple du CPV plastifié, des résines styrolène ou acrylique ou du bitume) favorisaient la croissance de micro-organismes, ce qui indique qu'ils soient susceptibles à être attaqués. Cela était confirmé par les résultats des observations de l'état des systèmes de revêtement et d'enveloppement qui ont été enterrés pour quelque temps. On souligne l'importance d'utiliser des matières protectrices qui ne sont pas attaquées par les micro-organismes du sol.

## Schutzanstriche und Umwicklungen für Vergrabene Rohrleitungen: Mikrobiologische Gesichtspunkte

### Zusammenfassung

Die an Gashauptleitungen und Ausrüstungen verwendeten Schutzanstrichmaterialien und Umwicklungen werden definiert, und Tests zur Bewertung ihrer Empfindlichkeit gegen Angriff durch Erdmikroorganismen beschrieben.

Resultate kurzfristiger Wachstumsversuche erwiesen, dass zahlreiche einfache Anstrichmittel oder Umwicklungsmaterialien auf Basis von Kohlenteer, Epoxyharzen und Polyäthylen das Mikrowachstum nicht unterstützten und mitunter Mikro-

organismen verhüteten. Kompliziertere Umhüllungen (enthaltend z.B. weichgemachtes PVC, Acryl- oder Styrolharze oder Bitumen) ermutigten das Wachsen, ein Anzeichen dafür, dass sie gegen Angriff empfindlich sein könnten. Dies wurde durch die Resultate von Beobachtungen des Zustandes von Umwicklungen und Anstrichsystemen, die einige Zeit in Erdumgebungen vergraben worden waren, bestätigt. Die Wichtigkeit der Anwendung von schützenden Materialien, die gegen Mikrobenangriff im Boden immun sind, wird betont.

## Защитные покрытия и обертки для подземных труб: микробиологические аспекты

### Резюме

Определяются различные типы защитных покрытий и обертки применяемых для газовых труб и обслуживания и описываются испытания для оценки их восприимчивости к атакам микроорганизмов почвы.

Результаты кратковременных испытаний роста показывают что многие простые покрытия и обертки основанные на каменноугольной смоле, эпоксидных смолах и полиэтилене, не поддерживают рост микробов и оказались иногда тормозящими

агентами по отношению к микроорганизмам. Более сложные обертки (содержащие например пластифицированную пигментную объемную концентрацию, акриловые или стироловые смолы, или битум) способствовали росту, что указывает их чувствительность к атаке. Это подтверждалось результатами наблюдения состояния обертки и покрытий погруженных на некоторое время в почвенную среду. Подчеркивается важность применения защитных материалов устойчивых против атак почвенных микробов.

\* Presented at the symposium on "Paint performance and the microbiological environment" held by the Manchester Section, 19 and 20 September 1972.

## Introduction

Unprotected metal buried in British soils is often severely damaged by anaerobic bacterial corrosion. This form of corrosion causes extensive pitting of steel and graphitisation of cast iron, and is, therefore, of considerable economic importance. It has been studied extensively since von Wolzogen Kühr and van der Vlugt<sup>1</sup> and Starkey and Wight<sup>2</sup> first implicated sulfate-reducing bacteria, but the mechanisms involved are still not completely understood. The process can be described as electrochemical corrosion accelerated or aggravated by the activities of sulfate-reducing bacteria, although other organisms may contribute as well. Sulfate-reducing bacteria flourish in poorly aerated soils, like water-logged clays (where anaerobic corrosion is most severe), and use hydrogen that accumulates at cathodic areas of the metal to reduce sulfate in the soil to sulfide. The depolarisation of the cathode causes more metal ions to enter into solution at the anode, and corrosion products are formed by reactions between the dissolved iron and sulfide produced during the bacterial reduction of sulfate. This theory of anaerobic bacterial corrosion is generally accepted, although the possible reactions in the vicinity of buried metal are very complex.

All authorities (for example, water undertakings, gas boards, oil companies) that bury pipes or other metal objects are concerned at some time or another with the effects of anaerobic corrosion. The costs of repairing and replacing corroded pipes, as well as the cost and potential hazards of lost products, are high. Although bare cast iron pipe has been known to survive in immaculate condition for 60 years or more, severe corrosion occurs in some environments in as short a time as one to two years, such is the variation in soil conditions in Great Britain. It is thus advisable, or even essential, for buried iron and steel to be protected in some way.

Measures for protecting pipes against corrosion include:

(a) The application of wrappings or coatings to the metal, to isolate it from the corrosive components of its environment (that is, soil water, gases and other chemicals and micro-organisms).

(b) The use of sacrificial anodes or the application of impressed current. Cathodic protection systems are widely employed, usually in conjunction with pipe wrappings or coatings, since to maintain uninsulated pipe at the correct potential would require too much current, and so be too costly. With coated or wrapped pipes, the cathodic protection system only comes into operation if there is a break in the coating or wrapping.

(c) The use of artificial "backfills." After a pipe has been laid, it is sometimes surrounded by a non-corrosive, relatively inert material (for example, sand, chalk or gravel) instead of the original soil. Such backfills help to maintain aerobic conditions and good drainage around the pipe, and prevent contact of the pipe with potentially aggressive soil. The backfill can be impregnated with a biocide, but information on the success of this method is limited.

## Coatings and wrappings for buried pipes

Pipelines, mains and services carrying gas are expected to last for at least 35 to 40 years; in most instances, they last very much longer. They are usually coated or wrapped, and

are often protected cathodically as well. Sometimes they are surrounded by a non-corrosive backfill.

The distinction between coatings and wrappings is not easy to define. Some coatings, but not all, are thinner than wrappings. Thin coatings can be applied to pipes by dipping, flood-coating, painting by brush, spraying or electrostatic deposition; they are normally, but not always, applied in the factory where the pipes are produced. Thicker coatings can be applied by continuous extrusion methods, or by a combination of flooding with hot molten material accompanied simultaneously by wrapping with a reinforcing fabric. Whether the coating is thick or thin, it is normally applied as a continuous film to the whole of each pipe section with the exception of a few inches at each end, where the pipe sections are joined or welded together just prior to or during pipe-laying.

Wrappings are prefabricated tapes or bands of material that are applied to pipe or joint areas by hand or machine, either spirally or longitudinally in discrete layers. Some of these materials are very thin and self-adhesive, whilst others are thick and "goeey"; many have to be used with a special primer. Wrappings are most frequently used on joints or weld areas of factory-coated pipes, but if necessary they can be applied to the whole of a pipe. They are normally applied spirally, with an overlap of at least 50 per cent of their width, so that the underlying metal is protected by two or more layers of material.

Joint or weld areas are usually wrapped in the field by hand, although machines can be used. Field-wrapping of large diameter pipe by machine is only feasible and economic if the pipe is to be laid across large stretches of land in open country. Suitable machinery is used in the USA for example, but seldom in the British Isles. Joint areas can be flood-coated in the field by a technique involving the simultaneous application of molten material and reinforcing material.

Until quite recently, the number of different types of coatings and wrappings available in Great Britain was comparatively small. However, in the last five years the number of manufacturers offering products for protecting buried pipes has probably trebled, and the choice facing pipeline engineers is bewilderingly large. It is particularly disturbing, however, that many of the newer firms have little conception of what is required, and do little or no evaluation of their products themselves.

The types of coatings and wrappings used and the ways in which they are applied are listed in Table 1.

## Coating and wrapping failures

If pipes are to function for many years, it follows that coatings and wrappings applied to protect them must also survive intact for a similar period of time. Often, however, they do not survive, and there is ample evidence to show that severe corrosion occurs frequently on the metal underneath coatings or wrappings that have failed.

No protective material, however good basically, will perform well if it has been badly or incorrectly applied. Usually, it should be applied to clean dry metal (primed if necessary) to the correct thickness, overlap and so forth, in a manner recommended by the manufacturer and agreed upon by the purchaser. In many cases, specifications are drawn up to cover all these aspects, as for example in the use of coal tar enamels (British Standard 4164 : 1967;<sup>3</sup>



Table 1  
Coatings and wrappings that can be used to protect buried pipes

Protective system	Region to which system can be applied	Method of application
<b>Thin coatings (&lt; 15 thou thick)</b>		
Coal tar .. .. .	Pipe body, in the factory	Dipping, painting by brush
Bitumen .. .. .	Pipe body, in the factory	Dipping, painting by brush
Epoxy resin .. .. .	Pipe body, in the factory	Spraying, electrostatic deposition
Vinyl copolymer paint .. .. .	Pipe body, in the factory or in the field	Painting by brush or roller
<b>Thick coatings (&gt; 20 thou thick)</b>		
Coal tar enamel, reinforced .. .. .	Pipe body, in the factory Weld areas, in the field	Flooding and wrapping
Bitumen enamel, reinforced .. .. .	Pipe body, in the factory Weld areas, in the field	Flooding and wrapping
Polyethylene cladding .. .. .	Pipe body, in the factory	Flooding and wrapping
Polyethylene sleeving, adhesive .. .. .	Joints or weld areas, in the field	Extrusion over mastic Shrinkage by heat
<b>Thin wrappings (&lt; 20 thou thick)</b>		
Pressure-sensitive self-adhesive tapes (pvc, pe, etc.) .. .. .	Joints and weld areas usually, in the field; pipe body sometimes, in the field. Sometimes also used as overwraps	Wrapping, spiral or longitudinal, by hand or machine. Primer necessary sometimes
Loose polyethylene sleeving .. .. .	Whole length of pipe, including joints, weld areas etc., in the field	Total envelopment, by hand
Overwraps (usually pvc) .. .. .	Over other wrappings and coatings, in the field, to prevent mechanical damage to pipe body and joint and weld areas	Wrapping, usually spiral and by hand
<b>Thick wrappings (&gt; 40 thou thick)</b>		
Laminated tapes containing polymers, glass fibre, rubbers, resins, bitumen .. .. .	Joints, weld areas etc., in the field; pipe body sometimes, in the field	Wrapping, spiral or longitudinal, by hand or by machine. Primer is sometimes necessary
Tapes containing polymeric, glass or natural fibre carriers and petrolatum or coal tar .. .. .	Joints, weld areas etc., in the field; pipe body sometimes, in the field	Wrapping, usually spiral, by hand or by machine
Overwraps (usually pvc) .. .. .	As for thin overwraps	Wrapping, usually spiral and by hand

American Water Works Association Standard C203-66<sup>4</sup>). Generally, of the systems applied in the field, the best are those that are relatively easy to apply correctly even by relatively unskilled personnel, in inclement weather and under other adverse conditions. Precautions are taken both in the factory and in the field to ensure that there are no "holidays" in coatings and wrappings; adequate supervision is most important as, apart from errors in application, wrapped or coated pipes can be mechanically damaged during pipe-laying (that is, during the lowering of the pipe into the trench (ditching) or during backfilling after ditching).

Once a coating or wrapping has been correctly applied, and the pipe has been laid, the protective system must continue to be effective. Conditions underground vary widely and are not necessarily stable; radical changes can and do occur. Coating and wrapping materials must tolerate seasonal and other variations in the temperature and water content of the surrounding soil; they must withstand soil movement and subsidence, contact with stones or other objects capable of damaging them physically, attack by soil chemicals or micro-organisms, and on occasions attack by insects and rodents, and even damage by plant and tree roots. Under all these circumstances, a successful coating or wrapping retains its strength, its impermeability to water and its other special characteristics. It must not crack or lose bond with the pipe surface, nor with itself if it was applied with an overlap.

Reasons for failure of coatings or wrappings are often extremely difficult to determine. Frequently there is neither the time nor the opportunity to investigate, especially as studies of what happens in the field really need a mixed-discipline team of investigators; this is sometimes overlooked, and engineers, electrochemists, chemists, physicists and microbiologists too often tend to work alone.

The biggest single cause of coating and wrapping failure is probably incorrect application. On the other hand, properly applied protective systems can fail. The reasons might be electrochemical, chemical, physical, mechanical or microbiological, or a combination of some or all of these factors; rarely is the cause of failure clear-cut.

To say that failures can often be attributed to microbiological causes would be most misleading and would immediately alienate most pipeline engineers and chemists, who are only too aware of the complex nature of the problem. On the other hand, it would be equally incorrect and naive to assume that micro-organisms are never involved; they certainly do contribute sometimes, if only for the very good reason that material known to be vulnerable to microbial attack has been used to protect buried pipes. For example, coatings and wrappings used during the first half of this century often contained susceptible natural fibres like cotton and hessian. Recently-developed products are not necessarily any better, although some may resist microbial attack because they contain specific synthetic or inert materials, or biocides.

#### Susceptibility to microbial attack

Although it is obviously important that pipe coatings and wrappings should not be attacked by soil micro-organisms, it is surprising how little thought is given to this requirement, either by the manufacturers or by the users of the materials concerned. Sometimes only the manufacturer knows the exact chemical composition of his product, and microbiological considerations are often ignored altogether during assessment of the suitability of coatings and wrappings for use on pipes. Even when a manufacturer does claim that his product is resistant to microbial attack, little is done to substantiate or disprove his claim.

The present paper reports work that has been and is being done by a very small team (a) to assess the susceptibility of pipe coatings and wrappings used by the gas industry to microbial attack, and (b) to determine the part played by micro-organisms in failures of these protective materials in the field.

There are basically two approaches. In the first, short-term or medium-term laboratory experiments are used to determine the effects of micro-organisms on coatings and wrappings. Some tests show whether these materials or their constituents support microbial growth or enhance microbial respiration rates; other tests show whether the materials lose or gain weight in the presence of growing micro-organisms and whether or not they weaken. These tests can be done with pure or mixed cultures of micro-organisms. The second approach involves medium-term and long-term exposure of the materials in actual or artificial soil environments. This approach might require planned experiments, but it can also take advantage of samples of coatings and wrappings from the field, submitted for examination to ascertain the cause of failure.

## Experimental

### Laboratory tests

#### Micro-organisms

The nine pure cultures used for laboratory tests included three species of bacteria, two species of yeasts, two species of actinomycetes and three species of fungi. Three of the cultures were obtained from culture collections; the others were isolated at the London Research Station. They were chosen because they can be found in soils, or because they have properties (for example, the ability to oxidise aromatic compounds or resins) that suggested they might degrade pipeline materials. Cultural and other details about the test organisms are given in Table 2.

#### Growth tests in liquid media

Ability to support growth was tested in liquid media containing mineral salts but no carbon source except for pipe coating or wrapping and any carbon dioxide dissolved in the medium.

Wrappings or coatings were broken into small fragments or cut into pieces approximately 1mm square. Samples (250mg) of cut or broken material were introduced into 100ml conical flasks each containing 50ml of medium; for test with fungi, the weight of test material introduced to each flask was increased to 1g. Primers, coating and adhesives were painted on to glass slides, which were allowed to dry or cure for 48 hours before they were placed in the media.

For each test, two flasks contained the basal medium and the appropriate coating or wrapping, and two control flasks contained the basal medium only. The flasks were inoculated with the test organisms and incubated at 30°C for one month. During this period, growth (or death) of bacteria, yeasts or actinomycetes was followed by counting at weekly intervals the numbers that had survived. Growth of fungi was assessed by weighing the mycelium that had developed after one month.

Full details of media and methods have been given previously (Pankhurst *et al.*<sup>5</sup>).

#### Weight loss tests

Coatings and wrappings were cut into pieces about 2cm square. These pieces were conditioned for 36 hours (24°C relative humidity 65 to 70 per cent), weighed and placed in dishes containing 25ml of liquid mineral salts medium with no other source of carbon. Except for very sticky materials, three samples were placed in each dish with their outer surfaces uppermost, and three with their inner surfaces uppermost; some samples floated, others sank. The six pieces in any one dish were distinguished from one another by means of small irregularities in shape. For each material tested, three dishes containing medium and wrapping or coating were prepared. One was inoculated with the test organisms, and two were left uninoculated, as controls. One control contained mercuric chloride (1 per cent, w/v), to ensure that it remained sterile, as difficulties with cross-contamination between dishes were foreseen.

After ten weeks at 30°C, dishes were examined for growth in the liquid and on the test material; checks were made for

Table 2  
Micro-organisms used in laboratory tests with coatings and wrappings

Organism*	Reason for choice as test organism	Test inoculum from:
<i>Pseudomonas aeruginosa</i> .. .. .	Isolated from effluent containing aromatic compounds	2-3 day cultures on <i>Oxoid</i> nutrient agar
<i>Pseudomonas resinovorans</i> (NCIB‡ 9280)	Utilises oily resins	—
<i>Serratia marcescens</i> (NCIB‡ 9523) ..	Caused pink colour in copolymer preparation	—
Yeast species 1 (unidentified) .. ..	Isolated† from pink-stained pvc tubing	7 day cultures on <i>Oxoid</i> wort agar
Yeast species 2 (unidentified) .. ..	Isolated† from medium containing adhesive tape	—
<i>Actinomyces</i> species 1 (unidentified) ..	Isolated† from soil	7 day cultures on Bennett's agar (Jones <sup>6</sup> ) modified by using tryptone (Difco) instead of NZ amine
<i>Streptomyces rubrireliculi</i> (CMI‡ 101,524)	Found on pvc sheeting	—
<i>Aspergillus niger</i> .. .. .	Isolated† from medium containing adhesive tape	7 day cultures on <i>Oxoid</i> wort agar
<i>Aspergillus fumigatus</i> .. .. .	Isolated† from neoprene latex	—

\* All cultures were regularly subcultured on the appropriate media at 30°C.

† Isolated at the London Research Station of the Gas Council.

‡ NCIB = National Collection of Industrial Bacteria; CMI = Commonwealth Mycological Institute.

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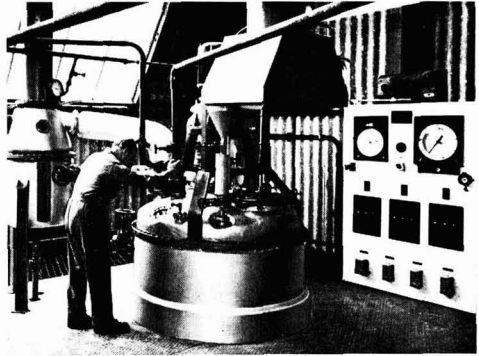
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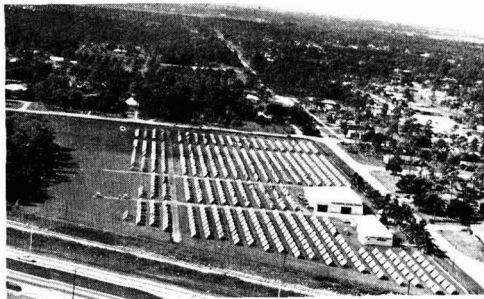
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contamination. The test pieces were removed, washed, dried and conditioned (for 36 hours at 24°C, relative humidity 65 to 70 per cent). They were then weighed, and the results compared with the pre-test weighings.

*Respirometric experiments*

The ability of some coatings and wrappings to stimulate oxygen uptake by resting cell suspensions was measured manometrically over a period of 48 hours. The indirect method of Warburg (Umbreit, Burris and Stauffer<sup>6</sup>) was used, and tests were duplicated (Pankhurst *et al.*<sup>9</sup>).

**Field observations**

A small number of coatings or wrappings that were suspected to have failed in the field were examined. As much information as possible was obtained about the history of the coating or wrapping, together with details of any observations made about the condition and appearance of the material when it was first exposed during the associated excavations. Rarely was it possible for the author to be on site when the material was retrieved. The next step was to determine what type of coating or wrapping had been used. This was not nearly so straightforward or easy as it sounds because not only were a great many different types of protective material used over a period of many years but, until recently, no precise information about such materials was available. Moreover, sometimes the situation was complicated by the fact that two different tapes had been used together. In such cases, the different layers were peeled apart, the degree of adhesion and overlap noted, and sometimes simple chemical tests were done to determine the nature of the reinforcing material or carrier.

Once the type of protective system had been ascertained, samples were very carefully inspected for any visible signs of deterioration, deposits or growths. During inspection care was taken to remember which side was uppermost when the material was in position on the pipe, and which side was in contact with the pipe surface. Samples were examined under the microscope for deposits, signs of fungal mycelium or fruiting bodies.

*Microbiological examinations*

Although there are always micro-organisms associated with coatings and wrappings (especially on surfaces in contact

with soil), it was considered worthwhile doing some cultural examinations. The purpose of such examinations was to determine, if possible, the types and relative numbers and distribution of micro-organisms on the protective materials, and to ascertain, if possible, whether or not their presence was adventitious, and whether they were having a harmful effect.

Three different procedures were tried for cultural work. Firstly, subcultures were made from the surfaces of coatings or wrappings on to nutrient agar, wort agar or Bennett's agar, using an inoculating needle or a swab of some kind. Secondly, portions of the material under examination were pressed firmly on to the surface of agar media; the material was held in position for a few seconds only, and then removed. Thirdly, impressions were taken from the surfaces of the coatings or wrappings with thin pressure-sensitive adhesive pvc tape sterilised in an autoclave. The tape was firmly pressed for a few seconds on to the sample being examined, and then removed. It was then itself pressed on to the surface of successive agar plates, so that the number of organisms left behind on the agar surface with each impression became progressively less. The same techniques were used occasionally for pipe surfaces.

Whichever method was used, plates were incubated for three to seven days and then examined. It was not possible to identify all the organisms that grew, but colony colour and size were used to distinguish between major groups of micro-organisms. In some cases, it was reasonably easy to identify the genus of an organism if growth was examined microscopically as well.

Sometimes, soil samples from the vicinity of the pipe and coating or wrapping were obtained as well; if time permitted they were examined for sulfate-reducing bacteria.

**Results**

*Growth tests*

The tests for ability to support growth proved very sensitive and reproducible. The contrast between the results for coatings and the results for some of the wrappings is immediately obvious (Tables 3 and 4, and Fig. 1). Coating materials like coal tar, epoxy resins and polyethylene supported little or no growth; in most cases (Fig. 1 A-C) they were definitely

Table 3  
The effects of pipe coatings on growth of test micro-organisms

Substrate	Stimulation or inhibition of growth after 28 days								
	<i>P. aeruginosa</i>	<i>P. resinovorans</i>	<i>S. marcescens</i>	Yeast 1	Yeast 2	<i>Actinomyces</i> 1	<i>S. rubrireticuli</i>	<i>A. niger</i>	<i>A. fumigatus</i>
High density polyethylene sleeving ..	0	0	0	0	0	=	0	0	0
Rubber/rosin mastic used with above	0	++	++	0	0	0	0	0	0
Heat-shrinkable polyethylene sleeve plus mastic .. .. .	0	+	-	NT	0	-	0	0	0
Vinyl copolymer paint .. .. .	0	0	=	0	-	=	0	0	0
As above, but with biocide .. .. .	=	=	=	=	=	=	0	0	0
Coal tar enamel 1 .. .. .	=	=	=	=	=	=	0	0	0
Coal tar enamel 2 .. .. .	=	=	=	=	=	=	0	0	0
Coal tar enamel 3 .. .. .	=	=	=	=	=	=	0	0	0
Coal tar enamel 4 .. .. .	=	=	=	=	=	=	0	0	0
Primer containing coal tar for use with 4 .. .. .	=	=	=	=	=	=	0	0	0
Synthetic primer for use with 4 .. .. .	0	0	-	0	=	0	=	0	0
Epoxy resin/coal tar coating .. .. .	=	=	=	0	0	=	0	0	0

0 no effect.  
 - a little inhibition.  
 = some inhibition.  
 = pronounced inhibition.  
 + a little growth.  
 ++ some growth.  
 NT not tested.

Table 4  
The effects of pipe wrappings on growth of test micro-organisms

Substrate	Stimulation or inhibition of growth after 28 days								
	<i>P. aeruginosa</i>	<i>P. resinovorans</i>	<i>S. marcescens</i>	Yeast 1	Yeast 2	<i>Actinomyces</i> 1	<i>S. rubrireticuli</i>	<i>A. niger</i>	<i>A. fumigatus</i>
Pvc wrapping, thin .. .. .	+	++	0	0	0	-	0	+(s)	0
Pvc wrapping, thick .. .. .	++	++	0	0	0	0	0	+(s)	0
Pvc tape, pressure-sensitive adhesive .. .. .	+++	+++	+++	NT	NT	NT	NT	NT	NT
Pvc/glass fibre/resin/pitch tape .. .. .	+++	+++	+++	0	0	+	+	+	0
Pvc/petrolatum tape .. .. .	++	++	++	0	0	+	+	+(s)	++(s)
Polypropylene/acrylic fibre/petrolatum tape .. .. .	+	+++	++	0	0	++	++	++(s)	++(s)
Pvc/butyl rubber tape plus biocide .. .. .	0	0	0	0	0	0	0	+(s)	0
Butyl rubber tape plus biocide .. .. .	0	0	0	0	0	-	0	0	0
Polyethylene tape, pressure-sensitive adhesive .. .. .	0	++	0	0	0	-	0	0	0
Polyethylene/rubber/bitumen wrapping .. .. .	++	++	+	0	0	0	+	+(s)	+(s)
Polypropylene/rubber/bitumen wrapping .. .. .	++	++	+	0	0	0	0	+(s)	+(s)
Nylon/coal tar tape .. .. .	-	-	+	-	0	≡	-	0	0
Nylon/coal tar wrapping .. .. .	-	=	≡	-	-	≡	-	0	0

0 no effect.  
- a little inhibition.  
= some inhibition.  
≡ pronounced inhibition.  
+ a little growth.  
++ some growth.  
+++ pronounced growth.  
NT not tested.

inhibitory towards the test micro-organisms. On the other hand, the more complex wrappings containing plasticised pvc, acrylic or styrene resins, polyethylene and polypropylene (examples are shown in Fig. 1 D-E) often encouraged growth. Tests with individual constituents usually showed that non-polymeric materials were responsible for the increased growth. In the case of pvc, the plasticisers and other additives were the culprits, whereas for polyethylene and polypropylene, materials like bitumen mixed with them were responsible (Pankhurst and Davies<sup>7</sup>; Pankhurst *et al.*<sup>5</sup>). Wrappings containing coal tar and nylon, or tapes to which efficient biocides had been added (Fig. 1F) caused marked inhibition of growth.

In most cases where protective materials had had a stimulatory effect on the test organisms, bacteria were encouraged to grow most, followed by fungi and actinomycetes; yeasts remained for the most part unaffected.

#### Weight loss tests

Unfortunately, cross-contamination between dishes occurred readily, and dishes without mercuric chloride, but supposed to be sterile, became contaminated. Although it was difficult to draw precise conclusions about the effects of the micro-organisms, the results gave useful information about water absorption. Statistical analysis showed that of the 14 materials tested, five gained weight significantly and six lost weight significantly; in three cases there were no significant gains or losses.

The materials that gained weight were all wrappings that contained bitumen or coal tar. Increase in weight was attributed to absorption of water by these components from the medium, as it also occurred in the sterile controls containing mercuric chloride. In the field, water absorption might seriously affect the performance of a material, for example by causing it to swell or lose bond with the pipe; so much

water might be absorbed that the surface of the pipe become wet.

The materials that lost weight included many of the wrappings containing pvc or petrolatum. Loss of weight may have been caused by migration of a soluble constituent of the wrapping into the medium, or by utilisation of one or more constituents during growth of the test organisms. Comparison with the controls containing mercuric chloride showed that in most cases extensive microbial growth had occurred, and this could explain the decrease in weight; growth of fungi and bacteria (especially of *Aspergillus fumigatus* and *Serratia marcescens*) was particularly marked. In other cases, the causes of weight loss were not clear, although removal of adhesive from sticky materials during handling almost certainly played a part.

#### Respirometric experiments

The results of manometric tests are not given in detail as they proved of value only for very simple materials (the individual constituents of coatings and wrappings). When complex coatings or wrappings were used as substrates, the results were extremely difficult to reproduce.

#### Field observations

A summary of the results of examinations of various coatings and wrappings is given in Table 5. The conclusions reached about microbiological participation in deterioration are necessarily subjective; there are many difficulties in doing this type of assessment. Seven coating or wrapping systems were included in this survey; only in two of these was it suspected that micro-organisms were playing a part in the failure of the system. Nevertheless, it is important that many more samples from the field should be examined in this way. Examples of corroded pipes and damaged wrappings and coatings are shown in Fig. 2.

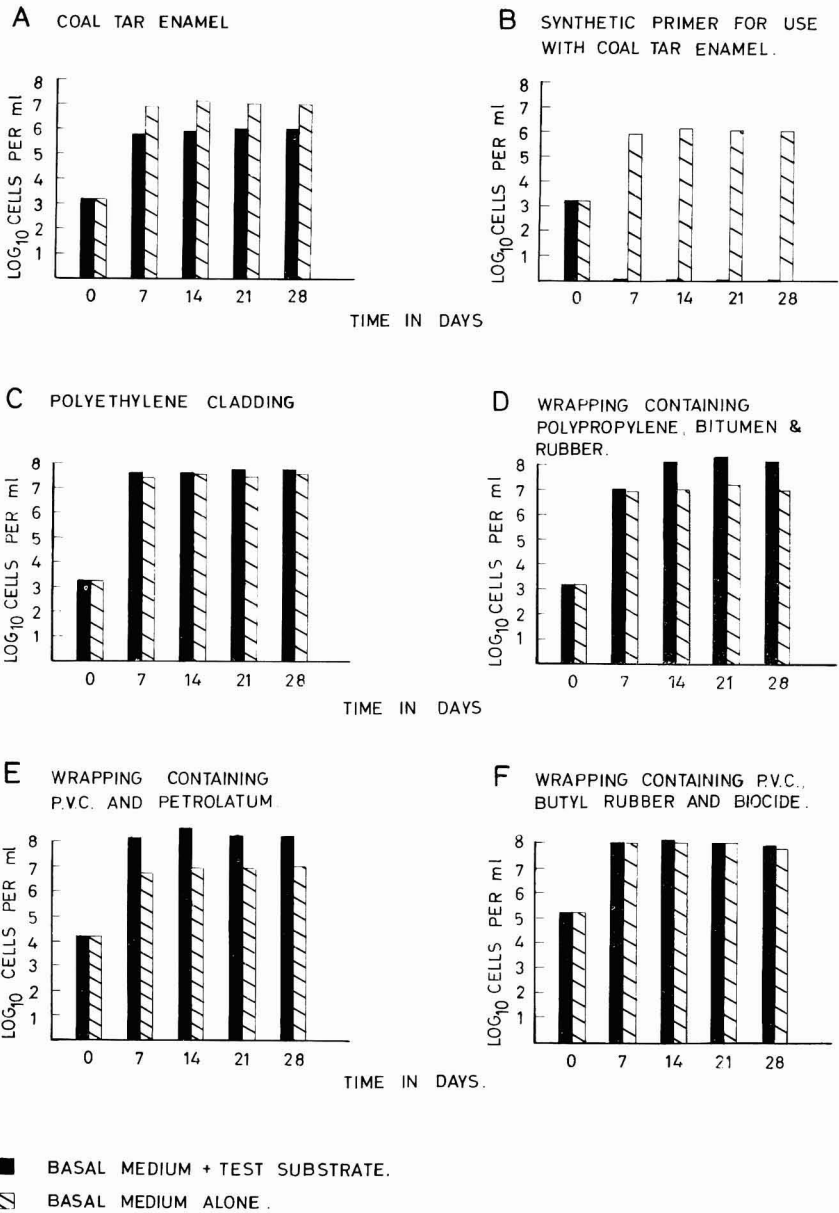


Fig. 1. The effects of different coating, wrapping and priming materials on the growth of *Pseudomonas resinovorans* in a medium of mineral salts containing no other source of carbon

Table 5  
Results of examinations of samples from the field

Type of protective material	Reason for retrieval	Comments	Microbiological findings	Microbiological involvement in failure
Coating: bitumen reinforced with glass fibre	Cathodic protection ineffective	Coating completely disbonded. Surfaces discoloured by ground water. Glass fibre too close to inner surface	Isolations from inner surface: 9 bacterial spp. (mostly <i>Bacillus</i> and <i>Pseudomonas</i> )—none utilised bitumen in Warburg; 3 fungi	Dubious
Wrapping: cotton with petrolatum	As above	Carrier still strong, little petrolatum left	Isolations: 9 bacterial spp., 2 fungal spp.	Probable
Coating: bitumen reinforced with hessian	Disbonding on a syphon	Hessian disintegrating, very close to contact surface	Isolations (inner surface): 11 bacterial spp. (including <i>Bacillus</i> sp.)—3 definitely utilised bitumen; 5 may have done, 3 did not. Also isolated—3 fungi	Yes
Wrapping: inner pvc pressure-sensitive adhesive tape; outer bitumen/asbestos fibre tape	Perforated mild steel pipe	Wrapping obviously damaged; loss of bond also	Fungal growth evident. Isolations, inner and outer surfaces: 12 fungal spp. (including <i>Penicillium</i> , <i>Fusarium</i> and <i>Pestalotia</i> ), 2 <i>actinomycetes</i> , 1 yeast (media for bacteria not used)	Yes, with mechanical damage. Evidence of anaerobic corrosion under wrapping
None: soil sample only	Fractured cast iron pipe	Clay soil	Contained sulfate-reducing bacteria ( <i>Desulfovibrio</i> and <i>Desulfotomaculum</i> )	Yes (corrosion)
(a) Coating: bitumen reinforced with hessian	Fractured mild steel pipe	Coating worn away or torn; no disbonding	Isolations: mainly <i>Bacillus</i> spp. Also gram-ve rods (including <i>Pseudomonas</i> spp.); very few fungi, no <i>actinomycetes</i> , 1 yeast	(a) No
(b) Soil	—	Heavy wet clay	Sulfate-reducing bacteria found	(b) Yes (corrosion)
(a) Coating: bitumen reinforced (glass fibre?)	Chance inspection welded mild steel pipe	Waterlogged soil; superficial cracks in coating	Isolations (cracked and uncracked external areas similar): <i>Bacillus</i> spp., gram-ve rods, 3 fungi; fewer but similar spp. on inner surface	(a) No
(b) Wrapping on joint; pvc adhesive tape plus bitumen/glass fibre wrap	—	Overwrap cracked and crumbling. Inner wrap: adhesion lost	Isolations: No obvious differences between cracked and uncracked areas. Organisms similar to those on (a). Possibly more ( <i>Bacillus</i> spp.)	(b) No
(c) Soil from vicinity	—	—	10 <sup>5</sup> -10 <sup>6</sup> sulfate reducers/gm of soil	(c) Yes (corrosion)



Fig. 2. Examples of corroded pipes and damaged wrappings and coatings



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## Discussion

The results of short-term laboratory tests suggest that protective coatings for buried pipes are less likely to be susceptible to microbial attack in soil than materials used as protective wrappings. The main reason for this is probably that coatings tend to be simpler in composition than wrappings, and they often contain materials that inhibit or do not affect microbial growth; examples are coatings based on coal tar, epoxy resins and polyethylene. Possible exceptions are coatings based on bitumen, which were not tested in the course of the present work. Wrappings that are potentially vulnerable to attack are those containing bitumen, petrolatum and plasticised pvc; those containing coal tar, biocides, polymers without additives or constituents incapable individually of supporting microbial growth are as satisfactory as some of the coatings.

These conclusions are based on determinations of the ability of coatings and wrappings to support growth of bacteria, actinomycetes, yeasts and fungi in tests lasting four weeks. Other short-term tests, to determine changes in weight of materials incubated with micro-organisms and changes in microbial respiration rates in the presence of these materials were not as useful nor as reliable as tests for growth.

Growth tests to evaluate susceptibility of pipe coatings and wrappings to microbial attack can be criticised on the grounds that the results obtained in the laboratory, with pure cultures of micro-organisms, do not necessarily represent what will happen in a soil environment; moreover, the results of tests lasting only 28 days cannot be expected invariably to predict what will happen to materials buried for several years. Nevertheless, the results obtained from the work are supported not only by reports in the literature about susceptibility of different materials individually, but also to a certain extent by the limited amount of information from the author's own field observations, and by those of other people. The author hopes to obtain further support for her results from experiments with pipe wrappings and coatings buried in soil at an experimental site for about two years; this work will include tests for any changes in mechanical and other properties.

The author believes that, within the limitations outlined above, short-term growth tests for evaluation of protective systems are of value. It is not feasible to perform tests lasting several years before accepting or rejecting every new material that appears on the market. Nevertheless, whenever possible, laboratory work should be supported by longer term field tests and observations.

It should be stressed that susceptibility to microbiological deterioration is not the only criterion for choosing pipe coatings or wrappings. Neither are microbiological factors the only ones contributing to failures of protective systems in the field.

## Acknowledgments

The author wishes to thank Mrs M. J. Davies, Miss H. M. Blake, Miss S. A. Masters, Mrs A. M. Treasure and Mr K. Allan for all their hard work in connection with this project. This paper is published by permission of the British Gas Corporation.

[Received 26 January 1973]

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# The occurrence and control of moulds and algae on paints\*

By P. Whiteley

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## Summary

A description of the ways in which moulds and algae affect buildings, especially painted surfaces, and of some of the factors which promote or control their growth are mentioned. Design details, such as avoidance of water runs or water retentive surfaces externally, and of conditions leading to condensation internally,

are at least as important in controlling growth as the formulation of paints and the use of biocidal additives. The effects of fungicides are sometimes inconsistent and disappointing in practice, even after extensive testing.

## Keywords

*Types and classes of coatings and allied products*

top coat

*Types and classes of structures or surfaces to be coated*

masonry

*Miscellaneous*

biodeterioration

## L'occurrence et le contrôle des moisissures et des algues sur peintures

### Résumé

On décrit les moyens par lesquels provoquent les moisissures et les algues l'altération des bâtiments et surtout leurs surfaces peintes, et d'ailleurs certains facteurs qui favorisent ou qui contrôlent leur croissance. Les détails de la construction tels que la nécessité d'éviter des cours d'eau pluviale sur la façade extérieure et d'assurer que la surface de celle-ci ne retienne pas d'eau pluviale, et également

d'éviter à l'intérieure les conditions qui favorisent la condensation d'humidité, ce sont aussi importants dans le contrôle de la croissance des moisissures que la formulation des peintures et l'emploi des adjuvants biocidaux. Les effets de fongicides sont quelquefois variables et décevants en pratique, même après des essais rigoureux.

## Auftreten und Kontrolle von Pilz- und Algenwachstum auf Anstrichen

### Zusammenfassung

Eine Beschreibung, wie sich Pilze und Algen auf Bauteilen, besonders gestrichenen Oberflächen, auswirken; ebenfalls werden einige der Faktoren, die das Wachstum fördern oder in Schach halten, erwähnt. Entwurfseinzelheiten, wie Vermeidung aussen von das Wasserabrinnen oder die Wasserzurückhaltung fördernden Oberflächen, sowie von Umständen, die innen zu Kondensation

führen, sind für die Kontrolle des Wachstums zumindest ebenso wichtig, wie die Rezeptur des Anstrichmaterials und die Anwendung biozider Zusatzmittel. Selbst nach ausgedehnten Versuchen erweist sich die Auswirkung von Fungiziden in der Praxis mitunter als widerspruchsvoll und enttäuschend.

## Появление и контроль плесени и морских водорослей в красках

### Резюме

Описываются различные эффекты плесени и водорослей на зданиях, в особенности на окрашенных поверхностях и упоминаются некоторые факторы которые способствуют или препятствуют их росту. Детали конструкции, как например избежание утеков воды или водоудерживающих поверхностей

снаружи и условий вызывающих конденсацию внутри, являются настолько же важными для контроля этого роста как и формуляция краски и применение биоцидных добавок. Эффекты фунгисидов бывают иногда противоречивыми и неудачными на практике, даже после продолжительных испытаний.

## Introduction

This is a subject which has evoked a great deal of activity through the years and there is a large volume of literature to which, especially in the tropical field, the author has contributed a share<sup>1-3</sup>. The abundance of bibliographies and references, and the inevitably conflicting results they contain, are, no doubt, reasons why nearly every investigator feels compelled to begin again from scratch.

When manufacturers of fungicides or paints put an effort into development, their own tests clearly show that they have

achieved a useful result. But independent, competitive or user organisations often have difficulty in repeating it. In fact, results seem to be so dependent on test methods and conditions throughout this field that each worker's results tend to be peculiar to himself, and the author would not claim to be an exception. Only after years of repeated tests and usage in different circumstances does it gradually become clear which are the preferred fungicides, and it is far less clear which are the commercial paints that use them, or incorporate other equally important factors in formulation, with effectiveness in practice as distinct from in laboratory tests. This is not to denigrate the importance of laboratory

\*Presented at the symposium on "Paint performance and the microbiological environment" held by the Manchester Section, 19 and 20 September 1972.

tests, in particular those developed by the Paint Research Association for both moulds and algae<sup>1</sup>, but many series of correlation experiments are needed before such tests can be considered reliable. The user with neither the time nor facilities for testing finds advice and reliable products difficult to obtain.

There has been no recent work on the subject by the Building Research Establishment (BRE) in the tropical field, nor any biological investigations of moulds and algae on paints or other materials. However, examples of both still appear frequently, in site inspections and in exposure test work, and from these this essentially practical paper has been compiled.

### Terrestrial algae

These are almost entirely confined to exterior surfaces, although green algae often collect on the lower internal putty where condensation on windows is severe, and are occasionally found in bathrooms or showers and the internal surfaces of swimming pools. Given weak or diffused daylight, the pattern of algal growth is largely that of water flow or retention, and to a considerable degree it can be controlled by design. Fig. 1 shows the unpleasant effect of dirt and growth on

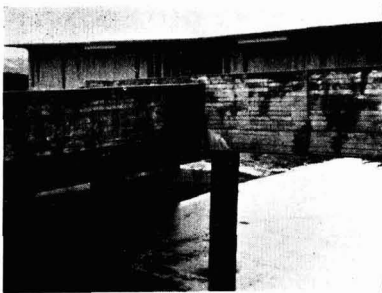


Fig. 1. Algal growth on unpainted concrete

unpainted concrete. The worst situation is where water can drain from a horizontal or inclined surface on to a vertical one, carrying with it accumulated mould spores and algal cells. Projections or drips which carry the water away from the wall surface below are only effective for a vertical distance proportional to their width; a window sill, for instance, will protect the area down to about half a metre below it, gutters and eaves perhaps one or two metres. It is difficult to protect by rainwater control the main surface of high buildings, but for one- to three-storey buildings the comparison between walls with plain fascias and those with eaves is often quite striking. Unfortunately, eaves sometimes produce conditions of stagnant air in which mould growth flourishes instead of algae. In buildings with a parapet or flat roof, the top of the parapet or verge should be sloped inwards and the rainwater channelled away out of sight. The run-off from the ends of sills and canopies, or splash-back on to the walls from any horizontal projection, are often the causes of unsightly growth, which is not easy to avoid with conventional designs.

Algae, as is well known, require light for growth, but not direct sunlight; a north light is quite sufficient, and in the northern hemisphere south faces are usually less affected than north because they dry out more readily; however, the direction of maximum driving rain, shown on the BRE

Index<sup>5</sup>, will often produce the most severe growth. The appearance of algal growth changes seasonally, being worst in winter (Figs. 2a and b). The green forms are commonest, changing in dry periods to black or becoming less prominent. Brown and pink organisms are often found in wet tropical climates, and when the surface is scraped produce a strong pink coloration.

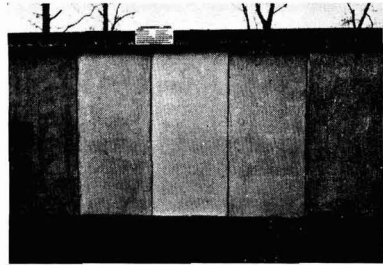


Fig. 2a. Algal growth on sections of a test wall, in wet weather

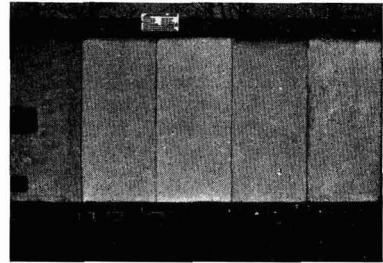


Fig. 2b. Algal growth on sections of a test wall, in dry weather

After design considerations come the surface properties of materials and paints. Fig. 3 shows the differing susceptibility of some commercial paints, part of a series for correlation of a laboratory test method with natural exposure. Smooth surfaces will certainly be less affected than rough textured ones, but growth is seen on glass and ceramic tiles in some situations. Cement based products (renderings, cast concrete and asbestos cement) seem to have high propensity for encouraging growth. Porosity is another factor, and those substrates which retain water strongly will be the more seriously affected. Permeability of paint films clearly comes into the matter, but other requirements for the building (that is, the need for certain types of wall structures to be able to evaporate water) may override the desirability of a highly impervious surface. Water repellency is a useful



Fig. 3. Algal growth on painted miniature walls. The walls were exposed at ground level, but were rearranged for photographing

property, which is not well developed in most permeable coatings, especially after weathering, but silicones and clear polymer solutions can reduce growth on porous surfaces, such as bricks, where it is not desirable to hide the substrate. Among other physical properties, hardness is important. Unfortunately, this again conflicts with the requirements for soft, extensible coatings on surfaces which are not always as stable and rigid as believed. Softness can certainly increase the tendency to pick up dirt, including biological growth, but excessive hardness is a common fault in the BRE's experience. In particular, if hardness is adjusted to provide good dirt resistance on 45° test panels, it will probably be excessive for the needs of vertical walls, where dirt pick-up and growth are very much less. This may be a reason why so many wall finishes are excessively hard and crack readily over substrates, such as renderings, which are themselves prone to crack, although there is a difference of opinion between manufacturers on this aspect.

Some pigments, water soluble colloids, plasticisers and even some media (for example, those containing vegetable oils) favour mould growth, and quite probably algal growth too. Zinc oxide is well known to improve the cleanliness of paints and resist biological growth, although not necessarily by chalking, which some forms may even reduce, and not necessarily by increasing the hardness, which it frequently does. Its value is more generally accepted in America and Australia than in Britain. There appears to be little use of it in conventional paints, particularly in emulsion paints because of problems of stability, although two emulsion manufacturers have offered suitable formulations with it. It could well be responsible for the good results which the author has seen with some very thick textured coatings of the type carrying the application contractor's guarantee. Among the toxic agents, copper compounds are useful against algae where the colour is permissible, but otherwise only thiurad was found to be effective in recent tests<sup>8</sup>, and the BRE is still awaiting the commercial exploitation of algicides in paints.

Algae are often the forerunners of lichens and mosses which begin to develop after perhaps three or four years. On roofs and old buildings, they are often considered to enhance the appearance, so much so that BRE continues to mention in the relevant Digest<sup>7</sup> methods of encouraging as well as preventing them. Their removal requires mechanical means followed by the normal treatments with fungicidal washes.

The effectiveness of fungicidal washes against all these growths prior to painting is considered to be of sufficient merit to continue their recommendation, and the BRE suggests a bleach solution because of its ready availability. However, in one recent case it caused serious damage to the adhesion of an existing coating which had not been fully removed. In such circumstances, a solvent-based fungicide would have been preferable. Thick growths of algae or lichens have to be scraped or scrubbed off before the fungicidal solution is applied.

### Fungi imperfecti (mould and mildews)

Moulds and mildews depend on a high humidity and a source of organic nutrients; they produce mainly surface growths and disfigure rather than destroy paint films. A few will penetrate and disrupt coatings by hyphal growth or by the formation of pycnidia which erupt through the film.

Mould growth can be separated to some extent into internal and external problems, and there is an incomplete differ-

entiation between the species in different environments. Internally, they are a symptom of an environment that is probably unsatisfactory in other ways than merely in supporting an objectionable growth on paint-work. Fig. 4 is a



Fig. 4. Mould growth resulting from condensation

typical example. Frequent high humidity in dwellings can be unhealthy and cause deterioration of other building materials, such as decay of timber and interstitial condensation in walls or roofing with loss of thermal insulation. Hence, control of internal conditions is always the first consideration. It is rather easy to say that an increase in ventilation is essential, but it is not always recognised that for lower income groups the available heat input may be so small that ventilation in winter conditions cannot reduce the humidity, and increasing the rate of air change only results in further discomfort. Fig. 5 demonstrates that for an outside temperature of 0°C and two typical fairly low heat inputs, no amount of air change can reduce the humidity to a satisfactory level<sup>8</sup>.

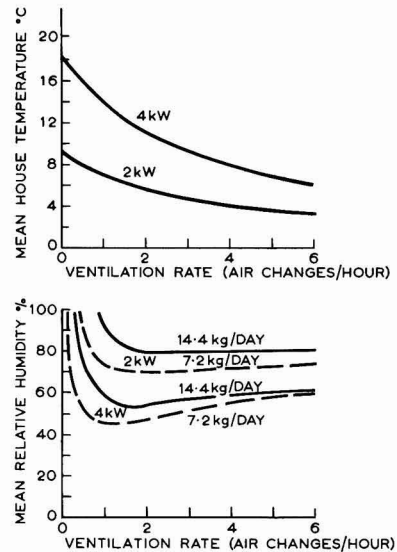


Fig. 5. Relation between humidity and ventilation rate for two values of heat input and water input

On the whole, trouble is most serious in new buildings where the water of construction has not evaporated, and the problem is aggravated by condensation of water vapour produced by the occupants. The cause is often a product of the changes in both living habits and design, where the absence

of flues, the sparing use of high cost heating methods and the deliberate restriction of ventilation, often with insufficient area, indoors or out, for drying clothes, can lead to very high humidity. The standards of thermal insulation could be improved; they are lower in Britain than in many continental countries. This would have the secondary effect of reducing mould attacks. A common feature is a cold bridge of un-insulated material in a structure in contact with outer air producing a patch of internal condensation, even where the overall values for heat transfer coefficients conform to the regulations. When a possible cure by ventilation and thermal insulation has been fully explored, there may still be a need for a mould resistant paint, which will give at least temporary relief, but it must not produce any obnoxious or toxic substance in an already ill-ventilated situation.

Even in normally occupied buildings, condensation is sometimes sufficient to induce mould growth, for example on metal windows, on bathroom and kitchen walls, or within the add-on type of double glazing, or in very old buildings where rising damp or structural defects cause localised high humidity. But even if control of these outbreaks is possible by means of mould resistant paints, there is a difficult marketing and economic question: should manufacturers make a special product, or should they add fungicide to the whole of their production? Neither product is readily available, there are no agreed standards of performance and it is difficult to make acceptable recommendations, particularly to individual members of the public.

Industrial premises, such as bakeries, dairies and breweries, are a separate problem. Even here, good housekeeping, general cleanliness and adequate heating and ventilation are not unreasonable requirements, but there are situations, such as the outside of cold vessels and tanks, or ceilings, where a mould resistant paint or anti-condensation composition is almost essential. There are a few products sufficiently well developed to be useful in this situation, but a number of others have been found unsatisfactory. Once again, where foodstuffs are concerned, toxicity limits the use of many effective materials when cost is not an important factor.

Externally, there is very little that can be done to minimise mould growth on painted surfaces because the environment cannot be greatly changed. Whereas many moulds, for example the *Penicillium* genus, succumb to strong sunlight, the black pigmented species can sustain growth on surfaces fully exposed to the sun. It has always been considered that heavy vegetation close to buildings promotes growth, not only as a source of spores, but because the shading and restricted ventilation produce a high-humidity microclimate. This lesson from the tropics is still applicable to temperate regions, where coniferous trees are a source of the widespread *Aureobasidium*, even at a long distance from buildings. Stagnant areas under eaves are commonly affected, but in general mould growth is more visible on the gloss paints used on windows, doors and timber cladding than on masonry paints used on the walls.

The dependence of mould growth on a microclimate is well illustrated in Fig. 8. On the air-conditioned part of the building there is sufficient cooling of the walls to create external condensation and induce mould growth, but there is less growth over the wooden studs whose thermal insulation is higher. Here again, where only one room is affected, the extra cost for fungicide is questionable if a single paint is used for the whole building. The real answer lies in improved thermal insulation, with economic benefits from lower power costs.

The variable susceptibility of paints to moulds has been demonstrated by many workers. Most would probably agree that oil-based and alkyd paints are very liable to growth, and it is rarely possible to separate the effects of physical properties, hardness, permeability and smoothness, from the chemical constitution which produces them. Hardness alone will certainly not compensate for the presence of growth-promoting ingredients, but it is desirable within the limits imposed by durability requirements, particularly on wood, because soft films are always susceptible. Polyurethane coatings, within the wide range that this term covers, appear at least as susceptible as alkyds and some of them even more so, and the  $\text{—NH—CO—}$  group may be a point of attack. Emulsion paints vary too widely in susceptibility to permit any generalisation. Zinc oxide has already been mentioned as a preferred ingredient in oil and alkyd paints. Hoffmann *et al.*<sup>10</sup> have published a series of papers on fungicides. Organo-mercurials have been shown to lose their activity after about a year's exposure<sup>2, 9</sup>, but even this life may be useful in conjunction with the slower acting but longer lasting zinc oxide. For interior paints<sup>9</sup> the fungicide "Phaltan" seems to be favoured, and the closely related "Captan."

On exterior wall finishes mould growth is, generally, less important than algae, but a test wall at BRE shows evidence of these on different paints, and even both together on some finishes. Again, there is no clear pattern with respect to composition, but possibly chlorinated rubber paints are among the more resistant. Both traditional oil-based types, including stone textured paints, and the modern emulsion based counterparts, are found to be affected. Whereas chalking is a useful mechanism for reducing growth, it must not be so severe that it leads to reduced durability or the possibility of wash-down on to unpainted areas below. Water resistance is essential in these coatings, and some water-based paints are found to be highly susceptible. On the other hand, some paints which are permeable nevertheless allow the surface to dry out readily and do not seem to be seriously affected. This is true, rather surprisingly, of many distempers which might be expected to suffer attack in view of their protein and oil content.

A question that arose from earlier work on wood primers which has not yet been resolved is worthy of mention. When the early examples of emulsion-based wood primers were examined in an exposure series under alkyd gloss and undercoats, it was found that the formation of surface moulds was to some extent controlled by the different primers. (There was no fungicide in the top coat.) The emulsion polymer primers seemed to show, generally, less growth (it was known that quite small amounts of mercurial fungicides were present in them to improve can storage stability, but it seemed unlikely that this would have much effect through the alkyd based coats). The difference in permeability seemed to be a possible factor, since the emulsion primer would let water out as well as in more rapidly than the oil-based types. These panels would, therefore, remain drier on average during exposure, although this could not be proved at the time. Trials with emulsion primers devoid of any active fungicide have been repeated at BRE, but so far the ageing has not progressed enough for differentiation.

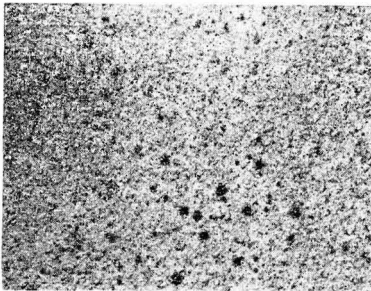
Premature decay in painted wooden windows arises from many causes<sup>11</sup>, but one factor is undoubtedly the tendency of paint films to hold the water when it has penetrated via cracked joints or unprotected end grains. In this situation, it is not uncommon to see the effects of both wood-rotting fungi and surface moulds, including the "blue stain" type with its hyphae penetrating between coats or between primer

and wood and with black pustules breaking up the surface of the paint. There is no direct connection between the two, but they both result from the excessive moisture content, a problem arising again from conditions in a given situation which might well be avoided, and does not need specifically mould resistant paints.

The preservative treatment of softwood joinery is now considered essential, even when it is protected by paint, but such a treatment will not necessarily improve the surface mould resistance of the paint on the surface. The high incidence of decay in window frames and timber framed light cladding emphasises the importance of good practice and adequate painting specifications.

It is often possible to observe the presence of mould growth on paint flakes or specimens which are investigated after a complaint of peeling or flaking. Not uncommonly, the growth is seen on the back surface, sometimes between two coats of poor adhesion, and the failure may be attributed to the presence of mould. But more often than not the mould is an effect rather than a cause. Partial detachment of films of poor adhesion is likely to lead to penetration by moisture and spores, with the conditions very conducive to growth. Mould would, therefore, develop after the failure was initiated. Algal cells can, likewise, be found in cracks and behind loose plaster. Each case needs to be judged separately, but it is only the eruption of pycnidia of blue-stain fungus which we really consider a common causative agent in paint failure. Degradation of coatings by fungi, possibly effected via enzymes, can occur, but except in unduly susceptible films it is too long-term an effect to be a serious source of complaint in Britain.

An unusual situation is shown in Figs. 6a and b, where a test panel of textured paint is seen to be colonised by strong



10 mm  
Fig. 6a. Mould growth on a textured paint

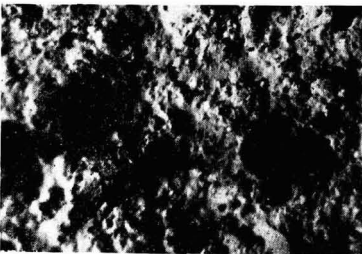


Fig. 6b. Close-up of Fig. 6a showing pits with mould

black spots, but in close up it is found that the mould is growing in pits which were present in the original film as a result, possibly, of poor wetting of the surface. Fig. 7 shows growth associated, in part, with the presence of synthetic fibres which provide lodgement for spores.

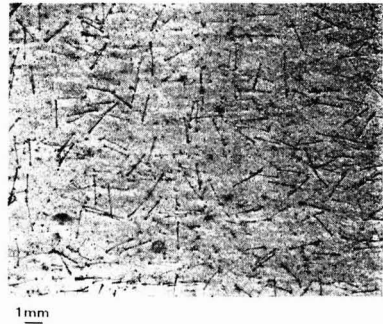


Fig. 7. Mould growth on a test panel; textured paint with synthetic fibres

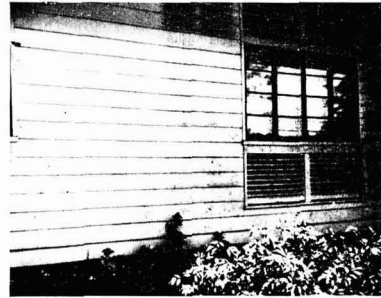


Fig. 8. Mould growth dependent on surface temperature and hence moisture condensation

## Conclusions

The number of users' complaints of mould or algal growth as a paint failure (as distinct from mould growth, generally, as a result of condensation) is extremely small, which indicates a need for caution when deciding the importance of these organisms in Britain, especially to investigators who, like the author, see frequent examples in exposure tests. Most internal complaints could have been avoided by the application of known principles and methods, but the undoubted need for good, safe, permanently effective fungus and algae resistant paints for exterior use is still hardly ever fully satisfied by commercial products, notwithstanding claims made by suppliers of fungicides. Clearly, the economics, as well as techniques, of protecting paint against sporadic and unforeseen demands set a limit on their ability to satisfy the demand.

## Acknowledgment

The work described has been carried out as part of the research programme of the Building Research Establishment of the Department of the Environment and this paper is published by permission of the Director.

[Received 26 January 1973]



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# The leaching mechanism of cuprous oxide from antifouling paints

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## Summary

An equation is derived to describe the leaching of cuprous oxide-containing antifouling paints of the continuous contact type, which relates the leaching rate to a number of variables. Experimentally the equation predicts very well the effect of these variables.

It is shown that the leaching is controlled by the diffusion of the copper chloride complex, formed when cuprous oxide dissolves in sea water, through the leached paint matrix and the boundary layer in the water adjacent to the paint film. Factors which have a great influence on the diffusion flux, and consequently on the

leaching rate, are the thickness of the leached matrix, the chloride- and copper-concentration in the sea water and the flow of the sea water along the paint surface. The influence of the above factors is such that the leaching is at its maximum when the ship is sailing and at its minimum when the ship is lying idle, whereas more or less the opposite would be desirable to prevent fouling.

Possible ways of overcoming these difficulties and improving the effectiveness of this type of paint are discussed.

## Keywords

*Types and classes of coatings and allied products*  
antifouling coatings

*Raw materials: prime pigments and dyes*  
copper oxide

## Le mécanisme de l'extraction de l'oxyde cuivreux à partir des peintures antifouling

### Résumé

On dérive une équation, qui rapporte le taux d'extraction aux diverses variables, pour décrire l'extraction de l'oxyde cuivreux à partir des peintures antifouling destinées à être immergées en continu. L'équation donne expérimentalement de très bonnes prévisions des effets de ces variables.

On montre que l'extraction est dirigée par la diffusion, à travers la matrice de la peinture et l'interface et vers l'eau voisinant au feuillet de peinture, d'un complexe de chlorure de cuivre formé lors de la dissolution de l'oxyde cuivreux dans l'eau de mer. Les facteurs qui exercent une influence importante sur le flux de

diffusion et, par conséquence, sur le taux d'extraction ce sont l'épaisseur de la matrice extractable, les concentrations des ions chlorure et de cuivre dans l'eau de mer, et le flux de l'eau de mer le long du feuillet de peinture. L'influence des facteurs ci-dessus est telle qu'il est au maximum où le navire se déplace et au minimum où il reste immobile, bien que le contraire soit plus ou moins à souhaiter pour empêcher la formation de salissures marines.

On discute les moyens éventuels pour surmonter ces difficultés et pour améliorer l'efficacité de ce genre de peintures.

## Der Auslaugmechanismus von Kupfer—I—Oxid aus Antifoulingfarben

### Zusammenfassung

Ableitung einer Gleichung, um das Auslaugen aus Kupfer—I—Oxid enthaltenden Antifoulingfarben des Dauerkontaktyps zu beschreiben, deren Auslaugeschwindigkeit mit einer Anzahl von Variablen in Zusammenhang steht. Die Gleichung sagt, wie aus Experimenten geschlossen, wird die Auswirkung dieser Variablen sehr gut voraus.

Es wird gezeigt, dass das Auslaugen durch Diffusion des als Folge des Auflösens des Kupfer—I—Oxids in Seewasser gebildeten Kupferchloridkomplexes durch die ausgelaugte Anstrichfilmmatrix hindurch und die Grenzschicht im nächst zum Anstrichfilm befindlichen Wasser kontrolliert wird. Faktoren, welche das Diffusionsfließen und infolgedessen auch die Auslaugeschwin-

digkeit stark beeinflussen, sind die Dicke der ausgelaugten Matrix die Chlorid- und Kupferkonzentration im Seewasser und das Fliessen des Seewassers entlang der Anstrichoberfläche. Der Einfluss obiger Faktoren ist derart, dass das Auslaugen am stärksten ist, wenn das Schiff sich in Fahrt befindet und am schwächsten, wenn es unbeweglich vor Anker liegt, wohingegen mehr oder weniger das Gegenteil zur Verhinderung des Anwuchses erwünscht wäre.

Möglichkeiten diese Schwierigkeiten zu überwinden und die Wirksamkeit dieses Anstrichmitteltyps zu verbessern, werden besprochen.

## Механизм выщелачивания закиси меди в необрастающих красках

### Резюме

Выводится уравнение описывающее выщелачивание необрастающих красок постоянного контакта, содержащих закись меди, которое связывает скорость выщелачивания с рядом переменных. Экспериментально это уравнение хорошо предсказывает эффект этих переменных.

Показано что выщелачивание контролируется диффузией хлорида меди, образующегося при растворении закиси меди в морской воде через выщелаченную матрицу и пограничный слой в воде, примыкающий к красочной пленке.

Факторами сильно влияющими на диффузный поток и следо-

вательно на скорость выщелачивания, являются толщина выщелаченной матрицы, концентрация хлорида и меди в морской воде и поток морской воды вдоль окрашенной поверхности. Влияние вышеуказанных факторов сводится к тому что выщелачивание является максимальным когда судно находится в движении и минимальным когда судно стоит на якоре, тогда как противоположное было бы желательным для предотвращения загрязнения.

Обсуждаются возможные методы для преодоления этих трудностей и для повышения эффективности красок этого типа.

## Introduction

It is essential for the effective action of antifouling paints that the toxin leaches from the paint film at a rate high enough to maintain a concentration at the paint surface which is lethal to the various types of fouling organisms.

The factors which play a role in this process have already been described partially<sup>1</sup>. Since the appearance of this book in 1952, a number of articles has been published which have contributed to a better insight into the mode of leaching of cuprous oxide. The publications of Wilkie and Edwards<sup>2</sup>, Marson<sup>3</sup>, Bishop and Silva<sup>4, 5</sup>, and those by Van Londen and De Wolf<sup>6, 9</sup>, may be mentioned. Marson was the first to attempt to give a theoretical basis to the leaching mechanism of continuous contact paints<sup>3</sup>; as a starting point he considered an idealised paint film, in which spherical cuprous oxide particles of equal size and encapsulated in a thin film of binder, are uniformly packed. The copper dissolved by the sea water diffuses to the surface of the paint through the interconnecting holes, which have been formed by the removal of previously dissolved cuprous oxide. The thin film of binder between two particles is ruptured during this dissolution process by the osmotic pressure developed.

Marson develops a very detailed equation for the leaching rate from this conception of the leaching process, but apart from the fact that his idealised concept of the paint film is hardly in agreement with reality, it is doubtful whether all the steps in Marson's derivation are correct and whether the equation so obtained can be proved to be correct in all details. In addition to this, any insight that could be obtained into the factors which are really important is obscured by Marson's too detailed treatment.

In this paper, therefore, a simpler model of the leaching mechanism of cuprous oxide-containing continuous contact paints will be used. A great number of experiments has been carried out to verify the usefulness of this model, and its performance will be discussed.

## Theory

The considerations given here are restricted to continuous contact paints containing cuprous oxide, in the films of which the cuprous oxide and the other soluble pigments are present in sufficient quantity for them to be in continuous contact. When the cuprous oxide and other soluble pigments dissolve during the leaching process, channels develop (as a result of this contact) through which the copper chloride complex diffuses to the surface of the paint film.

In this type of paint the binder is formulated in such a way that the matrix remains intact after the dissolution of the cuprous oxide and other soluble pigments.

As can be seen in a cross-section under the microscope, a paint film which has been leached for some time in sea water shows a leaching pattern like the one shown in Fig. 1.

A layer has been formed from which all cuprous oxide particles have leached; the leaching has progressed uniformly and a clear separation can be seen between the part of the paint film which still contains cuprous oxide and the leached layer, formed by the insoluble binder material.

In fact, in most cases some copper remains as copper resinate or as insoluble copper salts in the leached matrix. For the present this will not be taken into consideration.

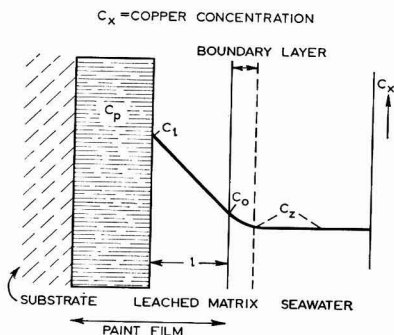
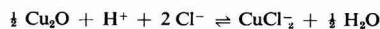


Fig. 1. Cross-section of a leached paint film (C refers to copper concentration)

Furthermore, in Fig. 1 the boundary layer in sea water is indicated. The thickness of this boundary layer varies with the velocity and conditions of water flow along the surface.

At high velocities the thickness decreases and the flow in the boundary layer changes from laminar to turbulent. Cuprous oxide dissolves in sea water<sup>1</sup> to establish the reaction equilibrium:



In the leaching of the copper, there are five principal processes:

1. The diffusion of chloride and hydrogen ions through the boundary layer to the paint surface.
2. The diffusion of these ions through the leached matrix to the unleached layer.
3. The dissolution of the cuprous oxide, according to the above reaction.
4. The diffusion of the copper chloride complex, so formed, through the leached matrix to the paint surface.
5. The diffusion of this complex through the boundary layer into the bulk of the sea water.

Of these five processes, those mentioned under 4 and 5 may be regarded as slowest and, therefore, as rate determining. Several different arguments can be advanced in support of this assumption. In the first place, it must be considered that the diffusion coefficients of the large copper-chloride complex in the leached matrix and the sea water will be lower than those of the smaller ions, such as the chloride and hydrogen ions. Furthermore, the chloride concentration in sea water is greater by a factor of about  $10^{15}$  than the saturation concentration of cuprous oxide. This much higher concentration means that the diffusion of the chloride ions will be much faster than that of the copper chloride complex. Finally, it should be pointed out that the leaching rate of copper decreases with the time of ageing. If the dissolution of the cuprous oxide were rate determining, the leaching rate would be constant.

If the diffusion of the copper chloride complex is indeed rate determining, a saturation concentration of  $\text{CuCl}_2^-$  ions

must be built up at the interface of the leached and unleached layers.

From this interface, these ions diffuse to the paint surface. A stationary state is thus obtained in which the concentration of the copper remains constant in every cross-section of the leached layer and the boundary layer parallel to the paint surface.

The concentration profile in both layers is shown in Fig. 1. Under stationary state conditions, the flux (the quantity of copper diffusing per unit time through a unit cross-section; that is, leaching rate) is the same in both layers.

In essence, the state described is not completely stationary because the interface of the leached-unleached layers continually shifts deeper into the paint film.

Because it is probable that this shift is very slow compared to a change in the leaching rate, the state may be considered as stationary. Therefore, the leaching rate in the leached layer can be described by Fick's<sup>9</sup> first law:

$$F = D Q (C_l - C_o)/l \dots\dots\dots (1)$$

where *F* = leaching rate

*D* = diffusion coefficient of the copper complex in the leached layer

*Q* = volume fraction of cuprous oxide in the dry paint

*C<sub>l</sub>* = concentration of the copper chloride complex at the interface of the leached—unleached layers

*C<sub>o</sub>* = concentration of the copper chloride complex at the paint surface

*l* = thickness of the leached layer.

In the boundary layer, *F* can be described by the formula:

$$F = k Q (C_o - C_2) \dots\dots\dots (2)$$

where *k* = mass transfer coefficient

*C<sub>2</sub>* = concentration of the copper chloride complex in the sea water.

As already remarked above, *F* is the same in the leached layer and the boundary layer and therefore *C<sub>o</sub>* may be eliminated from (1) and (2) which gives:

$$F = DQ (C_l - C_2)/(D/k + l) \dots\dots\dots (3)$$

or  $F^{-1} = ((C_l - C_2)kQ)^{-1} + l((C_l - C_2)DQ)^{-1} \dots (4)$

Equation 4, which is similar to the relationship given by Marson<sup>8</sup> predicts, therefore, a linear relationship between the reciprocal of the leaching rate *l/F* and the thickness of the leached layer *l*; furthermore, some influence of the flow rate along the surface (through *k*), of the chloride concentration (through *C<sub>l</sub>*) and of the copper concentration (through *C<sub>2</sub>*) may be expected. The influence of the composition of the paint is expressed in the diffusion coefficient *D* and in the volume fraction *Q*.

The picture of the leaching given here differs from that of Marson mainly in that no assumptions have been made regarding the shape and distribution of the pigment particles

in the paint film and what happens to the binder film around the particles.

**Experimental**

To determine the influence of several external conditions on the leaching, several experiments were carried out with a paint of the following composition (American Specification 121; MIL-P-15931 A):

cuprous oxide	46.5
vinyl resin VYHH	19.8
rosin WW	25.2
tricresylphosphate	8.5 (per cent by volume)

Having been applied to a suitable test panel, the paint was aged on a rotor apparatus (a cylindrical drum rotating in sea water) to which the panel was fastened.

The velocity of flow along the paint surface was varied by using rotors of different diameters.

Some of the experiments were carried out in natural sea water, which was renewed continuously, and some in artificial sea water, made up from commercially obtainable sea salt, which was renewed periodically. A description of the apparatus used has been given in the literature<sup>7</sup>.

A bigger rotor apparatus, on which 70 test panels can be aged at the same time, is shown in Fig. 2.

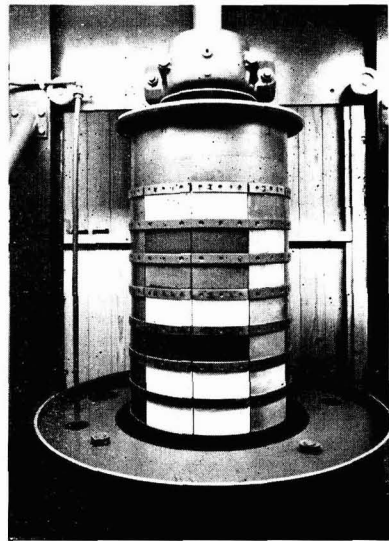


Fig. 2. Rotor apparatus with a capacity of 70 test panels

During the experiments the pH of the sea water was always about eight. The influence of pH on the leaching has not been investigated.

The leaching from the paint film was determined by measurement of the thickness of the leached matrix under the microscope after different times of ageing. This thickness

varies quite considerably from point to point over the cross section. Therefore, several measurements were always made for any one cross-section, and the average value taken as the thickness of the leached matrix.

From the graph of the leached matrix thickness versus the time of ageing, the rate of change of the leached matrix thickness  $dl/dt$  can be determined graphically. In this way the leaching rate  $F$ , given by equations 3 and 4, can be determined because it is equal to

$$C_p(dl/dt)$$

where  $C_p$  is the concentration of cuprous oxide in the paint film. For convenience  $F'$  will be used for  $dl/dt$ .

**The relationship between  $(F')^{-1}$  and  $l$**

From a great number of leaching curves, five have been chosen at random and are shown in Fig. 3.

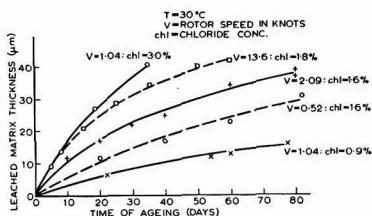


Fig. 3. The relation between leached matrix thickness  $l$  and time

The leaching curves have been determined under different conditions. From these curves,  $F'$  (in  $\mu\text{m}$  per day) was determined after different times of ageing, and  $(F')^{-1}$  was plotted against the leached matrix thickness. The results are shown in Fig. 4. As predicted by equation 4, in all cases a linear relationship is obtained. This linear relationship was found for all experiments which were carried out.

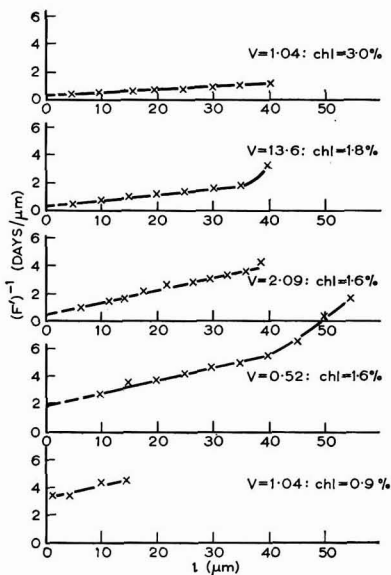


Fig. 4. The relation between  $F^{-1}$  and  $l$

In two cases in Fig. 4, a deviation from the linear relationship occurs at high values of  $l$ .

In other cases, a slowing down of the leaching rate has sometimes been found. This can be attributed to the formation of a surface layer.

**The relationship between  $(F')^{-1}$  and  $k$**

Equation 4 predicts that a change in the conditions of flow ( $k$ ) has an influence only on the first term of the equation. To examine this, a number of rotor experiments were carried out at different angular velocities in natural sea water, and both constants in equation 4 were determined from the linear relationships between  $l/F'$  and  $k$ .

In Fig. 5, these constants are plotted against the product of the circumferential rotor speed  $v$  and the rotor radius  $r$ , which quantify the flow conditions in the boundary layer.

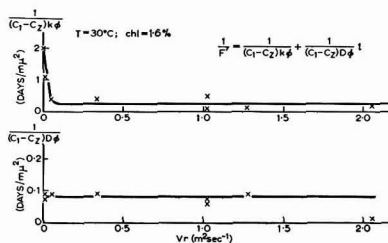


Fig. 5. The influence of the flow along the paint surface on leaching

In fact, these should have been plotted against the Reynolds' number ( $Re$ ) given by the relation:

$$Re = \rho v r / \eta \dots\dots\dots(5)$$

where  $\rho$  is the density and  $\eta$  dynamic viscosity of the sea water. However, during the experiments, these last two factors were unchanged, so  $v.r$  is proportional to  $Re$ .

As can be seen in Fig. 5, as predicted, only  $(C_1 - C_2) k.Q$  depends on the conditions of flow. Above about  $0.1 \text{ m}^2 \text{ sec}^{-1}$ , however, an influence was no longer found.

To verify this result, another experiment has been carried out. A paint with a composition according to specification 121 was applied to both sides of a pvc disc with a diameter of 36cm. The disc was fastened in the middle and rotated at  $535 \text{ rev min}^{-1}$  in natural sea water at  $30^\circ\text{C}$ . After an ageing of 1,000 hours, cross-sections of the paint film were taken at different distances from the centre, in which the thicknesses of the leached matrix were measured. The results are shown in Fig. 6.

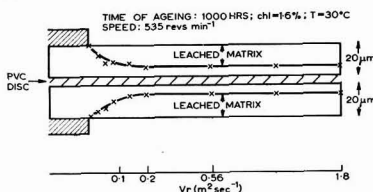


Fig. 6. The leaching on a rotating disc

The velocity of flow was found to have no influence above a rather low value of  $v.r$  ( $\pm 0.2 \text{ m}^2 \text{ sec}^{-1}$ ).

**Chloride concentration**

The concentration of the copper chloride complex at the interface of the leached—unleached layers ( $C_1$ ) depends directly on the salt concentration in the sea water because of the dissolution reaction of the cuprous oxide.

The chloride concentration thus influences the leaching rate given by equation 4.

To quantify this, rotor experiments were carried out with the paint of specification 121 in artificial sea water with different salt concentrations, at a temperature of 30°C. In Fig. 7.1 are shown the leaching curves obtained.

The great influence of chloride concentration on the leaching can be seen. As before, the constants in equation 4 were determined by the linear relation between  $1/F'$  and  $l$ . In Fig. 7.2 these constants have been plotted against the chloride concentration.

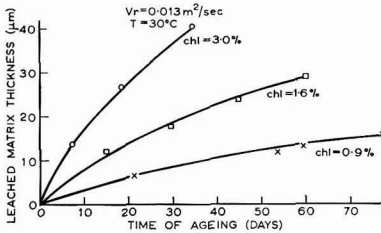


Fig. 7.1

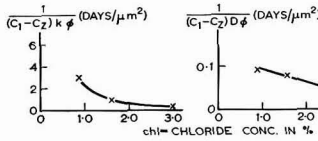


Fig. 7.2

Fig. 7. Influence of the chloride concentration on leaching

It can be seen that the constants decrease with increasing chloride concentration, as predicted by equation 4.

In another experiment the influence of the chloride concentration has been shown by means of a so-called "determination of the leaching rate." A number of glass panels were painted with the paint formulated according to specification 121, and were aged for six months in flowing natural sea water with a chloride content of about 1.8 per cent.

After this, the leaching rate was determined in the usual way<sup>8</sup> in sea water with different chloride concentrations, made up by the addition of distilled water or sea salt to natural sea water. The results are shown in Fig. 8.

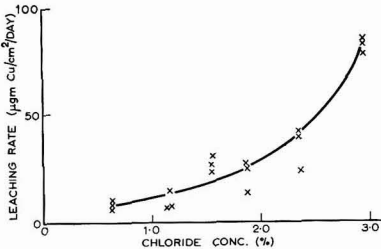


Fig. 8. Influence of the chloride concentration on leaching rate

Although it is evident that the reproducibility of the determination is rather low, the influence of the chloride concentration can be seen clearly.

**Copper concentration**

Equation 3 predicts that the leaching stops if  $C_2$  equals  $C_1$ . To check this, and to determine the value of  $C_2$ , a number of rotor experiments were carried out in sea water with different copper concentrations. These copper concentrations were kept constant by renewing the sea water in the tank continuously with sea water to which copper salts had been added. By changing the rate of refreshment and the amount of copper added, the copper concentration was kept constant during each experiment.

The results of these experiments are shown in Fig. 9.1.

The influence of  $C_2$  is evident. At a copper concentration of about 1.3ppm, the leaching stops totally.

Again, the constants in equation 4 were determined using the linear relation between  $1/F'$  and  $l$ . In Fig. 9.2, these have been plotted against the copper concentration. In the case of the concentrations lower than or equal to 0.15 and 0.4 ppm respectively, this has been done against these maximum values. In these cases, it was impossible to keep the copper concentration at these values.

The results are at least qualitatively in agreement with equation 4.

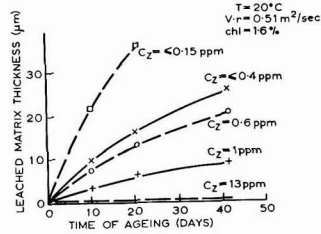


Fig. 9.1

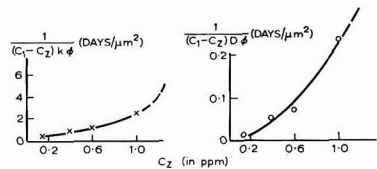


Fig. 9.2

Fig. 9. Influence of the copper concentration in sea water on leaching

**Temperature**

A temperature term is not explicitly present in equation 4. Nevertheless, an influence of temperature on the leaching can be expected because all factors in the equation are more or less temperature-dependent.

To investigate this, rotor experiments were carried out with a paint according to specification 121 in continuously renewed sea water at 10, 20 and 30°C. The results are shown in Fig. 10. As can be seen, no influence of the temperature on the leaching was found.

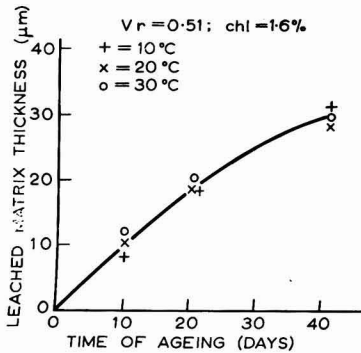


Fig. 10. Influence of the temperature on leaching

### Composition of the paint

The influence of the composition of the paint is expressed by the diffusion coefficient  $D$  and the volume fraction  $Q$ . To study this influence, the leaching of a number of paints, obtained by varying the following composition (in volume per cent), has been investigated:

cuprous oxide	50
vinyl resin VYHH	20
rosin WW	22.5
tricresylphosphate	7.5

Firstly, VYHH was replaced by VAGH or Alloprene R 20.

Then in the composition mentioned above 15 parts by volume of cuprous oxide were replaced by 15 parts by volume of zinc oxide, barytes, diatomaceous silica, magnesium oxide, titanium dioxide and red iron oxide one at a time.

The paints were aged on a rotor apparatus in artificial sea water of 30°C. The leaching curves are shown in Fig. 11.

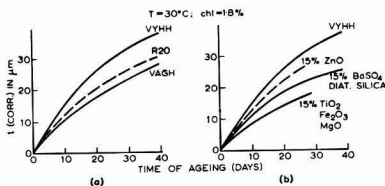


Fig. 11. Influence of the composition on leaching

A correction was made for the difference in percentage by volume of cuprous oxide between the reference composition and the other paints by multiplying the leached matrix thickness of the latter by the factor  $7/10$  ( $l$  corrected).

The graphs may then be compared directly. The reference composition is indicated by VYHH.

In the usual way, the relation between  $l/F'$  and  $l$  was determined from these leaching curves.

In this case, however, because of the general reliability of the results, it was impossible to draw definitive conclusions whether the mentioned variations in the composition are

indeed expressed correctly in the equation given for the leaching rate.

Although in this case, in a theoretical respect, no verification of the mechanism of the leaching could be obtained, nevertheless, Fig. 4 gives qualitative indications about the influence of the incorporation of different raw materials.

Thus the influence of the binder on the leaching is evident. The lower leaching with VAGH compared to VYHH is probably a result of the more hydrophilic character of VAGH, which makes the formation of copper complexes possible. Why Alloprene R 20 the rate slows down too is not clear.

From Fig. 11 it can be seen that, of the insoluble extenders, red iron oxide and titanium dioxide slow down the leaching compared to barytes and diatomaceous silica. It can be seen too that the soluble zinc oxide, in comparison with the insoluble extenders, has a beneficial effect. In this case, the leaching decreases less than proportionally to the quantity cuprous oxide replaced, as with barytes and diatomaceous silica. Magnesium oxide slows down the leaching strongly.

### Discussion

As is evident from the experimental results, the leaching generally follows the pattern outlined in the theoretical section.

In practice, of course, this pattern may be disturbed by other factors which have not been investigated. For example, it may be possible that deviations from the linear relation of  $l/F'$  and  $l$  occur because of the formation of surface layers. These might be slime layers, iron-containing layers formed by colloidal iron present in the sea water, or oil films taken up on the paint surface during dockings for example. Such layers might slow down the leaching.

Apart from this, however, a clear insight has been obtained into the factors which are important during leaching. For example, the fact that the influence of the product of rotor speed and radius ( $v.r$ ) disappears above  $0.1$  to  $0.2 \text{ m}^2 \text{ sec}^{-1}$  (Figs 5 and 6) means that a ship's speed has no influence on the leaching. This is because the given limit, which is equivalent to a Reynolds number of about  $1$  to  $2 \times 10^5$  is exceeded at about  $40 \text{ cm}$  from the bow of a ship sailing with a speed of only  $1$  knot. At a speed of  $10$  knots, the Reynolds number at only  $2 \text{ m}$  from the bow is  $10^7$ .

It follows that artificial ageing on a rotor apparatus does not need to be carried out at extremely high speeds. On the other hand, it must be realised that the leaching rate can decrease considerably below  $0.1$  to  $0.2 \text{ m}^2 \text{ sec}^{-1}$ , which is the case when a ship is lying idle.

The fact that above  $0.1$  to  $0.2 \text{ m}^2 \text{ sec}^{-1}$  no influence of  $v.r$  on the leaching rate is found means that leaching is only determined by diffusion through the leached matrix in this situation. Therefore, it is not reasonable to talk about "distances covered" with regard to the ageing of an anti-fouling paint; what is important is for how long a time the ship sails. Quantitatively, the results given in this paper do not agree completely with the measurements of Wilkie and Edwards<sup>2</sup> and the calculations of Marson<sup>3</sup>.

Very important factors are the chloride concentration (Fig. 7) and the copper concentration of the sea water (Fig. 9). Evidently the temperature has no influence.

This is contrary to the findings of Van Londen<sup>6</sup> and of Bishop and Marson<sup>5</sup>. The observations of these authors, however, are based on the so-called "determination of the leaching rate" which is known to be very inaccurate.

It may be assumed that the chloride concentration in harbours will, in most cases, be much lower than in the sea. This too may lead to a lowering of the leaching rate. To illustrate this, the leaching rate and the copper concentration have been calculated at the paint surface for the following conditions:

- (a) a ship sailing in sea water with a chloride concentration of 1.6 per cent and a negligible copper concentration,
- (b) a ship lying idle in the same sea water,
- (c) a ship lying idle in sea water with a chloride concentration of 0.8 per cent and a negligible copper concentration.

The leaching rate has been calculated using equation 4, and  $C_0$  by means of the following equation (which can be derived from equations 1 and 2):

$$C_0 = C_1(D/k)/((D/k) + l) \dots\dots\dots(6)$$

( $C_2$  has been neglected.)

In these calculations, it has been assumed that  $D \cdot Q$  has a value of 17, and that  $D/k$  equals 3 for a moving ship and about 25 for a ship lying idle. These values are based on data given in this paper. Furthermore, it has been assumed that the thickness of the leached matrix  $l$  is 25 $\mu$ m, that the solubility of cuprous oxide in sea water is about 1.3ppm, and that this concentration changes quadratically with the chloride concentration. The results of the calculations are given in Table 1.

Table 1  
Leaching rate and copper concentration for various chloride ion concentrations

Ship	Chloride ion concentration in sea water (per cent by volume)	Leaching rate gm per cm <sup>2</sup> per day	Copper concentration at the paint surface (C <sub>0</sub> ) (ppm)
Sailing	1.6	190 × 10 <sup>-6</sup>	0.14
Lying idle	1.6	105 × 10 <sup>-6</sup>	0.65
Lying idle	0.8	26 × 10 <sup>-6</sup>	0.16

As can be seen, the last value for the leaching rate in Table 1 is not far above the critical value of 10<sup>-5</sup>gm per cm<sup>2</sup> per day, which is given in the literature<sup>8</sup> as the value below which fouling organisms may survive on the paint surface.

Moreover, when a ship is going to lie idle in water with a constant chloride concentration, the decrease in leaching will be compensated for by a decreased transport of copper from the boundary layer because of which  $C_0$  increases to a value which makes fouling impossible.

In addition, fouling by barnacles is impossible on the ship lying idle in water with a chloride concentration of 0.8 per cent<sup>7</sup>.

There are, however, types of algae which can survive in sea water with copper concentrations of 0.1 to 0.5ppm<sup>10, 11</sup>.

It is evident that the situation becomes more unfavourable as the leaching of the antifouling paint proceeds further.

Factors such as the great influence of the chloride concentration upon leaching rate and the decrease of leaching with the time of ageing are without doubt disadvantages for copper-containing paints. It could be asked, therefore, what might be done to decrease the influence of these factors.

The only way to restrict the influence of the chloride concentration would be to modify the cuprous oxide in such a way that solubility is less dependent on chloride concentration. This will be very difficult to achieve.

With regard to the leached matrix thickness, it would be more favourable if the leaching rate were to depend less on  $l$ . As can be seen from equation 4, this means that the term

$$l/((C_1 - C_2)DQ)$$

should be as low as possible; that is,  $D \cdot Q$  should be as high as possible. The possibilities are rather restricted in this respect due to technical difficulties in paint formulation.

It is well known that the influence of the leached matrix can be reduced by making the matrix more soluble in sea water, as has been achieved in, for example, the American Specification 121/63 and in the soluble-matrix type of paint.

A factor which has not been investigated, but which might influence  $D$  and thus the leaching rate, is the particle size of the cuprous oxide, the pigments and the extenders.

In the last group, experiments have been carried out using insoluble materials of different particle size, but the results do not allow reliable conclusions to be made.

A smaller particle size of the cuprous oxide might increase the effectiveness of the anti-fouling action. De Wolf<sup>6</sup> has remarked that the distribution of young barnacles on an old antifouling paint is not uniform, and this might be caused by non-homogeneous leaching.

It is evident that the leaching could proceed more uniformly if the cuprous oxide in the paint film were more finely dispersed. Because the cypris larva settles on a spot (approximately 0.5 mm<sup>2</sup>) much bigger than the largest cuprous oxide particles, however, it is improbable that the fouling by barnacles could be better combated in this way; although this might be the case with algae, the spores of which settle on much smaller spots (6 to 10 $\mu$ m).

Finally some remarks can be made with regard to the testing of antifouling paints in the laboratory. It will be evident that it is important to keep the chloride and copper concentrations as constant as possible during the ageing, if useful results are to be obtained.

If the paints are aged on a rotor apparatus in sea water to simulate the conditions on a sailing ship, it is not necessary to use extremely high speeds. The product of the rotor speed and the rotor radius need only be higher than 0.1 to 0.2m<sup>2</sup> per second to achieve turbulent conditions. The other conditions should be as close as possible to those of natural sea water.

When the ageing of a paint on a rotor for different times is combined with biological testing on a raft or in the laboratory, an impression of the antifouling action of that paint can be obtained.



Because the ageing on a rotor is analogous to that on a ship, the antifouling action of the paint on a raft should be about the same as on a ship lying idle, after the same period of rotor ageing.

The rotor ageing thus gives a rather absolute value of the antifouling action of the paint. It must be borne in mind, however, that the conditions in harbours vary so much that the results in practice may be different.

### Acknowledgment

The results of the work reported in this paper have been obtained within the framework of a joint research programme by the Nederlandsche Vereniging voor Research op het Gebied van Scheepshuidverven (Research Organisation of Dutch Manufacturers of Ship Paints) and the Paint Research Institute TNO.

Thanks are due to Mr F. W. Kielhorn, H. van het Groenewoud and J. Roelofs for carrying out a number of the experiments.

[Received 4 February 1973]

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## Next month's issue

The Honorary Editor has accepted the following papers for publication, and these are expected to appear in the September issue:

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

**The influence of supermolecular structure on the properties of polymer films** by W. Funke and U. Zorll

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

**The American paint industry**

**Present trends and future possibilities** by F. Armitage

# Reviews

## Polyvinyl alcohol

By C. A. Finch

London: John Wiley Ltd.  
pp. xviii + 622 + Index. Price £14.00

With the increasing rate of expansion of information, it has become almost impossible for one person to write a book on any subject and hope that it will be up to date when published. The tendency, therefore, is to allocate specific aspects of a subject to various authorities in their field, and for one man to collate the resulting chapters into a coherent whole. In many cases this results in discontinuity of style, a penalty which must be paid for up-to-date information in one place.

In this instance, the editor has chosen his international co-workers wisely. Fourteen contributors, to 24 chapters, have produced a volume which covers everything from the history of polyvinyl alcohol to its applications in the textile, paper, clay and printing industries, in sufficient detail to satisfy anyone searching for information on this subject.

References to published work are lavish, and the layout excellent.

D. S. NEWTON

## Radiation drying of paints, inks and related systems

By N. L. Moore (Editor)

Published by HERTIS, Hatfield, Herts. April 1973, pp. 81. Price 50p.

Mr Moore has collected together over 300 abstracts of references relating to the subject of radiation drying. The bibliography covers the period from 1960 to late 1972, although the majority of references relate to material published since 1965. The references are grouped under the headings:

Gamma-ray polymerisation, electron beam curing, ultra-violet curing, microwave drying and infra-red drying.

Most of the references relate to the drying of coatings, although some relating to the drying of paper and textiles, and the curing of rubber coatings are included too. Most of the reference documents have been examined in the library of the Watford College of Technology and recourse has been made to standard journals and abstract documents. References to trade literature are not included.

The bibliography appears to cover the literature adequately, and gives references on both the theoretical and practical aspects of radiation drying. Patent literature, particularly that of the UK and the USA, is well covered and useful author and subject indices are included.

The book has been prepared from stencils and is stapled together and thus has the appearance of a library literature summary rather than a printed publication. However this is necessary if one is to have an up-to-date resume of literature and does not detract from the usefulness of the book.

The bibliography would be a very useful addition to any reference library and indeed should be found in any laboratory concerned with the drying of films.

A. G. WALKER

## Water and water pollution handbook Volume 4

By L. L. Ciaccio

New York: Marcel Dekker, 1973  
pp. xi + 630. Price £29.50

This volume completes a set presenting a multi-disciplinary approach to water and water systems. It is concerned with instrumental techniques for the detection of substances in natural waters and waste effluent. In addition, it contains the only complete subject and author indexes to all four volumes.

Every contribution to Volume 4 comes from the USA. The content of this volume, however, does not appear to be biased to any great extent towards an American viewpoint. Concerning water quality monitoring, for example; in the UK the emphasis so far has been to develop multi-parameter stations and portable submersible monitors, and these are adequately dealt with in Chapter 26 "Monitoring of water systems." In addition, many British river authorities have shown interest in the development of mobile stations, and these too are described. Other subjects covered include the determination of minor metallic elements and radioactive nuclides, automated methods of water analysis, gas chromatography, mass spectrometry, infra-red spectroscopy, and luminescence and electrochemical techniques.

I opened this book with mixed feelings. Such a comprehensive guide to water resources and water purity merits a reflection upon the considerable work in that field; at the same time, it is silent comment on the pollution of most waterways, on the misuse of water and water resources, and on the immensity of the problem presented by that state of affairs. Moreover, the title "Water and water pollution" would to some extent seem to indicate a defeatist attitude (why not "Water and water purity"?) Is the editor merely using his handbook, dust covers *à la mode*, to decorate the pollution bandwagon? Anyone reading his book would immediately dismiss this idea. Dr Ciaccio has completed an enormous undertaking, and has collated thousands of reports to add to his own vast experience of water systems. Volume 4 contains nine chapters; for many of these chapters there are hundreds of references (several as recent as 1971). The subjects covered, and the tests and instruments described are equally numerous. The subject index typifies the comprehensive nature of the publication—"Water quality standards for fishing," "SLR, *see* Sludge loading ratio," and "Rubidium in Hudson River."

This volume, and especially when completing a set with the other three, is almost an essential addition to the library of any association, university or company which is using water, conducting research into its behaviour, or treating polluted water and waste effluent.

C. A. TAYLER

# Information Received

## Anchor begin polyamide imide production

Anchor Chemical Company has begun production of a range of polyamide imides.

The range is being manufactured by Anchor's Italian subsidiary, Anchor Italiana, at its plant at Dorno, near Milan, for distribution throughout countries in the EEC. At a later stage production will begin at Anchor's plant at Manchester.

## Bayer extends anthraquinone capacity with new process

In addition to the existing production of anthraquinone, Bayer AG, Leverkusen, is to erect a plant for a newly developed process. This will considerably increase the present production, which is based on the oxidation of anthracene, and guarantee for the future a complete range of anthraquinone-based dyestuff intermediates.

## Bowater move offices

On Monday 2 July 1973 the headquarters offices of Bowater Packaging Limited, Bowater Industrial Packaging Limited, Bowater Building Products Limited and Bowaters United Kingdom Paper Company Limited moved from Bowater House to: Portland House, Stag Place, London SW1E 5DJ (01-834 9444).

## Change of name for J. Weil & Son

Following a general re-organisation of the Montedison Group, Joseph Weil & Son Ltd, a company which acts as commercial distributor of Montedison products in the UK, has changed its name to Montedison (UK) Ltd. The company markets in the UK chemicals, plastics, elastomers, fertilizers and pesticides, synthetic fibres, dyestuffs and intermediates for the dyestuffs and pharmaceutical industries.

## Laporte preliminary statement

The check to Laporte's financial progress since 1969/70 has been mainly due to the technical problems of bringing into full production the £11m chloride-route titanium dioxide plant at Stallingborough. The major aspects of this situation have now been resolved. In addition, since last autumn, changes in market conditions and new developments affecting other sectors of the group's business have been, on the whole, highly favourable. A preliminary statement was issued on 6 June 1973.

## New name for Nopco . . .

With effect from 1 July, Nopco Hess Ltd, the Leeds-based suppliers of speciality chemicals for industry, will be known as Diamond Shamrock Chemicals (UK) Ltd. The range of anti-foams and de-foamers marketed by Nopco Hess is already being extended by products from the research departments of other companies within the Diamond Shamrock Group.

## . . . And a new Scottish distribution centre

Diamond Shamrock Chemicals (UK) Ltd has announced the opening of a new depot to supply its Scottish customers. The company's range of chemical products can

be obtained from Len Lothian Ltd., Whitehall Industrial Estate, Glenrothes.

## 3.5 million Guilder investment in new laboratory by Scado BV

A new laboratory, involving capital expenditure of Fl 3.5 million, is planned by Scado BV at Zwolle, Netherlands. At a ceremony on 8 June, the Deputy Burgomaster of Zwolle, Mr G. Runhaar, drove in the first pile for the project; completion is scheduled for July 1974.

## Non-flammable printed circuit resists

Coates has announced that all its STANDARD circuit resists, lacquers and board-making inks are not subject to control under the Flammable Liquids Liquefied Petroleum Gases Regulations which came into force on 21 June 1973. This means that all Coates' products in this field can be used without special precautions.

## New products

### Fire-resistant coating from Liquid Plastics Ltd

Decadex-Firecheck is a tough plastic "membrane" which can be applied by brush or spray, is durable and elastic, and

will fill and bridge hairline cracks. It can be used on most kinds of materials, including wood, metal, and plastic and is manufactured by Liquid Plastics Ltd.

Two identical huts—of the size and appearance of garden sheds—were placed side by side on the waste ground. Each was made of solid wood, ½ in thick, with expanded polystyrene ceiling tiles, and externally covered with roofing felt. One hut was given two coats of normal emulsion paint inside and out, and the other treated with the same number of coats of Decadex-Firecheck. The dramatic results are shown in the photographic sequence.

## New fluorescence spectra published by Sadtler

Sadtler Research Laboratories, Inc., Philadelphia, has announced the publication of the two new continuing collections of Fluorescence Reference Spectra. One of these, the Standard Fluorescence spectra collection, contains a wide range of pure organic compounds of general interest; the second is a pharmaceutical collection.

## New resin for aqueous flexographic inks

Vincaryl 4020 is a new alkali-soluble copolymer emulsion, introduced by Vinyl Products Ltd, Carshalton, Surrey, as a medium for aqueous flexographic inks. It is already established for flexo inks in packaging, and has a good potential for wallpaper prints, and papers for the heat-transfer printing of textiles.

## Diaphragm valves lined with "Tefzel"

Du Pont's new fluoropolymer, "Tefzel" ETFE has been specified for linings in diaphragm valves manufactured by ITT, Grinnell Valve Division, for its superiority in two principal areas: thermal resistance and overall chemical resistance. In addition, the company is supplying valves lined with "Tefzel" at prices equal to or less than the equivalent sized valves lined with polyvinylidene fluoride (PVF<sub>2</sub>).

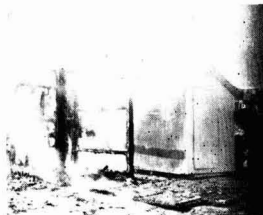
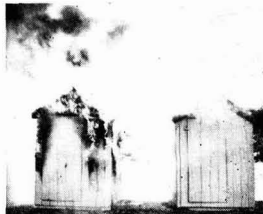
The fluoropolymer offers advantages over glass linings which are prone to damage by thermal or mechanical shocks.

## Conferences, courses, symposia

### FATIPEC Congress

For the XIth Congress scheduled to be held in Garmisch-Partenkirchen during the week 12 to 18 May, 1974, the filing date for the papers to be presented has just passed. In addition to nine plenary lectures, 80 applications for discussion papers have been received from speakers from more than ten countries.

A copy of the alphabetical list of the authors with the titles of their papers may be obtained from the President of the Congress: Dr Heinz Rechmann, Obere Strabe, 16, D-567 Opladen, West Germany. Programme and application forms for the XIth FATIPEC Congress will be available



Only the frame of the painted hut remains—total collapse occurred about half an hour after firing. The other hut was slightly scorched but intact, even though (because of the wind's direction) it was subjected to the flames of the other hut as well as its own internal fire.

in late autumn and can be ordered from the same address.

#### **LTSC course at South Bank**

The Department of Chemistry and Polymer Technology at the Polytechnic of the South Bank is offering a part-time course for students who have fulfilled the necessary examination requirements to complete the requirements for Licentiatehip in the Technology of Surface Coatings (LTSC). For further details see the Professional Grade notice in the Notes and News section of this issue.

#### **Particle size analysis**

A meeting of the Particle Size Analysis Group of the Society for Analytical Chemistry/Analytical Division, Chemical Society, will be held at 11 a.m. on Wednesday 5 September 1973 in the Hatfield Polytechnic, Room B.400, College Lane, Hatfield, Herts. The subject of the meeting will be particle size analysis in the sub-micrometre range.

#### **PIRA make plans for conference on gravure technology**

The Packaging Industries Research Association plans the first ever international

conference on gravure technology, to be held in London on February 25 and 27, 1974.

Topics to be covered in the three-day conference will be reproduction, methods of cylinder preparation, alternative surfaces and preproofing; machinery, including design, drying and infeed systems, and sheet as well as web machinery; materials including testing, lightweight papers and water-based inks. It is hoped to include sessions on environmental topics and gravure markets and marketing.

#### **Particle technology**

The Harold Heywood Memorial Symposium on particle technology will be held at Loughborough University of Technology on 17 and 18 September 1973. Lectures will both review past research and postulate future developments in the field of particle technology.

#### **Powder coatings in Japan**

A paper to be presented at the Amsterdam "Powder Coatings" conference in November by a representative of Mitsui Toatsu

#### **INFORMATION RECEIVED JOCCA**

Chemicals Co. will outline the latest technological developments in Japan. The conference is being organised by Technical Conference Organisation in conjunction with Paul Winter.

#### **SLF Conference**

The seventh SLF Conference will be held at the Park Hotel, Sandefjord, Norway from 1 to 3 October 1973. There will be ten lectures, given in the lecturer's language, with simultaneous translations into English when necessary. Three lectures have been designated the official contributions of FATIPEC, FSPT and OCCA. Subjects covered include aqueous dispersions, electrodepositing, automation, the drying of printing inks, and the maintenance of ships' hulls. The President of the Association, Mr L. H. Silver, intends to be present.

#### **Summer School in Paint Analysis**

A course on paint analysis is to be held at the Polytechnic of the South Bank, from 19 to 21 September. The cost for the three days (including meals) will be £9.00. Those wishing to attend should write to Dr D. F. G. Pusey at the Polytechnic of the South Bank, London SE1.

# Annual Report of the Council for 1972

Adopted at the Eleventh Annual General Meeting held at the Grand Hotel, Eastbourne, Sussex, on 22 June 1973.

## General

The year under review has been both one of the most difficult periods with which the Association has had to contend and at the same time an encouraging one in that it has seen the secure establishment and recognition of the optional Professional Grade for Ordinary Members, first introduced in September 1971. When the optional Professional Grade was first suggested it had been expected that it would take some years before it would reach the level achieved by the end of 1972, so that this can be regarded as a major step forward in the progress of the Association.

Financially, however, the year has caused the Council considerable concern. Through circumstances over which the Association has no control, the effects of the recession in the chemical industry were sharpened by the fact that there was only a ten month interval between the 1971 and 1972 Exhibitions and this led to a curtailment by some organisations. Similar considerations also affected the level of advertisements booked in the Association's publications. The Council considered the implications of increased costs and felt certain that members would appreciate that the membership subscription had remained unchanged since 1968, and could not be increased until 1974, and accordingly took the necessary steps to place the appropriate resolution on the Agenda for the Annual General Meeting in 1973.

It also took note that the monthly publication of almost all other societies with which the Association is concerned had adopted, or were about to adopt, the metric size A4. In order, therefore, not to cause difficulty in paper supplies or to deter advertisers, who otherwise would have to make special blocks only for the Association's *Journal*, Council resolved to change the size of the *Journal*, with effect from January 1973, to the A4 size.

Members may like to reflect that difficulties seldom come singly and Council had been aware that the lease on the offices in Wax Chandlers' Hall would have to be renegotiated before the end of 1972. It had been hoped that it would be possible to negotiate a short lease which would have enabled the Association to recover from the financial reverse sustained in 1972 so that the Council could explore the possibility of purchasing a headquarters building. In the event, however, the new rent proposed proved to be prohibitive and, since it also proved impossible to find suitable alternative accommodation at an acceptable rental in Central London, the Association, in company with many other societies, was forced to look for office accommodation in the suburbs. As there was very little time in which to make these arrangements, great efforts were made to view many premises in different areas, while continuing with the routine work in the Association's offices, and finally suitable accommodation was found in the Harrow Road, near Sudbury Hill Underground Station. This small building, though not ideal in all respects, will enable the Association to have complete occupancy and to hold committee meetings at its headquarters. Council meetings will, however, continue to be held in Central London.

The Twenty-Fourth Technical Exhibition took place at the Empire Hall, Olympia, London, W14, 17-21 April. A report appears later under the Exhibition Committee's Report and a review of the Exhibition appeared in the June issue of the *Journal*.

On 12 May, the Biennial Dinner and Dance took place at the Savoy Hotel, London WC2, when 280 members and guests were present. The guests and their ladies were received by the President and Mrs Blenkinsop and on this occasion seven other societies were represented.

After the Dinner the President welcomed the guests and the ladies and the reply was given by Mr A. S. Hooper, President of the Paintmakers Association. After the speeches, dancing continued until 1 a.m., with a break at 11.30 p.m. for refreshments. No cabaret was arranged on this occasion, but instead a gift was made to each lady. An account of the evening, with a photograph, was published in the July issue of the *Journal*.

The Tenth Annual General Meeting of the Incorporated Association took place on 7 June at Wax Chandlers' Hall, Gresham Street, London EC2V 7AB, when Mr L. H. Silver was elected President-Designate. The following Vice-Presidents were elected:

Mr R. G. Gardiner  
Dr H. W. Keenan  
Mr A. B. Lock  
Mr K. R. McDonald  
Mr N. H. Seymour  
Mr R. N. Wheeler  
Mr T. Whitfield

The Honorary Officers were elected as follows:

Honorary Secretary	.. ..	Mr D. S. Newton
Honorary Treasurer	.. ..	Mr F. Cooper
Honorary Editor	.. ..	Mr S. R. Finn
Honorary Research and Development Officer	.. ..	Mr A. R. H. Tawn

The report of the Auditors on the scrutiny of the postal votes was received and it was announced that the following members had been elected to the Council for the years 1972-74:

Mr H. C. Worsdall  
Mr H. G. Clayton  
Mr L. J. Brooke

Votes of thanks to Retiring Council Members, the Honorary Officers and the Chairman of the meeting were carried with acclamation.

After a short break for refreshments, the Members re-assembled to hear Mr C. G. Todd, a Past Master and Clerk of the Worshipful Company of Wax Chandlers, who gave a fascinating description of the Company and displayed some of its treasures. The proceedings of the Annual General Meeting were reported in the August issue of the *Journal*.

On the evening of 3 October a short service, conducted by the Rector, The Rev C. G. How, was held at St. Vedastias-Foster, Foster Lane, London EC2, to commemorate the foundation of the Association.

This was followed by the Foundation Lecture when some 60 members gathered in the Court Room at the Painters' Hall, Little Trinity Lane, London EC4, to hear Sir James Tait, Vice-Chancellor of the City University, speak on "The City—A Technological University. Are Tradition and Technology Compatible?" A vote of thanks was given by Mr D. S. Newton (Honorary Secretary).

After an informal reception, dinner was taken in the Dining Hall at Painters' Hall and during his Address the President particularly welcomed those Past Presidents and Past Honorary Officers of the Association who were able to be guests of the Council on this occasion. Dr H. W. Keenan (President 1944-47 and an Honorary Member) responded.

An account of the Foundation Lecture, and a photograph, appeared in the December issue of the *Journal*.

At the Congress of the Federation d'Associations de Techniciens des Industries, Vernis, Emaux et Encres d'Imprimerie de l'Europe Continentale held in Florence in June a paper was presented on behalf of the Association by Mr K. McLaren and Dr D. A. Plant entitled "ANLAB—a uniform colour space for pigment evaluation."

In October, the Association was represented by the President, Mr A. W. Blenkinsop, at the Fiftieth Annual Meeting of the Federation of Societies for Paint Technology held in Atlantic City, when he presented a Commemorative Scroll on behalf of the Association to the President of the Federation to mark the occasion. A photograph of this ceremony will be published in the January 1973 issue of the *Journal*.

The Manchester Section opened the 1972-73 session in September with a symposium entitled "Paint performance and the microbiological environment" held at the University of Manchester Institute of Science and Technology and which was attended by 180 people.

The South African Section held a conference in October on Powder Coatings at the Pine Lake Inn, near White River, East Transvaal.

The Tenth New Zealand Convention took place 21-23 July, attended by over 170 delegates and their ladies. The theme of the Convention was "Breaking with tradition" and while the delegates attended the technical sessions a varied and attractive programme was arranged for their wives.

At its meeting in March, Council were pleased to confer Honorary Membership upon Mr T. Howard, a member attached to the South African Section, in recognition of his service to the Association over many years, and the appropriate Scroll was presented to Mr Howard by the then Chairman of the South African Section (Mr L. F. Saunders) at the Section's Annual General Meeting in April. An account of this meeting, with a photograph, appeared in the July issue of the *Journal*.

In October, Council were pleased to endorse recommendations made by the Wellington Section Committee that Commendation Awards be presented to two former Chairmen of the Section, Mr T. W. Slinn and Mr A. C. McEwan, in recognition of the valuable service they had rendered to the Section over many years.

In January, Council agreed that badges of office be available for the Chairmen of Branches and these were duly supplied to be worn at relevant Branch, Section and Association functions.

During the year, the Director & Secretary has been pleased to help members both from home and overseas when they have visited the Association's offices. He was particularly glad to have discussions with Mr L. S. Cash (Honorary Member of the Oil and Colour Chemists' Association, Australia, attached to the New South Wales Section) in May, Mr K. M. Engelbert (Honorary Treasurer of the South African Section) who was able to attend the Association's Annual General Meeting in June, Mr J. P. Teas (President of the Federation of Societies for Paint Technology) in June, Mr A. O. Brantsaeter (President of the Federation of Scandinavian Paint and Varnish Technologists) in August, and Mr L. LeLievre (Member attached to the Victorian Section of the Oil and Colour Chemists' Association, Australia) in September.

Council was saddened to learn of the death in January of Dr H. Houlston Morgan, a Founder Member of the Association, President 1924-26 and an Honorary Member. An obituary notice appeared in the March issue of the *Journal*. In August the death occurred of Mr E. A. Brown, Chairman of the Hull Section 1968-70, and an obituary notice appeared in the October issue of the *Journal*.

Council wishes to place on record its sincere appreciation of the outstanding service rendered to the Association by the Director & Secretary, Mr R. H. Hamblin, and the members of his staff.

### Membership of the Association

The number of elections (250) during 1972 compared favourably with previous years and it was particularly pleasing to note the number of younger Ordinary Members who will be actively engaged in making application for admission to the new Professional Grade. The figures given below at 31 December 1972 relate only to those members whose 1972 subscriptions have been received; the names of those in arrears with subscriptions have been removed.

Section	Ordinary	Associate	Honorary	Student	Total
Bristol	80	17	—	8	105
Hull	58	8	—	9	75
Irish	48	16	—	4	68
London (including Southern Branch)	616	73	4	5	698
Manchester	355	55	2	17	429
Midlands (including Trent Valley Branch)	181	25	1	2	209
Newcastle	131	12	—	7	150
Scottish (including Eastern Branch)	107	26	—	30	163
Thames Valley	110	14	—	9	133
West Riding	60	18	—	14	92
Auckland	57	39	—	2	98
Wellington	67	35	—	—	102
South African	216	49	—	13	278
General Overseas	352	25	2	—	379
Total 1972	2,438	412	9	120	2,979
Total 1971	2,401	428	10	129	2,968
Net increase/decrease during 1972	+37	-16	-1	-9	+11

### The Council

During the calendar year the Council has met four times, the average attendance being 28. All meetings were held in London.

### Committees of the Council

The Committees of Council met as set forth below:

Exhibition Committee	..	..	2
Finance Committee	..	..	2
President's Advisory Committee	..	..	5
Professional Grade Committee	..	..	4
Publications Committee	..	..	1
Technical Committee	..	..	1
Technical Education Committee	..	..	1

*Exhibition Committee*

Chairman: The Honorary Treasurer, Mr F. Cooper

The Twenty-Fourth Technical Exhibition was held at the Empire Hall, Olympia, London, from 17 to 21 April. The opening day coincided with a work-to-rule on the railways which, coupled with the problems of finding car parking space in London and a work-to-rule on a national airline, made travelling to the Exhibition extremely hazardous. These conditions persisted throughout the week and the total attendance was naturally lower than previously, there being 8,500 recorded at the turnstiles. Nevertheless, visitors from 33 overseas countries were represented in the Visitors' Book at the Information Centre.

On the opening day the Exhibition Luncheon was held at the Savoy Hotel, prior to the opening ceremony by the Guest of Honour, Lord Ironside, Vice-President of the Parliamentary and Scientific Committee. A large number of members, exhibitors and visitors gathered for this occasion, but once again the Association had to contend with another problem since it was unfortunate that the date of the Parliamentary and Scientific Committee's Annual Luncheon, which is normally held in February and attracts a number of representatives from scientific societies, was changed so that it clashed with the Association's Luncheon.

In his Address of Welcome, the President of the Association, Mr A. W. Blenkinsop, pointed out that, owing to the restricted dates available at Olympia, only ten months had elapsed since 23-OCCA in June 1971 and it had been expected that some firms might have experienced problems in complying with the regulations of this unique annual display of technical developments by technical personnel for technical visitors. The Exhibition Committee was, therefore, gratified by the way in which they had found support, not only from exhibitors at 23-OCCA but from 14 companies which had not shown at previous OCCA Exhibitions. For future years the same situation was unlikely to occur since the Committee wished it to be widely known that, following the Silver Jubilee Exhibition in May 1973, the Empire Hall, Olympia, had been booked for April in both 1974 and 1975.

In his reply, Lord Ironside congratulated the Association on its achievements and referred to the importance of the application of advanced technology to solving industrial problems. His speech, which contained points of direct concern and interest to the surface coating industries for whom the Exhibitions are arranged, was received with acclamation by those present.

After the opening ceremony at the Empire Hall, Lord Ironside made a tour of the stands at the Exhibition accompanied by the President, the Chairman of the Exhibition Committee and the Director & Secretary.

The theme of the Technical Education Stand was "Pigments." Plaques described the chemistry and structure of eight of the most important pigment categories, and samples of pigments in each category were displayed. Several parties of sixth-form students from nearby schools attended the Exhibition and their interest in the paint industry was aroused by the stand and the lectures given to each party by Mr G. H. Hutchinson. Staff from various technical colleges in the London area manned the stand and were able to advise on suitable courses for students wishing to enter the industries.

A review of the Exhibition appeared in the June issue of the *Journal* and the Exhibition Committee is particularly grateful to Mr R. Wood (Assistant Editor) who collated the reports and comments from a team of 27 reporters.

*Finance Committee*

Chairman: The Honorary Treasurer, Mr F. Cooper

It was appreciated by the Finance Committee at the beginning of 1972 that this would be one of the most difficult years financially which the Association has had to face since the temporary decrease in the letting of Exhibition stand space led to a curtailment in this source of income.

These difficulties were considered carefully throughout the year by the Finance Committee and, in making their report and recommendations to Council, they had also to bear in mind that the lease at Wax Chandlers' Hall expired at the end of 1972. Faced with this very serious situation, the Finance Committee had no hesitation in recommending to Council that the membership subscriptions should be increased as soon as possible in order to meet the continuing short-fall, which has been apparent for many years, on the members' account.

The Finance Committee intends to build up the investments of the Association once again as soon as this becomes practicable but, in the meantime, it has been necessary to withdraw some of the money deposited on short call with local authorities. Rights issues have been taken up to increase slightly the investments in equities (which stood at £20,670 above their purchase price at the end of 1972) but no change has been made in the Government holdings (which stood at £1,138 below their purchase price) during 1972.

*Jordan Award Committee*

Chairman: The Honorary Research and Development Officer, Mr A. R. H. Tawn

It is hoped to present the third Jordan Award at the time of the Association's next Conference in June 1973 and applications have been invited, through the pages of the *Journal*, at regular intervals during the course of the period under review. The closing date was 29 December 1972 and early in 1973 the Committee will be meeting to consider the applications received.

*Liaison Committee*

Chairman: The President

An exchange of information, as discussed at the meeting of the Liaison Committee held during the course of the Association's Conference in 1969 (referred to in the Report for that year), has taken place and the Presidents of the four societies (Federation d'Associations de Techniciens des Industries, Vernis, Emaux et Encre d'Imprimerie de l'Europe Continentale, Federation of Societies for Paint Technology, Federation of Scandinavian Paint and Varnish Technologists, and Oil and Colour Chemists' Association) met at the Fiftieth Anniversary Meeting of the Federation of Societies for Paint Technology in Atlantic City in October and discussed matters of common interest.

*President's Advisory Committee*

Chairman: The President

It will be recalled that, in the Report for 1968, reference was made to the setting up of the President's Advisory Committee comprising the Honorary Officers of the Association together with three Section Chairmen, normally in their second year of office. For the 1972-73 session Mr A. W. Blenkinsop invited the Chairmen of the Bristol Section (Mr P. L. Gollop), the London Section (Mr D. E. Eddowes) and the Newcastle Section (Mr A. A. Duell) to serve on this Committee.

*Professional Grade Committee*

Chairman: The President

The Professional Grade Committee has met at regular intervals during the course of the year to consider applications received for admission to the optional Professional Grade which, as mentioned in the general part of this Report, have been most encouraging. In addition to meetings of the Committee, members thereof have examined dissertations prepared by those applying for admission to the Licentiate grade and have then conducted viva voce examinations. There have also been many viva voce examinations held for applicants to the Associateship grade. Details of the applications received to the end of 1972 are set out below and the full list of members admitted to the various grades is published in the December issue of the *Journal*.

	Applications received	Applications transferred between grades	Successful	Awaiting fulfilment of regulations	Not accepted
Fellowship	160	Less 34	119	—	7
Associateship	186	Add 34	189	11	16
Licentiate	16	Less 4	8	12	—
	362*	Add 4	316	23	23

\*In addition there are 37 applications which have not yet been considered by the Committee.

At its meeting in September the Committee reviewed the first year's working of the scheme, as a result of which it recommended to Council certain alterations to the regulations and increases in the certification fees which Council approved and which were notified to members through the *Journal* and set out on the forms of application for admission to the Professional Grade. Sponsorship, which had been waived for the first year, became obligatory after 1 November 1972.

*Publications Committee*

Chairman: The Honorary Editor, Mr S. R. Finn

During 1972, forty-one papers were published under the heading of *Transactions and Communications* compared with forty-nine in 1971 and fifty-three in 1970. The overall size of the *Journal* was 1,172 pages compared with 1,222 and 1,132 in 1971 and 1970 respectively. The number of pages covered by *Transactions and Communications* was 587 (50.1 per cent) compared with 829 (67.9 per cent) in 1971 and 740 (65.4 per cent) in 1970. The trend towards an increasing proportion of *Journal* space being occupied by technical papers was reversed in 1972, but this was due mainly to the innovation of publishing Part VII of the Paint Technology Manuals in the *Journal* as a series of *Student Reviews*; these occupied a total of 218 pages and if these are added to those occupied by *Transactions and Communications*, the total occupied by technical papers becomes 805, or 68.5 per cent of the total pages.

Five papers presented at the Third National Symposium of the South African Section on 11-13 September 1970 on Electrodeposition were published during 1972 commencing with the May issue. It is hoped to publish the papers from the Fourth Symposium on Powder Coating in due course. It is also hoped that it will be possible to publish at least some of the papers given at the Manchester Section Symposium, 19-20 September 1972 on Microbiology.

There was a further slight increase in the correspondence with the Honorary Editor (15 letters) compared with 12 in 1971 and only seven in 1970.

The number of books reviewed during the year was 17, against 14 in 1971 and 18 in 1970. Once again the standard of

reviewing was well maintained and the Committee wishes to thank all those who have contributed to this section of the *Journal*. The Honorary Editor wishes to thank the Honorary Publication Officers for their accounts of the Section Proceedings during the year.

The Publications Committee met on one occasion during the year; the meeting was brought forward to July, instead of being held in the autumn, as usual, in order to discuss and recommend to Council, the adoption of the A4 page size for the *Journal* as from January 1973.

At a meeting of the Technical Education Committee it had been suggested that as the Professional Grade Committee had now taken over most of the responsibilities formerly coming under the scope of technical education, their only remaining responsibility was for the Paint Technology Manuals and it was recommended that this should now be taken over by the Publications Committee. This proposal was discussed and accepted by this Committee.

A second edition of Part III of the Manuals has been published during the year, some stocks of Part VI remain and Part VII will become available in bound form from January 1973. The four remaining parts are all out of stock; new editions of them are under active consideration and discussions with Chapman & Hall are taking place.

Mr C. J. A. Taylor has resigned from both the Publications Committee and as Editor-in-Chief of the Manuals. The Committee desires to thank him for his long and valuable service and extend their best wishes for the future. Mr J. R. Taylor has been invited to join the Publications Committee but, due to the uncertainty on the future method of publication of the Manuals and the new allocation of responsibility for them, it was not considered desirable to make a new appointment as Editor-in-Chief at the present time.

The *Resins, Drying Oils, Varnishes and Paints Report* for 1971, reprinted from the Annual Reports of the Society of Chemical Industry, was published as usual in November and the authors have been invited to prepare the report for 1972. However, owing to the change in the page size of the *Journal*, it will no longer be possible to include this report in any bound volume of *JOCCA*. The desirability of continuing the reproduction of this report as a separate entity has, therefore, to be considered.

Twenty-six of the 41 papers published were submitted from direct sources. Twenty-three papers originated from overseas (including six each from Australia and South Africa), which represents 56 per cent of the number published.

**Survey of published papers**

Section	1970	1971	1972
Bristol	—	—	—
Hull	1	—	—
Irish	—	1	1
London	2	6	4
Manchester	13	1	—
Midlands	5	—	2
Newcastle	1	—	—
New Zealand	—	—	—
Scottish	—	6	—
South African	—	—	5
Thames Valley	1	—	1
West Riding	—	2	—
<i>Direct</i>			
United Kingdom	15	7	10
Overseas	15	12	18
Conference	—	13	—
Foundation Lecture	—	1	—
	53	49	41



*Technical Committee*

Chairman: The Honorary Research and Development Officer, Mr A. R. H. Tawn

The reconstituted Technical Committee, as referred to in the Report of the Council for 1971, met in February for the purpose of considering the programme for the 1973 Conference when a number of suggestions were submitted in respect of topics for papers and authors under the main theme "Towards 2000."

Later in the year the Committee was involved with the revision of British Standard 2015—Glossary of Paint Terms, since members of the British Standards Institution Committee concerned had been asked to approach the bodies they represented for observations on the terms which could be deleted from the existing Glossary and any new ones they wished to see included in the revision. Upon being approached by the Association's representative (Mr S. A. Ray) on British Standards Institution Committee PVC/11, the Council referred this matter to the Association's Technical Committee.

*Technical Education Committee*

Chairman: The President

The reconstituted Technical Education Committee, as referred to in the Report of the Council for 1971, met in January when members had the benefit of Dr J. G. Gillan being in attendance for the purpose of explaining the reasons why the City and Guilds of London Institute Paint Technicians Course 357 was being merged with the Chemical Technicians Course 315 and how this would affect the training undertaken by students. The details were conveyed to the Association's Professional Grade Committee for the purpose of reviewing the regulations for admission thereto.

**Representation on other organisations**

The Association was represented on other organisations, as follows:

Technical Training Board for the Printing Ink and Roller Making Industry: Mr N. Locke and Mr A. R. H. Tawn.

Paint Apprenticeship Council: Dr H. W. Keenan and Mr G. Copping.

The Parliamentary and Scientific Committee: The President and the Director & Secretary.

The British National Committee for Chemistry: Mr A. R. H. Tawn.

City and Guilds Advisory Committee for the Chemical Technicians Certificate: Dr J. G. Gillan.

East Ham Technical College Consultative Committee for the Science Department: Mr R. M. W. W. Wilson.

Association of Exhibition Organisers: The Director & Secretary.

Programme Liaison Committee: The Honorary Programmes Officer of the London Section and the Director & Secretary.

The Paintmakers Association Training and Technical Education Committee: The Honorary Secretary and the Director & Secretary.

The Society of Dyers and Colourists Terms and Definitions Committee: Dr J. Toole and Mr A. E. Honiball.

The Society of Dyers and Colourists "Review of Coloration Progress" Committee: Mr H. D. Brearley.

The Colour Group (Great Britain): Mr R. Smith.

Institution of Corrosion Technology Education Committee: Dr J. B. Harrison and Mr D. S. Newton.

**British Standards Institution:**

PVC Pigments, Paints and Varnishes Industry Committee: Dr J. B. Harrison

PVC/1 Pigments: Mr A. S. Lewis

PVC/9 Black Pigments: Mr J. S. Marsh

PVC/1/11 Extenders: Mr S. A. Ray

PVC/1/18 Zinc Dust Pigments: Mr D. S. Newton

PVC/3 Oils, Varnishes, Putty etc.: Mr G. H. Hutchinson

PVC/3/5 Test Methods for Paint Media: Dr L. A. O'Neill

PVC/4 and PVC/4/1 Lac: Dr B. S. Gidvani

PVC/6 Cement Paints: Mr W. O. Nutt

PVC/8 Plastic Wood: Mr V. P. Gellay

PVC/10 Test Methods for Paints: Mr A. N. McKelvie

PVC/11 Revision of the Glossary of Paint Terms: Mr S. A. Ray

PVC/14 Colours for Paints: Mr A. B. Lock

PVC/15 Water Paints and Distempers: Mr T. W. Wilkinson

PVC/16 Ready Mixed Paints: Mr G. A. Newell

PVC/19 Bituminous Paint: Dr H. B. Footner until October; then Mr J. Rogers

PVC/20 Calcium Plumbate Priming Paints: Mr A. G. Walker

PVC/23 Zinc Rich Paints: Dr D. Atherton

PVC/24 Water Thinned Priming Paints: Mr J. H. Sparrow

PVC/25 Organic Finishes for Aluminium Windows: Dr J. B. Ley

C/17 Artificial Daylight for Colour Matching: Miss O. Rawland

C/17 Viscosity: Mr A. N. McKelvie

C/17/2 Revision of BS.188 (Drafting): Mr A. N. McKelvie

CHE/43 Test Sieves: Mr M. J. F. Meason

CHE/50 Test Methods for Powder Properties: Mr D. S. Newton

CIC/4 Solvents and Allied Products: Dr L. A. O'Neill

CIC/6 Glycerol: Mr W. A. Ledger

OFFA/7 Sampling Oilseeds, Oils and Fats: Mr N. F. Lythgoe

OFFA/12 Vegetable Oils: Mr N. F. Lythgoe

OFFA/24 Analysis of Oilseeds, Oils and Fats: Mr N. F. Lythgoe

ELE/16/53/6 Varnishes: Mr J. McGowan

ACE/44 Aircraft Finishes: Mr J. B. G. Lewin

BLCP/18 Code of Practice: Painting: Mr P. J. Gay

M/26 Artists' Materials: Mr J. A. L. Hawkey

RDE/25 Road Marking Compounds: Mr T. R. Bullett

OC/20/4/12 Chemistry and Chemical Technology: Mr J. Orpwood

Reports from the above representatives may be seen by members at the Association's offices.

The Association was also represented on overseas organisations as follows:

South African Bureau of Standard's Specifications:

SABS 515 Decorative Paints, non-aqueous solvent base, interior use: Mr H. I. Bossman, Mr N. A. Brown, Mr K. M. Engelbert and Mr A. H. Meyling

SABS 630 Decorative High Gloss Enamel—non-aqueous solvent base, exterior and interior use: Mr H. I. Bossman, Mr N. A. Brown, Mr K. M. Engelbert and Mr A. H. Meyling

SABS 631 Decorative Oil Gloss Paint—non-aqueous solvent base, exterior and interior use: Mr H. I. Bossman, Mr N. A. Brown, Mr K. M. Engelbert and Mr A. H. Meyling

SABS 663 Primer and Enamel Paint for Hospital Furniture: Mr A. H. Meyling

SABS 681 Undercoats for Paints: Mr K. R. Hart

SABS 683 Roof Paints: Mr K. M. Engelbert

SABS 801 Epoxy Tar Paints: Mr P. A. Draper

SABS 912 Calcium Plumbate Primer: Mr M. P. Greef

Science and Education Advisory Committee, Natal College of Advanced Technical Education: Mr K. R. McDonald, Mr K. M. Engelbert.

Science and Education Advisory Committee, Witwatersrand College of Advanced Technical Education: Mr H. H. Aschenburg, Mr P. A. J. Gate.

Council of the National Association of Scientific and Technical Societies: Mr L. F. Saunders.

Standards Association of New Zealand—Paints and Coatings Sectional Committee: Mr T. W. Slinn.

## Appendix

### Report of the Council in accordance with the Companies Act 1967

1. The Council presents herewith the audited accounts of the Association for the year ended 31 December 1972.

#### 2. Results

The results for the year and the appropriation thereof are set out in the Income and Expenditure Account on page 9.

#### 3. Principal Activities of the Association

The Association has continued in its work of furthering the development of the science and technology of the oil and colour industries.

#### 4. Changes in fixed assets

The movement in fixed assets during the year is set out in the table on page 10. In December 1972 the Association acquired the Lease of Priory House, 967 Harrow Road, Wembley, Middlesex, HAO 2SF, for the remainder of the term of eighteen years.

#### 5. The Council

The following were members of Council at 31 December 1972:

A. W. Blenkinsop, FTSC  
 L. H. Silver  
 D. S. Newton, AMCT, CGIA, FInstCorrT, FIMF, FTSC  
 F. Cooper, BSc  
 S. R. Finn, BSc, FRIC, FTSC  
 A. R. H. Tawn, FRIC, FInstPet, FIMF, FTSC  
 K. R. McDonald, BSc, ATSC *elected 7 June 1972*  
 R. G. Gardiner  
 A. B. Lock *elected 7 June 1972*  
 H. W. Keenan, PhD, FRIC, FTSC *elected 7 June 1972*  
 R. N. Wheeler, BA, ARIC *elected 7 June 1972*  
 F. Schollick, BSc, FRIC  
 N. H. Seymour, FTSC  
 T. Whitfield, FTSC  
 V. T. Crowl, BSc, PhD, DIC, FRIC, ARCS, FTSC  
 D. J. Morris  
 A. T. S. Rudram, FTSC

L. J. Brooke, ATSC *elected 7 June 1972*

H. G. Clayton *elected 7 June 1972*

H. C. Worsdall *elected 7 June 1972*

P. L. Gollop, FTSC

F. E. Ruddick *elected 28 April 1972*

F. D. Robinson, BSc, ATSC

J. E. Gilroy *elected 27 March 1972*

F. D. H. Sharp

Miss P. Magee

D. E. Eddowes, BSc

H. R. Hamburg, PhD

F. M. Smith, BSc, PhD, ARIC, FTSC

S. Duckworth, ARIC, FTSC

A. S. Gay, ATSC *elected 14 April 1972*

D. E. Hopper, ACT, ATSC

A. A. Duell, ARIC, FTSC

K. F. Baxter

E. M. Burns

A. McLean, FTSC *elected 7 April 1972*

B. Jacob, FTSC

W. H. Tatton, ARIC, FTSC

Mrs K. Driver

D. Morris, ATSC

O. E. Rutledge

F. Sowerbutts, BScTech, FTSC

M. D. Thomson

G. Willison, FRIC

D. A. Kalwig (co-opted as President of the Oil and Colour Chemists Association Australia).

A. G. Holt, FTSC (co-opted as Representative of the Oil and Colour Chemists' Association Australia).

In addition, the following were members of Council at 1 January 1972 and served during the year; the date shown after each name denotes when service on Council terminated:

A. S. Fraser (7 June 1972)

S. H. Bell, PhD, DIC, ARCS, FRIC, FTSC (7 June 1972)

I. S. Moll, BSc (7 June 1972)

C. H. Morris (7 June 1972)

H. R. Touchin, BSc, FRIC, FTSC (7 June 1972)

J. R. Taylor, BSc, FRIC, FTSC (28 April 1972)

N. F. Lythgoe, FRIC (27 March 1972)

H. J. Griffiths, ACT, ATSC (14 April 1972)

L. F. Saunders, FTSC (12 April 1972)

A. Lowe, MSc, PhD (12 April 1972)

#### 6. Auditors

The auditors, Cooper Brothers & Co., who will change their name on 1 April to Coopers & Lybrand, will continue in office in accordance with Section 159(2) of the Companies Act, 1948.

By Order of the Council

ROBERT HAMBLIN

Director & Secretary

1 January 1973

**OIL AND COLOUR CHEMISTS' ASSOCIATION****BALANCE SHEET as at 31 December 1972**

1971		1972		1971		1972	
£	£	£	£	£	£	£	£
<b>ACCUMULATED FUND—</b>				<b>FIXED ASSETS—</b>			
52,997	Balance at 31 December 1971	59,874			Furniture, Fittings, Office Machines and Motor Car at cost .. .. .	8,922	
6,876	Add Surplus/(less Deficit) for the period .. .. .	(16,777)		8,578	Less Accumulated Depreciation ..	6,817	
<u>59,873</u>			43,097	<u>2,625</u>			2,105
<b>CURRENT LIABILITIES—</b>				Leasehold Property on short lease at cost .. .. .			
445	Provision for Paint Technology Manuals .. .. .	433					8,128
214	Provision for Professional Grade/Technical Activities .. ..	—			<b>QUOTED INVESTMENTS—</b>		
29,172	Receipts in Advance .. .. .	39,779		11,708	British Government Securities at cost .. .. .	11,708	
3,759	Creditors & Accrued Liabilities ..	6,456			(Market Value £10,570) .. ..		
<u>33,590</u>			46,668	26,605	Other Investments at cost .. ..	26,897	
					(Market Value £47,567)		
					<b>UNQUOTED INVESTMENTS—</b>		
					Local Authorities Short-term Loans .. .. .	2,000	
				60,313	<u>22,000</u>		40,605
					<b>CURRENT ASSETS—</b>		
					399	Stock of unsold publications at cost .. .. .	642
					1,540	Paper stock in hand at cost .. ..	2,441
					14,725	Debtors & Payments in Advance .. ..	15,656
						Balance at Bankers and Cash in Hand in United Kingdom and Overseas Sections .. ..	20,188
				30,525	<u>13,861</u>		38,927
	<b>A. W. BLENKINSOP</b> <i>President</i>						
	<b>F. COOPER</b> <i>Hon. Treasurer</i>						
	<b>R. H. HAMBLIN</b> <i>Director and Secretary</i>						
<u>£93,463</u>			<u>£89,765</u>	<u>£93,463</u>			<u>£89,765</u>

**REPORT OF THE AUDITORS TO THE MEMBERS**

Annual accounts submitted by the United Kingdom and Overseas Sections have been incorporated in these accounts, but the assets, liabilities and expenditure included therein have not been verified by us. Moreover, it has not yet been possible to obtain final accounts from all the Overseas Sections and therefore provisional or estimated figures, based on the half-year accounts, have been included. With these reservations in our opinion the accounts set out on pages 405 to 408 give a true and fair view of the Association's affairs at 31 December 1972 and of its results for the year ended on that date and comply with the Companies Acts 1948 and 1967.

COOPER BROTHERS & CO.

London, 2 March 1973

Chartered Accountants

**OIL AND COLOUR CHEMISTS' ASSOCIATION**

INCOME &amp; EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1972

£	1971	£	INCOME	£	1972	£
	£				£	
			<b>MEMBERSHIP AND GENERAL INCOME—</b>			
	14,367		Subscriptions .. .. .	14,838		
	694		Professional Grade Certification Fees .. .. .	720		
	139		Entrance Fees .. .. .	127		
	574		Sundry Publications .. .. .	590		
	3,734		Investment Income .. .. .	2,981		
	349		Surplus on Redemption of Investments .. .. .	—		
	16		Profit on sale of equipment .. .. .	25		
	<u>19,873</u>			<u>19,281</u>		
			<b>JOURNAL RECEIPTS—</b>			
	11,655		Advertising .. .. .	9,179		
	11,168		Sales .. .. .	13,005		
	2,246		Capitation Fees (OCCAA) .. .. .	2,208		
	1,075		Reprints .. .. .	1,174		
	<u>26,144</u>			<u>25,566</u>		
	67,007		<b>EXHIBITION RECEIPTS .. .. .</b>	40,717		
113,024	<u>67,007</u>			<u>40,717</u>		85,564
			<b>EXPENDITURE</b>			
			<b>MEMBERSHIP AND GENERAL EXPENSES—</b>			
	8,996		Administrative Expenses (Note 4) .. .. .	9,057		
	9,672		Journal .. .. .	9,768		
	4,873		Postage, Printing and Stationery .. .. .	4,834		
	1,074		Publications .. .. .	1,427		
	2,807		Section Expenditure (Note 5) .. .. .	2,041		
	277		Past Presidents' Dinner .. .. .	—		
	—		Dinner Dance and Foundation Lecture .. .. .	558		
	100		Provision for Paint Technology Manuals .. .. .	100		
	280		Torquay Conference .. .. .	—		
	1		Branch Chairmen's Badges .. .. .	74		
	1,741		General Expenses, including Accountancy .. .. .	2,185		
	1,334		Rolls-Royce Stock written down .. .. .	—		
	<u>31,155</u>			<u>30,044</u>		
			<b>JOURNAL EXPENSES—</b>			
	8,996		Administrative Expenses (Note 4) .. .. .	9,057		
	11,822		Printing and Publication .. .. .	11,938		
	740		Reprints .. .. .	860		
	2,056		Postage and Stationery .. .. .	2,417		
	795		General Expenses .. .. .	996		
	<u>24,409</u>			<u>25,268</u>		
			<b>EXHIBITION EXPENSES—</b>			
	40,793		Direct Expenses .. .. .	36,976		
	8,996		Administrative Expenses (Note 4) .. .. .	9,057		
	795		General Expenses .. .. .	996		
	<u>50,584</u>			<u>47,029</u>		
106,148	<u>50,584</u>			<u>47,029</u>		102,341
<u>£6,876</u>			Surplus (Deficit) for the year .. .. .			<u>£(16,777)</u>

## NOTES ON THE ACCOUNTS

1. *Fixed Assets*

Cost	£	£
At 1 January 1972	8,578	
Additions	638	
	<u>9,216</u>	
Less Disposals	294	8,922
	<u>6,817</u>	
<i>Depreciation</i>		
At 1 January 1972	5,953	
Charged to Income and Expenditure Account	1,026	
	<u>6,979</u>	
Less Disposals	162	
	<u>6,817</u>	
Net book value at 31 December 1972		<u>2,105</u>

The leasehold property acquired in December 1972 will be amortised over the unexpired period of the lease (approximately eighteen years); no amortisation has been charged in 1972.

2. *Foreign Currencies*

Overseas Section income, expenditure, assets and liabilities have been converted to Sterling at the following rates:

New Zealand	\$1.97
South Africa	Rands 1.84

## 3. The Ethel Behrens Fund and the Jordan Award Fund have not been incorporated in the Association Income and Expenditure Account and Balance Sheet but have been shown as separate accounts.

4. *Administrative Expenses*

Administrative expenses have been equally apportioned between the three main headings of expenditure in the Income and Expenditure Account on the basis of staff time involved. These expenses are:

1971	1972
£	£
20,604	20,250
581	593
699	596
3,787	4,331
350	375
100	
867	1,026
<u>£26,988</u>	<u>£27,171</u>

The charge to each heading is therefore:		
£8,996	Membership	£9,057
£8,996	Journal	£9,057
£8,996	Exhibition	£9,057

5. *Section Expenditure*

The Section expenditure is as follows:

1971	1972	
£	£	
65	108	
92	60	
329	208	
467	313	
	(Southern Branch £44)	
346	Manchester	(118)
217	Midlands	182
	(Trent Valley Branch £61)	
134	Newcastle	123
195	Scottish	255
	(Eastern Branch £95)	
126	Thames Valley	173
60	West Riding	32
107	Auckland (estimated)	64
64	Wellington (provisional)	129
327	South African (estimated)	512
<u>£2,529</u>	<u>£2,041</u>	
278	Underestimated overseas expenditure in the previous year	
<u>£2,807</u>	<u>£2,041</u>	

**ETHEL BEHRENS FUND****INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1972**

1971 £	<b>Expenditure</b>	1972 £	1971 £	<b>Income</b>	1972 £
54	Income Tax on Investment Interest ..	52	135	Interest on Investment (Gross) ..	135
—	FSPT Travelling Expenses .. .. .	254	—	Deficit .. .. .	171
81	Surplus .. .. .	—	—		—
<u>135</u>		<u>306</u>	<u>135</u>		<u>306</u>

**BALANCE SHEET as at 31 December 1972**

1971 £	<b>Liabilities</b>	1972 £	1971 £	<b>Assets</b>	1972 £
2,525	Accumulated Fund at 1 January ..	2,606	2,442	Local Government Securities at cost (Market Value £2,208)	2,442
81	Add Surplus .. .. .	—	164	Balance at Bank .. .. .	(7)
—	Less Deficit .. .. .	171	—		—
<u>2,606</u>		<u>2,435</u>	<u>2,606</u>		<u>2,435</u>

**JORDAN AWARD FUND****INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1972**

1971 £	<b>Expenditure</b>	1972 £	1971 £	<b>Income</b>	1972 £
100	Award .. .. .	—	65	Interest on Investments (Gross) ..	65
15	Printing .. .. .	—	50	Deficit .. .. .	—
—	Surplus .. .. .	65	—		—
<u>115</u>		<u>65</u>	<u>115</u>		<u>65</u>

**BALANCE SHEET as at 31 December 1972**

1971 £	<b>Liabilities</b>	1972 £	1971 £	<b>Assets</b>	1972 £
1,145	Accumulated Fund at 1 January ..	1,095	1,000	British Government Securities at cost (Market Value £927)	1,000
50	Less Deficit .. .. .	—	95	Balance at Bank .. .. .	160
—	Add Surplus .. .. .	65	—		—
<u>1,095</u>		<u>1,160</u>	<u>1,095</u>		<u>1,160</u>

# Proceedings of the Annual General Meeting

The Eleventh Annual General Meeting of the Incorporated Association was held on 22 June 1973 at 2.15 p.m. at the Grand Hotel, Eastbourne, Sussex, with the President (Mr A. W. Blenkinsop) in the Chair.

There were 60 Members and one Visitor present.

(iv) Mr A. T. S. Rudram

The notice convening the meeting was read.

(v) Mr T. W. Slinn

(vi) Mr R. N. Wheeler

(b) Vice-President who has held the office of President:  
Dr H. W. Keenan

## Apologies

Apologies for absence were received from Mr R. G. Gardiner, Mr I. S. Moll, Mr A. S. Fraser and Dr H. R. Hamburg.

## Election of Honorary Officers of the Association

It was unanimously agreed to elect the Honorary Officers as follows:

Honorary Secretary .. .. . Mr D. S. Newton

Honorary Treasurer .. .. . Mr F. Cooper

Honorary Editor .. .. . Mr S. R. Finn

Honorary Research and Development  
Officer .. .. . Mr A. R. H. Tawn

## Minutes

The President asked the meeting to take as read the Minutes of the Tenth Annual General Meeting held on 7 June 1972, as printed and circulated in JOCCA, pp. 756-759 inclusive, August 1972. There being no comments the adoption of the Minutes was put to the Meeting and carried unanimously. The President then signed the Minutes.

## Announcement of election of three Elective Members to Council 1973-75

The President read the following report which had been received from the Auditors:

*We have scrutinised and counted the voting papers received from the members of the Association in the United Kingdom and Overseas, and certify that the votes cast, including those notified by telex from the South African Section, show that the following obtained the largest number of votes:*

*D. E. Eddowes    H. R. Hamburg    N. Cochrane*

*Four voting papers were rejected as not being in order.*

*London,    COOPERS & LYBRAND  
12th June 1973.    Chartered Accountants.*

The President then declared the three members listed elected to Council.

## Chairmen of Sections for the coming session

The names of the Section Chairmen for the coming year were given as follows:

Auckland .. .. . Mr P. F. Sharp

Bristol .. .. . Mr F. E. Ruddick

Hull .. .. . Mr F. D. Robinson

Irish .. .. . Dr F. W. Stoyke

London .. .. . Mr R. H. E. Munn

Manchester .. .. . Mr S. Duckworth

Midlands .. .. . Mr A. S. Gay

Newcastle .. .. . Mr C. N. Finlay

Scottish .. .. . Mr E. M. Burns

South African .. .. . Mr R. A. Eglington

Thames Valley .. .. . Mr W. H. Tatton

Wellington .. .. . Mr M. D. Taylor

West Riding .. .. . Mr D. Morris

## Report of the Auditors to the Members

The Report of the Auditors to the Members was read.

## Annual Report of the Council for 1972

Mr D. S. Newton (Honorary Secretary) moved the adoption of the Annual Report of the Council and the Statement of Accounts for 1972.

There were two questions from Dr E. E. Longhurst and Dr G. D. Parfitt on the allocation of "Journal" costs and the number of papers in the "Journal" respectively, which were satisfactorily answered by the Director & Secretary.

There being no further comments or questions on the Annual Report of the Council and Statement of Accounts, these were formally adopted by the meeting.

## Election of President

Mr Blenkinsop stated that, as indicated on the Agenda, Mr L. H. Silver had been nominated by Council as President of the Association and he now asked the Annual General Meeting to accept the nomination.

This was carried unanimously with acclamation.

Mr Silver thanked the meeting for the high honour bestowed upon him and stated that he would do his best to uphold the dignity of the office and the good work carried out by former Presidents of the Association. He then asked Mr Blenkinsop to take the Chair for the remainder of the meeting and to preside at the Dinner later in the day.

## Election of Vice-Presidents of the Association

The President read the nominations of the Council as printed on the Agenda and asked the meeting to accept them en bloc. This was agreed. The following were then elected as Vice-Presidents:

(a) Vice-Presidents who have not held the office of President:

(i) Mr R. G. Gardiner

(ii) Mr A. B. Lock

(iii) Mr K. R. McDonald

### Membership subscription rates

The Honorary Treasurer proposed that in accordance with Article 11 and the resolution passed by the Council at two successive Council Meetings on 3 October 1972 and 15 February 1973, the following Resolution be confirmed by the Annual General Meeting:

*That with effect from 1 January 1974 the annual membership subscription rates in the various categories of membership shall be as follows:*

*Ordinary and Associate Member £8.00 per annum*  
*Students under 21 years of age .. £2.00 per annum*  
*Students between 21 and 25 years of age .. .. . £4.00 per annum*  
*Retired Member .. .. . £1.50 per annum*

*By resolution of the Council, Value Added Tax will be applicable to membership subscriptions paid by those members resident in the United Kingdom.*

Mr A. A. Duell seconded the proposal.

The President invited comments from members and referred to the additional information circulated with the Agenda. During the discussion the following took part: Dr E. E. Longhurst, Mr A. G. Holt and Mr J. R. Taylor on the necessity to make the total payable including VAT clear to members; Mr J. T. Tooke-Kirby on the distinction by age now made between categories of Registered Students; Dr F. M. Smith and Mr K. R. W. Chitty on the possible effect of the increase on younger members; Dr L. Valentine on the setting aside of funds for the purchase of property for headquarters; Mr W. O. Nutt who wished that the additional information be added as an appendix to these Proceedings (which was agreed); Mr K. F. Baxter on the wisdom of increasing subscriptions regularly by smaller amounts rather than by larger amounts at longer intervals; Mr F. Sowerbutts, Mr F. Cooper, Mr D. S. Newton, Mr A. R. H. Tawn, Dr S. H. Bell and the President on the extreme care taken by both the Finance Committee and Council in accordance with the provision of the Articles mentioned above. The Director & Secretary gave answers to the points raised to the satisfaction of those asking questions.

On a show of hands, the President stated that it was clear that the Annual General Meeting overwhelmingly supported the Council's recommendation and he asked, therefore, for members who wished to vote against the motion to signify. Three members then voted against the proposal and the President declared the motion carried.

### Presentation of Jordan Award

The President indicated that he now had the pleasant duty of presenting a certificate and cheque to the value of £100 to the winner of the 1972 Jordan Award, referred to in the Annual Report of the Council for 1972.

For the benefit of those present he explained that the Jordan Award had been instituted in 1967 by Mrs Marjorie Jordan, in memory of her late husband, Dr L. A. Jordan, who was President of the Association in 1947-49 and became an Honorary Member in 1955. Mrs Jordan, who had since died, wished the Award of £100 to be made for the best contribution to the science or technology of surface coating by a member, under the age of 35, of any nationality working in either the academic or industrial field.

On this occasion the Jordan Award Committee had decided to make the Award to Mr D. F. Tunstall for his papers on the optical behaviour of pigmented systems, which appeared in the November 1971 and August 1972 issues of the *Journal*.

The President then presented the certificate and cheque to Mr Tunstall with acclamation.



Mr D. F. Tunstall receives his Jordan Award Certificate and the award of £100 from the retiring President, Mr A. W. Blenkinsop

### Reappointment of Auditors and fixing the remuneration thereof

It was proposed by Mr R. N. Wheeler that Coopers and Lybrand (Chartered Accountants) be reappointed Auditors of the Association and that their fee be £450. This was seconded by Mr A. G. Holt and carried unanimously.

### Vote of Thanks to retiring President

In proposing the vote of thanks to the retiring President, Mr F. Sowerbutts (President 1967-69) acknowledged the regret of members that Mr A. S. Fraser (Immediate Past President) could not be present at this Annual General Meeting to propose this vote of thanks but he was pleased to do so on his behalf. He thought Mr Blenkinsop must be relieved that he was approaching the termination of his duties, since he had been President during a most difficult period. Not only had he been President during three Exhibitions but during his term of office the Professional Grade had been introduced and the headquarters of the Association had moved out of London. Nevertheless, he had been able to attend the Golden Jubilee Celebrations of the Federation of Societies for Paint Technology in Atlantic City in 1972 and present a scroll on behalf of the Association.

The President had been ably assisted by Mrs Blenkinsop to whom a vote of thanks would be moved by Mr Silver at the Dinner that evening.

Mr Sowerbutts then asked the members to show in the usual way their appreciation and thanks to Mr Blenkinsop for the services he had rendered during the last two years. The vote of thanks was carried unanimously and with acclamation.

Mr Blenkinsop thanked Mr Sowerbutts for his kind remarks.

### Vote of thanks to retiring Council Members

The President called upon Mr K. R. W. Chitty to propose a vote of thanks to the members retiring from Council.

Mr Chitty thanked all those members, both at home and overseas, who were retiring from Council after service in various capacities, as Vice-Presidents, Elective Members, Section Chairmen and Section Representatives. He specifically mentioned Mrs K. Driver (Chairman, West Riding Section) who had been the first lady to serve on Council.

This vote of thanks was carried with acclamation.



### Vote of thanks to Honorary Officers of the Association

In proposing a vote of thanks to the Honorary Officers, Mr C. H. Morris thought that the Honorary Research & Development Officer (Mr A. R. H. Tawn) had produced a larger technical content than ever before in this year's Conference. He mentioned the excellence of the "Journal" so ably edited by the Honorary Editor (Mr S. R. Finn) which was acclaimed as being the best in its field and thanked both the Honorary Secretary (Mr D. S. Newton) and the Honorary Treasurer (Mr F. Cooper) for their valuable work on behalf of the Association. He also wished to mention the work of the Director & Secretary (Mr R. H. Hamblin) in this most difficult year. Mr Blenkinsop, as President, stated that he particularly wished to second Mr Morris's thanks to the Director & Secretary for his work on behalf of the Association during his term as President.

Mr Morris then asked the meeting to show its gratitude to the Honorary Officers and the Director & Secretary and this was carried with acclamation.

### Any other competent business

There being no other competent business, the President declared the meeting closed at 3.30 p.m.

## Appendix to Proceedings of 1973 Annual General Meeting

### Special notice on increase in Membership Subscriptions 1974, as circulated with the Agenda dated 11 May 1973

The Council feels that Members of the Association will appreciate a note on the necessity to increase membership subscriptions next year.

The Annual Report and Accounts which are enclosed show that 1972 was a particularly difficult year financially for the Association, in that a deficit of nearly £17,000 had to be met by drawing in most of the short term loans which the Association had built up with local authorities.

The Income and Expenditure Accounts have for many years been divided under three main headings, so as to demonstrate the ways in which revenue is obtained and expenditure incurred. Thus it has long been apparent that—even after taking into the members' account the interest derived from investments and charging to this account only those *Journal* costs which could be shown to be directly involved for members—the expenditure on behalf of members much exceeded the income derived from their subscriptions.

In 1972, the financial position was complicated by the short-fall in the revenue normally derived from the Exhibition, which emphasised the very great percentage of gross income from this source. Allied to this was the continuing decrease in advertising income which the Association's *Journal* experienced in common with most technical publications. Finally, at the end of the year, the lease expired on the offices at Wax Chandlers' Hall and the agents acting on behalf of the landlords were only willing to negotiate on the basis of an increased rent of between 300 per cent and 400 per cent. The review of rateable values would also have increased the Association's outgoings if it had remained at Wax Chandlers' Hall.

Faced with these difficulties what steps did the Council take to alleviate the position? It had already arranged several years ago to register as a charity, thus effecting savings in taxation and rates (and SET up to April 1973). It now

examined the sources of income available and determined to bring the *Journal* into line with the international A4 size for many reasons, some of which were financial. For 20 years, the Association has bought its own paper, cut to its own size for the *Journal*, thus avoiding wastage, but it became clear that the standardisation of sizes would make such purchases much more costly in future. Secondly, there was evidence to suggest that advertisers were unwilling to make special blocks for the *Journal* but might be persuaded to use the *Journal* more if it were a standard size and at least two of this year's issues have shown a marked improvement in this way.

Members will readily understand that, since the Association had been in occupation at Wax Chandlers' Hall for fourteen years and had assembled a trained staff of many years' experience, how reluctant Council were to make a decision to move away from those offices, which were well suited to a professional association, particularly as we were able to hire the Hall for Council and Committee Meetings. Indeed, it would have been a simple matter for Council to have retained the offices there, merely on the justification that a well-trained staff would be hard to replace at a most critical time in the Association's life. But, in accepting that it felt the members' wishes would be to effect economies by moving out of the City, Council had also to face the possibility that—since staff had been recruited over the years from widely scattered areas round London—it might well find that the Director & Secretary had no trained staff left at all, a state of affairs which in fact was realised.

The position, therefore, is that the Council has to build up anew the resources of the Association, bearing in mind the Finance Committee's recommendation that consideration must eventually be given to the purchase of a property for the Association's headquarters. With this in mind, Council points out that membership subscriptions have only been increased twice since 1947, when they stood at £2.10 for Ordinary and Associated Members; in 1963 they moved to £3.15 and in 1968 to £5.25. During this time, moreover, the subscriptions paid by members in the United Kingdom have become eligible for income tax relief. Even with the rates proposed for 1974, they compare favourably with many other societies, some of which do not have a monthly publication.

Council feels, therefore, that it can rely upon the membership to support its efforts during this most critical time to set the finances of the Association on a much sounder basis with a greater direct financial participation by members.

On the proposed new structure, Council was aware that many societies have a differential rate for registered students at different ages; otherwise, the transition from registered student to full membership (as at present) creates too large an increase in the annual subscription paid. At present, a registered student may only remain in that category between 21 and 25 years of age if he can produce a certificate showing that he is following an approved course of study, so that the new subscription structure fits in with this existing pattern.

It will be noticed that the agenda states that Council has resolved that membership subscriptions will be liable to Value Added Tax and members will like to know that the main reason for this is that, unless this is done, the Association would not be able to reclaim all the input of the tax which much of the Association's expenditure attracts but would be disallowed input of the tax on expenditure on behalf of the members. Since this is a United Kingdom tax, we have been advised that this would not be payable by members resident overseas but it will be possible for companies in the United Kingdom (who have registered for VAT) to reclaim the VAT where the company pays the subscription direct to the Association.

May 1973

### Hull

#### The control of polymer lifetime under environmental conditions

A lecture was held at the Hull College of Technology on Monday 2 April. Mr N. F. Lythgoe, in the chair, introduced Professor G. Scott, of the University of Aston-in-Birmingham, who gave a lecture on the control of polymer lifetime under environmental conditions.

Professor Scott began his lecture with a series of slides showing the condition of various synthetic packaging materials which had been collected on the sea shore in Scotland. Besides demonstrating the remarkable stability of such materials, the slides revealed the influence of pigmentation to enhance stability by "screening out" destructive radiation. The durability of these polymers on exposure to light and oxygen was related to the electron inductive effect of the substituent atoms or groups (for example, the electron repelling effect of the methyl group in polypropylene) and to the stability of the transition complex. Polyvinyl chloride and polyacrylonitrile were more stable than polyethylene which, in turn, was more stable than polypropylene.

Professor Scott continued with a discussion of the mechanism of free radical depolymerisation via hydrogen atom abstraction, and described work which had been carried out with various novel stabiliser systems. Zinc diethyl dithiocarbamate and copper or ferric stearate in combination behaved initially as antioxidants for cumene, which was used as a model compound. The dithiocarbamate conferred protection by the destruction of hydroperoxides and was gradually removed from the system until the ferric stearate, when present in excess, behaved as a pro-oxidant. It was thus possible to provide initial protection against oxidation and free radical degradation followed at a later stage by accelerated breakdown which continued even in the absence of ultra-violet light. The successful exploitation of such stabiliser systems in preventing environmental pollution was illustrated with slides showing the condition after various intervals of time of plastic shrouds used for

the protection against frost of young banana trees in Israel. Rapid degradation and disintegration of the shrouds after their initial role had been fulfilled was clearly evident.

A long and interesting discussion period followed and a vote of thanks was proposed by Mr N. F. Lythgoe. The meeting was attended by 11 members and nine visitors.

J.A.H.

### London

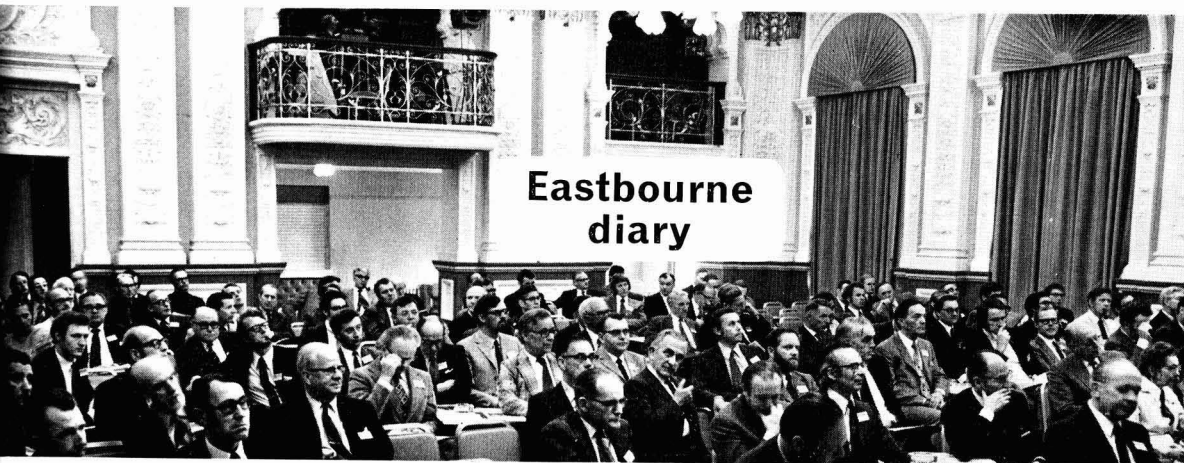
#### Thirty-fifth annual general meeting

The thirty-fifth AGM was held on 10 April 1973 at the Cafe Royal, Regent Street. In proposing the adoption of the Committee's Report, Mr R. H. Munn, the Section Honorary Secretary, said that attendances had been similar to those of the previous session. The Committee were attempting to find a more suitable and congenial venue for the technical meetings. In thanking the retiring members of the committee, he made special mention of Dr H. M. Morgans, who had been very helpful in liaison with the Polytechnic of the South Bank. The Committee's report was seconded by Mr M. Hess and adopted unanimously.

Dr H. R. Hamburg presented the financial report: OCCA's share of the profit of the Warwick symposium was quite substantial. The report was adopted unanimously. Officers were elected for the coming session. (Listed at the front of this issue.)

Mr J. T. Tooke-Kirby presented a brief report of the activities of Southern Branch. Four meetings had been held, and the students' symposium at Winchester had attracted an attendance of 60.

Following a buffet meal, Mrs W. Gumbel JP, a member of the Greater London Council, gave a talk on the work of the Council, showing a film entitled "Everybody's London" which presented an interesting survey of the work of the GLC.



The Lecture room at the Grand Hotel. A high level of attendance was maintained at all sessions

### Another successful OCCA Conference

The venue for the 1973 Conference, "Towards 2000," was Eastbourne. Delegates from 14 countries converged on this pleasant seaside town situated on the south coast of England, and listened on and discussed a wide range of topics focusing on likely future trends towards the year 2000 in the surface coatings industries. For once, "blazing June" deserved that epithet although, by the time the Conference was begun on the evening of Tuesday 20 June, the mid-summer heat had become less oppressive, remaining so until the programme was complete four days later. Thus, whilst the ladies enjoyed the amenities and tours organised by the Association, lively discussions ensued among delegates, and all technical sessions were very well attended—on this occasion there being sessions in both the mornings and afternoons of the three main days.

The headquarters of the Conference was the Grand Hotel where most delegates were accommodated, with other delegates staying at the Burlington Hotel. A coach service was arranged between the Burlington and the Grand, and the thanks of the delegates are due to Mr D. S. Newton (Hon. Secretary) who kindly offered to act as coach steward.

It was the view of the majority that the deliberate widening, this year, of the range of topics covered had been successful in maintaining interest throughout the period of the Conference. Certainly, the slight fall in numbers, compared with 1971, was not reflected in any reduction in the participation in the discussions at the Technical Sessions. The Workshop Sessions also proved of interest, one continuing until long after the scheduled time.

#### Tuesday 19 June

The first function of the Conference was the reception held by the President, together with the Honorary Officers and

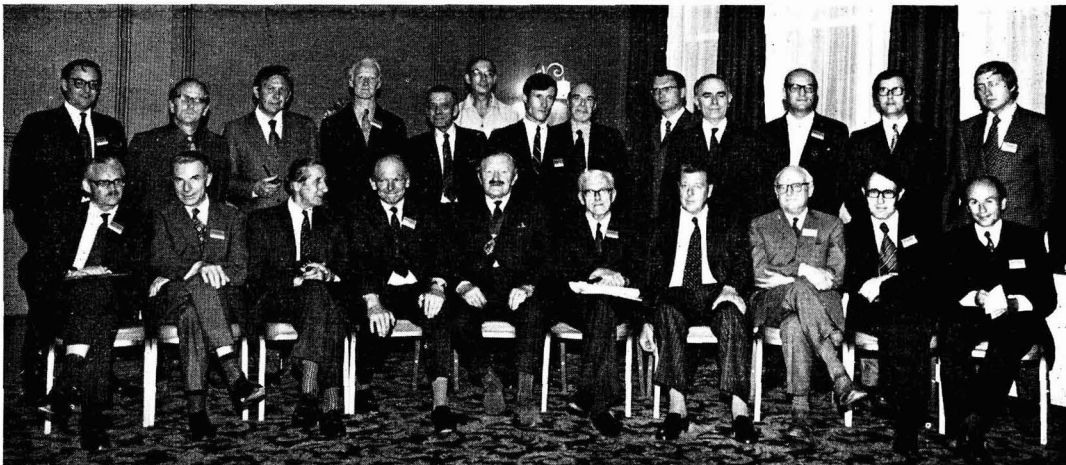
the Director & Secretary, for overseas Members and visitors before dinner. Delegates from Austria, Belgium, Canada, Czechoslovakia, Denmark, Finland, Germany, Holland, Japan, Norway, Poland, Sweden, Switzerland, and the USA had registered for the Conference, and the Association was pleased to have present at the Overseas Reception representatives from the other three societies of the international liaison, Dr H. Reckmann (President of FATIPEC), Mr R. W. Matlack (Past President of the Federation of Societies for Paint Technology) and Mr H. R. Nielsen (Past President of the Federation of Scandinavian Paint and Varnish Technologists).

After dinner, the Honorary Research & Development Officer, Mr A. R. H. Tawn, gathered together the lecturers, chairmen of Sessions and convenors of the Workshop Sessions to discuss the way in which the technical part of the Conference would be conducted.

Meetings were held too to organise the golf, tennis and table tennis tournaments, and thanks are due to Mr S. Duckworth (golf), Mr R. N. Wheeler (tennis) and Mr D. J. Silsby (table tennis), whose hard work made these events both successful and enjoyable, and to Mrs F. Sowerbutts who kindly chose not only the tournament prizes but also the ladies gifts and spot



Representatives of the four Societies. Left to right: Mr R. W. Matlack (FSPT), Dr H. Reckmann (FATIPEC), Mr A. W. Blenkinsop (OCCA) and Mr H. R. Nielsen (SLF)



The Lecturers' meeting. *Standing:* Mr R. L. J. Morris, Mr D. S. Newton, Mr R. Woodbridge (Convenor), Mr D. E. Eddowes (Chairman), Mr A. T. S. Rudram, Mr C. Meredith, Dr H. D. Hanus, Mr F. Armitage, Dr E. Ladstadter, Mr G. Isserlis, Dr J. B. Ley (Chairman), Dr J. D. Murray, Dr V. P. Simpson; *and seated:* Mr K. McLaren, Dr H. Gysin, Prof. C. E. H. Bawn, Mr A. R. H. Tawn (Hon. Research & Development Officer), the President (Mr A. W. Blenkinsop), Hon. Editor Mr S. R. Finn (Convenor), Mr S. T. Harris, Dr J. E. O. Mayne (Convenor), Prof. W. Funke, Dr U. Zorll

prizes for the Dinner Dance on the Friday evening.

#### Wednesday 20 June

At 9.30 a.m. the President declared the Conference open and handed over to the Honorary Research & Development Officer, A. R. H. Tawn (who had arranged the papers for the Conference) and acted as Chairman of the first Technical Session.

All papers from the Conference, together with the ensuing discussions, will be published in full in the Journal later in the year, and no attempt at reportage will be made here. However, it must be noted that the discussions following the papers were both lively and long, reflecting the interest aroused by the speakers. Compliments are due both to the contributors to the discussions, and to the chairmen, who encouraged, controlled, and, in many cases, closed the discussions in a prudent and tactful manner.

After the first Technical Session, the President and Mrs Blenkinsop welcomed all those attending the Conference at an informal reception before lunch.

In the afternoon, the ladies visited Bateman's Burwash—the home of Rudyard Kipling from 1902 to 1936—on the first coach tour of the Conference, whilst the second Technical Session, chaired by the then Chairman of the London Section Mr D. E. Eddowes, included a Panel Discussion on the theme "Britain and the EEC—technico-commercial aspects." The panel comprised Mr L. Silver (President Designate of OCCA), Mr Y. Pasate (Shell International Chemical Co. Ltd.), Dr L. Valentine (Research Director Berger Jenson Nicholson Ltd.) and Mr E. W. Osmond (International Paint Co. Ltd). First, Dr Valentine made some introductory remarks stating that he welcomed the recent enlargement of the EEC, and outlining some likely consequences of



At the Dinner Dance: (left to right) Mr L. H. Silver (President designate), Mrs Silver, the President (Mr A. W. Blenkinsop), Mrs Blenkinsop, the Mayoress, Sir Sydney Caffyn (Mayor of Eastbourne) and Sir Charles Taylor (MP for Eastbourne)

Britain's entry. There were difficulties to be overcome; variations, for example, in raw materials used in the different countries and in the sizes of cans for paint, as well as social and political factors. The resolving of these problems, however, would be to the mutual benefit of the industries concerned and the consumers throughout the community. The meeting soon warmed to this subject, and a long discussion followed. The whole of this session was centred around worldwide technico-economic and social aspects and, in addition to the panel discussion, two papers were presented by Mr F. Armitage and Mr A. T. S. Rudram and discussed.

In the evening the Mayor of Eastbourne, Alderman Sir Sydney Caffyn CBE, and the Mayoress, together with the President and Mrs Blenkinsop, received delegates at a Civic Reception, which was followed by dancing until midnight. During the dance, the company was entertained by Margaret Eales of the Sadlers Wells Company and her performance was warmly applauded.

#### Thursday 21 June

Dr J. B. Ley chaired the Technical Session on Thursday morning, when four papers



Karen Bjorkman, daughter of Mr L. Bjorkman, President of the Swedish Society for Paint Chemists, presenting a bouquet to Lady Caffyn at the Dinner Dance reception



Mr A. W. Blenkinsop (left) invests Mr L. H. Silver with the Presidential Insignia

were presented. A measure of interest was that all the discussions following these papers had to be cut short to avoid running too far over the schedule.

For the ladies, a Pottery Demonstration was given in the Grand Hotel by Mrs Dawkins of Hastings, a Member of the Guild of Sussex Craftsmen. This was well attended, and so successful that, as a result, some ladies later paid visits to the pottery.

In the afternoon a further Technical Session was held, chaired by Dr F. M. Smith, former Chairman of the Manchester Section. Three papers were presented.

A coach tour was organised to Brighton, which included a visit to the Royal Pavilion and tea at the White Hart Hotel.

After dinner delegates who wished were able to join a party visiting the Congress Theatre for the "Summer Spectacular" variety show.

#### Friday 22 June

The Final Technical Session of the Conference was chaired by Dr S. H. Bell. Once again the discussions which followed the presentation of papers had to be cut short to keep within the schedule, and allow delegates to lunch before the Annual General Meeting of the Association in the afternoon.

The Association would like to thank the two Members, Mr S. R. Finn and Mr D. J. Silsby, who helped at all Technical Sessions by distributing microphones and question forms for the discussions.

The Annual General Meeting was held at 2.15 p.m., and a full report appears elsewhere in this issue. The three Workshop Sessions—"Sales forecasting" (Convenor Mr S. R. Finn), "The changing influence of 'do-it-yourself' on the retail paint market" (convenor Mr R. J. Woodbridge) and "The measurement of research output" (Convenor Dr J. E. O. Mayne)—were held after the AGM. The Association's policy of not recording the proceedings, in order to foster a freer interchange of ideas, was proved successful once again, and Council thanks each of the convenors for his help.

The evening saw the final event of the Conference, the Association's Dinner and Dance, held in the Grand Hotel. Delegates and their ladies were received by the President and Mrs Blenkinsop, and the Mayor (Sir Sydney Caffyn CBE) and Mayoress of Eastbourne. The Association was also pleased to welcome Sir Charles Taylor, MP for Eastbourne.

After the Dinner and following the Royal Toast proposed by the President, the Toast to the Association was proposed by Dr H. Rechmann.

Dr Rechmann (President of FATIPEC) explained that his Federation was a sister society to OCCA, the FSPT and the SLF. Thus he had attended the last OCCA Conference in Torquay (1971) and the 1972 FATIPEC Congress in Florence. This year he was at Eastbourne for the OCCA Conference and next year he would be at the FATIPEC Congress in Garmisch Partenkirchen. He felt that there should be even closer links between the four societies and at the next FATIPEC congress OCCA members would pay the same registration fee as if they were members of FATIPEC. The same would apply to members of the FSPT and the SLF. He offered his congratulations to OCCA on the Conference and on its Journal which was so high in its standard and especially good in its new standardised size. He extended an invitation to those present to attend the FATIPEC Congress in Garmisch from 12 to 18 May 1974, when there would be ten plenaries and 80 other papers. The ladies were particularly invited for the social programme arranged for them.

The President, replying on behalf of the Association, thanked Dr Rechmann for his congratulatory remarks. He also read a telegram from Mr A. O. Brantsaeter, a Past President of the SLF now living in Singapore, who sent his good wishes to the Association for a successful conference.

Mr Blenkinsop welcomed delegates, lecturers and the chairmen of the sessions, and thanked them for their work in running the Conference. In welcoming the Mayor and Mayoress, Mr Blenkinsop thanked the Borough for the Civic Reception it had provided on the Wednesday of the Conference. He then proposed a toast to the Mayor and Lady Caffyn and to the Association's other guests.

In his reply, Alderman Sir Sydney Caffyn, CBE, (Mayor of Eastbourne) extended the thanks of all the guests and ladies for the hospitality shown by the Association at the Dinner. He was impressed by the high number of overseas guests, there being 14 overseas countries

represented, which was a tribute to the high standing of the Association.

Following Alderman Caffyn's speech, the ceremony of the presentation of the Presidential Insignia to Mr L. H. Silver, who had been elected President of the Association's AGM that afternoon, took place. Mr Blenkinsop, in investing Mr Silver, used the traditional form of words:

*Leslie Silver, in accordance with the resolution passed at the Annual General Meeting this afternoon, it is now my duty to invest you with the insignia as President of this Association, and I charge you to guard well the interests of our Association and at all times to uphold the dignity of our high office.*

Mr Silver then presented Mr Blenkinsop with his Past President's Medallion engraved with his years of office, and paid tribute to the fine way in which he had carried out his duties during his term as President. In this he had, of course, been ably supported by Mrs Blenkinsop. Mr Silver thanked Mrs Blenkinsop for her work as President's Lady, particularly in her visits to the various functions of the Sections of the Association, where she had charmed everyone. In recognition of the considerable part she had played in helping the President during his term of office, Mr Silver presented her, on behalf of the Association, with a silver salver.

Mrs Blenkinsop thanked Mr Silver and the Members of the Association for their kindness in making this presentation. She had much enjoyed visiting the Sections of the Association and meeting so many Members and their ladies, and would treasure the gift in the years to come as a happy memento of this time.

Following the speeches, the top table party left the dining room, and the assembled company made its way to the ballroom for the dance.

During the dance, the new President and his Lady presented the prizes for the various tournaments. The winners were: *Golf*: Mr S. Duckworth (Sam Sharp Golf Trophy, replica and sweep), *runner-up* Mr A. A. Duell. *Men's Tennis*: Mr G. J. Shepherd. *Ladies' Tennis*: Mrs H. G. Clayton. *Men's Table Tennis*: Dr J. D. Murray. *Ladies' Table Tennis*: Mrs L. H. Silver.

**Saturday 23 June**

Saturday saw the dispersal of delegates. Once again the verdict was that an enjoyable and successful Conference had been held.

C.A.T.

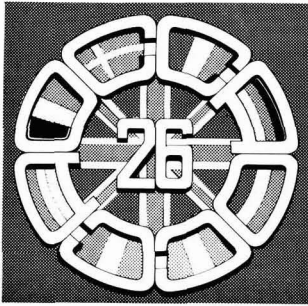


The newly elected President, L. H. Silver, presenting Mr A. W. Blenkinsop with his Past President's medallion



Following his investiture as President Mr L. H. Silver presents Mrs Blenkinsop with a silver salver in recognition of her work as President's Lady

The next OCCA Conference is scheduled to take place at Scarborough, Yorkshire, England, in June 1975. Full details will appear in this "Journal" when the programme has been arranged.



#### Motif of the Exhibition

The motif for the twenty-sixth Technical Exhibition of the Oil and Colour Chemists' Association, designed by Robert Hamblin, shows the flags of the enlarged European Economic Community, linked by the initials OCCA. By converging on the flag of the United Kingdom, the motif symbolises the welcome extended by OCCA for many years to exhibitors and visitors, both from these countries and farther afield, to its Exhibitions in London, one of the capital cities of the EEC.

#### Hours of opening

As announced at the Exhibition Dinner in May, the Exhibition next year will be of four days' duration and will open on the Tuesday morning at 9.30 and will close on the Friday at 16.00. The Exhibition will thus be open for a total of 32 hours and it is felt that the times will meet with the approval of both exhibitors and visitors alike. The Exhibition of raw materials, plant and equipment used in the paint, printing, ink, colour and allied industries will take place at the Empire Hall, Olympia, London, on the following dates and times:

Tuesday 23 April	..	09.30-18.00
Wednesday 24 April	..	09.30-18.00
Thursday 25 April	..	09.30-18.00
Friday 26 April	..	09.30-16.00

#### Exhibition dinner

Following the success of the Exhibition Dinner held on the occasion of the Silver Jubilee Exhibition in May 1973, it has been decided to hold a Dinner on the opening date (Tuesday 23 April) at the Savoy Hotel, London, WC2. The reception will be at 19.00 hours for dinner at 19.30 hours. Informal dress will be worn. Following the custom of many years, the Association will invite as its guests to this function principal officers from other scientific societies and kindred organisations, who will be invited to visit the Exhibition in the afternoon. Full details of the Exhibition Dinner will be announced in the *Official Guide* to the Exhibition, each copy of which will contain an application form for tickets.

At the request of some exhibitors who were present at the 1973 Dinner, it has been decided to arrange a cash bar in the River Room after the function until midnight.

#### Invitation to exhibit

Copies of the Invitation to Exhibit have now been despatched to those companies and organisations, in the United Kingdom and overseas, which have shown at past exhibitions or have already requested information on the 1974 exhibition. Completed application forms for stand space must be returned to the Director & Secretary of the Association **not later than 1 November 1973**. Since the United Kingdom is now a member of the European Economic Community, it is expected that even more Continental firms will participate in this exhibition; but any organisation from any part of the world wishing to exhibit should write immediately for details from the Director & Secretary of the Association, since exhibitors are welcome from all countries.

At the Twenty-Fifth Exhibition, in May 1973, there were direct overseas exhibitors from 14 countries, besides many overseas companies who showed through British associates. Representatives from over 50 overseas countries visited the exhibition on that occasion. A full review of this Exhibition, showing the countries from visitors came and the products on display appeared in the July issue of this *Journal*. Intending exhibitors and advertisers will be supplied with copies of the "Official Guide" to the 1973 Exhibition.

The Exhibition affords a splendid opportunity for the technical display of information and a forum for the interchange of technical advice and experience between those employed in the supplying and manufacturing industries.

#### Technical education stand

In continuance of its interest in the educational field, the Association will once more provide a stand devoted to technical education, at which details of courses at technical colleges will be available as well as information on the optional Professional Grade for Ordinary Members, introduced in September 1971, which has attracted widespread interest and support.

#### Information in foreign languages

The practice of distributing abroad a specially designed information leaflet in six languages (English, French, German,

Italian, Russian and Spanish), will be continued and interpreters (French, German, Italian and Spanish) will be available without charge at the Exhibition for the convenience of visitors and exhibitors.

#### Admission

As at all previous exhibitions organised by the Association, there will be no charge for admission, and free copies of the "Official Guide" will be available to those intending to visit the Exhibition several weeks before the event so as to enable them to plan their itineraries to the maximum benefit.

#### Official Guide

This unique publication, of which 17,000 copies will be printed, will contain descriptions of all exhibits and advertising space is available to both exhibitors and those organisations not able to show at the 1974 exhibition. Full details of advertising, the basic rates for which are the same as for this *Journal*, can be obtained from the Association's offices.

## Optional Professional Grade

#### LTSC qualifications

Students who have fulfilled the necessary examination requirements may complete the requirements for Licentiatehips by taking, as a one-year part-time course, appropriate course modules from courses such as the HNC Supplementary Studies in Surface Coatings Technology at the Polytechnic of the South Bank. Other routes via the Polytechnic Certificate in Surface Coatings and further details can be obtained by contacting the Head of the Department of Chemistry and Polymer Technology, Polytechnic of the South Bank, Borough Road, London SE1 0AA.

It is hoped that full details of the requirements for the optional Professional Grade for Ordinary Members, which last appeared in the January 1973 issue, will be published in the September issue of the *Journal*.

## Register of Members

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

### Ordinary Members

ANDERSON, SYDNEY GRAHAM, ARIC, 246 Haynes Park Court, Slewins Close, Hornchurch, Essex RM11 2DG. (*London*)  
 AUNGIER, JOHN STEPHEN, LIRI, May & Baker Ltd., UK Agency Unit, Dagenham, Essex. (*London*)  
 BOSE, SUNIL KUMAR, BSc, FTC, 79 Gurney Road, London E15. (*London*)  
 DAMSELL, ANTHONY ARTHUR, 47 Queens Road, Brentwood, Essex. (*London*)  
 DAVIES, WILLIAM GRENVILLE, PhD, BTech, ARIC, 5 Fairlight Cross, New Barn, Longfield, Kent. (*London*)  
 HANSON, ROBERT EDWARD THOMAS, FRIC, 16 Abbots Close, Shenfield, Essex. (*London*)  
 HUMPHREY, COLIN NORMAN, BSc, May & Baker Ltd, UK Agency Unit, Dagenham, Essex. (*London*)

SEARLE, CHARLES BENJAMIN, 61 Coxtie Green Road, Brentwood, Essex. (*London*)  
 SPENCELEY, DAVID MICHAEL, 17-37th Avenue, Greenwood Avenue, Hull HU6 8AU. (*Hull*)  
 TAYLER, CLIVE ANTHONY, BSc, "West Glebe", Brightwalton, Nr Newbury, Berkshire. (*Thames Valley*)  
 TAYLOR, DAVID FREDERICK, PhD, BSc, 40 Bishopsford Road, Morden, Surrey. (*London*)

### Associate Member

SYMONS, HEUGH SHERWOOD, 4 Redcliffe Parade East, Bristol BS1 6SW. (*Bristol*)

## News of Members

Mr D. Stewart, an Ordinary Member attached to the Manchester Section, is now employed as Export Manager by Mander Kidd (UK) Ltd, who produce printing inks in Wolverhampton. Mr Stewart served on the Manchester Section Committee from 1968 to 1971.

Mr V. Watson, an Ordinary Member attached to the Manchester Section, has retired as a director of Burrell & Co Ltd after more than 41 years' service with that company. He is now acting as a consultant to Burrell & Co.



Mr V. Watson



Mr H. G. Clayton



Dr F. Dalton

Mr H. G. Clayton, an Associate Member, has been appointed Divisional Operations Director.

Dr F. Dalton, an Ordinary Member, takes up the position of Marketing Director.

## London Section

### Course on surface coatings

A short course on "Surface coatings—newer techniques in application and curing," arranged in association with the East Ham College of Technology, has the following programme:

- 22 October 1973: Future requirements—motives for development. Dr L. A. O'Neill (PRA)  
 29 October 1973: Product finishing with powder coatings. Dr S. Kut (E. Wood Ltd.)  
 5 November 1973: Electrodeposition and other uses for water soluble coatings. Mr S. Erratt (Valentine Varnish Manufacturing Co. Ltd.)  
 12 November 1973: Radiation Curing. Mr. A. Wright (D. Macpherson Group Ltd.)  
 19 November 1973: Metal decorating, including roller coating and printing. Mr A. D. Lott (Metal Box Co. Ltd.)  
 26 November 1973: Curtain coating. Mr K. Waddington (C. Macpherson Co. Ltd.)

The fee will be £3.75 for Members and £4.25 for non-Members.

Rearrangement of personnel in the Pigments Division of CIBA-GEIGY (UK) Ltd has involved the following three Members, all of whom are attached to the Manchester Section:

Mr H. D. Brearley, an Ordinary Member, who was previously Phthalocyanine Products Manager, now becomes Pigments Production Manager for the Division.



# Section programmes for 1973-74 session

## Main Association Events

1974

**Tuesday 23—Friday 26 April**

OCCA-26 Technical Exhibition, to be held at the Empire Hall, Olympia, London W14. *For further details see back outside cover of this issue.*

**Friday 31 May**

Dinner Dance, to be held at the Savoy Hotel, London.

## Bristol

All meetings will be held at the Royal Hotel, Bristol, at 7.15 p.m., unless otherwise stated.

1973

**Friday 28 September**

"Colour in the home" by Mr R. G. Stay, Berger Paints Ltd.

Ladies' Evening.

**Friday 26 October**

"The Testing and Performance of Flame Retardant Paints" by Mr F. C. Adams of the Building Research Establishment, Fire Research Station.

**Thursday 1 November**

"Future trends and requirements for automotive finishes" by Mr W. Dabbs, of Pressed Steel Fisher. Joint Meeting with the Birmingham Paint Varnish and Lacquer Club at the Imperial Hotel, Birmingham.

**Friday 30 November**

"Water pollution—legislation, case study and one answer" by Mr B. Cryer and Mr Shepherd of Berger Paints, Mr Hunt of Bristol City Engineers Department, and Mr R. Evans of Pollution Technical Services.

1974

**Friday 25 January**

"Printing ink developments" by Mr G. H. Hutchinson of Croda Polymers Ltd., Ink Division.

**Friday 22 February**

Details to be announced.

**Friday 8 March**

Annual Dinner Dance at the Mayfair Suite, New Bristol Centre.

**Friday 29 March**

"The New Flashpoint Regulations—Flashpoint and Combustibility Tests" by Mr A. N. McKelvie of the Paint Research Association, at the Angel Hotel, Cardiff.

**Friday 26 April**

Annual General Meeting.

## Hull

Unless otherwise stated the meetings will be held at 7.00 p.m. at the Dorchester Hotel, Beverley Road, Hull.

1973

**Monday 1 October**

"Polyacrylates in emulsion paints" by a speaker from Allied Colloids.

**Friday 5 October**

Annual Dinner/Dance to be held at Cave Castle, South Cave, Hull.

**Tuesday 6 November**

"Some aspects of personnel management" by Mr K. Yates of Laporte Industries Ltd. at the Haven Inn, Barrow Haven, Lincs at 6.30 p.m.

**Monday 3 December**

"A review of the current and future trends in industrial finishing" by Mr R. McD. Barrett of BIP Chemicals Ltd.

**Thursday 13 December**

Joint meeting with the Chemical Engineers—South Humberside Group at 6.30 p.m. at the Haven Inn, Barrow Haven, Lincs. "The Humber Bridge Construction" by Mr J. A. Hyatt of Freeman Fox and Partners.

1974

**Monday 7 January**

"New developments in colour instrumentation" by Mr R. P. Best of Instrumental Colour Systems Limited.

**Monday 4 February**

Ladies' Evening.

"Wallpaper—Design and manufacture" by Mr B. C. Callaghan of ICI Wallpapers Ltd.

**Monday 4 March**

"Etch and blast primers" by Mr H. F. Clay of Cromford Colour Co. Ltd.

## Irish

All meetings will be held at the Clarence Hotel, Dublin, at 8.00 p.m. unless otherwise stated.

1973

**Friday 21 September**

"Pollution, its causes and effects" by a speaker from the Institute for Industrial Research and Standards.

**Friday 19 October**

"The use of extenders in titanium dioxide" by Mr M. Hart, Croxton & Garry Ltd.

**Thursday 15 November**

Annual Dinner Dance at the Clarence Hotel, Dublin.

**Friday 7 December**

Ladies' night. A lecture on "Old Dublin" by Mr F. Dixon.

1974

**Friday 18 January**

To be announced.

**Friday 15 February**

Works visit to the Irish Glass Bottle Company.

**Friday 15 March**

"Dispersible pigments for printing inks" by Mr H. Bower, BSc, CIBA-GEIGY (UK) Ltd.

**Friday 19 April**

Annual General Meeting.

*The usual social events (Treasure Hunt and Golf Outing) will be held in May and June venues to be announced.*

## London

All meetings will be held at Great Northern Hotel, King's Cross, London N1 9AN, at 7.00 p.m. unless otherwise stated.

1973

**Thursday 27 September**

Chairman's Open Forum: "Whither the London Section?"

**Tuesday 16 October**

"Some aspects of technical training" by Mr G. P. Birtles of Selection & Industrial Training Administration Ltd.

**Wednesday 7 November**

"Newer analytical techniques and their application to the surface coatings industry." One-day joint meeting with the Society for Analytical Chemistry, Analytical Division, Chemical Society, at Thames Polytechnic, Woolwich, commencing at 9.30 a.m.

**Monday 12 November**

"Optical methods in colloid and surface chemistry." Joint meeting with Society of Chemical Industry, Colloid and Surface Chemistry Group, at 14 Belgrave Square, London, SW1X 8PS, commencing at 11.30 a.m.

**Friday 30 November**

Ladies' night.

**Tuesday 11 December**

Ladies' Invitation Lecture. "Driving the Police way" by Chief Inspector N. A. M. Ferguson of the Metropolitan Police.

1974

**Monday 21 January**

"Modern marine coatings and their application" by Mr J. C. Smith of the Central Dockyard Laboratory at East

Ham College of Technology, High Street South, London E6.

#### Tuesday 12 February

"Recent developments in metal decorating" by Mr J. Holt and Mr M. Reid of the Research Division, Metal Box Company.

#### Saturday 23 to Sunday 24 February

Weekend conference on "Colour," with participation from the French Association, AFTPV, at the Queen's Hotel, Hastings, Kent.

#### Tuesday 12 March

"Additives in paint." Half-day symposium at the Polytechnic of the South Bank, Borough Road, SE1, commencing at 2.00 p.m.

## Manchester

All meetings will be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester at 6.30 p.m., unless otherwise stated.

#### 1973

##### Tuesday 18 September

Symposium on "Wallcoverings," at the University of Manchester Institute of Science & Technology, Sackville Street, Manchester.

##### Tuesday 9 October

Joint meeting with the North Western Branch of the Institute of Printing. "Change in printing ink technology and the influence of Europe" by Mr G. Whitfield, Mander Kidd (UK) Ltd., at the Cottons Hotel, Manchester Road, Knutsford, at 7.00 p.m.

##### Friday 19 October

Annual Dinner Dance at the Piccadilly Hotel, Piccadilly Plaza, Manchester.

##### Friday 9 November

"Industrial relations and communications" by Mr W. Davies of the Manchester Business School.

##### Friday 7 December

"Are we at risk with chemicals?" by Mr K. R. Butterworth of The British Industrial Biological Research Association.

#### 1974

##### Friday 11 January

"Colour difference, the measure of the future" by Mr K. McLaren, ICI Ltd., Organics Division.

##### Friday 8 February

Instrument Evening.

- "The Gel Permeation Chromatograph" by Dr R. Ellis of The Walpamur Co. Ltd.
- "The Zeiss Goniophotometer" by Dr W. Carr, CIBA-GEIGY (UK) Ltd., Pigments Division.

#### Friday 8 March

"Recent trends in wood finishing" by Mr K. Waddington of Donald Macpherson & Co. Ltd.

#### Friday 5 April

Annual General Meeting, at the University of Manchester Institute of Science and Technology, Sackville Street, Manchester, at 6.30 p.m.

### Student Group

All meetings to be held at the Manchester Literary and Philosophical Society at 4.30 p.m.

#### 1973

##### Wednesday 26 September

"Powder coatings" by Mr N. H. Seymour of Sterling Varnish Co. Ltd.

##### Wednesday 17 October

"Instrumental colour measurement" by Mr Bravery of Berger Paints.

#### 1974

##### Wednesday 30 January

"Organic pigments in paints—Automotive finishes" by a lecturer from CIBA-GEIGY (UK) Ltd., Pigments Division.

##### Wednesday 27 February

"Paint additives" by a lecturer from Byk-Mallinckrodt.

## Midlands

All meetings will be held at 6.30 p.m. in the Birmingham Chamber of Commerce and Industry, PO Box 30, 75 Harborne Road, Birmingham B15 3DH, unless otherwise stated.

#### 1973

##### Friday 21 September

Ladies' Evening 7.00 p.m. Westbourne Suite, Botanical Gardens, Birmingham.

##### Friday 28 September

"Recent developments in radiation curing" D. R. Bailey (Donald Macpherson & Co. Ltd.).

##### Friday 19 October

"The current status and role of amino resins in surface coatings" R. McD. Barrett (BIP Chemicals Ltd.).

##### Friday 16 November

"Recent progress in organic pigments" E. R. Inman (CIBA-GEIGY (UK) Ltd.).

#### 1974

##### Friday 18 January

Annual Dinner Lecture, "Who needs paint anyway?" L. H. Silver (SPL Group).

##### Friday 15 February

"We need paint" R. J. King (Blundell Permglaze Ltd.).

#### Friday 15 March

Annual J. Newton Friend Lecture 7.30 p.m., "Wines" D. J. Smith (Seligman & Co. Ltd.).

#### Wednesday 20 March

One day Symposium 10.00 a.m. at Pavilion Suite, County Ground, Edgbaston, Birmingham, "Atmospheric Pollution—will the Paint User overcome this Problem?"

#### Friday 19 April

Annual General Meeting.

### Trent Valley Branch

#### 1973

##### Thursday 11 October

"Paint manufacturing techniques" by Mr B. L. Lucas, Joseph Mason & Co. Ltd., Derby.

##### Thursday 8 November

"Solvents and safety" by Mr K. W. Smith, HM District Inspector of Factories, Derby.

#### 1974

##### Thursday 10 January

"Pollution" by Mr J. B. Davies, Goodlass Wall & Co. Ltd., Speke, Liverpool.

##### Thursday 14 February

"Developments at British Rail" by Mr D. M. Bishop, Railway Technical Centre, Derby.

##### Thursday 14 March

"Marketing" by Mr J. E. Fowles-Smith, Mebon Ltd., Sutton-in-Ashfield, Notts.

##### Thursday 4 April

AGM, followed by "Colour Television" by a speaker from Pye Television Ltd., Cambridge.

## Newcastle

#### 1973

##### Thursday 4 October

"Painting of Wooden Joinery" A. F. Sherwood, Paint Research Station.

##### Thursday 1 November

Acrylic Emulsions in Maintenance Paints, Dr R. N. Washburne, Rohm and Haas.

##### Thursday 6 December

Determination of the Dispersibility of Organic Pigments in Paints, Mr Hafner, Hoechst Cassella Dyestuffs Ltd.

#### 1974

##### Thursday 3 January

"Masonry Coatings" G. W. Rothwell, Building Research Association.

##### Thursday 7 February

"Profitability in the Paint Industry" Mr L. Silver, Silver Paint and Lacquer.

**Friday 22 February**

Ladies Night. Five Bridges Hotel, Gateshead.

**Thursday 7 March**

"Coatings for Plastics" Dr Kut, E. Wood Ltd.

**Thursday 4 April**

Annual General Meeting.

**Scottish**

All meetings will be held in the St. Enoch Hotel, Glasgow at 6.00 p.m. unless otherwise stated.

1973

**Friday 21 September**

Wine and Cheese Party at a venue to be announced.

**Thursday 11 October**

Visit to Planetarium of Glasgow College of Nautical Sciences.

**Tuesday 20 November**

Colour difference—"The measure of the future" by Mr K. McLaren (ICI Organics Division). Joint meeting with the Society of Dyers and Colourists—Scottish Region at 7.30 p.m. in The Whitehall Restaurant, West George Street, Glasgow.

**Thursday 13 December**

"Review of plastics" by Professor N. Grassie (University of Glasgow). Joint meeting with the British Paper and Board Manufacturers Association, Technical Section at 7.30 p.m.

1974

**Friday 11 January**

Annual Dinner Dance in the Albany Hotel, Glasgow.

**Thursday 17 January**

"A trade journalist speaks his mind" by Mr D. E. Eddowes (Polymers Paint and Colour Journal).

**Thursday 14 February**

Talk on matters of topical interest by R. W. Kay of HM Factory Inspectorate.

**Thursday 14 March**

"Paint and Joinery" by Mr A. Sherwood (Paint Research Association).

**Eastern Branch**

All lectures will take place in the Carlton Hotel, North Bridge, Edinburgh at 7.30 p.m. unless otherwise stated.

1973

**Saturday 6 October**

Joint meeting with the Scottish Junior Section on "Dispersions of titanium dioxide in modern paint making" by Mr Derek Craig of Tioxide International Ltd. in the Lady Nairn Hotel, Willowbrae Road, Edinburgh at 10.30 a.m. followed

by lunch and the annual skittles match at the Abercorn Inn.

**Wednesday 17 October**

"Advances in polymers" by Dr I. Soutar, Heriot Watt University, Edinburgh.

**Wednesday 7 November**

Joint lecture with BPBMA on "Marketing" by Mr G. Mandel of Thomas and Green 7.15 start.

**Wednesday 19 December**

"Newer modified hydrocarbon resins for paint and printing inks" by Mr A. Chemicals and Mr K. B. Gilkes, Berger Chemicals.

1974

**Wednesday 16 January**

"Marketing in Europe" speaker to be announced.

**Friday 8 February**

Burns Supper in the Lady Nairn Hotel, Edinburgh.

**Wednesday 20 February**

"Computers in general" by Mr F. Lawry, Croda Polymers.

**Wednesday 20 March**

AGM 7.00 p.m. Followed by a lecture on coloured television by Mr L. Ashton, BBC.

**Wednesday 17 April**

"North sea oil" speaker from the Scottish Council of development and industry.

**Saturday 1 June**

Annual Car Treasure Hunt and Barbecue.

**Student Group**

All meetings will be held at the St. Enoch's Hotel, Glasgow, at 10.15 a.m. unless otherwise advised.

1973

**Saturday 6 October**

Joint Meeting with Eastern Section to be held in the Lady Nairn Hotel, Willowbrae Road, Edinburgh, and afterwards at the Abercorn Bar for the yearly skittles match for the Newton Cup. The lecture will be on "Dispersions of titanium dioxide in modern paint making" by Mr Derek Craig of Tioxide International Ltd.

**Saturday 10 November**

"Powder coatings" by Mr M. P. Stanley of Shell Chemicals UK Ltd.

**Saturday 15 December**

"Marketing techniques" by a lecturer to be advised at a later date.

1974

**Saturday 19 January**

Works visit to Continex International—Carbon Black Manufacturers. This will be a joint meeting with the Eastern Section owing to the intermediate

position of Continex International between Glasgow and Edinburgh.

**Saturday 16 February**

"Communications" by Mr D. Glenn of CIBA-GEIGY (UK) Ltd.

**Saturday 16 March**

"Pigment elaborations" by Mr A. G. Able of Hoechst Cassella.

**Thames Valley**

All meetings to be held at the Beech Tree Hotel, Maxwell Road, Beaconsfield, Bucks., at 7.00 p.m., unless otherwise stated.

1973

**Thursday 27 September**

"Modern developments in Europe on woodfinishing" by Herr Anskinovitch and Dr Schwarz of Glasurit.

**Thursday 25 October**

"Printing inks in the '70s" by Mr G. H. Hutchinson of Croda Polymers Ltd.

**Thursday 22 November**

"Newer modified hydrocarbon resins for paint and printing inks" by Mr K. Gilkes of Berger Chemical Resin Division.

1974

**Thursday 24 January**

Paint Research Association's "Inventions" by R. A. Brett.

**Friday 8 February**

Buffet Dance at Great Fosters, Egham.

**Thursday 21 February**

"Corrosion, the vulture of metallurgy" by Dr M. Clarke of Sir John Cass School of Science and Technology.

**Thursday 21 March**

"Dispersymer two year's production experience" by Mr M. Waghorn of ICI.

**Thursday 4 April**

Annual General Meeting to be followed by a talk on Windsor Castle by Mrs G. Grove.

**Student Group**

All meetings will be held in the main Lecture Theatre, Slough College at 4 p.m. except the Works Visit.

1973

**Thursday 4 October**

"Aerosols" by Mr Southby of Aerosols International Ltd., Downmill Road, Bracknell.

**Thursday 1 November**

"Printing and printing inks" by Mr B. Ellison, Winstones Ltd., Summerhouse Lane, Harefield.

**Thursday 5 December**

"Electrostatic application" by Mr Mounce, Henry W. Peabody.

1974

**Thursday 7 February**

"The basic principles of dispersymers" by Dr D. Pont, ICI Paints.

**Thursday 7 March**

Works Visit.

**Thursday 2 May**

"Some thoughts on the future of solvents in coatings" by Mr C. J. Nunn, Shell Research, Egham.

**West Riding**

All meetings will be held at the Griffin Hotel, Leeds, at 7.30 p.m. unless otherwise stated.

1973

**Tuesday 11 September**

"Radiation curing" by Mr A. G. North of Cray Valley Products.

**Tuesday 9 October**

"The performance of wood primers" by Mr P. Whitely of Building Research Station.

**Tuesday 13 November**

"Water-based metal primers" by Mr K. A. Safe of Vinyl Products Ltd.

**Friday 23 November**

Annual Dinner and Dance at Crown Hotel, Harrogate.

**Tuesday 4 December**

"Flame retardant coatings" by Mr F. C. Adams of Building Research Establishment.

1974

**Tuesday 8 January**

"Epoxy resin curing agents" by Dr C. G. Tilley of Anchor Chemical Co. Ltd.

**Tuesday 12 February**

"Fast air drying vegetable oils" by Dr Gorke of Chemische Werke Huls AG.

**Tuesday 12 March**

"The forensic examination of inks and paints" by Mr R. M. Kevern.

**Tuesday 9 April**

Annual General Meeting.

## Reunion Dinner for past and present Members of Council

Council has decided this year to hold a Reunion Dinner for those Members who have served on Council at any time, in place of the biennial Past Presidents' Dinner. Notices were despatched at the end of July to all those known to have served on Council. The Dinner will take place on Wednesday 17 October 1973 at the Cafe Royal, 68 Regent Street, London W1, at 6.30 for 7.00 p.m., and informal dress will be worn.

The price of the ticket, to include drinks at the reception, dinner,

wines and liqueurs, will be £6.00 (inclusive of VAT). Past Presidents, Past Honorary Officers, Honorary Members and Founder Member have been invited as guests of the Association, as they would have been invited to a biennial Dinner. 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.

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CHEMISTS'

ASSOCIATION



TECHNICAL EXHIBITION

OLYMPIA LONDON APRIL 1974

The motif for the twenty-sixth Technical Exhibition of the Oil and Colour Chemists' Association, designed by Robert Hamblin, shows the flags of the enlarged European Economic Community, linked by the initials OCCA. By converging on the flag of the United Kingdom, the motif symbolises the welcome extended by OCCA for many years to exhibitors and visitors, both from these countries and further afield, to its Exhibitions in London, one of the capital cities of the EEC.

**PLEASE COMPLETE AND RETURN THIS COUPON FOR A COPY OF THE INVITATION TO EXHIBIT**

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