# JOURNAL
OF THE
# OIL AND COLOUR CHEMISTS' ASSOCIATION

**Vol. 55 No. 11** **November 1972**

Tar/polyurethane systems and their fields of application *F. Blomeyer*

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Some factors affecting the water absorption of films from synthetic latices *J. Šňupárek*

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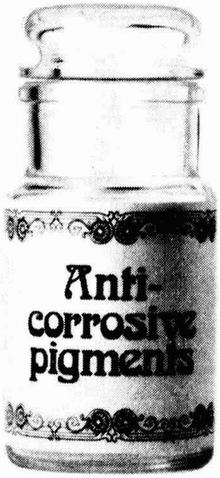

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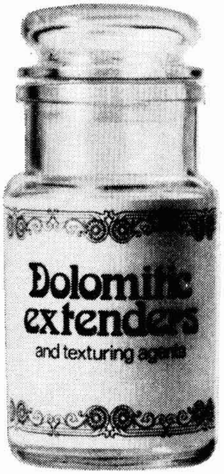

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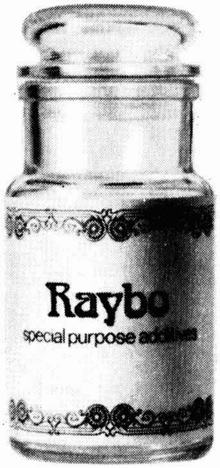

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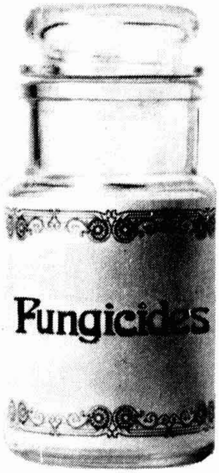

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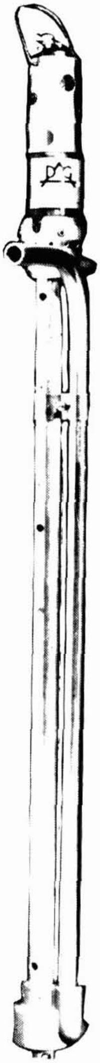

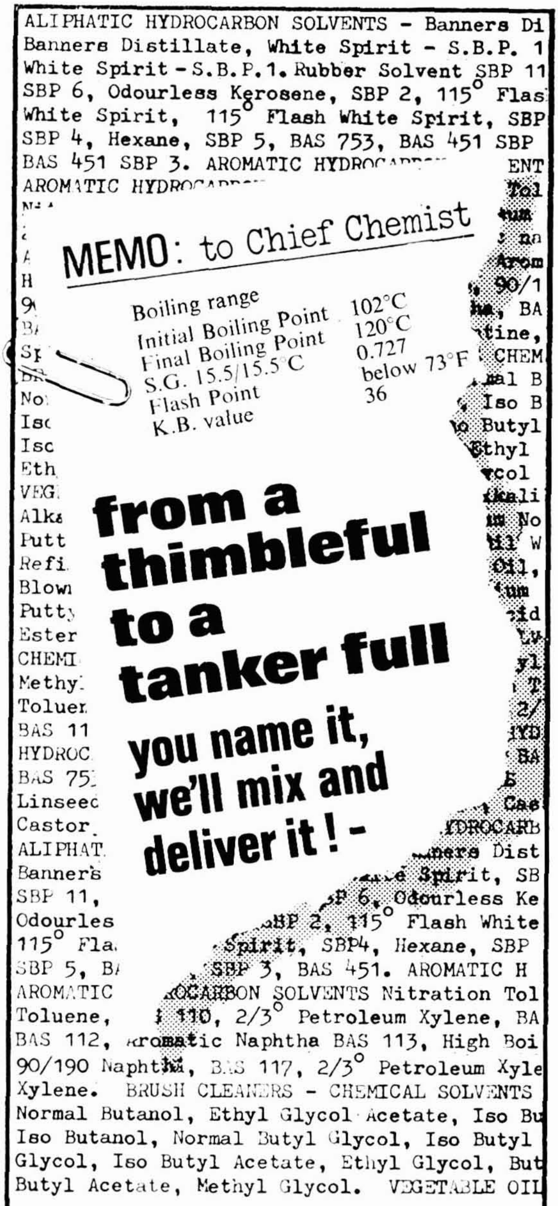

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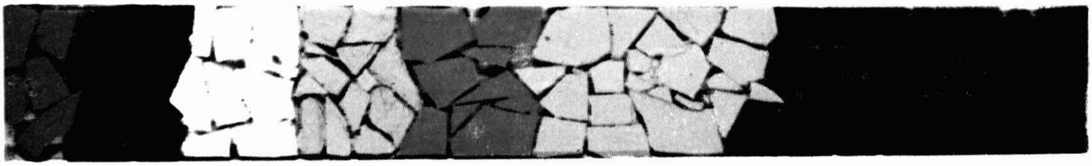


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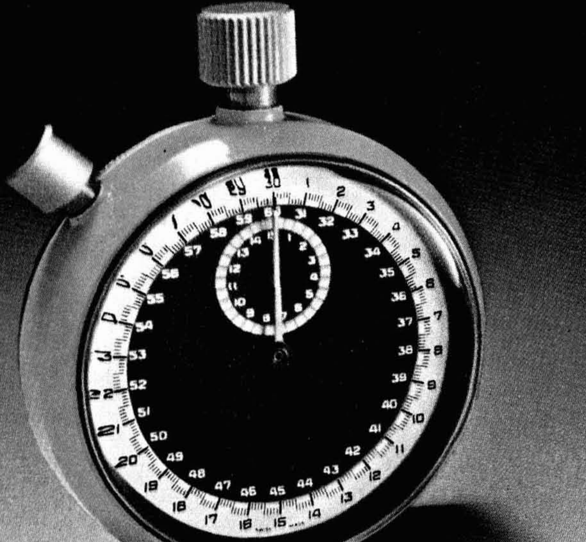

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**Vol. 55 No. 11 November 1972**

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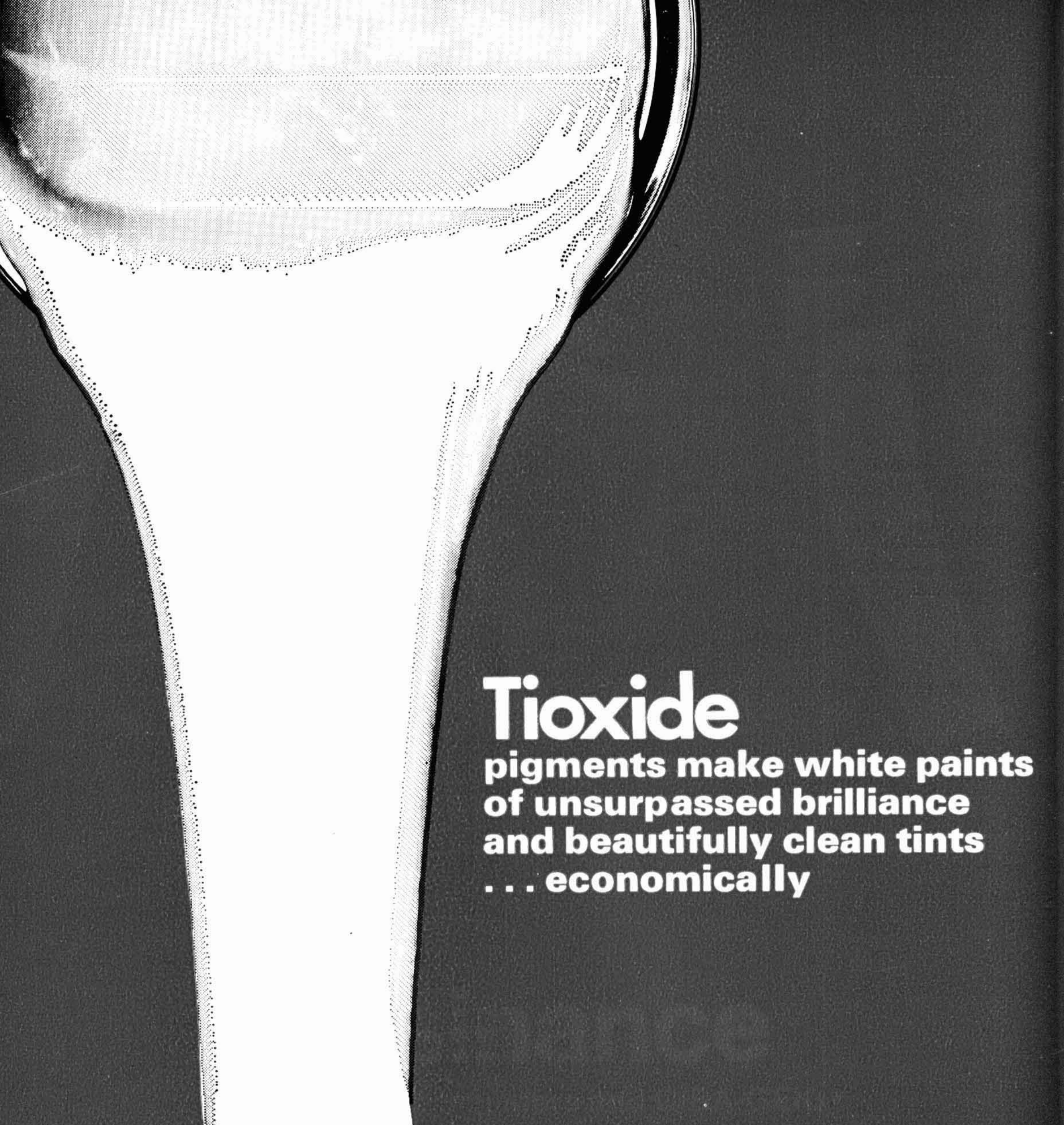
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## *Transactions and Communications*

# Tar/polyurethane systems and their fields of application*

**By F. Blomeyer†**

Bayer Chemicals Ltd., Bayer House, Richmond, Surrey

*Summary*

Coal tar may be used in conjunction with a number of synthetic resins to produce coatings with useful properties, particularly in respect of toughness and flexibility. One combination of particular interest is tar with polyurethane resins. In order to illustrate the large number of possible combinations, the characteristics of the individual components are outlined, with reference to their chemical structure.

Tar/polyurethane formulations may be of the two-component solvent-based, two-component solventless, or one-component solvent-based types and, by varying the tar and resin components, a variety of properties can be obtained. Typical uses and application methods for compositions of each type are shown.

**Keywords**

*Binders, resins etc.*
coal tar resin
coal tar polyurethane resin

## Systèmes goudron/polyuréthannes et leurs domaines d'utilisation

*Résumé*

On peut utiliser le goudron de houille en mélange avec une gamme de résines synthétiques pour la production de revêtements ayant des propriétés utiles, surtout à l'égard de tenacité et de flexibilité. Une combinaison d'un intérêt spécial est du goudron avec des résines polyuréthannes. Afin d'indiquer le grand nombre de combinaisons éventuelles, on trace les grandes lignes des constituants individuels en faisant référence à leur structure chimique.

Les systèmes goudron/polyuréthanne peuvent être à deux emballages et à base de solvant; à deux emballages mais sans solvant; ou à seul emballage à base de solvent, et en faisant varier le goudron et la résine on peut obtenir une variété de caractéristiques. On démontre les usages typiques et les méthodes d'application pour les compositions de chaque type de système.

## Teer/Polyurethan-Systeme und deren Anwendungsgebiete

*Zusammenfassung*

Kohlenteer kann gemeinsam mit einer Anzahl von Kunstharzen eingesetzt werden, um Beschichtungsmittel mit nützlichen Eigenschaften, insbesondere Festigkeit und Elastizität, zu erzeugen. Von besonderem Interesse ist die Kombination von Teer mit Polyurethanharzen. Um die grosse Zahl möglicher Kombinationen zu zeigen, werden unter Bezugnahme auf ihre chemische Struktur die Charakteristika der einzelnen Komponenten skizziert.

---

*Presented to the Trent Valley Branch on 4th March 1971.

†It is with regret that we record the death of Dr Blomeyer at the end of August, at the age of 51. With Bayer for 17 years, he had been a frequent speaker at Section meetings, several of his papers being published in *JOCCA*.

Teer/Polyurethan—Rezepturen können Lösungsmittel enthaltende Zweikompenenten-, lösungsmittelfreie Zweikomponenten-oder Lösungsmittel enthaltende Einkomponententyps sein, und durch Variationen der Teer-und Harzkomponenten kann man die verschiedensten Eigenschaften erzeugen. Es werden charakteristische Anwendungsgebiete und Auftragsmethoden für Kompositionen jeden Typs aufgezeigt.

## Смольно/полиуретановые системы и области их применения

*Резюме*

Каменноугольная смола может применяться в сочетанни с рядом синтетических смол для получения покрытий обладающих полезными свойствами, в особенности по отношению к их прочности и пластичности. Одно соединение представляющее особый интерес является соединение каменноугольной смолы с полиуретановыми смолами.

Для иллюстрации большого числа возможных соединений, прилагаются характеристики индивидуальных составляющих элементов, по отношению к их химической структуре.

Смольно/полиуретановые формуляции могут быть двух-компонентного типа на основе растворителя, двух-компонентного типа без растворителя или однокомпонентного типа на основе растворителя и меняя состав каменноугольной и других смол, можно получить большое разнообразие свойств. Показаны типичные использования и методы применения каждого типа соединений.

## Introduction

Tar and polyurethane can be combined in many ways to provide products with interesting properties. To illustrate this, it is first necessary to describe the properties of the individual components, particularly the tar.

Asphalts are naturally occurring products recovered from surface mining operations. They are characterised by excellent water resistance and have been used for many years for sealing purposes.

The residues from crude oil distillation are called bitumens, and by the addition of suitable mineral additives a synthetic asphalt may be obtained.

Depending upon their origin, asphalts and bitumens are aliphatic or cycloaliphatic in structure. It is difficult to detect any active hydrogen even by the Zerewitinoff method. Their oxygen content is negligible. Because of their chemical structure, asphalts and bitumens can either be dissolved in white spirit or are very easily compatible with it. They have very limited compatibility with compounds having polar hydroxyl groups, such as polyester- and polyether-alcohols and epoxide resins.

Cyclohexanone and, to a lesser extent, the aromatics, can be used as solvents or thinners to promote compatibility.

Combination with rubber and its derivatives has a favourable influence on the properties of asphalts and bitumens; for instance, the addition of approximately 2 to 2.5 per cent halogenated polybutadiene in the form of an emulsion to bitumen imparts:

an increase in strength and toughness,
an increase in flexibility,
an increase in the softening point,
a reduction of the penetration,
an improvement in the ductility, and
a reduction in the flow length.

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## "TOWARDS 2000"

Preliminary details of the Association's Biennial Conference have already appeared in the Association's Journal and summaries of the papers will be appearing in the December issue. Biographies of the lecturers will be appearing in the January 1973 issue of the Journal.

There will be 17 papers arranged in five sessions, together with three workshop sessions so that there will be a full programme for the three days of the Conference. Arrangements are also being made for the usual OCCA activities connected with a Conference, including a Reception for overseas members and visitors, a civic reception given by the Mayor, a Conference Dinner & Dance and coach tours to places of interest as it is expected that many ladies will be present.

be despatched to all Members of the Association at the end of the year.

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These improvements are useful in road construction and joint-filling compounds.

Even today asphalts and bitumens are being used for many purposes where their useful properties, for instance their excellent underwater resistance, can be utilised. They are used as sealants, for joint filling, as caulking compounds, in ships bottom paints and in paints in coastal areas, for lock installations, for corrosion protection, for lining of pipelines and drinking water containers, as underseals for cars, and for tar concrete, especially in road construction. Their low price favours their use, but they have disadvantages in low resistance to petrol, aromatics and oil. Their weather resistance is poor because they tend to show heavy chalking.

### Coal tar

The term "tar" refers to the residues from coal tar distillation. As a rule, for reasons of rationalisation, distillation is continued until pitch is produced. Various grades of "tar" are manufactured from pitch by the incorporation of tar oils, using the process known as "refluxing." The viscosities and softening points of the compounds vary widely, and indicate the proportion and the boiling range of the oils used. The tar oil proportion may vary from nil, in the case of pitch residue, to approximately 50 per cent, for a liquid tar.

The boiling ranges of the tar oils used for adjusting the viscosity may vary widely, but for surface coatings the boiling range should be above 200°C.

The high tar oil proportion of liquid tar is responsible for their unique weathering performance. When exposed to weather, tar tends to crack, lose gloss and to chalk. As the temperature decreases, so the brittleness is increased. Like the asphalts, coal tars show good underwater resistance and low water absorption; unlike the asphalts, tars are resistant to petrol and oil. They are, however, attacked by aromatic solvents.

The chemical composition of the coal tar is interesting. Essentially, it consists of a large number of condensed carbocyclic and heterocyclic compounds. Analysis by the Zerewitinoff method shows that the proportion of active hydrogen present is about 0.8 to 1 per cent. This hydrogen is present as phenolic and alcoholic groups as well as free carbonic acid groups, amino and imino groups. This is consistent with the reactions of coal tar, as shown below.

Coal tar can be alkoxylated, which means that ethylene oxide and/or propylene oxide can be polymerised with, or grafted upon, the tar.

Coal tar reacts with free isocyanate groups in two stages: at room temperature partial reaction of the isocyanate occurs and further reaction takes place on heating. This suggests that, at lower temperatures, reaction is due to the hydroxyl, amino and imino groups present, whilst on heating the phenolic OH groups, which are slow to react in the cold, react also.

Coal tar/epoxide resin mixtures may show an increase in viscosity, even reaching the stage of thickening, when stored for several months. It is concluded that reaction of the phenolic groups of the tar with the epoxy groups of the epoxide resin must occur. This reaction corresponds to an alkoxylation.

Tar exerts a catalytic effect on the various reactions of free isocyanate groups. This kind of action is especially important with regard to the pot-life of two-component polyurethane/tar coatings. A stable pot-life can be obtained only by taking special precautions.

The dependence of water vapour permeability, swelling capacity and water vapour absorption of the coal tar on, inter alia, the phenol and naphthol content, is interesting. These properties are markedly reduced by lowering the phenol content. A determination of the water vapour permeability of various tars with differing phenol content has given the results shown in Table 1.

*Table 1*

*Relation between water vapour permeability and phenol content*

| | Phenol content (%) | Water vapour permeability per day (mg) |
|---|---|---|
| Tar A .. .. .. | 1.64 | 2.792 |
| Tar B .. .. .. | 0.24 | 2.51 |
| Tar C .. .. .. | 0.21 | 1.899 |

It is not claimed that these measurements are precise because the experimental method used resulted in values spread over a wide range. In these tests a tar foil was produced between copper gauze sheets and was then used as a cover to seal small containers. These containers were filled with a certain quantity of water, then stored in the desiccator and weighed periodically.

For the manufacture of coatings, in general the only tars that are suitable are those which give smooth mixtures with the other materials present and which are satisfactorily compatible with them. For this purpose, it is necessary that any sediments formed owing to the presence of incompatible components are separated. The compatibility or otherwise of the materials can easily and quickly be determined by rubbing the combination with a finger on a glass panel and inspecting the film in transmitted light.

The proportion of tar oil added to produce a compatible mix should be kept as low as possible; the quantity necessary can easily be determined as above. Generally, it will be of the order of 12 to 15 per cent. Higher proportions of tar oil are necessary for solventless coatings. The unfavourable effect of higher tar oil proportions on the weathering resistance can be reduced by the incorporation of pulverized pitch, which is ground in a manner similar to that used for pigments.

It is important that any tar used is of suitable composition and that a consistent quality is always available. Suitable tars vary with respect to the tar oil fraction used in the "refluxing" and with respect to the proportion of tar oil present. Analytical data for suitable tars for a solvent-based and for a solventless coating are given in Table 2.

Tar and asphalt are not easily compatible with each other, and this can have an effect on adhesion in cases where the asphalt is overcoated with tar or tar/polymer combinations. So-called blended tars are also available.

*Table 2*
*Characteristics of tars for tar/polyurethane coatings*

| | Solvent-based coatings | Solventless coatings |
|---|---|---|
| Viscosity .. .. .. .. .. | 6,000 Poise/25°C | 15 Poise/25°C |
| Water content .. .. .. .. | 0.1% | 0.1% |
| Tar oils up to 300°C, boiling range .. | 10–17% | — |
| Tar oils from 250 to 350°C, boiling range | — | 50% |
| Softening point of the residue in Kraemer-Sarnow-Nagel .. .. | 64–78°C | 45°C |
| Phenol content .. .. .. .. | 0.2% | 0.2% |

It is important to realise that solvent retention and slow solvent release are likely in solvent-based compositions. This may lead to tar combination coatings possessing brittle properties initially, or which become brittle during ageing. This opinion has been endorsed by tests of commercial tar/polymer coatings. Furthermore, it should be pointed out that asphalt, bitumens, tars and their mixtures are thermoplastic materials. The degree of plasticity depends on the proportion and properties of the other components present. For this reason it is necessary to test the thermoplasticity of mixtures over the range of temperatures likely to be encountered. In summer this may be as high as 70° to 90°C, and it should be pointed out that the tar, owing to its black colour, absorbs radiation. The incorporation of a special aluminium bronze, however, can be used to produce light reflecting paints. The cold flow should also be considered, especially in the case of flexible combinations, because under hot conditions the film may be subject to slow plastic deformation under its own weight.

So-called "albino" or colourless tars are available commercially; derivatives of coumarone resins are present in them, and compatibility with polyurethane coatings is thus obtained. Coal tar, however, shows a far better underwater resistance.

## Coal tar/polyurethane combinations

The combination of tar with polyurethane will now be considered. It has already been pointed out that the tar can act as a catalyst for the addition reaction of the isocyanate group to the hydroxyl group resulting in the urethane group.

$$\text{—NCO} + \text{—OH} \longrightarrow \text{—NHCOO—}$$

This reaction causes a reduction in pot-life, which in many cases is as low as a few minutes, necessitating special equipment for their application. Two-component spray equipment is available by means of which two-component coatings having a particularly short pot life can be applied. In order to obtain a longer pot life, some pretreatment of the tar with isocyanates is necessary to render the catalytically effective groups inactive. The normal bi- and higher functional isocyanates often show this effect only at elevated temperatures, and at normal temperatures only a slight reaction may occur. Mono-functional inorganic isocyanates of high reactivity react at normal temperatures and can effectively remove the catalytically active groups. Owing to their high reactivity, these isocyanates must be added portionwise to the liquid or liquefied tar in order to avoid excessive foaming.

The properties and practical use of epoxide/tar combinations is well known. This combination is also of interest in connection with polyurethane/tar combinations, since the epoxide resin can also be considered as a hydroxyl group-containing compound, as Fig. 1 shows.

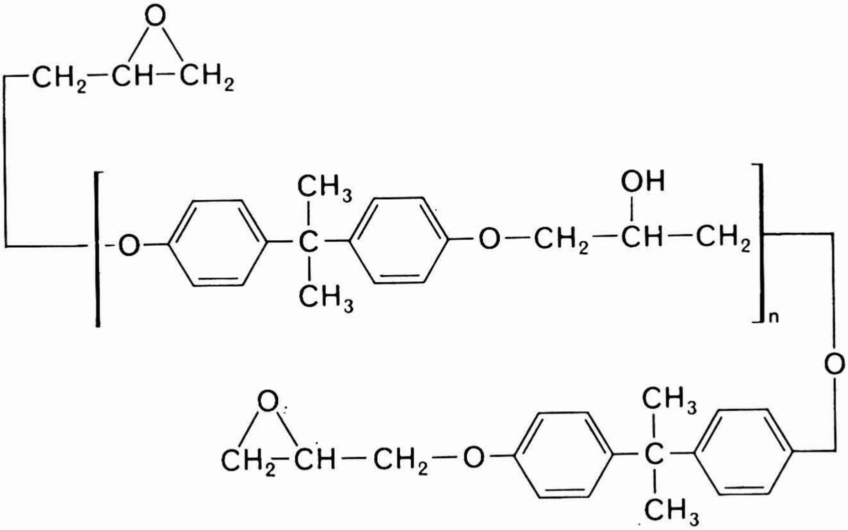


**Fig. 1. Structure of epoxide resin**

Secondary hydroxyl groups are involved, which at normal temperatures react smoothly with free isocyanate groups. Consequently, the following tar combinations can be manufactured with epoxide resins:

Epoxide/tar/amine
Epoxide/tar/polyamide
Epoxide/tar/isocyanate.

This raises the question of the drying and curing, the mechanical properties at low temperatures, and the adhesion to shop primers of the combinations. Isocyanate curing takes place even at 0°C and below. Naturally, the curing speed is reduced, but in one case it has been reported that the curing of such coatings with isocyanates can occur as low as −19°C. At such temperatures, however, any porous surface to which the coating is applied must be free from ice.

In contrast to isocyanate curing, amine or polyamide curing does not take place below 10°C. The speed of curing of the isocyanate is also considerably faster than that of either the amine or the polyamide. Suitable catalysts, for instance dibutyl tin dilaurate, amines etc., can greatly accelerate the rate of isocyanate curing, but at a sacrifice of the pot-life.

It has already been stated that the brittleness of the coal tars increases with decreasing temperatures. The same effect is also observed in the case of amine and polyamide/epoxide/tar combinations. The hardness of isocyanate/epoxide/tar combinations also increases with diminishing temperatures, but a certain amount of flexibility is retained.

It is easily possible to combine highly flexible polyisocyanate/polyoxy compounds with a proportion of tar, and thus to maintain their rubber-like flexible properties at −20°C; even at −40°C these compounds still show a flexibility similar to that of hard rubber. Generally, it may be said that tar/polyurethane combinations show less tendency to embrittlement at low temperatures.

The adhesion of amine and polyamide cured systems seems at first sight to be superior to that of isocyanate-cured systems when applied directly to metal. The opposite is the case with surfaces treated with a shop primer or a wash primer, as for instance in ship building. The following types of primers are concerned: wash primers, red oxide primers based on reinforced wash primers or other binding media, and zinc dust primers based on epoxide/polyamide and silicates. The isocyanate-cured epoxide/tar combinations show superior adhesion to these shop primers, even when they have been weathered previously. Adhesion tests by the pull-off method gave values of 170 kg cm$^{-2}$ on weathered zinc dust primers. Comparative tests (under the conditions of cathodic protection, which is of particular importance for ships bottom paint) resulted in practically the same performance of the differently cured epoxide/tar combinations. Other factors relevant to ships and construction work are the ability to overcoat and the inflammability.

Various combinations of two-component reactive paints with coal tar show an almost equal ability to be overcoated. The intercoat adhesion is reduced proportionately with increasing drying time of a coat before overcoating, and can become inadequate if three days elapse before overcoating. The differences in this respect between polyurethane/tar and epoxide/polyamide/tar are very small, but more exact tests disclose slight advantages with the former combinations.

There is a wide variation of opinion regarding combustibility of the tar/polymer combinations owing to their tar oil content, and because of the evaporation of these oils, the inflammability may vary considerably. This phenomenon is almost independent of the particular resin present, e.g. polyurethane or epoxide/polyamide, but depends on the mixing ratios, because this affects the proportion of tar oil present. A higher proportion of fillers will reduce the combustibility, but underwater resistance will in this case be impaired. Another way to reduce the inflammability is to use a tar-free top coat of low combustibility over a tar combination. In this case, polyurethane coatings filled with antimony trioxide and based on polyisocyanates with a cyanuric acid structure are suitable.

## Types of formulation

### *Solvent-based two-component systems*

Solvent-based two-component polyurethane systems are well known. Several polyisocyanates and polyoxy compounds can be used in accordance with well-known principles, see Figs. 2-4.

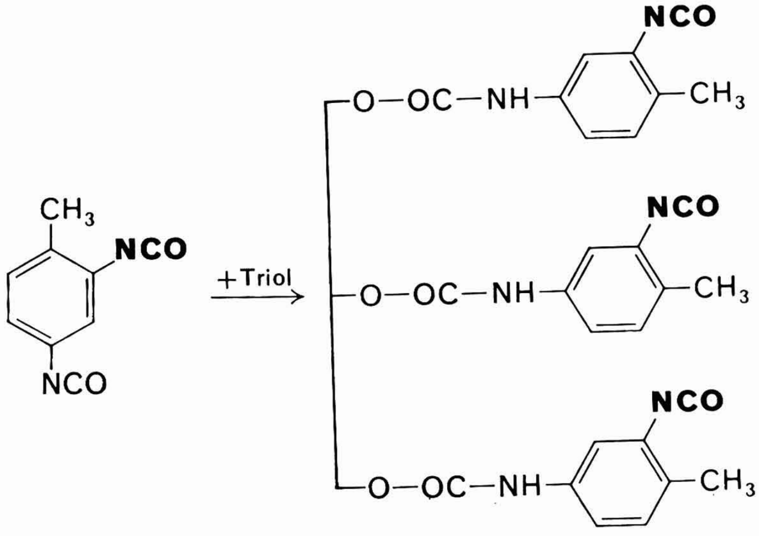


Fig. 2 Polyisocyanate I

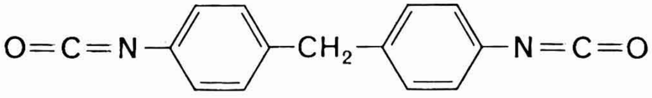
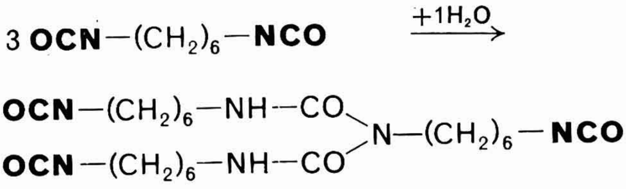


Fig. 3 Polyisocyanate II



$$3\,\mathrm{OCN{-}(CH_2)_6{-}NCO} \xrightarrow{+1\,H_2O} \begin{matrix}\mathrm{OCN{-}(CH_2)_6{-}NH{-}CO} \\ \mathrm{OCN{-}(CH_2)_6{-}NH{-}CO}\end{matrix}\!\!>\mathrm{N{-}(CH_2)_6{-}NCO}$$

Fig. 4 Polyisocyanate III

The most important is the prepolymer consisting of toluylene diisocyanate and trimethylolpropane (polyisocyanate I) as well as diphenylmethanediisocyanate (polyisocyanate II). Other isocyanates are also suitable, as for instance aliphatic polyisocyanates, an example of which is a biuret-triisocyanate made from 3 moles hexamethylene diisocyanate and 1 mole water (polyisocyanate III). A marked improvement of the weather resistance, especially the chalking performance, is obtained in this case.

Apart from the polyisocyanates mentioned above, so-called prepolymers prepared from high molecular weight polyester, polyether or polythioether alcohols and toluylene diisocyanate and/or polyisocyanate II are also used mainly for purposes of plasticisation.

By combining the polyisocyanates I or II with the prepolymers already mentioned, and by selecting the polyoxy compound and the grade of tar, any degree of hardness and flexibility can be obtained. However, the state of aggregation of the polyisocyanates I and II has to be considered. Polyisocyanate I is a brittle, hard resin. In combination with polyoxy compounds and tar it gives suitable coating properties. Polyisocyanate II is liquid and thus leads to more flexible paint films. In this connection, however, it should be borne in mind that:

hard and brittle tars increase hardness and diminish flexibility proportionately,

tars retain solvents; consequently their combinations may seem to be too soft when first applied,

the tar oil content of the tar exerts an influence on the weather resistance.

Apart from the polyisocyanate and the grade of tar, the polyoxy compounds and the ratio of NCO to OH can influence the properties of solvent-based two-component tar combinations in the usual way. Polyester and polyether alcohols, as well as epoxide resins, may be used. The degree of branching, in conjunction with the hydroxyl content, determines not only the mechanical properties and chemical resistance but also the effect which is known as "bleeding" of the tar oils and their migration into the tar free coating applied over it. Generally, it is found that, with an increasing hydroxyl content and at a ratio of NCO to OH of 1:1, bleeding is reduced. It should be pointed out that this bleeding depends on the tar, particularly on its tar oil content, and on the proportion of tar in the formulation, as well as on the solvent mixture of the paint.

The choice of the starting components for tar/polyurethane two-component combination has to be made according to the degree of chemical resistance required. Thus, for instance, alkali resistance at pH values between 12 and 14, underwater resistance and resistance to benzene, petrol and oils are, inter alia, required for ships' bottom paints. In this case, very good results can be achieved by using hydroxyl compounds of the epoxide resin or polybenzyl ether types.

Solvent-based two-component polyurethane/tar combinations can be applied by most of the normal methods, such as brushing, normal or airless spraying (in the latter case film thicknesses of 100 to 400 microns can be obtained), roller or curtain coating. As already mentioned, the pot-life can be adjusted over a range from about eight hours to a few minutes according to whether or not the tar has been pretreated with isocyanates, and by the use of suitable catalysts. The application time is correspondingly reduced, and in such cases two-component spray units, by means of which coatings with a very short pot-life can easily be applied, must be used.

The possible applications of solvent-based tar/polyurethane coatings are very numerous and only a few of the more important fields of application can be mentioned. Because of the anti-corrosive effect of the tar, these formulations are suitable as primers and maintenance paints. In this connection the question of the bleeding already discussed will inevitably arise. The adhesion of these combinations to the conventional shop primers, as are used in the ship-building industry, is excellent and in practice very good results can be obtained in ships' bottom paints, which show sufficient durability under the conditions of cathodic protection. In this connection it should be pointed out that, by the addition of anti-fouling products to this combination (for instance organic metal compounds) very effective anti-fouling paints can be manufactured. So far, tests have been carried out only for the duration of one growth period. The hard and abrasion-resistant polyurethane/tar surface and the resistance to crude oils, petrol and water make these combinations satisfactory for the interior and exterior coating of pipelines and pressure ducts. The smooth surface obtained increases the rate of water flow in hydro-electric plant and results in a higher output of electrical current. These coatings can also be used successfully in coastal areas and lock installations, and they give excellent service when used for under-floor protection and soundproofing.

### *Solventless two-component systems*

Solventless polyurethane/tar combinations can be manufactured most easily on the basis of polyisocyanate II, and a suitable liquid tar of the composition already described. Only a few low-viscosity liquid polyoxy compounds are available. These include the polyester alcohols, alkoxylation products of polyvalent alcohols, polythioether alcohols, castor oil and its modified products, triethanolamine and glycerine. In order to obtain blister-free coatings the simultaneous use of sodium aluminosilicate or molecular sieves to remove water is of advantage. In this connection, it should be remembered that pot-life and drying time, which are invariably interdependent, can be controlled. By the addition of catalysts (for instance dibutyl tin dilaurate, tertiary amines) the drying time and pot-life can be influenced in such a way that application is possible only with a two-component spray gun. Such coatings, however, dry in two to five minutes.

Solventless formulations can be used for similar applications to those for solvent-based two-component types; some special fields of application may, however, be mentioned.

Solventless polyurethane/tar combinations may be used for road repair and construction of skid-resistant crossings, in which case a suitable gritting material must be included. It should again be pointed out that the drying time can be controlled over a range from a few minutes to about 45 minutes, which is very important where the traffic flow is concerned. Hardness and flexibility can be adjusted as required.

Road bridges made of concrete and iron are attacked by salt used as an anti-freeze. Protection is achieved by the preliminary use of solventless polyurethane/tar systems before applying the conventional tar/concrete.

Ships' decks and floors can be coated with polyurethane/tar combinations, but the possibility of thermoplasticity in the presence of intense solar radiation has to be taken into account.

Joint-sealing compounds with resistance to water, petrol and weathering can be manufactured from polyurethane/tar combinations. The necessary low

Shore hardness and the required modulus of elasticity, in combination with very high extensibility, can be obtained by suitable formulation, using one of four methods:

polyisocyanate I alone or with polyether alcohols and tar (one-component process),

TDI prepolymer or polyisocyanate II prepolymer or mixtures of these prepolymers with polyalkylene glycols and tar (one-component process),

TDI prepolymer on the basis of high-molecular polythioether alcohols and triethanolamine/triethylene glycol and tar (one- and two-component process);

polyisocyanate II in combination with various polyester and/or polyether alcohols or their mixtures with tar (two-component process).

Mixtures of these polyisocyanates can also be used as starting material. The weather resistance of tar combinations formulated so as to give flexible coatings depends very greatly on the tar oil content of the tar. They often tend to show superficial cracking. As underwater joint-sealing compounds, they show a very good resistance, and since they can be formulated to give thixotropic properties they are suitable for horizontal and vertical joints. The hardness and chemical resistance can be increased at the expense of flexibility to such an extent that the compounds can be used for the filling of joints on air-fields and in roads in the normal way.

In all these cases the question of the adhesion to most types of surface must be considered. The application of an adhesive primer is possible. For this purpose the following primers can be used:

on concrete: solvent-based polyurethane/tar combinations, clear prepolymers of polyisocyanate II or solvent-based two-component coatings on the basis of polyisocyanate II,

on metal: two-component wash primers.

The solventless polyurethane/tar combinations can be used successfully below ground in mines. In addition to giving protection against corrosion they act as fillers for cracks in the mine walls.

### *One-component systems*

The use as under-seal coatings for cars may also be mentioned. Good anti-corrosion performance is required, as well as good sound insulation and resistance to salt water, petrol and oil. By selecting the starting components for the polyurethane/tar combination, and by the simultaneous use of large quantities of barytes, such properties can easily be achieved. For this application solvent-based and solventless polyurethane/tar combinations, as well as mixtures of prepolymers with tar, so-called one-component tar/polyurethane coatings, can be used. These moisture-curing one-component combinations have some valuable properties.

As is known, one-component polyurethane coatings are through-drying on account of the isocyanate/water reaction. The resulting polyurethane films are characterised by their high abrasion resistance and low combustibility. However, the adhesion of subsequent coats to them is often poor. These failings are also present to some extent in corresponding combinations with tar. Since overcoatability is an invariable demand in the ship-building industry, this property must be considered. During some tests it was found that mixtures consisting of tar and a prepolymer based on the polyisocyanate I and a polypropylene glycol with a molecular weight of 1000 showed that the desired overcoating properties could be obtained. Prepolymers of the polyisocyanate II type with castor oil or its derivatives or with polyalkylene glycols are also possibilities. Storage stability can be achieved by removing any water, either by azeotropic distillation or by addition of inorganic isocyanates or with orthoformic acid esters.

The field of application for one-component polyurethane/tar combinations corresponds closely with that of the two-component coatings. The one-component coatings can be applied by the usual methods. They possess an interesting property regarding the overcoating of moist surfaces: contrary to expectations, blister-free films with good adhesion result, which show the valuable properties already mentioned, such as underwater resistance and good resistance to petrol and oil and, in part, to aromatics. Their weather resistance, however, is considerably poorer. Compared with the two-component systems, this may be due to a lower degree of cross-linking, resulting in a faster release of solvents, especially tar oils. This, however, provides a suitable leaching rate which can be utilised in anti-fouling paints. Tests carried out in the North Sea off Cuxhaven have confirmed this. With suitable toxic agents, for instance organotin compounds, these one-component polyurethane/tar combinations efficiently prevented any growth over the period of test to date. These tests are still continuing.

So far the film thicknesses to be achieved have not been considered. The thicknesses that can be achieved by suitable methods of spraying are shown in Table 3.

*Table 3*

*Film thicknesses achieved with tar/polyurethane formulations*

| Type of coating | Thickness after spraying | |
|---|---|---|
| | Average film thickness μ | Thickness with special formulations μ |
| Solvent-based two-component coating.. | 80–120 | 400–500 |
| Solventless two-component coating .. | — | 400 |
| Solvent-based one-component coating.. | 60–80 | 400–500 |

Blocked isocyanates can also be combined with tar, thus permitting the manufacture of stoving finishes.

## Conclusion

The survey of the various polyurethane/tar combinations shows their superior through-drying, especially at low temperatures. This property favours their use in all fields of application requiring low temperature curing.

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# An apparatus for the electronic recording of creep in polymer films

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*Summary*

An apparatus for the automatic recording of creep in detached polymer films, operating under constant temperature and relative humidity, has been developed.

The accuracy of the apparatus is compared with a manual method using a cathetometer, and found to be equally as good, whilst considerable savings in time are effected.

**Keywords**

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

creep

*Process and methods primarily associated with analysis, measurement and testing*

creep measurement

*Equipment primarily associated with analysis, measurement and testing*

cathetometer

## L'enregistrement électronique du cheminement des feuils de peintures

*Résumé*

On a perfectionné un appareil pour enregistrer automatiquement le cheminement de feuils de polymères détachés, qui fonctionne sous des conditions constantes de température et d'humidité relative.

On a fait comparer la précision de l'appareil auprès de celle de la méthode manuelle à l'aide d'un cathétomètre, et elle s'est avérée également fiable, tandis que les économies de temps sont considérables.

## Die Elektronische Wiedergabe der Wärmedehnung in Polymerfilmen

*Zusammenfassung*

Es wurde ein Apparat zur automatischen Wiedergabe der Wärmedehnung in abgelösten Filmen entwickelt, der bei konstanter Temperatur und relativer Luftfeuchtigkeit arbeitet.

Die Genauigkeit des Apparates wird mit einer nur mit der Hand unter Verwendung eines Cathetometers ausgeführten Methode verglichen und dabei wurde festgestellt, dass sie gleich gut, sowie gleichzeitig erheblich zeitsparender ist.

## Электронная запись ползучести в полимерных пленках

*Резмюе*

Развивается прибор для автоматической записи ползучести в отслоенных полимерных пленках функционирующих в условиях постоянной температуры и относительной влажности.

Точность прибора сравнивается с ручным методом применения катетометра и найдено что прибор одинаково пригоден и позволяет в то же время осуществить значительную экономию времени.

## Construction of apparatus

An apparatus with which creep in films can be recorded automatically under conditions of constant relative humidity and temperature, has been constructed on the following principles. It is based on an inductive displacement transducer (Philips PR 9314/10) in combination with a suitable converter (Philips PR 9309). The transducer includes two coils, connected in a half-bridge circuit, and a freely moving core. The location of the core in relation to the two coils determines the inductive imbalance of the half-bridge circuits, which is completed to a full bridge in the measuring instrument. Displacements of the core from zero to +10 or −10mm can be measured with a great accuracy. The output signal of the converter varies from zero to +1 or −1 volt which, after suitable attenuation, can be measured as a function of time by means of a recorder. A small titanium jaw is used to fasten the lower part of the film. This is connected to the sensing rod by means of a thin steel rod. This steel rod carries an aluminium pan on which weights are placed. The upper end of the film is fastened in another jaw, and the apparatus is placed in a double walled Perspex thermostat. The aluminium pan rests on a platform that can be moved up and down, to release the load on the film. The highest position of this platform also determines the minimum length of the film to be used. By changing the position of the inductive displacement transducer, the signal can be adjusted in such a way that the minimum length of the film corresponds to a zero signal output from the converter. In the apparatus described, the minimum length of film is 10.00cm and the strain is measured over the ranges of 10, 5 or 2.5 per cent extension for the full recorder scale.

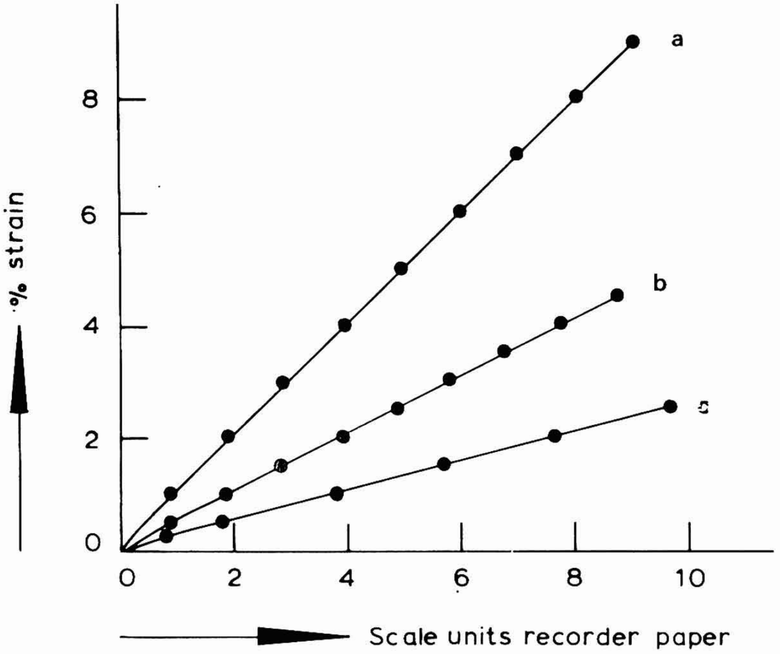


**Fig. 1. The calibration curves**

a: 10 per cent strain on full recorder scale b: 5 per cent strain on full recorder scale
c: 2.5 per cent strain on full recorder scale

Although the manufacturer claims a perfect linearity of the signal with the displacement of the sensing rod over at least 10mm, it appeared that this was not quite true, and hence a calibration is necessary. If conditions (temperature, relative humidity) are carefully kept constant, the calibration does not change greatly with time. Calibration was effected by placing a metal strip of 10,000 ± 0.002cm in the lower jaw and displacing this strip with the aid of a micrometer. The increase in length of the strip and the recorder signal are plotted in Fig. 1 for 10 per cent strain, 5 per cent strain and 2.5 per cent strain over the full recorder scale.

The apparatus is maintained at 25°C by circulating water at 25 ± 0.1°C between its double walls and by passing an air stream of 25 ± 0.1°C through the interior. Isolation of the exterior with polyurethane foam appeared to be unnecessary because the room temperature was 22 ± 2°C.

The air stream was kept at a constant, arbitrarily adjustable, relative humidity as described elsewhere[1, 2]. The complete apparatus is shown in Fig. 2,

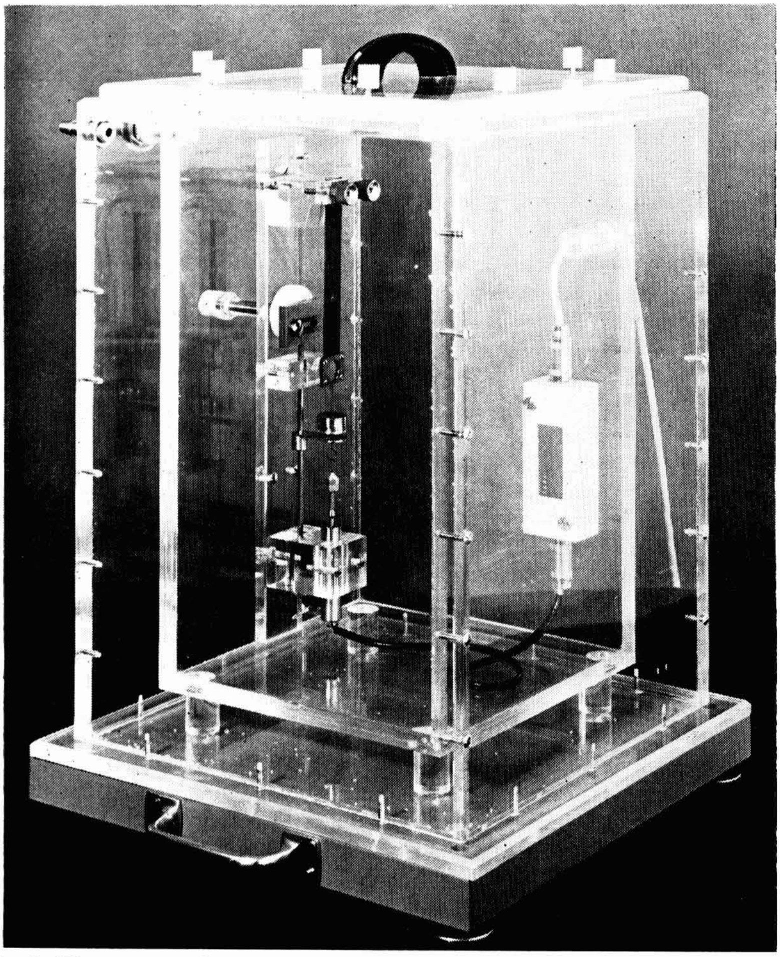
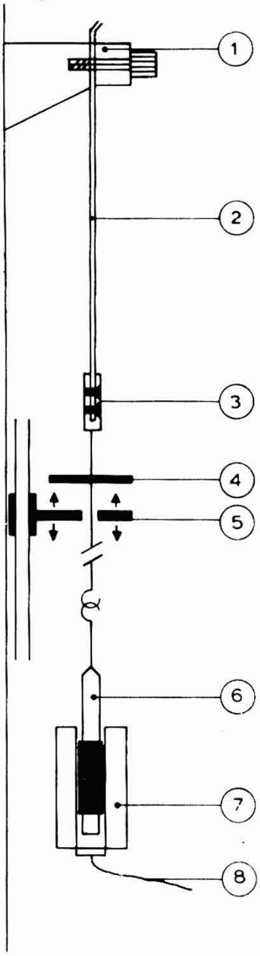


**Fig. 2. The perspex thermostat used for electronic recording of creep in films**

and the film, its load and the measuring equipment shown diagrammatically in Fig. 3.



The numbers indicate the following parts:

1. upper film jaw
2. film
3. lower film jaw
4. aluminium pan on which the weights can be placed
5. Vertically movable platform to prevent the film from loading before the experiment started
6. Sensing rod of the inductive displacement transducer
7. half bridge circuit of the inductive displacement transducer (two coils)
8. connection wires to the converter

**Fig. 3. The measuring device of the creep apparatus**

## Method of use

The method of carrying out a creep experiment is described below.

Lacquer films are applied to carefully cleaned glass panels by means of a doctor blade, and dried in a dust-free room. After drying, strips 1.5cm wide and 16cm long are cut from the films and removed from the substrate$^2$. The film thickness is measured and the films are selected so as not to vary significantly in thickness (the maximum variation in film thickness in each strip should be less than 10 per cent). Before fastening in the jaws, the films are placed for a few hours in the thermostat, and are then fastened in the jaws and conditioned overnight. An indication of sufficient preconditioning is that no dimensional changes occur in the films during the night and no zero point drift occurs. The experiment is started by lowering the platform. The extension, $\varepsilon$, is measured as a function of time. From the total weight of the lower jaw and its connections, the load $\sigma$ acting on the film can be calculated. From the measured strain ($\varepsilon$) versus time $t$ the $\varepsilon/\sigma$ versus $t$ curve can be calculated.

It has previously been shown[2, 3, 4] that the viscoelastic properties of an alkyd resin film can be described with the model shown in Fig. 4.

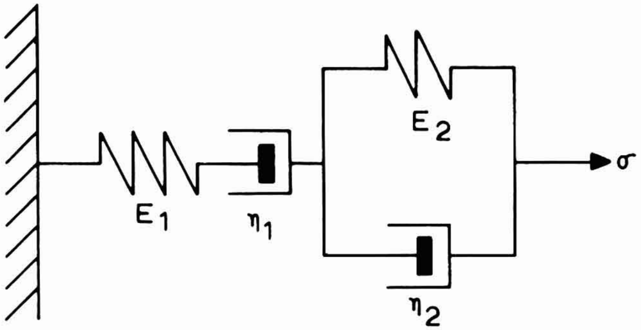


**Fig. 4. The mechanical model used for the description of the creep of the alkyd resin films**

The creep equation, resulting from this model, is:

$$\frac{\varepsilon - \varepsilon^2}{\sigma} = \frac{E_1 + E_2}{E_1\, E_2} + \frac{t}{\eta_1} - \frac{1}{E_2} \exp\left[\left(-E_2/\eta_2\right)t\right] \ldots\ldots\ldots \quad (1)$$

## Investigation of the accuracy of the method

To obtain information on the accuracy of the results obtained with electronic recording of the creep, parallel series of experiments were carried out. One series was made with the new apparatus, the other with the cathetometer as used previously. In both cases the experiments were carried out with films about 130 days old, at 76 per cent RH and 25°C. The films (60$\mu$ thick) had been stored at 22°C and 55 per cent RH. From the results shown in Fig. 5 it can be concluded that both methods give results which coincide within satisfactory limits of experimental error.

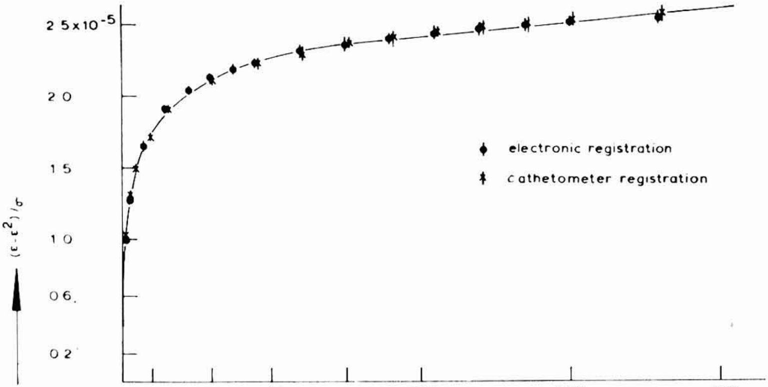


**Fig. 5. A comparison of creep curves determined for identical films using electronic and cathetometric methods**

Also, the values of $(\varepsilon - \varepsilon^2)/\sigma$ are listed in Table 1.

*Table 1*

*The mean values of $(\epsilon - \epsilon^2)/\sigma$ for the creep of an alkyd resin film obtained with the self-registering apparatus and with the use of a cathetometer. Film age 130 days, RH 76 per cent, $t = 25°C$. Results of paralleled experiments*

| Electronic apparatus | | Cathetometer | |
|---|---|---|---|
| Time (minutes) | $(\epsilon - \epsilon^2)/\sigma \times 10^5$ ($cm^2$ $g^{-1}$) | Time (minutes) | $(\epsilon - \epsilon^2)/\sigma \times 10^5$ ($cm^2$ $g^{-1}$) |
| 0 | 0 | 0 | 0 |
| 1½ | $0.73 \pm 0.02$ | 1 | $0.60 \pm 0.03$ |
| 3 | $1.00 \pm 0.03$ | 3 | $1.03 \pm 0.05$ |
| 4½ | $1.16 \pm 0.02$ | 6 | $1.31 \pm 0.05$ |
| 6 | $1.28 \pm 0.03$ | 10 | $1.49 \pm 0.04$ |
| 15 | $1.65 \pm 0.03$ | 20 | $1.71 \pm 0.05$ |
| 30 | $1.91 \pm 0.03$ | 30 | $1.91 \pm 0.04$ |
| 45 | $2.04 \pm 0.03$ | — | — |
| 60 | $2.12 \pm 0.04$ | 60 | $2.11 \pm 0.05$ |
| 75 | $2.19 \pm 0.04$ | — | — |
| 90 | $2.23 \pm 0.04$ | 90 | $2.23 \pm 0.05$ |
| 120 | $2.32 \pm 0.04$ | 120 | $2.30 \pm 0.05$ |
| 150 | $2.36 \pm 0.04$ | 150 | $2.37 \pm 0.04$ |
| 180 | $2.40 \pm 0.04$ | 180 | $2.40 \pm 0.05$ |
| 210 | $2.44 \pm 0.05$ | 210 | $2.44 \pm 0.04$ |
| 240 | $2.47 \pm 0.05$ | 240 | $2.48 \pm 0.05$ |
| 260 | $2.50 \pm 0.04$ | 270 | $2.51 \pm 0.06$ |
| 300 | $2.53 \pm 0.04$ | 300 | $2.55 \pm 0.05$ |
| 360 | $2.55 \pm 0.05$ | 360 | $2.58 \pm 0.06$ |

From these results and from Fig. 5 it can be concluded that there is hardly any difference between the two methods. The electronic apparatus gives a somewhat more accurate description of the first stages of the creep experiment. The explanation is probably that, for the small displacements at the beginning of the experiment, the inaccuracy of the cathetometer causes relatively large errors. The effect of these errors decreases as the strain increases.

For both methods, the accuracy of the results will decrease considerably when films showing large local differences in thickness are used; hence the films have to be selected for uniform thickness. Another cause of poor reproducibility, especially when using fresh alkyd resin films, is the use of films differing considerably in mean thickness. This is caused by the fact that a thin film dries considerably faster than a thick one.

Finally, it should be mentioned that some obvious causes for poor reproducibility are dust and air bubbles in the film, poor thermostatic control, the use of films having different degrees of polymerisation, and poor preconditioning of the films.

## Conclusions

With sufficient care in film preparation and measurement, the electronic recording of creep gives good results. Its major advantage is the great saving of time that is achieved.

[*Received 1 March 1972*

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# Creep in paint films

**By P. M. Heertjes and J. de Jong**

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*Summary*

A theory has been developed to describe the influence of pigment particles on the creep in paint films. From this theory it follows that the creep equation for paint films can be derived from the equation of the pure resin, by multiplication with a correction factor which is solely a function of the pigment volume concentration.

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

**Keywords**

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

creep

## Le cheminement de feuils de peintures

*Résumé*

On a mis au point une théorie pour décrire l'influence exercée par les particules pigmentaires sur le cheminement de feuils de peintures. A partir de la théorie il s'ensuit que l'équation de cheminement de feuils de peintures peut se dériver à partir de l'équation pour la résine elle-même, en multipliant cette équation par un facteur de correction qui est une fonction seulement de la concentration pigmentaire par volume.

Les expériences sur des peintures alkydes pigmentées avec de $TiO_2$ et de $BaSO_4$ donnent une confirmation satisfaisante de la théorie.

## Die Wärmedehnung von Lackfilmen

*Zusammenfassung*

Es wurde eine Theorie entwickelt um den Einfluss von Pigmentpartikeln auf die Wärmedehnung von Lackfilmen zu beschreiben. Aus der Theorie ergibt sich, da ss die Wärmedehnungsgleichung für Filme von Beschichtungsmitteln von der Gleichung des reinen Harzes durch Multiplikation mit einem Korrekturfaktor, der lediglich eine Funktion der Pigment Volumen Konzenyration ist, abgeleitet werden kann.

Diese Theorie wird durch Versuche mit Alkydharz-lackfarben enthaltend $TiO_2$ und $Ba\ SO_4$ im Grossen und Ganzen bestätigt.

## Ползучесть в красочных пленках

*Резюме*

Развивается теория для описания влияния пигментных частиц на ползучесть красочных пленок. Из этой теории следует что уравнение ползучести для красочных пленок может быть получено из уравнения чистой смолы, путем умножения на коррекционный множитель, который является исключительно функцией объемной пигментной концентрации.

Опыты с алкидными смольными красками, пигментированными с $Ti0_2$ и $BaS0_4$, удовлетворительно подтверждают теорию.

## Introduction

As with unpigmented lacquer films,[1] creep experiments can be used to study the rheological behaviour of paint films which are exposed to slow, small deformations. The creep equation used should describe the experimental behaviour of the films up to comparatively high pigment volume concentrations.

In all known cases, the introduction of a pigment into a paint film causes an increase in the modulus of the composite material. Guth[2] has developed a theory based on the Einstein equation for the viscosity of liquid suspensions. He concludes that the modulus $E$ of a rubber filled with spherical pigment particles is related to the modulus $E_o$ of the pure rubber in the following way:

$$E = E_o\,(1 + 2.5\,\varphi_F + 14.1\,\varphi_F^2)\quad\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

where $\varphi_F$ = volume fraction of the pigment.

The strain, $\varepsilon$, developed in a pigmented film after loading with a stress, $\sigma$, is:

$$\varepsilon = \sigma / E\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Using Guth's equation (1) for a paint film results in the following relation between the strain, the stress, the mechanical properties of the pure resin ($E_o$) and $\varphi_F$:

$$\varepsilon = \frac{\sigma}{E_o}\left\{\frac{1}{1 + 2.5\,\varphi_F + 14.1\,\varphi_F^2}\right\} = \frac{\sigma}{E_o}A\ \ldots\ldots(3)$$

The correction factor $A$, introduced in equation (3), corrects the strain for the amount of pigment present in the film, thus according to Guth:

$$A = 1/(1 + 2.5\,\varphi_F + 14.1\,\varphi_F^2).$$

Some other expressions for $A$ are given in the literature.

Eilers-Van Dijck[3] give the following expression:

$$A = \left\{1 + \frac{1.25\varphi_F}{1 - V\varphi_F}\right\}^{-1} \text{ in which } V \simeq 1.3\ \ldots\ldots\ldots\ (4)$$

Nielsen[4] derives:

$$A = 1 - \varphi_F^{\frac{1}{3}}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (5)$$

For perfect adhesion between polymer and pigment, according to Sato[5]:

$$A = \left\{1 + \frac{\varphi_F^{\frac{2}{3}}}{2\,(1 - \varphi_F^{\frac{1}{3}})}\right\}^{-1}\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Kerner's approach[6] could not be used for quantitative comparison because of lack of information about the mechanical properties of the pigments used. It is known, however,[4] that this theory predicts values for the modulus of the composite material which, in general, are too low.

The values of the factor $A$ as expressed by the equations (3), (4), (5) and (6) have been calculated for several values of $\varphi_F$ and given in Table 1 together with mean experimental data for alkyd resin films pigmented with an uncoated rutile $TiO_2$ (see experimental).

*Table 1*

*A comparison of some theoretical values of A with the experimental data for an alkyd resin—$TiO_2$ paint*

| $\phi_F$ | Value of A | | | | |
|---|---|---|---|---|---|
| | Guth | Eilers-van Dijk | Nielsen | Sato | Experimental |
| 0 | 1 | 1 | 1 | 1 | 1 |
| 0.08 | 0.77 | 0.81 | 0.57 | 0.86 | 0.77 ± 0.02 |
| 0.16 | 0.57 | 0.64 | 0.46 | 0.76 | 0.59 ± 0.02 |
| 0.24 | 0.41 | 0.48 | 0.36 | 0.66 | 0.39 ± 0.01 |
| 0.32 | 0.31 | 0.35 | 0.32 | 0.58 | 0.24 ± 0.01 |

As can be seen, none of the equations given offers a satisfactory description of the experimental results. Guth's approach gives the best fit to the experimental data, but even in this case the differences for $\varphi_F = 0.24$ and $\varphi_F = 0.32$ are too large. These results in the authors' opinion justify a renewed consideration of the theory.

## Theory

The modulus of the pigments used in a paint is so much higher than the modulus of the resin used, that in most cases the deformation occurring in the pigment particles during a creep experiment can be neglected. Another factor increasing the stiffness of a paint film, as compared with unpigmented films, may be the Van der Waals attraction forces between the (very fine) pigment particles. A theoretical analysis of the problem should include both these factors. The theory will be developed for the following model:

the pigment particles are spherical and uniformly distributed throughout the film in a cubic arrangement,

the adhesion between resin and pigment is perfect in all cases,

the viscoelastic properties of the resin are not changed by the presence of the pigment in the film, so that no chemical interaction between pigment and resin occurs.

Let it first be assumed that the Van der Waals attraction forces between the pigment particles are negligibly small. As a consequence of the pigment distribution assumed, cylindrical fibres parallel to the force applied to the film can be distinguished, consisting of alternating pigment particles and resin segments. These fibres are surrounded by pure resin. If it is assumed that the strain of the film, $\varepsilon$, is the same both for the pigmented fibre and for the unpigmented resin, it follows that the strain in the resin part of the fibres, $\varepsilon_1$, should be larger than $\varepsilon$. If a unit volume of paint contains $n^3$ pigment particles of diameter $d$, then:

$$n^3 = \frac{\varphi_F}{\frac{1}{8}\pi d^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

The unit of cross-sectional area contains $n^2$ pigment particles, hence the area $O_1$ of all pigmented fibres per unit cross-sectional area can be given as:

$$O_1 = \frac{\pi n^2 d^2}{4} \quad \ldots\ldots (8)$$

The area of the resin part, again per unit cross-sectional area, is then:

$$O_2 = (1 - O_1)$$

Now, to realise a strain $\varepsilon_1$ in a pigmented fibre, the stress $\sigma_1$ should be:

$$\sigma_1 = \varepsilon_1 E_o \quad \ldots\ldots (9)$$

Moreover, per unit length, the pigmented fibre contains a length of resin of $(1 - nd)$, therefore:

$$\varepsilon_1 = \frac{\varepsilon}{1 - nd} \quad \ldots\ldots (10)$$

The stress on the unpigmented resin is:

$$\sigma_2 = \varepsilon E_o \quad \ldots\ldots (11)$$

therefore the total stress $\sigma$ is:

$$\sigma = \sigma_1 O_1 + \sigma_2 O_2 \quad \ldots\ldots (12)$$

Combination of the equations (8), (9), (10), (11) and (12) gives:

$$\sigma = \varepsilon E_o \left\{ \frac{\pi n^2 d^2}{4(1-nd)} + 1 - \frac{\pi n^2 d^2}{4} \right\} \quad \ldots\ldots (13)$$

Hence it follows from equation (2) that the correction factor $A$ is:

$$A = \left\{ \frac{\pi C^2}{4(1 - C)} + \frac{4 - \pi C^2}{4} \right\}^{-1} \quad \ldots\ldots (14)$$

in which $C = nd = \left( \frac{6 \varphi_F}{\pi} \right)^{\frac{1}{3}}$

For $E_o$ any expression for the creep modulus of the resin as a function of time can be substituted. The four parameter model, which has been found to give a good description of the creep of alkyd resin lacquer films[1] gives:

$$\frac{1}{E_o} = \frac{E_1 + E_2}{E_1 E_2} + \frac{t}{\eta_1} - \frac{1}{E_2} \exp - \frac{E_2}{\eta_2} t \quad \ldots\ldots (15)$$

### *Van der Waals forces*

For one particle in a plane perpendicular to the direction of the stress, the total attraction by all particles in a plane at a distance (the distance between the pigment particles) can be found by summation of the components of the attraction forces parallel with the stress.

By multiplying this force by the number of particles per unit area, $n^2$, the total attraction force between two layers of pigment particles can be established. The higher $\varphi_F$, the larger this force will be.

For different values of $\varphi_F$ the attractive force has been calculated for two particle diameters ($0.25 \times 10^{-4}$cm and $0.10 \times 10^{-4}$cm). The results are shown in Table 2.

*Table 2*

*The attractive force between the pigment particles in a paint film in dyn cm$^{-2}$*

| $\phi_F$ | $d = 0.25 \times 10^{-4}$cm | $d = 0.10 \times 10^{-4}$cm |
|---|---|---|
| 0 | 0 | 0 |
| 0.08 | 1 | 18 |
| 0.16 | 6 | 92 |
| 0.24 | 21 | 307 |
| 0.32 | 68 | 1043 |

From this table it can be concluded that the Van der Waals attraction forces are small compared with the stresses used in the experiments, which are larger than $0.1 \times 10^3$g cm$^{-2}$, or $\sim 10^5$ dyn cm$^{-2}$. Therefore, for the cases under consideration (particle diameter used $0.25 \times 10^{-4}$cm) it can be concluded that the contribution to the increased stiffness of the films by Van der Waals attraction forces can be neglected.

For small deformations, when non-linear viscoelastic behaviour of the resin can be neglected, equation (13) should be valid. The values of $A$ have been calculated for values of $\varphi_F$ up to 0.40 and compared with experimental data for alkyd resin films pigmented with an uncoated rutile $TiO_2$ pigment (Table 3). The particle size was about $0.25 \times 10^{-4}$cm and, as follows from the foregoing, the Van der Waals attraction forces can be neglected in this case.

*Table 3*

*Theoretical values of A compared with experimental data for alkyd resin pigmented with $TiO_2$*

| | | $A$ |
|---|---|---|
| $\phi_F$ | Theory | Experimental mean value (for details see experimental) |
| 0 | 1 | 1 |
| 0.08 | 0.78 | 0.77 ± 0.02 |
| 0.16 | 0.58 | 0.57 ± 0.02 |
| 0.24 | 0.39 | 0.39 ± 0.01 |
| 0.32 | 0.24 | 0.24 ± 0.01 |
| 0.40 | 0.11 | 0.12 ± 0.02 |

The conclusion is that the equation derived from the model used gives a good description of the experimental data for the cases considered. The correction factor $A$ is a unique function of $\varphi_F$.

### Experimental

All experiments were carried out at 25°C. It has been shown above that the theory as given, and as expressed in equation (13), can be used to describe creep in paint films. To prove this, some mean values of $A$ as determined have been used. In this section a more detailed description of the experimental work will be given. The experimental determination of the factor $A$ is quite simple: the creep of an unpigmented film and of paint films based on the same binder containing different amounts of pigment are measured under the same conditions and for the same time. The factor $A$, by which the creep curve of the unpigmented film has to be multiplied to obtain the best fit to the creep curve of a paint film, is determined. This value is then compared with the calculated value of $A$. Five series of experiments with alkyd resin films containing $TiO_2$ or $BaSO_4$ as a pigment have been carried out. The experimental values of $A$ are given in Table 4 and compared with the theoretical values.

*Table 4*

*Experimental values of A of alkyd resin paint films compared with the theory*

| | $A$ | | | | | |
|---|---|---|---|---|---|---|
| Stress (g cm$^{-2}$)<br>Rel. humidity (%)<br>Pigment<br>Film age (days) | $0.6 \times 10^3$<br>74<br>$TiO_2$<br>40 | $0.5 \times 10^3$<br>45<br>$TiO_2$<br>70 | $1.8 \times 10^3$<br>69<br>$TiO_2$<br>125 | $1.5 \times 10^3$<br>65<br>$TiO_2$<br>30 | $1.5 \times 10^3$<br>73<br>$BaSO_4$<br>30 | Theory |
| $\phi_F$ | | | | | | |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| 0.08 | 0.76 | 0.77 | 0.77 | 0.80 | 0.78 | 0.78 |
| 0.16 | 0.61 | 0.57 | 0.58 | 0.58 | 0.59 | 0.58 |
| 0.24 | 0.35 | 0.41 | 0.40 | 0.40 | 0.39 | 0.39 |
| 0.32 | 0.23 | 0.26 | 0.24 | 0.24 | 0.24 | 0.24 |
| 0.40 | — | — | — | 0.12 | — | 0.11 |

The stiff and brittle films with $\varphi_F = 0.40$ are difficult to handle. Therefore only one $A$ value is given. From the results given in Table 4 it can again be concluded that the agreement with the theory is satisfactory. In Fig. 1 the experimental values of $A$ are plotted against the theoretical curve of $A$ as a function of $\varphi_F$ to illustrate this conclusion.

It follows from Table 4 that $A$ is independent of the relative humidity, the film age and the applied stress as required by the theory. Equation (13) is based on the tacit assumption that $A$ is also independent of the duration of the stress. This is also confirmed by the experiments, as illustrated in Figs. 2, 3 and 4. In these figures the experimental points for the creep of unpigmented

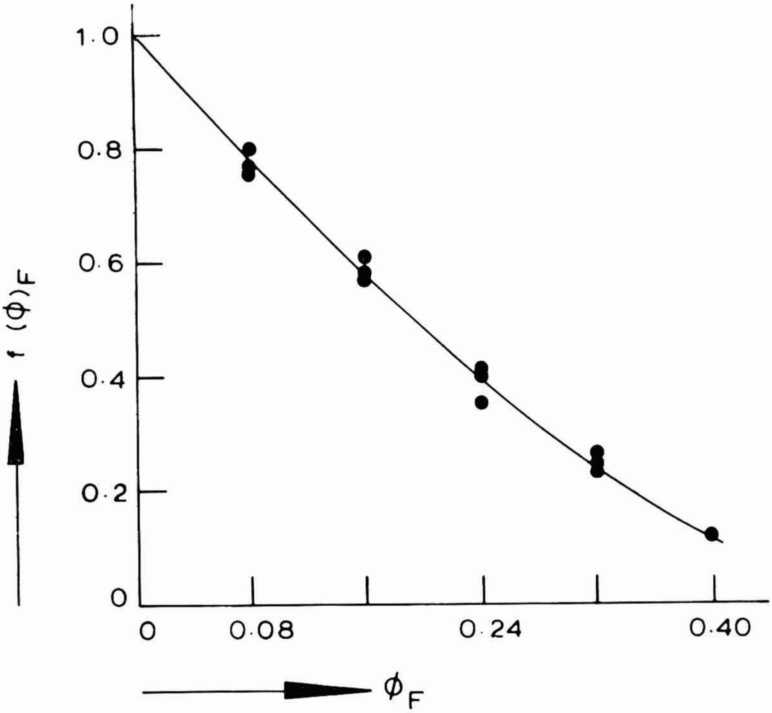

**Fig. 1.** The experimental values of A compared with the theoretical curve of A as a function of $\phi_F$

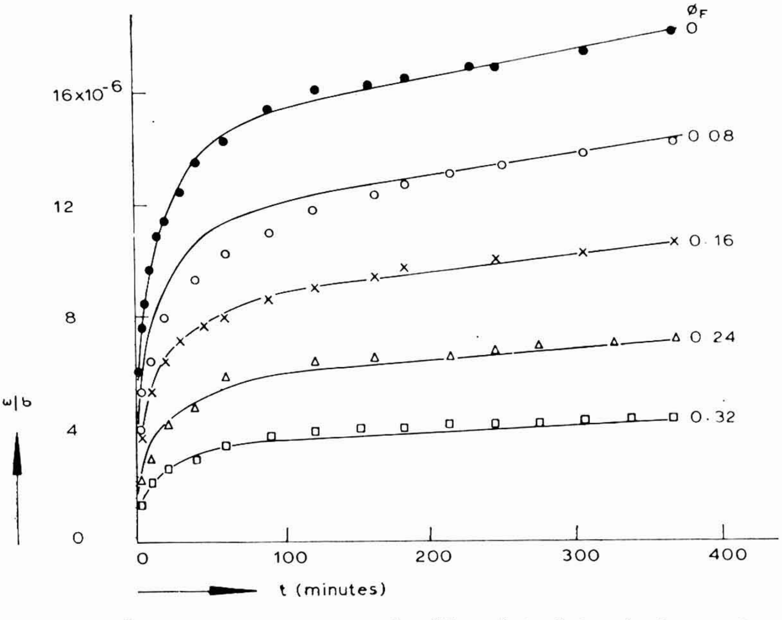

**Fig. 2.** Calculated creep curves compared with points determined experimentally. RH. 71%, 125 days old

and pigmented films are compared with the continuous theoretical curves. Figs. 2 and 3 are for films pigmented with $TiO_2$; Fig. 4 is for films having $BaSO_4$ as a pigment.

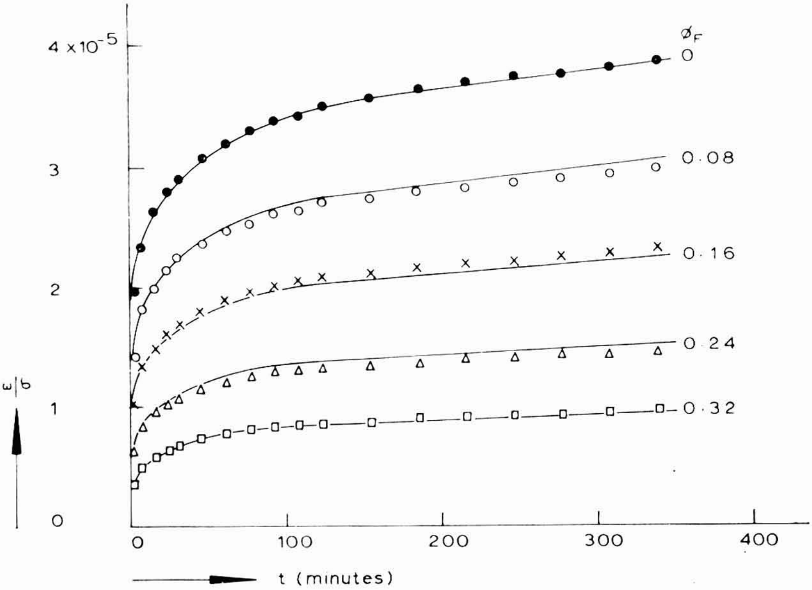

**Fig. 3. Calculated creep curves compared with points determined experimentally. RH. 74%, 40 days old**

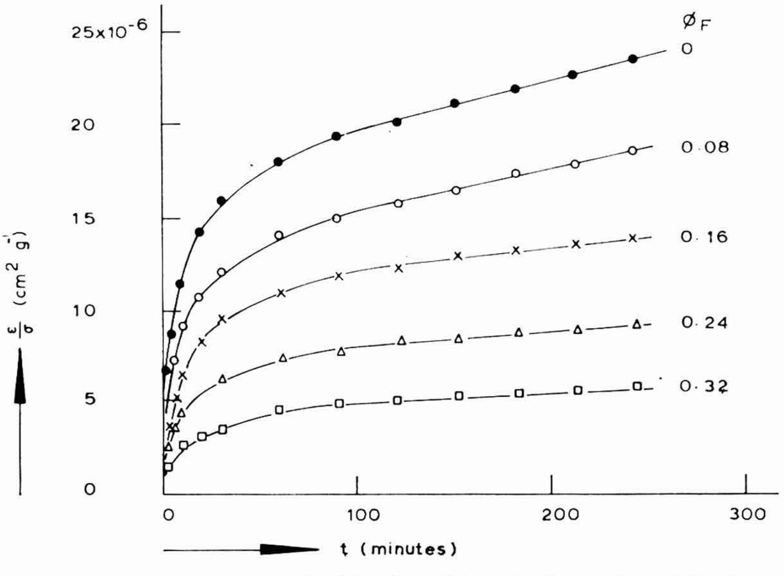

**Fig. 4. Calculated creep curves compared with points determined experimentally for alkyd resin $BaSO_4$ films. RH. 73%, 30 days old**

From these results it can be concluded that the agreement between the calculated lines and the points experimentally determined holds good for any length of time. It also follows from equation (13) that, after a constant time $t$, the strain developed in a paint film should be a linear function of the applied stress $\sigma$ at constant values of $\varphi_F$. Plots of $\varepsilon$ as a function of $\sigma$ should pass through the origin. If these experiments are performed with films containing different amounts of pigment and graphs plotted, the values of $A$ can be calculated by means of equation (3) from the slopes of these curves, by recognizing that for $\varphi_F = 0$, $A = 1$. The results of these experiments are shown in Fig. 5, in which the strain measured 240 minutes after loading of the film has been plotted against the applied stress. The relative humidity was 71 per cent, the film age varied from 135 to 160 days.

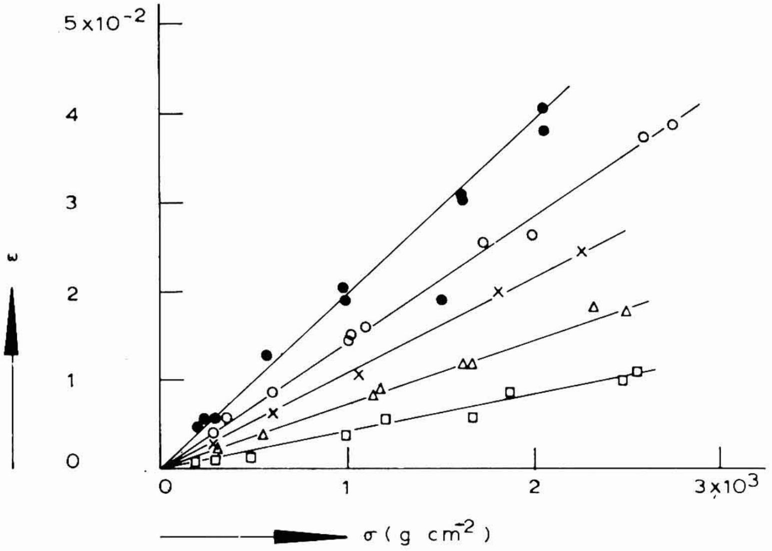

**Fig. 5. The strain developed four hours after loading as a function of the stress $\sigma$ for five pigment concentrations**

● $\phi_F = 0$,
○ $\phi_F = 0.08$,
× $\phi_F = 0.16$,
□ $\phi_F = 0.24$ and
Δ $\phi_F = 0.32$

It can be seen from Fig. 5 that a linear relation between $\varepsilon_{240}$ and $\sigma$ is found for all values of $\varphi_F$. The values of $A$ calculated from the slopes of these curves are summarised in Table 5.

At a constant relative humidity, film age and temperature $E_0$ should be only a function of time. Therefore, by plotting $\varepsilon/\sigma\ A$ versus time, one curve for each set of conditions should be obtained (Fig. 6).

*Table 5*

*The values of A calculated from the slopes of $\varepsilon_{240}$ versus $\sigma$ curves compared with the theoretical values of A*

| | *A* | |
|---|---|---|
| $\phi_F$ | Calculated | Theoretical |
| 0 | 1 | 1 |
| 0.08 | 0.77 | 0.78 |
| 0.16 | 0.58 | 0.58 |
| 0.24 | 0.38 | 0.39 |
| 0.32 | 0.23 | 0.24 |

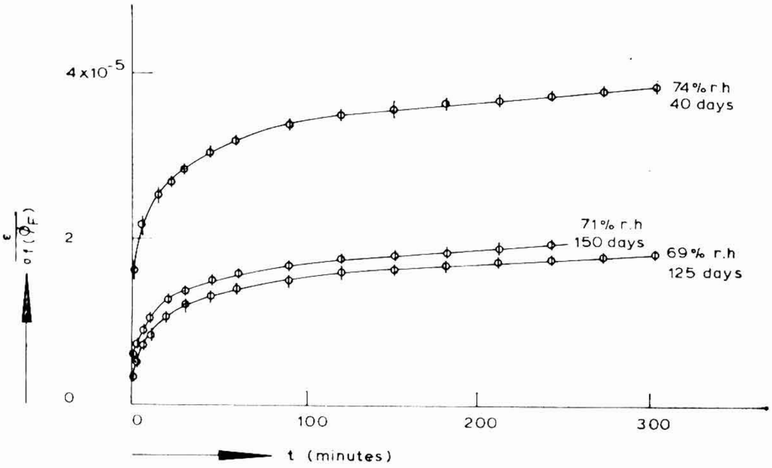

**Fig. 6. Calculated $\varepsilon/\sigma$ A curves compared with the experimental points for different sets of conditions. System: alkyd resin $TiO_2$ paints with $\phi_F$ up to 0.32. The mean deviation of the experimental points is indicated**

It follows from Fig. 6 that this conclusion is fully justified.

## Conclusions

The existing theories of reinforcement of a resin by a pigment proved to be inadequate for the description of creep in alkyd resin paint films pigmented with $TiO_2$ or $BaSO_4$. A new theory has been developed which offers a satisfactory description of the observed creep in paint films.

The Van der Waals attractive forces seem to give no measurable contribution to the increase of the stiffness of the paint films over the usual range of pigment particle size.

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# Some factors affecting the water absorption of films from synthetic latices

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*Summary*

The water absorption of films deposited from butyl methacrylate/butyl acrylate copolymer latices was investigated. The presence of carboxylic groups in the copolymer and/or the post-stabilisation of latices by a nonionic emulsifier cause the increase of the water absorption rate during initial stages of immersion. The total amount of water absorbed after longer exposures, however, is lower in consequence of the better consolidation of globules in the film. The effect of the polarity of the emulsifier was observed using nonylphenol/ethylene oxide adducts containing various numbers of ethylene oxide units. More hydrophilic emulsifiers caused a higher water absorption. The effect of the polymer elasticity was studied using copolymers with various butyl methacrylate/butyl acrylate ratios. The films deposited from softer copolymers exhibited a higher level of water absorption.

**Keywords**

*Types and classes of coating*
latex coating

*Binders, resins etc.*
acrylic resin
methacrylate resin

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

## Quelques facteurs influectant l'absorption de l'eau dans les films préparés à partir des latex synthétiques

*Résumé*

L'auteur a étudié l'absorption de l'eau dans les films préparés à pertir des latex à la base des copolymères de l'acrylate de butyle et du métacrylate de butyle. La stabilisation du latex par un émulgateur non-ionique secondaire, ainsi que la présence des groupes carboxyliques dans le copolymère se refletaient dans la vitesse plus élevée de l'absorption de l'eau dans le film au stade de début. La quantité totale de l'eau absorbée après 10 jours de l'exposition était moindre chez les latex plus stabilisés par la suite de la consolidation meilleure des particules du polymère dans le film. L'influence de la polarité de l'émùlgateur secondaire a été étudié chez plusieurs phénoles nonyliques éthoxylisés. La polarité plus élevée de l'émulgateur présent se reflétait dans l'absorptivité plus élevée du film. On a étudié l'influence des propriétés physico-mécaniques des films à l'absorptivité chez plusieurs copolymères dont la proportion de l'acrylate de butyle et du métacrylate de butyle était différente. Les films préparés à partir des polymères à l'élasticité plus élevée et à la résistance plus réduite sont caractérisés par la quantité plus élevée de l'eau absorbée après 10 jours.

## Einige der Wasserabsorption in Filmen aus synthetischen Latexen beeinflussende Faktoren

*Zusammenfassung*

Die Wasserabsorption in den aus Latexen auf Basis von Butylakrylat-Butylmethakrylat-Kopolymeren hergestellten Filmen wurde studiert. Die Stabilisierung der Latexe durch den sekundären nichtionogenen Emulgator und die Anweseheit der Karboxylgruppen im Kopolymeren kommt durch erhöhte Geschwindigkeit der Wasserabsorption in den Film im Anfangsstadium zutage. Die Gesamtmenge des absorbierten Wassers nach 10 Tagen Exposition ist jedoch bei mehr stabilierten Latexen niedriger, infolge einer besseren Konsolidation der Polymerpartikel im Film. Der Einfluss der Polarität des sekundären Emulgators wurde an einer Reihe von ätoxylierten Nonylphenolen verfolgt. Die höhere Polarität des anwesenden Emulgators zeigt sich durch grössere Wasseraufnahmefähigkeit des Films. Der Einfluss der physikalisch- mechanischen Filmeigenschaften auf die Wasseraufnahmefähigkeit wurde an einigen Kopolymeren mit verschiedenem Butylakrylat-Butylmethakrylat-Verhältnis studiert. Die aus Polymeren mit höherer Elastizität und niedrigerer Festigkeit hergestellten Filme zeichnen sich durch höhere Menge während 10 Tagen absorbierten Wassers aus.

## Некоторые факторы влияющие на абсорпцию воды в пленках на основе синтетических латексов

*Резюме*

Было изучено поглощение воды в пленках латексов на основе сополимера бутилакрылата и бутиметакрылата. Стабилизация латекса вторичным неионогенным эмульгатором и присутствие карбоксильных груп в сополимере проявляются в повышенной скорости поглощения воды пленкой в первоначальной стадии. Общее количество поглощенной воды по 10 дневной экспозиции у более стабилизированных латексов вследствие лучшей консолидации частиц полимера в пленке ниже. Влияние полярности вторичного эмульгатора было изучено у ряда этоксилированных нониловых фенолов. Повышенная полярность присутствующего эмульгатора проявляется в повышенной влагопоглощаемости пленки. Влияние физико-механических свойств пленок на влагопоглощаемость было изучено для ряда сополимеров при разном соотношении бутилакрылата и бутилметакрылата. Пленки, полученные на основе полимеров с повышенной эластичностью и пониженной прочностью, отличаются повышенным количеством поглощенной воды, измеряемой в течение 10 дней экспозиции.

## Introduction

Under suitable drying conditions, polymer emulsions—latices—are able to form clear films of polymer. The theory of film formation has been discussed by various authors.[1–17] In accordance with present knowledge, it is assumed that various mechanisms formerly suggested are complementary. Film formation is influenced by the surface tension[2] as well as by capillary forces.[3] During the film formation, "conglomeration" or "autohesion" occurs,[7] i.e. mutual interdiffusion of the free polymer chains across the particle/particle interface in the coalesced film. The radii of interfacial curvature are very important to the coalescence of the spheres and must also be taken into account.[12–14] Film formation is also significantly influenced by emulsifiers and protective colloids.[8–11] Ideally, each sphere becomes a dodecahedron and never loses its identity in the dried state.[6] It is supposed that emulsifiers and other water-soluble materials form an independent network in the film,[15] that they are forced into isolated pockets or towards the surface or that emulsifiers diffuse into the polymer, as in the case where they are compatible with the polymer.[16, 17]

Thus, polymer films formed from latices and from solvent vehicles differ considerably. The different structure and the presence of various water-soluble materials cause a specific behaviour of latex films when in contact with water. A film deposited from latex undergoes several changes upon exposure to water. Whitening and swelling of the film, accompanied by plasticisation and destruction of the film continuity, occur. Loss of adhesion to the substrate results from the destruction of specific adhesion forces through the presence of water. According to the Brown and Scullin theory[18] the two possible mechanisms of water penetration into the films are diffusion through the polymer and capillary flow, which would occur in channels representing imperfections in the film. Diffusion alone is assumed during initial stages of exposure, capillaries apparently being opened during later stages.

The suggested mechanism for water penetration is that water enters the polymer, in which it is soluble to a slight extent, and diffuses into small pockets formed by salts and other water-soluble materials. The driving force for penetration is provided by the osmotic pressure. Opposition to water penetration results from the increasing hydrostatic pressure on the water cell produced in the film, this force being supplied by the resistance of the polymer to the deformation, and being a function of the elastic modulus of the polymer under existing conditions. Hence, the water absorption in the latex is influenced by various factors, including the type and amount of water-soluble materials, the elasticity of polymer and its chemical composition,[19-21] the particle size of the original latex,[22] and the drying conditions, etc.

In this paper the effects of the type and amount of secondary non-ionic emulsifier, the carboxylic groups present, and polymer elasticity are investigated.

## Experimental

Water absorption of polymer films may be followed by observing the changes of optical density (whitening) or by measuring the weight of water absorbed. The former method suits the study of early stages of the water absorption, the latter is useful in investigations during longer periods. In this study, the latter method was used.

### *Latices*

The latices used were produced in the author's laboratory by semicontinuous emulsion copolymerisation of butyl methacrylate, butyl acrylate and small amounts of acrylic acid. Anionic emulsifier (1 per cent on polymer) and an initiating system of persulfate/metabisulfite, were used in the polymerisation. The solid content of the latices was 50 per cent (wt). The distributions of particle sizes were narrow and the average particle sizes were from 0.22 to 0.25 microns.

*The effect of the amount of acrylic acid and secondary emulsifier* was studied on latices with a butyl methacrylate/butyl acrylate ratio of 80:20. The latices were prepared in the presence of 0, 1, 2, 3 and 4 per cent wt acrylic acid respectively in three sets:

1—under alkaline (ammoniacal) conditions, where acrylic acid was present in the form of the ammonium salt;

2—under acidic conditions;

3—under acidic conditions followed by the adjustment with ammonia to $pH = 8—9$.

The latices were post-stabilised by 0, 1, 2, 3 and 4 per cent on the weight of polymer of non-ionic emulsifier (Slovafol 909) in the form of 25 per cent aqueous solution.

*The investigation of the influence of the given type of non-ionic emulsifier* was carried out using the latex consisting of BMA/BA = 80/20 copolymer. The latex was made under ammoniacal conditions in the presence of 1 per cent acrylic acid. Various members of the Slovafol 900 series of non-ionic emulsifiers (CHZWP Nováky, ČSSR) were used as post-stabilisers. These are nonylphenol —ethylene oxide adducts with varying polyoxyethylene chain lengths. Slovafol 909 emulsifier contains nine moles ethylene oxide per mole nonylphenol, Slovafol 920 contains twenty moles per mole etc. The full amount of Slovafol emulsifiers, of both 2 and 4 per cent on the weight of polymer, were added to the latex in the form of 25 per cent aqueous solutions.

*In order to elucidate the effect of the polymer elasticity*, latices with a varying BMA/BA ratio were used. The latices containing 10-25 per cent butyl acrylate by weight were made under ammoniacal conditions in the presence of 2 per cent acrylic acid. The latices were post-stabilised by 3 per cent by weight of Slovafol 909 in the form of 25 per cent aqueous solution.

### *Films*

Latices were cast on the glass plate to give a film thickness of 250 microns. The films were dried in a air-conditioned room at 23°C and 60 per cent relative humidity. After ten days of ageing, circular samples of the films were prepared. The weight of these samples was approximately 1g. The samples were immersed in distilled water and the weight increase observed. After ten days of immersion, the samples were dried again in the air-conditioned room for a period of ten days. The weight losses of the films were measured.

## Results and discussion

### *Effect of non-ionic emulsifier and acrylic acid*

A sufficient stability of latices is often the crucial and limiting factor in various applications. An overall increase in the mechanical and freeze-thaw stability, as well as the stability to electrolytes, may be reached by post-stabilisation with emulsifiers; for this purpose non-ionic emulsifiers are usually used. The freeze-thaw stability may be improved via copolymerisation with unsaturated carboxylic acids (carboxylic groups are built into the polymer). The effects of these two ways of stabilisation of water absorption of the latex films are shown in Figs. 1, 2 and 3.

Fig. 1 represents the development of water absorption of films from latices prepared under alkaline conditions. Under these conditions, the formation of ammonium polyacrylate may be expected.[23] In Fig. 2, the relationships of the films from acid latices, containing undissociated carboxylic groups, are shown. The increase of the water absorption of films from latices made alkaline after preparation, where dissociated carboxylic groups are present, is shown in Fig. 3.

That various forms of acrylic acid are present in the three series of latices is evident from Fig. 4. Latices made under alkaline conditions contain acrylic acid in the water-soluble ammonium polyacrylate form. The relationship between the weight loss of the film and the acrylic acid content is practically linear. The remaining two curves indicate that the respective latices also contain

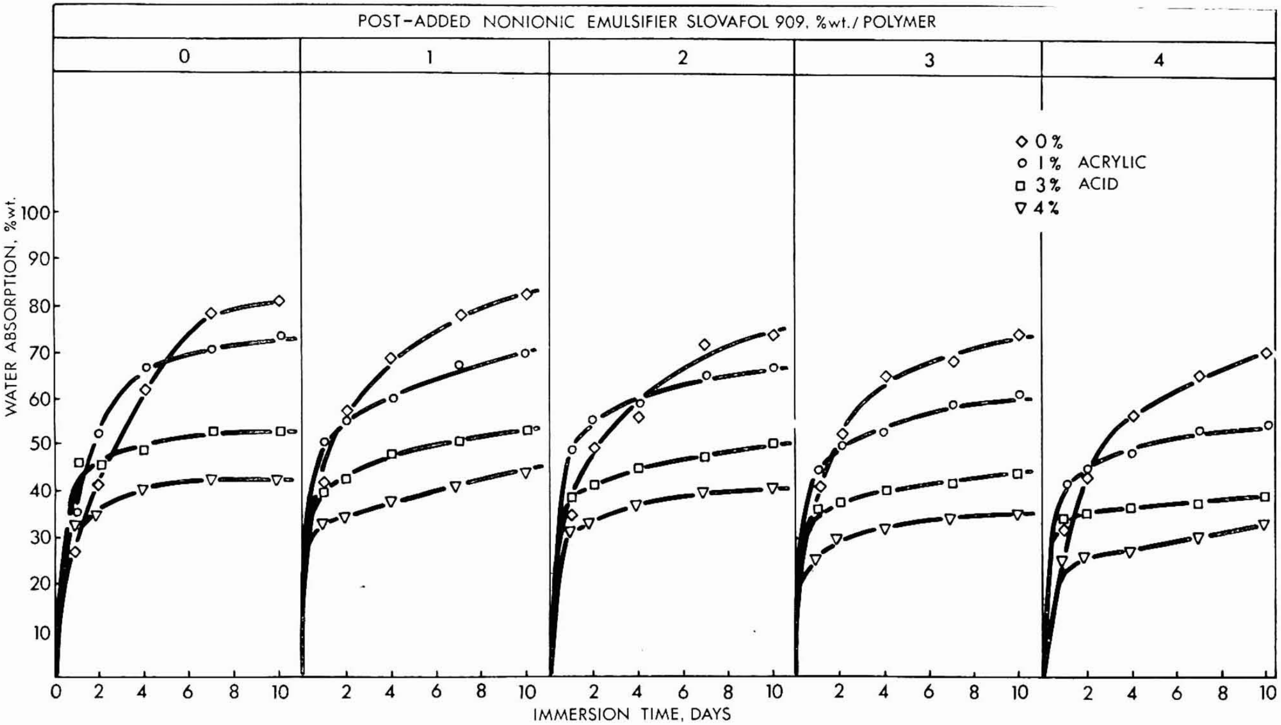


Fig. 1. Development of the water absorption of films deposited from latices prepared under alkaline conditions

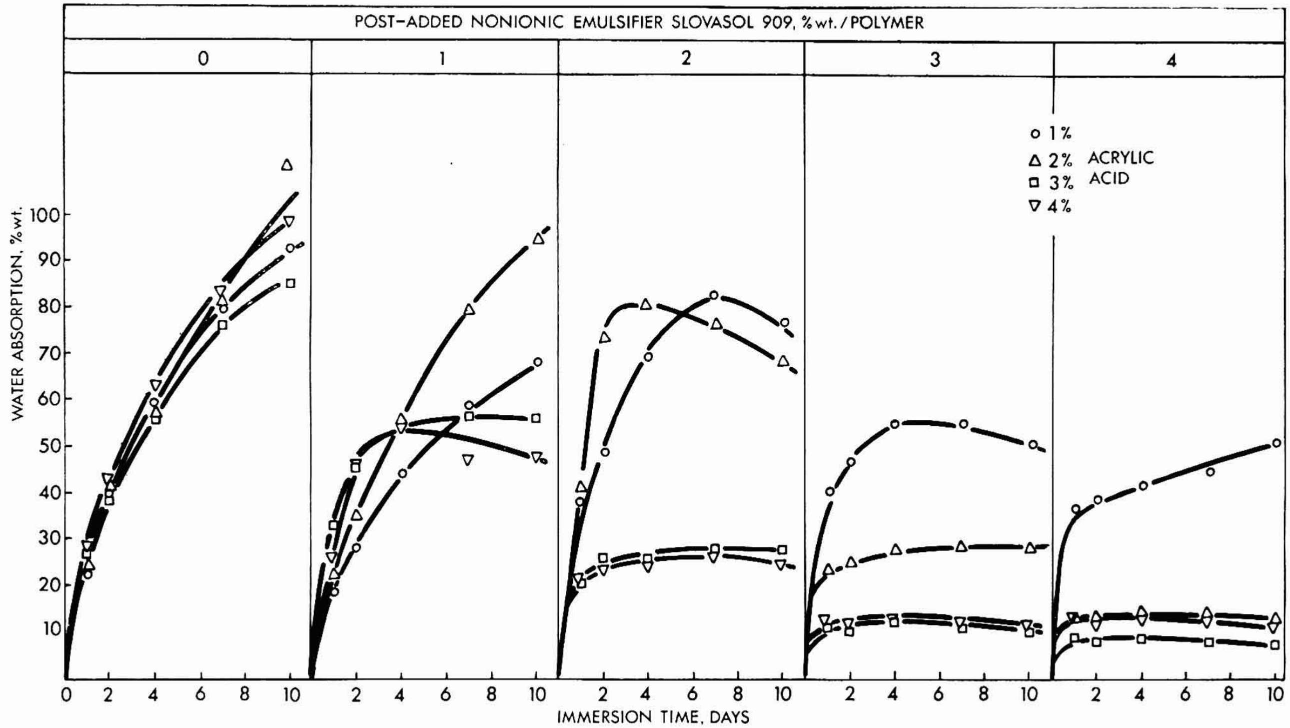
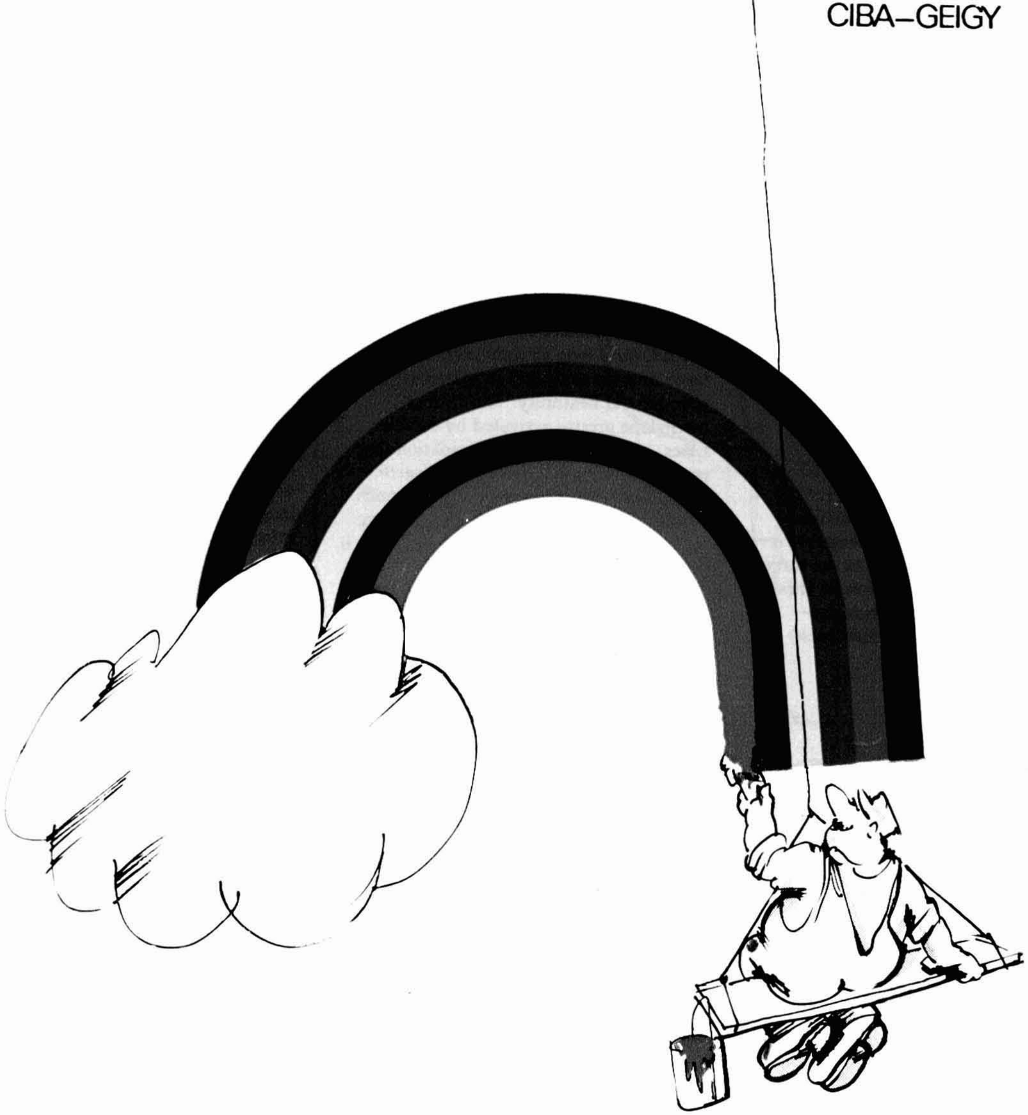


Fig. 2. Development of the water absorption of films deposited from latices prepared under acidic conditions



# FAT·FAX 8

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

## Four whys and a wherefore re fatty acids

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

## Not every good backbone's an alkyd

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

## But to get below the surface, read the good book

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

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Chemicals Limited

U0

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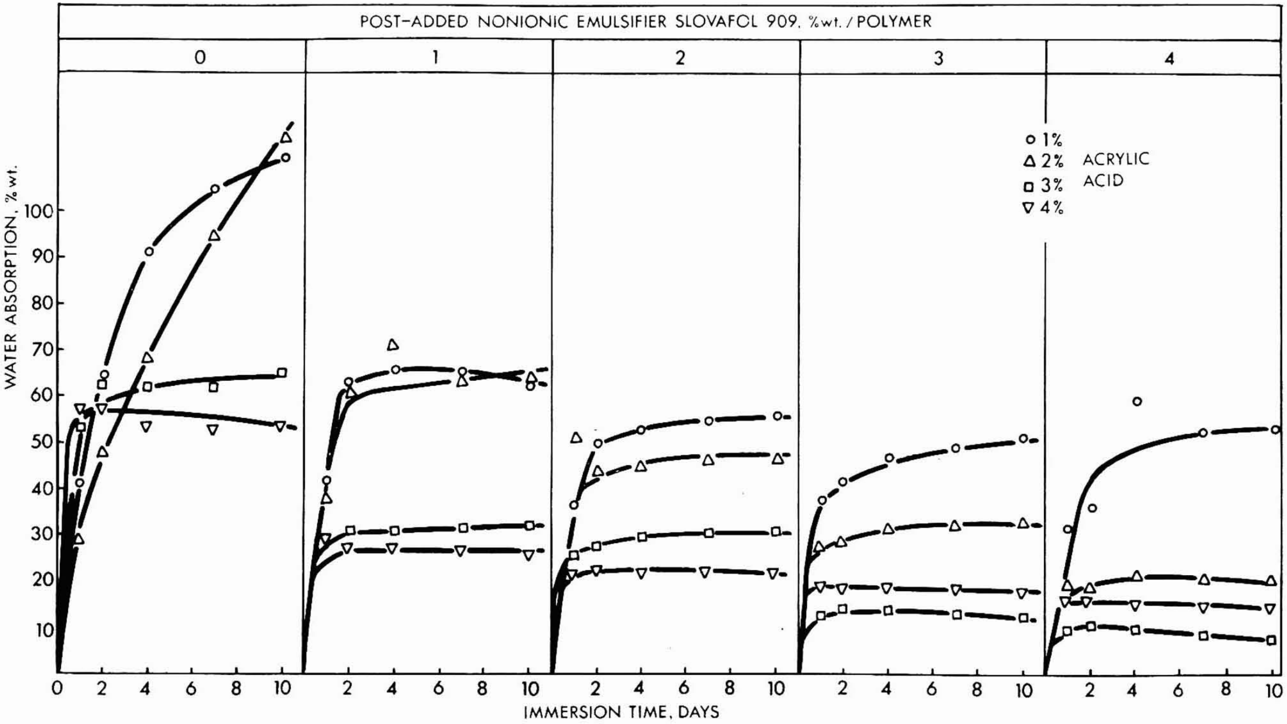

Fig. 3. Development of the water absorption of films deposited from latices made alkaline with ammonia after preparation

amounts of water-soluble and alkali-soluble polymer, especially at higher contents of acrylic acid. In the course of polymerisation, solution polymerisation of acrylic acid also proceeds to some extent. This may be expected particularly in the early stages of the polymerisation process used.[24]

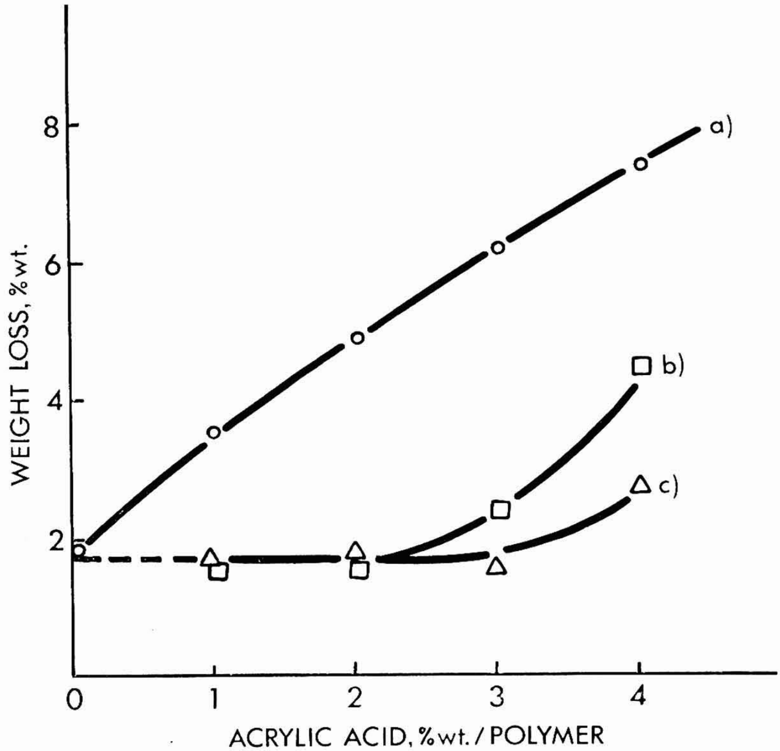

**Fig. 4. Weight losses of films after ten days' immersion in water, the latices used without post-stabilisation**

(a) latex prepared under alkaline conditions
(b) latex prepared under acidic conditions
(c) latex made alkaline by ammonia after preparation

The water absorption results (Figs. 1-3) indicate that the stabilisation of latices by emulsifier, as well as carboxylic groups, significantly reduces the total amount of water absorbed at the end of ten days' immersion. In the early stages, however, the speed of the water absorption is increased. This trend is distinctly apparent with many samples, in spite of the fact that the first weighings had not been carried out until after five hours of immersion (e.g. Fig. 5).

The water absorption results indicate two contrary effects. Water-soluble materials and polymer polarity increase the initial absorption speed, but in the later stages the further swelling of films is decreased. It can be suggested that the decrease in the total amount of water absorbed during longer periods is due to the better consolidation of latex particles in the film. The most probable explanation is the importance of the latex stability during the film formation.

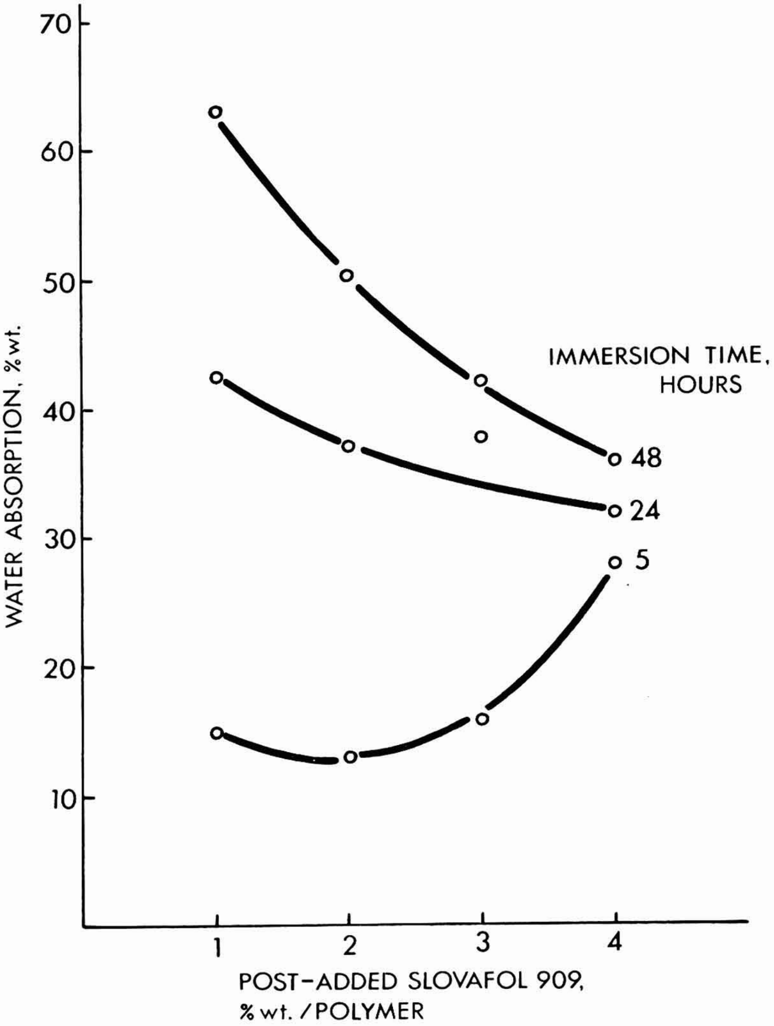

**Fig. 5. Water absorption after 5, 24 and 48 hours' exposure in relation to the amount of secondary emulsifier. Films were deposited from latex containing 1 per cent wt of acrylic acid in the copolymer, made alkaline after preparation**

In a better stabilised latex, a gelation of particles is postponed until true close packing is reached: the number of interglobular contacts will be greatest under those conditions. If the system gels before close packing is reached, the globules are immobilised and the less effective packing of spheres causes a poorer consolidation of film. This suggestion is also borne out by the character of film surfaces. Fig. 6a shows a surface replica of the film made from latex into which no secondary emulsifier was post-added. Fig. 6b shows a surface replica of the film made from the same latex but post-stabilised by 4 per cent Slovafol 909 on weight of polymer. The latter film is not so well sintered but nevertheless seems to be more closely packed. These results are in good agreement with the conclusions of Isaacs.[11]

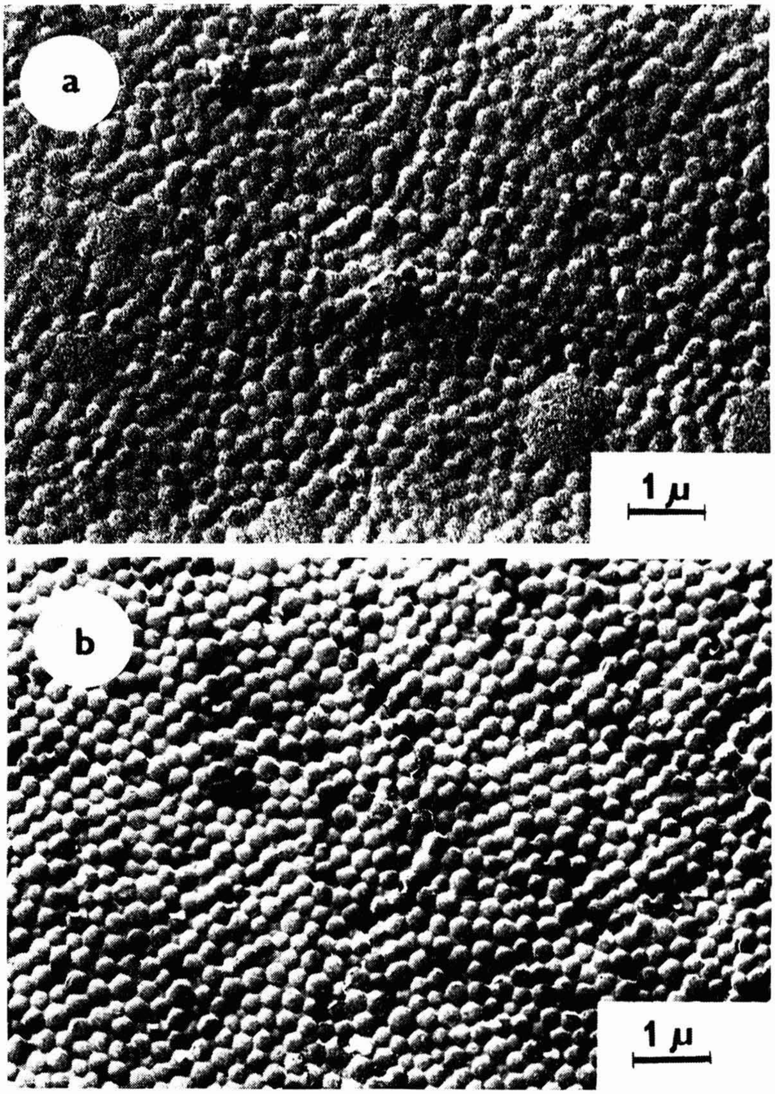

**Fig. 6. Film surface replicas**
(a) without secondary emulsifier
(b) with 4 per cent wt Slovafol 909

The effect of carboxylic groups may be explained similarly. Dissociated carboxylic groups affect the overall charge of particles and zeta potential, upon which the protective properties of the electric double layer depend.

It is evident from Figs. 2 and 3 that the effects of emulsifier and carboxylic groups are complementary. The stronger influence of dissociated groups (in comparison with undissociated) is distinctly visible, especially on samples having a lower content of the secondary emulsifier. A high content of emulsifier and of carboxylic groups taken together, however, leads to higher values of absorbed water. The effect of ammonium polyacrylate (Fig. 1) is much greater than that of the emulsifier. Nevertheless, the decrease of the water absorption caused by the post-added emulsifier is also distinctly visible.

### *Effect of emulsifier hydrophility*

The influence of the emulsifier polarity on the amount of water absorbed was studied using nonylphenol/ethylene oxide adducts containing various numbers of ethylene oxide groups ($n = 5$, 9, 20, 35 and 45 which refer to HLB = 10.0, 12.9, 16.0, 17.5 and 18.0). The relationships between the number of ethylene oxide units and the amount of water absorbed are shown in Fig. 7. The increasing hydrophilicity of the emulsifier used causes the increase of the total amount of water absorbed after ten days. Films containing a higher level of emulsifier again showed lower absorption.

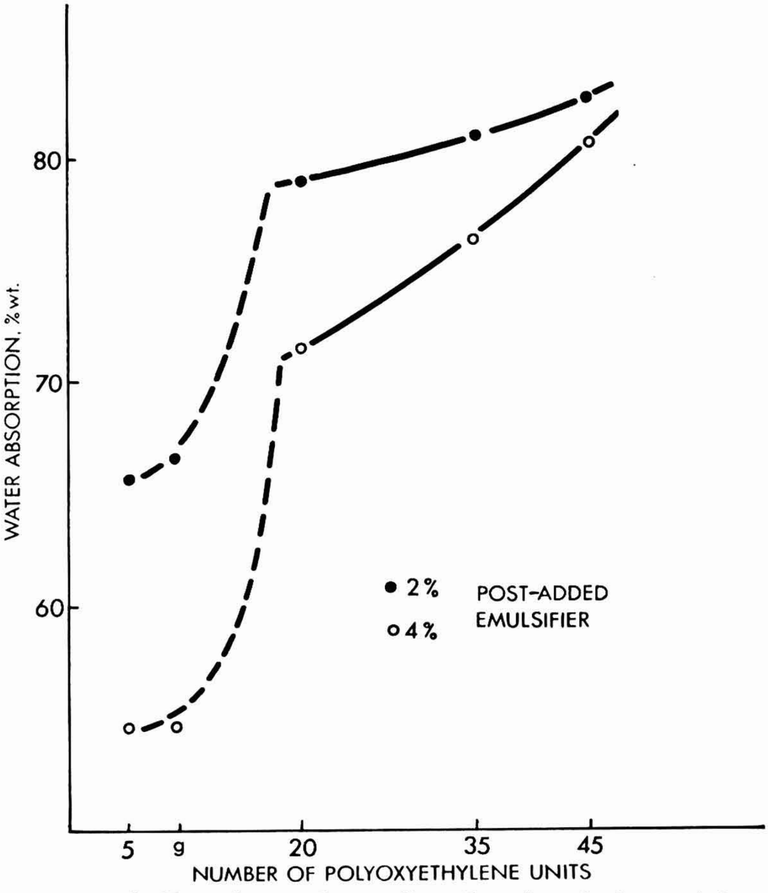

**Fig. 7. Water absorbed in films after ten days—effect of number of polyoxyethylene units in the emulsifier**

A higher absorption of the films containing emulsifiers having a higher HLB is due to their greater affinity for water. In consequence of this, higher osmotic pressures develop, causing greater deformation of the condensed globules. A considerable discontinuity in effect of emulsifiers with 5 and 9 polyoxyethylene units and those with 20, 35 and 45 units was found. This "jump" is probably caused by the diffusion of less polar emulsifiers into the polymer. It was demonstrated by Vanderhoff[14] that this type of emulsifier, containing 4-15 polyoxyethylene units, does not exude to the film surface, unlike those with 20-40 units. This has been explained by the increased compatibility of less hydrophilic emulsifiers with the polymer.

The types of emulsifiers affect the weight losses of films only slightly (Fig. 8). Water-soluble materials seem to be almost completely extracted after ten days' immersion in water.

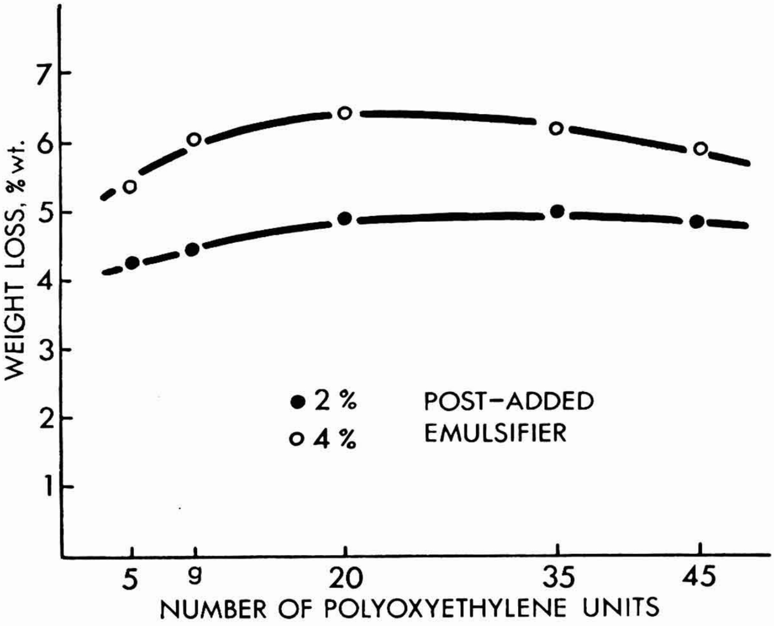

**Fig. 8. Weight loss of films after ten days' exposure—effect of number of polyoxyethylene units in the emulsifier**

*Effect of polymer elasticity*

The relationships shown in Figs. 9 and 10 indicate the influence of the polymer elasticity in the water absorption of latex films. Copolymers of varying elasticity were obtained by varying the BMA/BA ratio from 90/10 to 75/25. Glass transition temperatures ($T_g$) of the copolymers were in the range from +12°C to −2°C. The mechanical properties of the copolymers are shown in Fig. 11. The hydrophile number of the copolymers[21] does not change appreciably hence the differences in the water absorption have to be accounted for by the varying elasticities of the copolymers. The total amount of water absorbed is proportional to the elasticity of polymer—this is in accordance with the proposed mechanism of the water absorption of latex films.

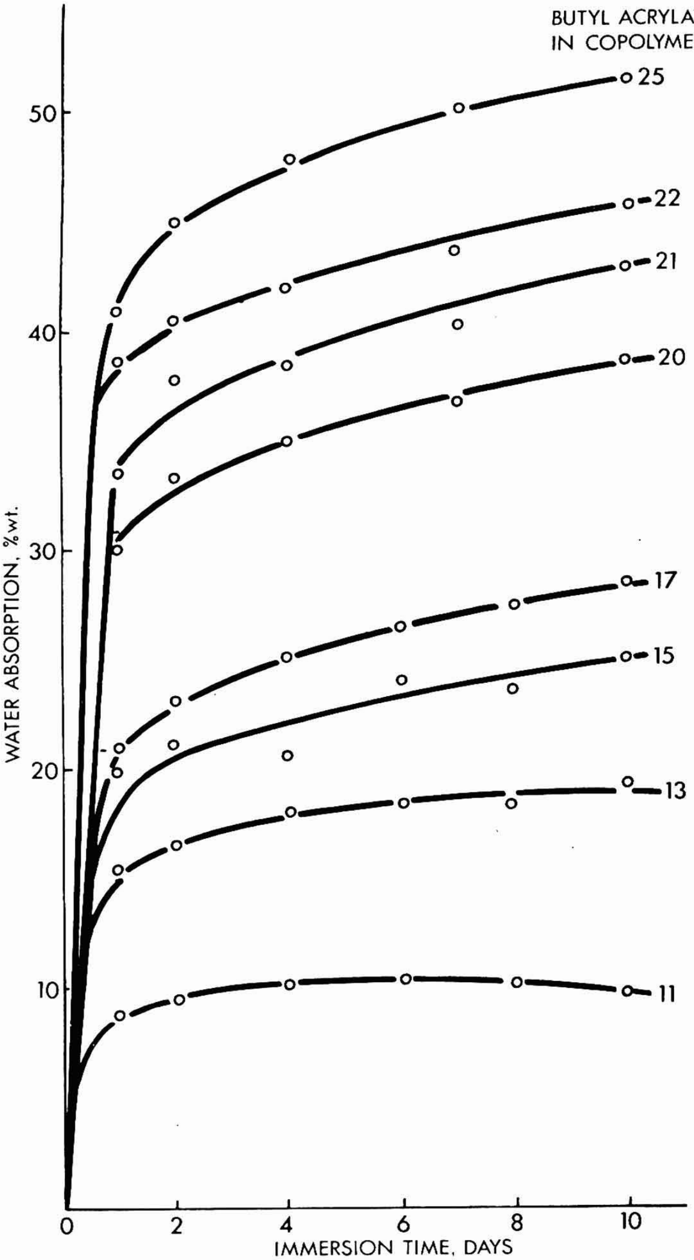

Fig. 9. Development of the water absorption of films with various butyl methacrylate/butyl acrylate ratios

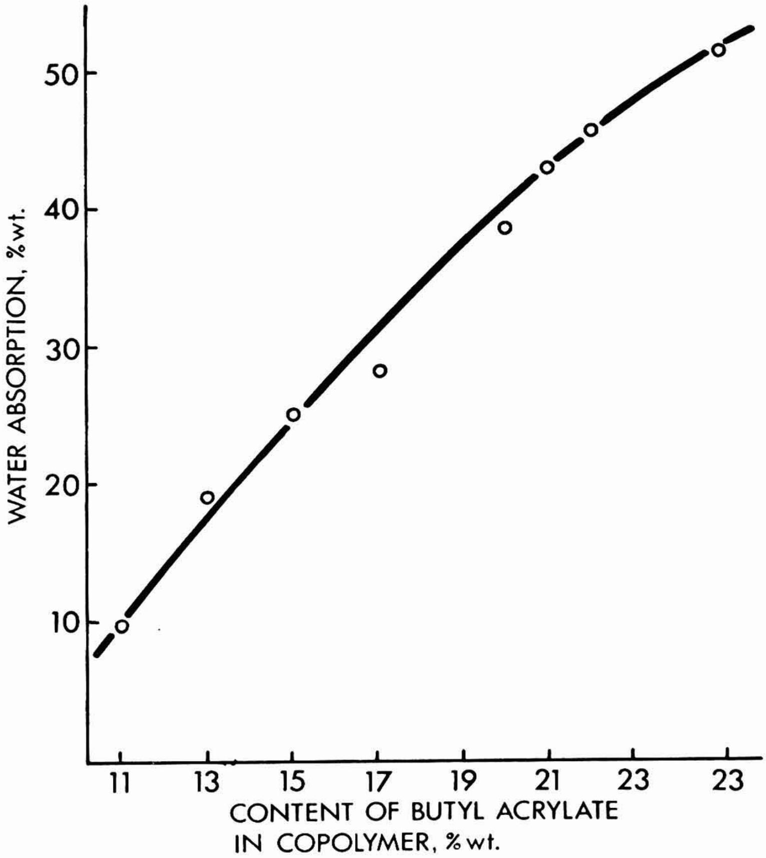

Fig. 10. Water absorbed in films after ten days—effect of the polymer elasticity

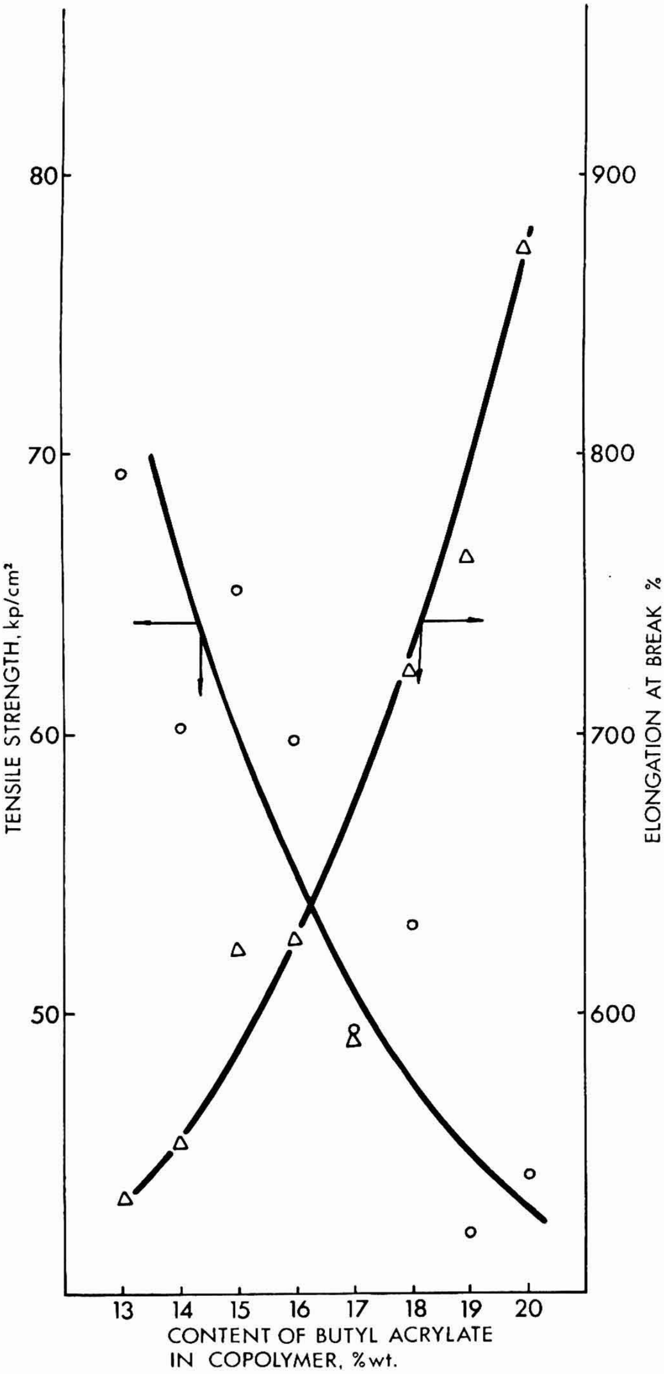

Fig. 11. Properties of BMA/BA copolymers in relation to their compositions (at 20°C)

## Conclusions

Two phases of the process have to be considered when the behaviour of latex films in the contact with water is studied. In the first phase, the water absorption is supported by hydrophilic materials present in the film. They increase the rate of whitening as well as of weight increase. During longer exposures, however, the influence of water soluble materials disappears and that of the initial latex stability becomes evident. Stabilisation of latices by emulsifiers, as well as by carboxylic groups, decreases the water absorption after longer exposures. This is due to the better consolidation of particles in the film. However, it is reasonable to expect that a further increase in the amount of emulsifier and number of carboxylic groups will lead to increased absorption.

Emulsifiers of higher polarity cause an increase in the amount of water absorbed. This is due to the greater affinity of more hydrophilic emulsifiers for water and, probably, also to the compatibility of less polar emulsifiers with the polymer. The elasticity of the polymer affects the water absorption in accordance with the proposed mechanism. Films formed from elastic globules deform easier and permit a greater swelling in water. Films from polymers with a $T_g$ about 10°C lower exhibited an absorption approximately four times higher. This indicates a considerable effect of mechanical properties in the process.

These results were obtained for BMA/BA copolymers. It is difficult to say whether the other polymers, especially those which are more polar, will behave in the same manner. Nevertheless, it is possible to conclude that the process of the water absorption in latex films is affected by various factors. When the water absorption of films deposited from various latices is compared, many factors have to be taken into account, including the chemical nature of polymer, particle size, polymer elasticity as well as the form and degree of the latex stabilisation.

## Acknowledgments

The author wishes to thank Dr B. Hájková for the electron microscopy replicas and Dipl.-Ing. L. Formánek for many valuable suggestions.

[*Received 9 May 1972*

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# Next month's issue

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

**"A test for ability to support combustion for liquids including paints and allied products,"** *by A. N. McKelvie*

**"Weathering of paint films V. Chalking in emulsion paint films caused by silicone coated anatase $TiO_2$ and ZnO at varying humidities,"** *by E. Hoffmann and A. Saracz*

**"The peeling-off of paint films,"** *by J. de Jong and P. M. Heertjes*

# Correspondence

## Investigation of the water and ion permeation characteristics of certain polymers

Sɪʀ—This is in response to the above paper by Boxall, Fraunhofer and Werren (*JOCCA* 1972, **55**, 24) in which test data show chlorinated rubber to have poor water permeation characteristics and poor salt spray resistance. These conclusions certainly do not agree with case history and exposure studies which show chlorinated rubber paints to be the best, or among the best, time after time for water and salt spray exposure conditions.

One explanation why chlorinated rubber performed as poorly as these authors reported is that it was not properly plasticised—the films used in their study were not properly formulated. Parlon is a hard polymer, and for optimum properties, must contain higher levels of plasticiser than used in the work of Boxall *et al.*

Chlorinated rubber paint systems have demonstrated excellent salt spray resistance. Consequently, more and more shipping lines and marine paint specialists are specifying the use of these systems.

Readers may be interested in a study entitled "Minimum paint film thickness for economical protection from hot-rolled steel against corrosion" performed by Keane, Wettach and Bosch under the direction of the Corrosion Committee of the Federation of Societies for Paint Technology. The report by Hercules Incorporated, M-342A, contains excerpts from this study. In this a chlorinated rubber paint system was compared to US Federal Specification oil based, alkyd, phenolic and vinyl coating systems, as well as a suggested epoxy ester system. When compared for oxygen and water permeability at various film thicknesses, the chlorinated rubber coating system had both the lowest water vapour permeability and lowest oxygen gas transmission rates. The chlorinated rubber paint system was the most durable and the least permeable of all systems tested. Consequently, the system demonstrated the lowest critical film thickness for corrosion protection in sea coast exposures. There are also many other additional studies by Hercules, Imperial Chemical Industries, many different paint companies, Steel Structures Painting Council and several independent laboratories that indicate the superiority of chlorinated rubber paint systems in these salt spray and water permeation areas.

Yours faithfully,

C. W. Gᴀᴜʟᴛ.

*Hercules Incorporated,*
*Coatings and Speciality Products Department,*
*Hercules Tower,*
*910 Market Street,*
*Wilmington, Delaware 19899,*
*USA.*
*8 September 1972*

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Sɪʀ—With regard to the letter from Mr Gault, we would point out that when this work on permeation was performed we were concerned primarily with the characteristics of the polymer films themselves rather than with the behaviour


SETIN RUBBER
2½"

of marketable paint products. We are well aware of the fact that the chlorinated rubber film was under-plasticised, although this should perhaps have been stated more clearly in the paper. A more important factor, however, was the fact that none of the polymer films were pigmented, so that we were able to investigate the behaviour of the polymers without any complications from pigments or fillers.

The work to which Mr Gault refers, together with other work that we have published, clearly indicates that chlorinated rubber films *per se* do not prevent diffusion of water or ions through the film to its substrate. We would agree, however, that chlorinated rubber does appear to exhibit very high resistance to degradation upon immersion. Consequently when paints are formulated with the correct degree of plasticisation and inhibitive pigments are incorporated, durable and protective paint coatings should be produced.

Yours faithfully,

J. A. VON FRAUNHOFER
J. BOXALL
S. C. WERREN

*Institute of Dental Surgery,*
*Gray's Inn Road,*
*London WC1X 8LD,*
*14 September 1972.*

## The role of research on paint technology in the Australian building industry

SIR—I have read with interest the reasons ascribed by Hoffman (*JOCCA*, 1972, **55,** 708) why paint technology research should be carried out by a fully government controlled research laboratory—in this instance "a building research institute". With all deference to Dr Hoffman, the reasons he puts forward are strongly reminiscent of the small boy who, having eaten a pound jar of jam out of the larder, then justifies this by convincing himself that it was really good for him but would have been harmful to anybody else.

The most obvious and undoubtedly the best places for paint technology research to be carried out are dismissed by Hoffman as "their findings are only available to subscribers and not interested parties". It is only when a job is paid for by a particular individual that the results are treated in this way.

Paint research associations should be the first organisations to be considered for such research. They have the know-how, the industrial contacts (and this includes confidential information which many firms are very reluctant to divulge to government departments), and facilities for liaison with other research organisations, universities, etc., wherever the use of specialised knowledge or equipment is involved. If a government department or any other responsible organisation thinks that a particular research project should be done, it should be sub-contracted out to the appropriate research association after approaching industry to pay its share. Why build up another technical organisation, for which the taxpayer would be entirely responsible, and which must, at times, be uneconomically staffed due to the varying work load? We are becoming increasingly civil service controlled and the current thinking amongst the higher ranks of the UK technical civil service "We will consider doing a job only if industry or research associations cannot undertake it" has, therefore, much to commend it.

From the technical angle there is one other very important argument against Dr Hoffman's idea. Industrially orientated research—and paint research will finally have to refer back to the paint industry—is often more practical than the academical. This latter can, and does, sometimes result in a degree of genuine technical optimism based on theoretical concepts which, when put to the final test of manufacture, are found to be only partly true.

The views expressed in this letter are purely personal and do not necessarily represent the views of either my present or past employers—one of whom, incidentally, was a technical branch of the civil service.

Yours faithfully,
R. R. HILL.

*7 Desborough House,*
*Rectory Avenue,*
*High Wycombe,*
*Buckinghamshire.*
*15 September 1972*

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## Legibility of coloured inks on coloured papers

SIR—Some readers may, like myself, at times have found themselves reading technical or other literature for which the chosen colours of ink and paper make reading difficult and tiring. May I therefore draw attention to a most excellent November 1944 *JOCCA* article "Investigation of the legibility and aesthetic value of coloured printing inks on coloured papers" (*JOCCA* 1944, **27,** 209) by Drs Vickerstaff and Woolvin. Although a wartime publication, the article includes excellent illustrations in colour, and certainly deserves wider appreciation.

Yours faithfully,
A. S. FREEBORN.

*50 Blackbrook Lane,*
*Bickley, Bromley, Kent.*
*5 September 1972.*

# Reviews

## CHALLENGING YEARS: MY LIFE IN CHEMISTRY

BY K. WINNACKER. Translated by D. Goodman. London: Sidgwick and Jackson, 1972, pp. xiv + 440. Price £4.00

It is not usual to review a book of this nature in this *Journal*, but the outstanding interest of Prof. Winnacker's memoirs justifies the exception. To quote from the foreword by Lord Longford, who was Minister for the British Zone of Germany in 1947 and 1948: "It can be read and appreciated on at least three levels. In the first place, it is a first class account of how modern science and technology can be applied to the development of a great business under very varied conditions. Secondly, much light is thrown on the social, economic and psychological conditions which brought about the tragedy of Nazi rule and yet enabled Germany to achieve her fine moral and material recovery. Thirdly, it provides a fascinating human and in many places humorous story from one who was at the centre of the storm and survived to give such a creditable account of it." The book itself well merits this assessment.

Winnacker was born in 1903 and so passed his childhood before the advent of the first World War and most of his school days during it. In 1922, after four years which saw the transformation from an empire to a republic, he took his final examination at Barmen High School and began to think about his career. He started his chemical studies at Brunswick University without any prior knowledge of the subject and after some time transferred to Darmstadt. Here he was greatly influenced by Prof. Ernst Berl, who, after Winnacker had obtained his diploma, offered him a post as private assistant. This position he retained until 1933 when Berl, who was a Jew, was dismissed from the University when the Nazi party achieved power.

Winnacker then obtained a job in the alizarin laboratory of Hoechst, which had started dyestuffs manufacture in 1863 employing "five workers, a bookkeeper, a chemist and a small steam engine". At the time when Winnacker joined the company it was a comparatively small division of the enormous I. G. Farbenindustrie, which dominated practically the whole of the German chemical industry. By 1941 Winnacker had become technical manager of the central Rhine group of IG factories and was largely concerned with "Buna" manufacture, and two years later he was appointed a director of IG and returned to Hoechst. A notable feat in rapid promotion.

At the end of World War II the Allies decided, in order to reduce the risk of future war, to disband the enormous German combines, such as Krupp's, and IG was included in this process. Hoechst, itself, came under American control and within a short time Winnacker was dismissed from his post and managed to obtain a job as gardener in a nursery. He was fortunate not to be involved in the first industrial trials at Nuremberg, when the directors of IG, the Flick Group and Krupp's were in the dock.

In May 1947, when the control conditions had become somewhat easier, he obtained a position as chemist at the Duisburger Kupferhütte, in the British zone, and a year later was offered a post as departmental head at Knapsack. These two firms later both joined the Hoechst Group. It was agreed by the Allies that IG should be reorganised into three principal groups, Bayer, BASF and Hoechst, and Winnacker returned to Hoechst as a member of the board of management of this group which was founded in December 1951; a year later he became its chairman and a member of the supervisory board.

From this point the book becomes a fascinating account of the development of the newly formed Farbwerke Hoechst into a major international industrial organisation. In this Winnacker played the leading role; the judgement, skill and enterprise shown in the development is quite remarkable. During the period acquisitions were made in the synthetic resin and paint fields. The accounts of staff and labour relations are of great interest. Winnacker retired in 1969 and completed the book in 1971.

The book is eminently readable, a virtue that must, at least in part, be due to the excellent translation.

HON. EDITOR

## Fibres, Films, Plastics and Rubbers

By W. J. Roff and J. R. Scott. London: Butterworths, 1971, pp. 688. Price £15.00

This is a much expanded and up-dated version of Roff's earlier "Fibres, Plastics and Rubbers" which was intended as a reference work primarily for those in the textile industry. In its new form it should prove to be of great value to all polymer users.

The book is in two parts, the first, of 482 pages, dealing with individual or closely related groups of polymers in 42 sections, and the second, of 274 pages, concerned with specific properties and related information under 34 headings.

In the first part, all sections are presented in uniform manner under the sub-headings synonyms and trade names, structure, chemistry, physics, fabrication, serviceability, utilisation, history, additional notes and further literature, a treatment greatly to be commended. The section on polyamides, for example, lists most of the classical nylons and mentions the dimer acid polyamides. The sub-section on chemistry is much concerned with the routes to key intermediates like hexamethylene diamine but has nothing to say about the mechanism of polycondensation or about production equipment. (The former is treated in a general section, curiously situated in Part 2.) There is a bias towards the fibre-forming types but not an unfair one in view of their importance. Nevertheless this does lead to some overgeneralisation, like the statement, "For useful properties the number average molecular weight must be above 10,000," which is not true of dimer acid types. The physics sub-section deals with general, thermal, electrical and mechanical properties without reference to dimer acid types, and the serviceability, utilisation and history sections are again restricted to the nylons. The "additional notes" cover the nylon numbering system, modified nylons, and related materials—the polyimides, polynonamethyleneurea and the polyaminotriazoles. Under "further literature" one is referred to standard texts on polyamides, some useful trade literature, and specifications. Such is the pattern and character of Part 1. For once, a general work on polymers gives alkyds a fair crack of the whip: they have a 13 page section to themselves. It is not sufficient for a surface coatings technologist but quite enough for the non-specialist to see where they fit into the polymer industries.

Part 2 contains notes on molecular weight, x-ray data, solvents, plasticisers, polymer preparation and identification, but is most noteworthy for its treatment of a wide range of properties such as permeability, power factor, tensile strength and hardness, which embraces definitions, units, notes on test methods and comparisons of important groups of polymers. Data throughout are presented in cgs units but there is a note on the SI system which includes a table of conversion factors.

The whole is an excellent work of reference for the polymer user and for the general reader, despite a certain bias deriving from its ancestry. Polymer manufacturers will have little time for the sections on their own product groups but will find the book a useful source of information about others.

A. R. H. TAWN

## REVIEWS IN POLYMER TECHNOLOGY, VOLUME 1

BY I. SKEIST (Editor). New York: Marcel Dekker Inc., 1972. Price £9.30

This is the "applied" complement of Dekker's "pure" series, "Reviews in Macromolecular Chemistry," volume 4 of which was reviewed in this *Journal* last year (p. 906). It is well produced and its contents are both authoritative and timely, but we feel obliged to reiterate our wonderment at the number of polymer review series which the market seems able to support. It has long been impossible for one reader to keep up with the original literature, and few can now have the time to follow all the secondary sources. Industrial readers will nevertheless want this one since, as far as this reviewer is aware, it stands alone in dealing with applied polymer science.

Readers of this *Journal* will find most of the contents directly interesting, the exceptions being, perhaps, Zimmermann's account of the processing of powdered polyethylene, and the brief, uninspired, survey of organic colourants for plastics by Reeve. Cassidy and Yager's discussion of coupling agents as adhesion promoters is naturally biased towards glass-reinforced plastics but covers also the promotion of adhesion to metals. Skeist and Miron provide much food for thought in their review of the developing use of plastics in building. Fire retardance of polymeric materials is competently treated by Einhorn who provides data on a wide range of polymers, discusses the relationship between flammability and structure, and reviews the use and *modus operandi* of halogen, phosphorus, antimony and boron retardants. Those concerned with reprographic processes and plate-making will find Delzenne's account of recent advances in photocross-linkable polymers particularly useful, though the field is developing so rapidly that at least a dozen significant papers and patents have appeared since the last one referenced.

The standard for the most part is high, as indeed it should be, but several of the papers are sparsely referenced and, with so few references dated later than 1969, one suspects a delay in publication quite inexcusable in a review series.

A. R. H. TAWN

***Student Review***

*Paint Technology Manuals. Part Seven: Works practice*

# Chapter VI. Legal requirements

It must be emphasised that legislation regarding the operations of a factory is a highly specialised subject. This review is intended to give only a general outline of the legal requirements; further information may be obtained from the relevant published Acts, but if any uncertainty arises in their interpretation, a solicitor should always be consulted. Whilst care has been taken to present information accurately, the Association, its officers, and the authors cannot be held responsible for any misinterpretation or errors arising from this review.

It is unfortunate that, at about the time that this chapter will appear, a revised form of the Factories Act is due to be published, whose detailed requirements cannot be ascertained precisely at the time of writing this article. It is hoped that it will be possible to outline the major changes in the last part of these reviews (see also under Cellulose Regulations.)

A good deal of effort is being directed towards the "harmonisation" of legislation within the EEC and this will no doubt affect Great Britain when entry into the Common Market takes place. However, it seems likely that such unification will apply mainly to such matters as labelling, composition etc., rather than to regulations on factory operation.

There is a large number of Acts and Regulations that affect the operation of a factory. It would be possible to classify them into those which are directly applicable, such as the Factories and Petroleum Acts, and those which are more directly applicable to the product sold. An example of the latter is the restriction of the lead content of a paint to be used on toys to 0.5 per cent. This is primarily a matter of correct formulation, but nevertheless the factory management must be aware of the restriction and take steps to ensure that no contamination can occur at any stage during manufacture. Such a classification would roughly be the same as dividing the Acts into those which (a) safeguard the health, safety and welfare of those employed in the factory, and (b) safeguard those outside the factory, but who may use or come into contact with its products and (c) protect the environment from various forms of pollution which may arise from the factory.

In Great Britain, legislation of the kind discussed in this review must originate by the presentation of a Bill in Parliament which, after having passed through all its necessary stages, enables the government department concerned to issue an Act (e.g. Factories Act, Petroleum Act etc.) taking effect from some specified date. An Act, which may contain a number of Regulations and Orders, is divided into numbered sections and paragraphs for ease of identification and to avoid confusion. Some parts of a regulation may be specific to a particular industry and where this is intended appropriate "definitions" are given. Additional Regulations under an Act may be added from time to time to cover situations not foreseen at the time when the Act came into force.

## The Factories Act 1961

This Act may be obtained from Her Majesty's Stationery Office, price 47½p, postage 6½p. A short guide to the Factories Act is also available from the same source. Books giving detailed information are: "Redgrave's Factory Acts" by Fife and Machin, 21st edition 1966, Butterworth & Co. (Publishers) Ltd., and "Factory Law" by H. Samuel, 8th edition 1969, Charles Knight & Co. Ltd., London.

The 1961 Act repealed and replaced the earlier Factories Acts of 1937, 1948 and 1959 and is itself due to be replaced by a new Act in about November 1972. The Act applies to factories in general, but in many industries, including the paint industry, special conditions arise which require legislation. The Secretary of State has power to make Orders to cover these conditions; such regulations and orders may still continue in force, even if they were made under repealed Acts.

In addition, local authorities are empowered to impose certain additional legislation, generally known as bye-laws. The works management has, therefore, to deal with a number of authorities; an appendix at the end of this chapter contains tables which summarise the more important acts and indicate the enforcing officer.

A factory is defined under Section 45 of the Act as "any premises (whether or not within a building) in which one or more persons are employed in manual labour in any process or incidental to:

(a) the making of any article or part of an article

(b) the altering, repairing, ornamenting, cleaning or washing or breaking up any article, and

(c) the adapting for sale of any article

where the work is carried on by way of trade or for the purpose of gain, or by a local authority or on behalf of the crown . . . In addition . . . warehouses with mechanical power, . . . building and civil engineering work, and certain other premises are to some extent within the scope of the Factories Act and of special safety, health or welfare regulations made under it, though the whole of the Act does not in most cases apply to them.

The question often arises whether laboratories in a works are subject to the Act. Broadly it may be taken that any laboratory concerned with production (i.e. "carried on for the purpose of gain" or where "mechanical power is used") is subject to legislation, whilst pure research laboratories usually fall outside this definition.

The following are brief notes on the main requirements of the Factories Acts.

### *Health*

(1) Every factory must be kept clean, workrooms must be swept daily and cleaned weekly. Interior walls and ceilings should be washed with hot water and soap or detergent every 14 months if of impervious surface, and repainted (or varnished) every seven years; if distempered or white washed recoated every 14 months. A record of this must be entered in the general register (See end of section on Factories Act. para 6, 39 and 40).

(2) No overcrowding of employees is permitted. (400cu ft per person, space over 14ft high not being taken into consideration).

(3) A reasonable temperature must be maintained by non-injurious methods and, if much of the work is done seated, and no serious physical effort is involved, then this temperature must be 60°F after the first hour's working. At least one thermometer shall be provided in a suitable position.

(4) Adequate ventilation of work rooms must be secured by the circulation of fresh air. All practical measures must be taken to protect the workers against the inhalation of dust, fumes or other impurities likely to be injurious or offensive, and local exhaust ventilation must be provided and maintained where practicable.

(5) There must be sufficient and suitable lighting in every part of the factory in which persons are working or passing.

(6) Where wet processes are carried on, adequate means of draining the floor must be provided.

(7) Suitable and sufficient sanitary conveniences (separate for each sex) must be provided, subject to conformity with standards prescribed by regulations. The conveniences must be maintained and kept clean and effective provision must be made for lighting them.

(8) A person must not partake of food or drink or remain during meal time in work rooms where any poisonous substance is so used as to give rise to dust or fumes: nor may any person remain during meal times in any room in which is carried out any process prescribed by regulations as one which gives rise to siliceous or asbestos dust. Suitable provision must be made to enable persons employed in all such rooms to take their meals elsewhere.

(9) No work is to be carried on in an underground room (unless used for storage or other specially accepted purpose), if the district inspector certifies that it is unsuitable as regards height, light or ventilation or on any hygienic ground, or for example, because means of escape in case of fire are inadequate. Notice must be given to the district inspector before an underground room is used as a workroom in a factory, if it was not so used on 1 July 1938.

(10) No one must be employed to lift, carry, or move any load so heavy as to be likely to cause injury.

(11) A woman or young person must not be employed in certain lead processes or in cleaning workrooms where any of those processes are carried on. Where women or young persons are employed in any other process which involves the use of a lead compound producing dust or fume, or if they are likely to be splashed with any lead compound: the dust or fume produced must be drawn away by an efficient exhaust draught, they must undergo medical examination as prescribed and may be suspended from further employment in lead processes, no food, drink or tobacco may be brought into the work room, protective clothing must be provided by the employer and worn, suitable cloakroom, messroom and washroom accommodation must be provided as prescribed, and all tools and apparatus must be kept clean.

(12) Cases of poisoning by lead, phosphorous, arsenic, mercury, carbon bisulphide, managanese or aniline, chronic poisoning by benzene, compressed air illness, toxic jaundice due to tetrachlorethane or nitro or amine derivatives of benzene or other poisonous substance, toxic anaemia, epitheliomatous ulceration and chrome ulceration must be reported to the appointed factory doctor immediately, and entered in the general register.

*Safety*

(13) Accidents causing loss of life or disabling a worker (for more than three days) from earning full wages at the works at which he was employed must be reported forthwith to the factory inspector and entered in the general register. Certain dangerous occurrences, whether or not disablement is caused, must be reported to the factory inspector on a prescribed form. Such incidents include the bursting of a revolving vessel, the collapse or failure of a crane, hoist, or other lifting device or any part thereof (except the breaking of a chain or rope sling) or overturning of a crane, and explosion and fire in certain circumstances.

(14) Every part of the transmission machinery and every dangerous part of other machinery ". . . must be securely fenced, unless in such a position or of such construction as to be as safe to every person employed or working on the premises as if securely fenced . . ." Fixed vessels etc. containing scalding, corrosive, or poisonous liquids must, unless the edge is three feet above the adjoining ground or platform, be securely fenced to at least that height, or be securely covered. Where this is impracticable, other precautions must be taken as far as practicable. Where any such vessel is not securely covered, no ladder, stair, or gangway may be placed above, across or inside it which is not at least 18 inches wide, securely fenced to a height of at least three feet and securely fixed. When any such vessels join each other and the space between them is either less than 18 inches in width or is not securely fenced to a height of at least three feet, barriers must be placed so as to prevent passage between them. All fencing must be of substantial construction, maintained in an efficient state, and kept in position whilst the parts required to be fenced or safeguarded are in motion or use.

(15) Devices or appliances for promptly cutting off power from the transmission machinery must be provided in every room or place where work is carried on. Efficient mechanical appliances must be provided to move driving belts to and fro on fast and loose pulleys. Driving belts must not rest or ride on revolving shafts when the belt is not in use.

(16) New power machines must not be sold, let, or hired, unless certain parts are effectively guarded.

(17) A woman or young person must not: clean a prime mover in transmission machinery whilst it is in motion; clean any part of any machine or adjacent machinery.

(18) A young person must not work at any machinery specified by the Minister to be dangerous unless: he has been fully instructed as to the dangers and

precautions, and he has received sufficient training in the work, or is under adequate supervision by an experienced person.

(19) Every hoist or lift must be of good mechanical construction, sound material, and adequate strength, and must be properly maintained. It must be thoroughly examined every six months by a competent person whose report must be entered in the general register. Every hoistway must be protected by a substantial enclosure and landing gates with efficient interlocking or other devices. The safe working load must be conspiciously marked on each hoist. Additional safeguards (e.g. devices to prevent overrunning) must be provided on hoists used for carrying persons, whether primarily intended for goods or otherwise.

(20) No chain, rope, or lifting tackle used for lowering or raising persons or goods may be used unless it is of good construction, sound material, adequate strength, and free from patent defect. Tables of safe loads must be posted in the stores and elsewhere, but need not cover lifting tackle, the safe load of which is marked on the tackle itself. Tackle must not be used for any load exceeding its stated safe working load. Chains, ropes, and lifting tackle in use must be examined by a competent person every six months and must not (excepting fibre ropes and fibre rope slings) be taken into use for the first time in the factory unless they have been tested and certified. Periodic annealing is required, except in the case of rope and rope slings and other tackle exempted by HM Inspector. A register of all chains etc. and also all certificates of test must be kept.

(21) Similar requirements are laid down as to construction, maintenance, testing every 14 months and keeping records for cranes, derricks and travelling cranes. In addition, effective measures have to be taken to give warning of the approach of any mobile lifting device.

(22) Floors, steps, stairs, passages and gangways must be soundly constructed, properly maintained and, as so far as is reasonably practicable, kept free from obstruction and from any substance likely to cause a person to slip. All ladders must be soundly constructed and properly maintained. Openings in floors must, wherever possible, be securely fenced.

(23) So far as is reasonably practicable: there must be provided safe means of access to every place at which any person has at any time to work; every place must be made and kept safe for anyone working there; fencing or other means must be provided to ensure the safety of any person who is to work at a place from which he would be liable to fall more than 6ft 6in and which does not afford secure foot-hold and, where necessary, hand-hold.

(24) Special precautions have to be taken where men are liable to be overcome by dangerous fumes.

(25) Precautions against explosions are laid down for certain processes and for soldering and welding (or applying any operation involving the use of heat) containers which hold or have held inflammable substances.

(26) Every part of every steam boiler must be of sound construction, sound materials, adequate strength, and free from patent defect. Detailed instructions are given concerning valves and other fittings, and the outlet of every

steam container must be kept open at all times and free from obstruction. Steam boilers and fittings must be properly maintained and must be examined thoroughly by a competent person, in the case of boilers every 14 months and after any extensive repairs, and in the case of steam receivers every 26 months. A report of such examinations must be attached to the general register. New boilers must be certified and second hand boilers must be properly examined before being taken into use.

(27) Every air receiver and its fittings must be of sound construction and properly maintained. Detailed requirements are laid down concerning the fittings. Air receivers must be thoroughly cleaned and must be examined and tested by a competent person every 26 months and the report entered in the general register.

(28) Every factory falling within one of the classes defined in Section 45 of the Act must have a certificate from the fire authority that means of escape in the case of fire are such as may reasonably be required. The means of escape must be properly maintained and kept free from obstruction. Effective fire alarms must be provided and maintained; they must be tested or examined every three months and a report attached to the general register. The contents of workrooms must be so arranged that there is a free passageway to the means of escape. In factories employing more than 20 workers in the same building above the first floor or more than 20 feet above ground level, or where explosive or highly inflammable substances are used, or stored, in the same building, effective steps must be taken to ensure that the workers are familiar with the means of escape and their use and the routine to be followed in the case of fire. Fire fighting equipment must be provided, maintained and kept readily available. In *every* factory, irrespective of the number of persons employed, hoistways and liftways inside buildings constructed after June 1938 must be enclosed completely with fire resistant materials, and the means of access to them must be fitted with fire resistant doors, except that the top of unvented hoistways and liftways must be enclosed by material broken easily by fire. Whilst any person is in any factory for the purpose of employment or meals, doors must not be so locked or fastened that they cannot easily and immediately be opened from the inside. Any doors opening on to a staircase or corridor from any room in which more than ten persons are employed must open outwards, unless they are sliding doors. The same requirement applies to all doors affording a means of exit from factories constructed or converted after 30 June 1938. Fire exits must be distinctively and conspicuously marked by a notice printed in letters of adequate size.

(29) Suitable goggles or effective screens must be provided for processes specified by the Minister.

(30) An adequate supply of wholesome drinking water with an upward jet convenient for drinking, or suitable drinking vessels with facilities for rinsing them, must be provided.

(31) Adequate and suitable washing facilities (to include a supply of clean running hot and cold water or warm water, and clean towels or other

suitable means of drying) must be provided, maintained and kept in a clean and orderly condition.

(32) Adequate and suitable accommodation for clothing not worn during working hours, with such arrangements as are reasonably practicable for drying such clothing, must be provided.

(33) Where any employed persons (irrespective of sex) have, in the course of their employment, reasonable opportunities for sitting down without detriment to their work, there must be provided for their use facilities for sitting sufficient to enable them to take advantage of these opportunities. Detailed requirements are given as to seats and seating arrangements for work of which a substantial portion can be done seated.

(34) In every factory there must be provided a first aid box, or cupboard of the prescribed standard, containing nothing except first aid requisites. Where there are more than 150 people employed at one time, an additional box or cupboard for every 150 persons, or fraction of that number, is required. Each box or cupboard must be placed in the charge of a responsible person who, in the case of a factory where more than 50 persons are employed, must satisfy prescribed conditions as to training in first aid treatment. The responsible person must always be readily available during working hours and a notice must be affixed in every work-room stating the name of the person in charge of the box or cupboard provided in respect of that room.

*Miscellaneous*

(35) There is no restriction on the hours of work of men, but specific limitations are laid down concerning the permitted hours of work of women and young persons. Limits are similarly imposed upon the overtime worked by women and young persons. Employment outside the factory (outworking), working on Sundays, and the regular annual holidays which must be granted, are also laid down for women and young persons. Generally, any variations from the declared hours of working must receive approval from the Inspector before their institution is permitted.

(36) No young person under the age of 18 years may remain in employment in a factory after a period of 14 days unless he, or she, has been medically examined by the appointed factory doctor and given a certificate of fitness for that employment. Such a certificate must be renewed every 12 months, or earlier if the doctor so directs. In addition, boys between the ages of 16 and 18 years who are employed in certain industries or processes in shift systems involving work at night are required to undergo further examination before the expiration of the first three months of such employment, and thereafter every six months.

(37) The occupier (employer) must not make a deduction from wages in respect of anything he has to do or provide in pursuance of the Act, or permit any person in his employment to receive payment from other employees for such service.

(38) A person employed must not wilfully interfere with, or mis-use, any means, appliances, conveniences, or other thing provided in pursuance of the Act for securing health or safety provided for his use under the Act.

He must not wilfully or without reasonable cause do anything likely to endanger himself or others. These special duties supplement the general duty of employed persons not to commit breaches of the Act, even though the employer may be primarily responsible for seeing that they are observed; where an act or default for which the factory owner, or occupier, is liable under the Act is, in fact, the act or default of some other person (agent or worker) that person can be prosecuted and is liable to the same fine as the occupier or owner.

(39) The occupier must keep a general register in the prescribed form. Codes of regulations and orders made for particular factories, industries, processes, plant, etc. must be observed. Printed copies, or prescribed abstracts, of any codes of special regulations in force must be kept posted in the factory.

(40) HM Inspectors have power to inspect every part of a factory by day and by night. They may require the production of registers, certificates, and other papers. They may examine any person found in the factory, either alone or in the presence of any other person, as they think fit, and may require him to sign a declaration of the truth of the matters about which he is examined. They may also exercise such other powers as may be necessary for carrying the Act into effect, including certain powers of taking samples for analysis. Every person obstructing an inspector is liable to a penalty. The officials of local authorities have similar powers as far as required by their duties under the Act.

It will have become evident from the foregoing resumé that interpretation of and adherence to the requirements of the Act is a formidable task. The best advice that can be given is to ask for help and co-operation to the fullest extent. Factory inspectors are not obstructionists, and experience shows that they are always willing to give help and advice when asked. They may often admit that they are not sure on some point, but will always take steps to find out what is required by law and pass the information on to the factory.

The general register, to which reference has been made in several places, is a specially printed book with various divisions for the purposes intended. Thus, one section comprises a series of pages on which details of accidents have to be recorded, (para 13) showing the name of the person involved, the date and time of the accident, the nature of the accident and so on. The general register must be kept in a safe place, generally in the main office block of a factory, and is taken out only when entries have to be made or when checked by a visiting inspector.

The factory doctor is appointed by the Factory Inspectorate to handle various requirements under the Act which call for medical knowledge, including examination of fitness of young persons which has to be recorded in the general register. The usual practice is to send the young person concerned to the doctor accompanied by the general register, so that details required can be entered in the appropriate section by the doctor at the time. The same doctor carries out medical examination called for under para. 11, and is the person referred to under para. 12 regarding cases of industrial poisoning. The address of the local factory doctor must be publicly displayed on the Factories Act abstract at a suitable point in the factory.

Sanitary accommodation (para. 7) is inspected by the sanitary inspector of the local authority, although the factory inspector may also inspect during a general visit. Other persons entitled to inspect the factory under the Act are the local authority buildings inspector, who may check the suitability of fire exits (para. 28) and a fire officer of a local authority, who may inspect the premises generally as an assessment of the danger to a fire crew who might be called upon to deal with a fire, as well as the suitability of the fire fighting equipment installed by the occupier. This reference to the legal requirements under the Act regarding fire fighting gives an opportunity to draw attention to the fact that various sections of the Act have been the subject of additional explanatory pamphlets, and fire fighting is one such section.

The certification of steam boilers and air receivers is usually undertaken by a qualified boiler inspector from the insurance company that covers the equipment. Inspections are carried out at a convenient time (often when renewal of the policy is due) and the report and/or certificate, when received, is attached to the general register. It is customary for the certificate to be withheld by the inspector until any repairs considered necessary by him have been effected to his satisfaction. The insurance company will not cover any apparatus unless they are satisfied with it and their inspector will not pass anything that does not reach the standards required by the Act.

It should be pointed out that plant such as vessels used for the manufacture of alkyd and other resins is subject to the requirements under paras. 26 and 27 of this resumé.

## The Petroleum Act

This Act is possibly the most important "specialised" Act as far as the paint and allied industries are concerned. Many of the solvents handled are subject to the provisions of the Act, because the definition of "petroleum mixtures" causes products containing such solvents to be themselves subject to the various legal requirements.

More than one legal instrument is involved, namely: The Petroleum (Consolidation) Act, 1928; the Petroleum Mixtures Order, 1929; the Petroleum (transfer of licences) Act, 1936; the Petroleum (inflammable and other dangerous substances) Order, 1947 and the Petroleum (inflammable liquids) order, 1971. Petroleum is defined as "crude petroleum oil made from petroleum substances, or from coal shale, peat or other bituminous substance and other products of petroleum" and the requirements of the Act are applied to "such petroleum as, when tested in the manner set forth in Part 2 of the 2nd schedule of this Act, gives off an inflammable vapour at a temperature of less than 73°F." This definition is extremely important because it introduces the point that a petroleum mixture may be a blend containing a petroleum which has itself a flash point well above 73°F, but nevertheless the mixture is subject to the Act.

Firstly, a licence is necessary for the keeping of petroleum spirit and/or mixture, if the quantity involved is more than three gallons. It might be thought that this might mean that a licence is necessary for the petrol in a car, lorry or boat, but no licence is required for the storage of up to 60 gallons of spirit intended for such use provided the person storing the spirit complies with the relevant regulations (containers of only 2 gallons capacity etc.) The licence required is issued by the local authority of the area in which the factory is situated and can be quite a formidable document. It is renewable annually on payment of a nominal fee to the local authority and it may be observed that the fee is not intended to raise revenue, but as a means of ensuring that the actual licences are kept properly up to date, and that the conditions laid down in the licence are observed.

The local authority is empowered to impose any conditions it thinks fit upon the factory storing and using petroleum and these will include details of the manner of storage, the position of the storage site, the construction of the store, the nature of the goods with which the petroleum may be stored, the facilities for its testing and, in general, any other considerations which may be relevant to safe storage. This last general requirement is frequently used as a legal instrument whereby the factory owner has to exhibit notices at stated points, showing clearly what special conditions are in force under the Act for that particular point or area. For example, a licence might call for a detailed plan of a whole factory site; on this plan the number of gallons which are permitted to be stored at various points would be shown. The requirements at one point might be different from those at another point and the notices displayed in each sector would make this clear.

Containers of petroleum spirit have to be marked "PETROLEUM SPIRIT HIGHLY INFLAMMABLE," and if such marking is impracticable on the actual container, e.g. an underground tank, then a suitable notice must be displayed nearby. Red lettering on a white background is customary but, as the Act states, notices must be printed in conspicuous characters; some local authorities specify the size of the lettering to be used. Reasonable precautions are required to prevent the ignition of petroleum spirit or petroleum mixtures, and no operation should be carried out involving the use of either spirit or mixtures near a fire or any other source of ignition. No spirit or mixture is permitted to be emptied down drains or sewers. Fire extinguishers of the correct type to deal with either spirit or mixture fires have to be provided, together those of a type for fires of any other material likely to be involved.

Electrical equipment installed within 50 feet of any place where petroleum spirit is kept, handled, or exposed, should either be certified flameproof to Group 2 standard by the Minister of Power, in accordance with British Standards Nos. 229 and 889, have been approved by the local authority, or have been certified safe by HM Chief Inspector of Factories. All circuits should be automatically protected so as to prevent damage to the installation by means of overload, short circuit, or leakage of current to earth. The wiring used should be of satisfactory type, the metal enclosures of all apparatus and wiring should be efficiently earthed.

An important aspect of the Petroleum Mixtures Order which needs careful consideration is the definition of Petroleum Mixtures, which refers to the use of such mixtures and not only to their preparation or manufacture. This means, of course, that not only is a paint manufacturer who handles petroleum mixtures subject to the various regulations discussed, but customers who use his products (of the petroleum mixture type) will also be subject to them if their stocks exceed 3 gallons. This introduces similar complications at the customers works, for instance an engineering company that may wish to use paint products falling within the scope of the Act at a point in the factory near a welding operation. This example illustrates the value of the licensing and inspection system.

Enforcement and inspection of the whole petroleum legislation is the responsibility of the local authority. It is usually carried out by the local petroleum inspector who, under the original 1928 Act, may enter the premises at all reasonable times to take samples for test and generally to satisfy himself that the legal requirements are being met. Should the inspector be dissatisfied, he can recommend withholding or withdrawal of a licence, with obvious results. Other points under this general heading of petroleum legislation are listed below.

Notice must be given to the Secretary of State of any accident involving loss of life or personal injury arising from fire or explosion involving:

> petroleum spirit or petroleum mixtures in premises licensed for their storage, petroleum spirit and any substance brought in by Section 13 of the 1928 Act, if the accident occurs during its loading or unloading or conveyance by a vehicle,
>
> as above, but if a ship is the means of conveyance an enquiry may be ordered into the accident falling under one of the above headings.

When petroleum spirit or mixtures are kept, conveyed between two places in Great Britain (by means of transport), or sold or offered for sale, the container must be conspicuously marked in a similar manner to the tanks referred to above, petroleum mixtures requiring "Petroleum mixture giving off an inflammable heavy vapour," together with the name of the owner, sender or vendor. In this latter connection, cases have been known where the inspector insisted that all containers should carry the full labelling (i.e. name and address) in a factory where petroleum mixtures were moved within the precincts for production reasons; the containers never left the actual factory at any time.

The transport of petroleum spirit or mixtures by road is also closely controlled, including certain requirements in the construction of the vehicles which may be used.

The Petroleum (Inflammable Liquids) Order 1971 applies certain provisions of the Petroleum (Consolidation) Act 1928 to a wide range of inflammable substances specified in Part I of the Schedule to the Order. These include, amongst many others, solvents such as acetone, ethyl acetate, butyl acetate, methyl ethyl ketone, methyl isobutyl ketone, ethyl alcohol, and any solution or mixture containing the specified substance. Thus many lacquers, synthetic resin solutions and thinners previously outside the scope of the petroleum regulations are now brought within them. A typical example is shellac knotting. The regulations that cover the conveyance of such inflammable liquids by road (The Inflammable Liquids (Conveyance by Road) Regulations 1971) require the display, on vehicles carrying inflammable liquids, of a notice with the word "Inflammable" together with the flame symbol. Containers must also be labelled indicating the name of the inflammable substance and, in the case of mixtures, the name of the inflammable substance present in the largest proportion.

## The Offices, Shops and Railway Premises Act, 1963

This Act is aimed at laying down standards of cleanliness and safety in offices outside the scope of the Factories Act. Such matters as ventilation, lighting, sanitary arrangements, fire exits and first aid requirements are covered. One important point that should be remembered is that accidents in offices require similar action and notification to those laid down for accidents in factories.

## The Weights and Measures Bill

This is a bulky piece of legislation in which there are some matters of direct concern to the works management. Fundamentally, the Act is effective only if the goods are bought by the general public. Schedule 7, part 10, section 1, refers to paint (other than paste paint), paint thinners, turpentine substitute, varnish and wood preservative fluid. Part 11, section 1, refers to . . . "enamel, liquid paint remover, petrifying fluid and rust remover." The requirements are as given below.

### *Part 10 section 1*

Goods to which this part of the schedule applies:

unless prepacked shall be sold only by capacity measurement;

shall be prepacked only if the container is marked with an indication of capacity measurement and ". . . there shall be exempted from all requirements of this part of the schedule goods of any description in a quantity of less than 5 fluid oz."

### *Part 11 section 1*

". . . goods shall be prepacked only if the container is marked with an indication of quantity by capacity measurement," the exemption being the same as quoted above.

Distemper and paste paint are covered by part 8 section 1(a), and the requirement is a clear indication of the prepacked quantity by weight. Sale, if not prepacked, must be by weight and exemption is granted only if the quantity is less than half a pound.

Other relevant points are shown below.

Units of measurement must be selected from those specified in the Bill unless the goods are for export. Note that metric measures have now become legal. Where the general public is the purchaser, in addition to the requirements about labelling, it is necessary that any apparatus used for measuring fluids into the prepackage be checked regularly by the weights and measures inspector and certified; the inspector has the right of access to the factory at any reasonable time when the factory is at work.

In cases where a works canteen is in operation, it is advisable to ensure that certain foodstuffs sold there conform to the requirements of the Bill. In such cases the management must also be aware of the Food Regulations.

## The Food Regulations (1955)

These apply to anyone running or managing a "food business," which quite simply means any undertaking where food is sold or supplied for human consumption, whether or not for profit.

The persons liable to the regulations are those who sell, put up for sale, prepare, transport, store, pack, wrap, or deliver food, together with the premises where each or all of these operations is carried on (which includes under "selling," the actual dining or eating rooms).

The requirements are primarily aimed at obtaining cleanliness and freedom from the risk of food poisoning. With these objectives it is necessary to provide:

an adequate constant supply of hot water,

proper clean sanitary accommodation with "WASH YOUR HANDS" notices displayed,

proper washing facilities for staff with constant hot and cold water,

proper storage for clothing and footwear,

first aid dressings for the staff and, in addition, a supply of approved waterproof outer dressings for food handlers,

separate washing facilities for the food and the apparatus used in preparing it; it is a further requirement that any such apparatus must be kept clean.

Canteens have also to take special precautions with meat, game, poultry, fish, gravy, imitation cream, meat pies, cooked meat, fish patties, and other prepared foods, excepting bread, biscuits, cakes and pastries. Fundamentally, these requirements refer to the temperature at which food must be kept, either really hot or really cold, the limits specified being outside the range 50°F to 145°F. Any canteen employee suffering from typhoid fever, paratyphoid fever or any other salmonella infection or from dysentry, or staphylococcal infection likely to cause food poisoning, must inform the employer and he, in turn, must inform the local Medical Officer of Health. If the occupier of any food premises, or the person in charge, fails to take all reasonable precautions to ensure obedience to the regulations by the workers under his control, he will be guilty of an offence under the regulations.

## Road Traffic Act

In factories running their own transport fleet, the provisions of this Act must be obeyed. Briefly, it is necessary to ensure that:

all personnel allowed to drive company vehicles on the Queen's Highway are in possession of a driver's licence currently valid for the type of vehicle they may be asked to drive,

the vehicles themselves are insured for the work they perform,

proper log books are kept showing journeys made and the times of rest for the driver,

the "maximum possible load" notice is properly displayed on each vehicle and,

the correct type of carriers licence is held by each vehicle (or group of vehicles) i.e. an "A", "B" or "C" licence.

It should be noted that later legislation requires that the "plated weight" permissible on each axle should not be exceeded, so not only may the maximum load not be exceeded but the load must be so arranged that at no stage of the journey may the load on any axle be exceeded. The plated weight may be reduced if, during examination, it is considered that the vehicle is in such a condition that it is unsafe to carry the original maximum load.

It must also be clearly understood that vehicles used, or likely to be used, for the conveyance of petroleum spirit or petroleum mixtures must comply with the Petroleum Consolidation Act (1928) as regards certain details of their design and construction.

Laws relating to the movement of goods other than by the company's own vehicles concern four main methods: by post, by rail, by sea, and by air.

It should be stated that the transportation of goods by road vehicles, other than those owned by the company, (e.g. by British Road Services) will be largely dependent upon the flash point of the material concerned and will usually depend upon arrangements made between the factory and the transporter.

*By post*

Subject to the standard requirements concerning size and weight limitations of the package, liquids may be sent by mail if there is adequate packing to absorb all of the liquid in the event of leakage and if the flash point is above 150°F. Should the flash point be less than this, but above 90°F., then liquids may be sent by mail in quantities of not more than one quart at a time. Each quart must be packed in a separate container which is itself packed in another outer container which is leakproof and capable of holding an extra 7.5 per cent by volume. Liquids which come within the scope of either the Cellulose Regulations and/or the Petroleum Act are absolutely forbidden as far as postal carriage is concerned.

*By rail*

The regulations here are the outcome of historical development and refer to the transport of "dangerous goods," which as far as this review is concerned are "inflammable liquids," "dangerous, corrosive and poisonous chemicals" and "miscellaneous."

Inflammable liquids are; Class A, those miscible or immiscible with water and with an Abel Flash point of 73°F or under, and Class B, those flashing between 73°F and 150°F.

Dangerous, corrosive and poisonous chemicals cover a wide range of materials (e.g. acids, alkalis, dichlorobenzene) and it is advisable to consult "General Classification of Merchandise," "Dangerous Goods by Merchandise Train" and a large number of amendments before deciding into which category any particular material may fall. This is especially important when considering the miscellaneous class which actually refers to ". . . sundries including turpentine."

The basic requirements as far as the sender is concerned are:

clear labelling as "dangerous," "inflammable" etc., and

notification in writing to the railway of the class of goods being consigned.

The use of passenger train facilities for goods transportation should be very carefully checked as far as any danger is concerned.

*By sea*

Here again the sender is expected to know what legal obligations are imposed upon him. Classification of goods is similar to those quoted for rail carriage and is generally accepted from "The Merchant Shipping (Dangerous Goods) Rules 1952". The classification of interest is:

Category 4 . . . poisonous substances,

Category 5 . . . substances giving off inflammable vapours—immiscible with water and with a flash point below 73°F, miscible with water and with a flash point below 73°F, and goods with a flash point between 73°F and 150°F.

The methods of test for flash point are laid down as;

For substances with FP of 66°F to 90°F—Abel closed cup

For substances with FP of 90°F to 120°F—modified Abel closed cup

For substances with FP of 120°F and over—Pensky-Martens apparatus.

In addition, information must be given on whether the material is: *M* = miscible with water, *I* = immiscible with water, or poisonous.

A comprehensive list of materials is given, and as an example butyl acetate is classified as *I* at 83°F. Labelling of containers (which must be strong enough for the goods contained in them) is carried out in accordance with recommendations based on paragraph 10, appendix B, part 1 of the regulations referred to above and these labels (which must be at least 4 × 4in) are specified as follows:

| | |
|---|---|
| (i) Substances giving off inflammable vapours, | |
| FP below 73°F | Label A1 |
| FP 73°—150°F | Label A2 |
| (iv) Poisonous substances | Label C |
| (v) Corrosive substances | Label D |
| (vi) Combustible substances | Label E |

## The Cellulose Solutions Regulations (1934)

The regulations described in the following section are those currently in operation at the time of writing. It is anticipated that these will be revoked when the new Highly Flammable Liquids regulations come into force. Information regarding the proposed new regulations on highly flammable liquids can be found in: Department of Employment, Factories Act 1961. "Report by the Commissioner appointed to hold an Inquiry with respect to the Draft Highly Flammable Liquids Regulations". HMSO, 29p net. The proposed requirements resulting from this inquiry will be discussed later, after the existing regulations have been outlined.

The current Cellulose Regulations (1934) are directed against the dangers associated with the manufacture, storage and use of cellulose nitrate and similar lacquers. Detailed precautions are given for guarding against fire or explosion arising from what are called "cellulose solutions" or "inflammable liquids" but the regulations do not apply to:

the manufacture of gas mantles,

rayon manufacture,

explosive manufacture,
the painting of any building.

In addition, some relaxation of their stringency is allowed in cases where the cellulose solution is used for less than 15 minutes daily.

The definitions of "cellulose solution" and "inflammable liquid" are interdependent. The former is a solution of any cellulose derivative in however small an amount of the latter, and this in turn is defined as any liquid with a flash point below 90°F (measured by the method laid down in the second schedule to the 1928 Petroleum Act) "used or intended to be used with the cellulose solution". It is not the purpose of this review to discuss the reasonableness of such a definition, but attention is drawn to the very wide range of materials covered.

The regulations are divided into two main sections, dealing with the duties of the occupier and the duties of persons employed.

*Duties of occupier*

(1) The occupier shall not undertake the manufacture, use or storage of cellulose solutions ". . . unless and until he has given the district inspector of factories fourteen clear days' notice in writing of his intention to do so, or such shortened notice as the inspector may agree to accept.

(2) No person under 16 years of age shall be employed in the manipulation or use of inflammable liquids containing more than 15 per cent of benzene by weight.

(3) There are specific requirements concerning "cellulose cabinets" (cabinet, booth or similar structure within which cellulose solutions or inflammable liquids are manipulated or used) and "cellulose space" (room or part of a room where similar manipulation etc. is carried out other than in a cellulose cabinet). It covers materials of construction, which have to be fireproof, and the design. All ducts, trunks or casings used for ventilation have to be constructed of fire resistant material.

(4) Every cellulose cabinet, or cellulose space, shall be adequately ventilated by mechanical means so as to remove from the building any vapours of cellulose solution or inflammable liquid and to prevent their escape into any occupied work place or room. Such ventilation shall be kept in full operation for a period of at least five minutes after the cessation of any process in the manipulation of cellulose solutions or inflammable liquids. Then follow instructions regarding the spraying of cellulose solutions.

(5) No flame, open light or any other agency likely to ignite cellulose solutions or inflammable liquids or the vapours thereof shall be allowed within 20 feet of any cellulose cabinet, space or store room, unless effectively separated therefrom by means of intervening fire-resisting material. All heating and electrical apparatus (including lamp fittings and resistances) liable to attain a temperature of 180°F shall be situated or so protected to prevent deposition thereon of any solid residue resulting from manufacture or use of cellulose solutions.

(6) Adequate means of escape in case of fire, including a sufficient number of safe exits, not less than two in number, shall be provided and maintained in every room in which a cellulose cabinet is situated and for every cellulose space, and such exits shall be so constructed as to open outwards.

(7) Cotton waste, cleaning rags, or similar materials liable to spontaneous combustion shall, after use, be deposited without delay in metal containers with covers, or removed without delay to a safe place.

(8) Effective steps shall be taken to remove any solid residues resulting from the manufacture, manipulation, or use of cellulose solutions from all cellulose cabinets or cellulose spaces, and from all ducts, trunks, casings or fans used in connection therewith, and such residues shall be deposited in a safe place. No such removal shall be effected by scraping with iron or steel implements.

(9) An adequate supply of efficient fire extinguishing appliances in suitable positions, having regard to the structure and situation of the premises and the quantity and nature of the substance used, shall be provided for every room in which a cellulose cabinet is situated and for every cellulose space.

(10) All stocks of cellulose solutions or inflammable liquids shall be kept in:

(a) fixed storage tanks in safe positions,

(b) metal drums, cans or similar vessels, situated in store rooms which shall either be constructed of fire-resistant material or be in safe positions not less than 30 feet from the nearest occupied building.

Provided that, until the Secretary of State otherwise directs, the provisions of this regulation and of No. 12 as to the position and construction of tanks and store rooms shall not apply to any tank or store room in respect of which a licence under The Petroleum Consolidation Act 1928 has been granted by the local authority.

(11) The quantity of cellulose solution or inflammable liquid in any work room shall be kept as small as practicable having regard to the work carried on, and in rooms where either is used the quantity kept shall not exceed sufficient for one day's work. When not in use, the material shall be kept in a metal cupboard or something at least as safe.

(12) All drums, cans, or similar vessels containing cellulose solutions or inflammable liquids shall be kept securely closed when not in use, and shall, when empty, be removed to a safe place outside the building, or to a store room constructed or situated in accordance with (10) and kept therein.

(13) Cellulose solutions or inflammable liquids containing more than 15 per cent of benzene shall not be procured or stored otherwise than in receptacles legibly marked as containing benzene.

(14) The occupier shall allow any inspector of factories to take at any time sufficient samples for analysis of any substance which the inspector may have reason to believe to be cellulose solution or inflammable liquid. The inspector shall, at the time any such sample is taken, divide the sample into two parts and seal and deliver to the occupier in a suitable receptacle one such part. The result of an analysis made under these regulations shall not be published or disclosed except in as far as is necessary for the purpose of a prosecution for an offence under the regulations.

*Duties of persons employed*

(15) No smoking is permitted in a cellulose space, cabinet, or store room unless there is effective separation therefrom by a fire-resisting screen.

(16) Any person using cotton waste, cleaning rags, etc. must comply with (7) above.

(17) Every person employed in manipulating or using cellulose solutions or inflammable liquids must use the ventilating apparatus provided, shall report to the management any fault therein, and shall carry out any instructions given by management in accordance with the regulations.

These regulations necessitate careful thought and consideration in factories either making or using cellulose solutions and/or highly inflammable liquids coming within their scope. Attention is drawn also to the discussion regarding the storage of nitrocellulose in the solid form in Chapter 2 (p. 162 *ptm* 28) of this review.

"The Highly Flammable Liquids and Liquefied Petroleum Gases Regulations" referred to earlier in this section will be laid before Parliament during 1972 and will come into operation in 1973. In many respects they will be similar to the Cellulose Regulations described above, but it may be useful to consider a few of the more important changes. The sections of the draft regulations are:

(1) Citation, commencement and revocation.

States that the regulations will come into force one year after they are made (with the exception of regulation 10(4) which will be after two years) and that the Cellulose Solution Regulations 1934 (c) will be revoked.

(2) Interpretation.

Defines terms used in the regulations, e.g. "commercial butane" and "commercial propane". More important definitions in the context of this review are "dangerous concentration of vapours" as a concentration greater than the lower flammable limit of the vapours, and "factory" as including any premises and place to which these regulations apply.

"Highly flammable liquid" means any of the following, other than aqueous ammonia, liquefied flammable gas and liquefied petroleum gas, that is to say, any liquid, liquid solution, emulsion or suspension which, when tested in the manner specified in Schedule 1 to these Regulations, gives off a flammable vapour at a temperature of less than 32° Celsius and, when tested in the manner specified in Schedule 2 to these Regulations, supports combustion.

"Liquefied flammable gas" means any substance which at a temperature of 20° Celsius and a pressure of 760 millimetres of mercury would be a flammable gas, but which is in liquid form as a result of the application of pressure or refrigeration or both.

(3) Applications of Regulations.

Gives the premises to which the Regulations apply, which basically are those to which the Factories Act applies. Premises to which the Explosives Act 1875, the Special Regulations applying to the testing of aircraft engines, and the storage tanks on ships apply are excluded from the regulations.

(4) Exemption certificates.

The Chief Inspector of Factories may by certificate in writing exempt any factory or part of a factory from all or any of the regulations, if he is satisfied that the regulation exempted is not necessary for the protection of persons employed.

(5) Storage.

Storage conditions are basically similar to those required by the Cellulose Regulations, but the regulations do not apply to

(a) premises licensed under the Petroleum (Consolidation) Act 1928 (a),
(b) highly flammable liquids in the fuel tanks of vehicles or engines,
(c) suitable small closed vessels containing not more than 500cc of highly flammable liquid.

(6) Marking of store rooms, tanks, vessels, etc.

The requirements follow the lines of those of the Cellulose Regulations but specify the markings "Highly Flammable" or "Flash Point below 32°C" or "Flash Point in the Range 22°C to 32°C" or otherwise with an appropriate indication of flammability.

(7) Liquefied petroleum gas—storage and marking of tanks, vessels, cylinders, etc.

The requirements are not, in general, of importance to the paint industry but the Act should be consulted in cases where liquefied gases are in use or aerosol containers are charged.

(8) Precautions against spills and leaks.

There are a number of requirements which are reasonable in relation to the hazards arising from spillage of highly flammable liquids and are similar to those required by the Petroleum and Cellulose Acts.

(9) Sources of ignition.

The requirements are again similar to those of the Cellulose Regulations and refer again to cotton waste. However, the new Act specifies only the removal of residues of cellulose nitrate, whereas the Cellulose Regulations refer to any solid residue or deposit. For instance, cellulose acetobutyrate would be regarded as a cellulose derivative and therefore subject to the regulations.

(10) Prevention of escape of vapours and dispersal of dangerous concentrations of vapours.

Although different in some minor respects, the requirements are on the lines of those required by the Cellulose Regulations regarding cabinets and ventilation.

(11) Explosion pressure relief of fire resisting structures.

Provision must be made in the construction of fire resisting structures for pressure relief in the case of explosion and the venting of any such pressure to a safe place.

(12) Means of escape in case of fire.

There shall be adequate and safe means of escape in case of fire from every room in which any highly flammable liquid is manufactured, used or manipulated.

(13) Prevention and removal of solid residues.

Wherever a process involving a highly inflammable liquid leads to the deposit of any solid waste residue liable to give a fire risk:

steps must be taken where reasonably practicable to prevent such deposition, and

effective steps must be taken, as often as necessary, to remove such deposits and put them in a safe place.

Where such residues contain cellulose nitrate no removal shall be carried out with an iron or steel implement.

(14) Smoking.

No person shall smoke in any place in which any highly flammable liquid is present and the circumstances are such that smoking would give rise to a risk of fire. The occupier must display at or as near as possible to every place to which the regulation applies a clear and bold notice indicating that smoking is prohibited or display at the entrance at which persons are employed a similar notice that smoking is prohibited throughout the factory, except in places where a notice is displayed indicating that smoking is permitted.

(15) Control of ignition of highly flammable liquids.

Except for the disposal of waste, no highly flammable liquid shall be ignited except in a plant suitable for the purpose and by the proper use of such plant. Where waste is to be burnt, it must be done in a suitable plant or apparatus, or by a competent person in a safe manner in a safe place.

(16) Power to take samples.

This is on the same basis as in the Cellulose Regulations.

(17) Fire fighting.

Requires the provision and maintenance of fire fighting equipment in every factory where any highly flammable liquid is used and so placed as to be readily available for use.

(18) Duties of persons employed.

This follows the lines of the Cellulose Regulations.

*Schedule 1: Method of test by flashpoint (closed cup method)*

It is stated in the discussion of Regulation 2—Interpretation para. 12—that the method of testing the flash point set out in Schedule 2 to the Petroleum (Consolidation) Act 1928 was considered unsatisfactory by several organisations (including the Paintmakers Association), who proposed a method similar to British Standard 3900 Part A8. A slightly modified method is proposed and is described in Schedule 1 to which reference should be made for details and dimensions.

*Schedule 2: Method of test for combustibility*

Certain paints, for example those containing trichloroethylene, and some water-based paints, present a difficulty because, although when tested for flash point they may give an evanescent flash below the specified temperature limit, they do not support combustion. Thus, judged by flash point, they must be regarded as "highly flammable", but they do not present the same danger as would a liquid which supported combustion. A test for combustibility is therefore introduced in Schedule 2 to overcome this difficulty and Regulation 2 has been modified, as given above, for this purpose. Full details of the test method are given in Schedule 2.*

Before ending this section it should be stressed that the current Cellulose Regulations cover solutions of all cellulose derivatives whether or not they are themselves inflammable, provided that the flash point of the solution is below 90°F. It is worthy of note that the new "Highly Flammable Liquids Regulations" do not specify any special requirements for cellulose nitrate other than in Regulations 9 and 13, both of which refer to the handling of solid residues.

The "Highly Flammable Liquids Regulations" do not refer to any special conditions for solutions containing more than 15 per cent benzene, as do the current "Cellulose Regulations". It is worthy of note that the Paintmakers Association has suggested a voluntary prohibition of the use of benzene in paints, which is no doubt observed by its member companies. The use of the word "flammable" in the new regulations in place of "inflammable" in the current earlier ones should be noted.

## The Methylated Spirits Regulations

The purchase, receipt and sale of industrial methylated spirits is covered by these regulations and certain sections are of importance whenever methylated spirits is used in the paint industry.

Sections 24 to 27 should be noted in particular; provided the necessary formalities are complied with, these sections allow a person to receive industrial methylated spirits and to use it in manufacture, provided he does not distil it, nor re-sell it as such. Any manufactured article must contain more than 8oz of gum or rosin per gallon of mixture, but this may be reduced to 6oz per gallon in the case of shellac.

This section will not prohibit the manufacture of thinners in which methylated spirit is a minor constituent. It must be noted that stocks of methylated spirits must be kept under lock or otherwise secured.

The factory purchasing industrial methylated spirits, provided it has complied with the necessary formalities, will receive a book of permits to buy its requirements. All orders must be accompanied by this permit and the counterfoil must be filled in and kept for inspection when required.

The Methylated Spirits Regulations were made under the Customs and Excise Act of 1952; one important item covered by this Act is the use of a still in any form, whether it be laboratory equipment or process plant. As far

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*A paper by A. G. McKelvie describing the apparatus for determination of combustibility under Schedule 2 and its use will appear in the December issue of this Journal.

as the factory is concerned the equipment which is likely to be involved is any closed vessel fitted with a condenser which could possibly be used for distillation. Customs and Excise Officers have the right to inspect and take samples from any plant or apparatus which they consider might be used for the distillation of industrial methylated spirits, including laboratory apparatus used for the preparation of distilled water.

### Paints containing compounds of lead

Legislation regarding the lead content of paints can be placed into two categories; that designed to protect persons engaged in the manufacture of lead-containing paints and that designed to protect the general public, and children in particular, against contamination from painted surfaces.

The first category is part of the Factories Act, which requires that all containers of lead compounds must be clearly and suitably marked. It is advisable to consider the definition of a "lead compound", since if any material or product falls within it, then the legal obligations referred to will be operative with respect to both the paint manufacturer (or compound manufacturer) and the user of the product. "Lead compound" means any compound of lead, other than galena or alloys of lead which, when treated in the prescribed manner with an aqueous solution of hydrochloric acid, yields a quantity of soluble lead compound, calculated as lead monoxide, exceeding 5 per cent of the dry weight of the portion taken for analysis. Briefly, the analytical method consists in shaking a portion of the sample (in the case of paint the extracted pigment dried at 100°C) with 1,000 times its weight of an aqueous solution of hydrochloric acid containing 0.25 per cent HCl, precipitating any dissolved lead as sulphide, and finally determining the lead as sulphate. In cases where a manufacturer employs an outside staff who have to handle lead compounds, the manufacturer must ensure that each painter is given a copy of the regulations annually. Where the use of lead paint is concerned the regulations are designed to:

prohibit the use of any lead compound, except in the form of paint ready for use or paste,

prohibit dry rubbing down or scraping of the dried paint, and

prevent danger arising from the application of lead paint by means of spray.

Legislation to tidy up some of the omissions which existed was introduced in 1964, as The Lead Processes (Medical Examination) Regulations. Briefly, these specify certain details of the actual tests to be conducted by the factory doctor (as required by statutory instruments) which are based on the haemoglobin content of the blood of operators; the levels specified are 13g per 100ml of the whole blood for men and 12g per 100ml for women. Attention is also drawn to the fact that this is only the first step towards detecting lead poisoning, and that, whilst it indicates whether or not an operator is suffering from anaemia, where necessary further tests must be conducted by certain hospitals under National Health Service arrangements to finalise proof of lead poisoning. The permissible fees chargeable by the factory doctor for this examination are controlled by "The Fees of Appointed Factory Doctors (No. 1) Order 1964". These fees are additional to those for Factories Act examinations.

More recently, a realisation of the danger to young children who may come into contact with articles painted with lead-containing paints has led to further legislation. As a first step, a voluntary agreement was reached in 1962 between the Paintmakers Association and the then Ministry of Health, that any paint containing more than 1 per cent of lead with a tolerance of 0.5 per cent must carry a notice—"Caution: do not apply on toys, furniture or interior surfaces which might be chewed by children". The tests for the determination of lead are, in this case, colorimetric, and the agreement obviously excludes the use of any lead-containing pigments.

This agreement and the following regulations are primarily a matter of correct formulation and are not directly the concern of the factory management, which should, however, be aware of the labelling requirements and the restrictions on lead content. Lead in excess of the specified maximum can be introduced very easily by contamination with previously manufactured materials even if they were not actually based upon lead-containing pigments.

### The Toys (Safety) Regulations 1967

These regulations cover many requirements regarding design, but only those concerned with paint need be considered here. After 31 October 1968, paint used on toys shall not contain more than 5,000 parts of lead, calculated as the element (Pb), in 1,000,000 parts of the dry paint film (0.5 per cent). Stringent restrictions are also placed on compounds of arsenic and any soluble compound of antimony, barium, cadmium or chromium. Obviously, close attention to and control of all pigments used in paints for toys is very necessary. The possible presence of mercury or other toxic materials in any fungicides etc. added must be guarded against.

### The Chemical Works Regulations 1922

These regulations are directed at maintaining standards of safety and cleanliness in chemical works, but a paint manufacturer might be affected, since the manufacture of synthetic colouring matter or its intermediates is one of the processes included in the schedules. The requirements embrace exhaust ventilation, lighting, precautions against dangerous fumes and gases and against falls into fixed vessels, the provision of protective equipment, ambulance rooms, and drinking water, and the reporting of accidents. (The first aid requirements under these regulations are superseded by the requirements under the Factories Act.)

### The Alkali Works Regulations 1906

This is another legal instrument that may be imposed upon a paint factory, since it covers, amongst other matters, works where gas or tar is distilled or is heated in any manufacturing process and works in which creosote or other distillation product of tar or coal is heated in any manufacturing operation involving the evolution of noxious or offensive gases; the requirements lay down that gases, fumes, or smoke evolved in the process must be controlled. The discharge of certain liquids into drains or sewers is forbidden and the disposal of alkali is also covered. Any works subject to this particular Act has to be registered with the Factory Inspectorate.

## The Clean Air Acts (1956 and 1968) and The Dark Smoke (Permitted Periods) Regulations (1958)

The requirements under this Act are reasonable and straightforward, and will be in force in a particular area dependent upon whether or not the locality has been declared a "clean air zone." Fundamentally, the object of the Act is to eliminate the emission of smoke from chimneys, fires etc., with the aim of reducing the risk of "smog" in the area. It will be noted that there is a relationship between this Act and those parts of the Alkali Works Regulations discussed in the last section that control the evolution of noxious gases. Thus, if it is thought that some gaseous pollutant should be controlled in future, new regulations can be introduced under either of these Acts.

Briefly, the main provisions of the Clean Air Act are as follows.

Furnaces installed after the 31 December 1956 must, as far as is practicable, be capable of being operated continuously without emitting smoke when burning the type of fuel for which they were designed. Furnaces installed before this date and likely to emit more than the permitted amount of smoke must be altered to comply with the Act.

When it is proposed to construct a chimney for carrying smoke, dust, grit, or gases from an industrial building, the height of the chimney must be such that its emission will not create a nuisance.

Furnaces used to burn pulverised fuel, or other solid fuel or waste, at a rate of more than one ton per hour, must, if installed after July 1955, be fitted with plant to arrest grit and dust.

The emission of dark smoke and black smoke from any chimney is prohibited, except during certain specified periods (e.g. one chimney serving one furnace is allowed ten minutes "smoke time" every eight hours when soot blowing is not involved). The method of assessing smoke colour is visual comparison of the smoke with a Ringleman Chart. This consists of a series of grey wedges printed fanwise, each successive shade being darker and numbered 1-9 (light to dark). Dark smoke is Ringleman two and upwards, whilst black smoke is Ringleman four and upwards.

## The Electricity (Factories Act) Special Regulations 1944 (SRO 1944, 739)

The requirements under this heading apply, with few exceptions, to all electrical equipment in factories.

### *General requirements*

(1) All apparatus and conductors must be sufficient in size and power for the work they have to perform and must be constructed, installed, protected, worked and maintained so as to prevent danger as far as is reasonably practicable. All conductors must either be covered with insulating material and further protected where necessary to prevent danger, or else must be so placed and guarded as to prevent danger.

(2) Every electrical joint and connection must be of proper construction as regards conductivity, insulation, mechanical strength and protection.

(3) Adequate precautions must be taken to prevent any metal other than conductors from being electrically charged, if such a charge would create danger. The precautions may consist either of earthing or of some other effective means.

(4) Every fuse and circuit breaker must be so constructed and arranged as to interrupt the current before it becomes so excessive as to become dangerous. Fuses and automatic circuit breakers must be so constructed, or so guarded or placed, as to prevent any danger from overheating or from the scattering of hot metal or other substance.

(5) Fuses must be so constructed, or so protected by switches, that the fusible metal can be readily renewed without danger.

*Switches and circuit breakers*

(6) There must be some means of shutting off all current from every part of the system so as to prevent danger. Such means must be suitably located.

(7) Every switch, switch fuse, circuit breaker and isolating link must be so constructed, placed or protected as to prevent danger. It must be constructed and adjusted so that it maintains good contact accurately and must be provided with an efficient handle or other means of working such handle or other means being insulated from the system and so arranged that they cannot accidentally fall or move into contact when left out of contact.

(8) Every switch intended for breaking a circuit, and every circuit breaker, must be so constructed that it cannot be left in partial contact if proper care is exercised. This applies to each pole of a double- or multiple-pole switch or circuit breaker.

(9) Every switch intended for breaking a circuit, and every circuit breaker, must be so constructed that an arc cannot be maintained accidentally.

*Switchboards*

(10) The general arrangement of every switchboard must, so far as is reasonably practicable, satisfy the following requirements:

all parts which may have to be adjusted or handled must be readily accessible,

it must be possible, where necessary, to trace the course of every conductor readily,

conductors not arranged for connection to the same system must be kept well apart and, where necessary, must be readily distinguishable,

all bare conductors must be so placed as to prevent danger from accidental short circuit.

*Fixed apparatus*

(11) Every motor, converter and transformer must be protected by efficient means suitably placed and must be so constructed that all current can be cut off from it. If, however, one part of the system is connected to earth, there is no obligation to break the connection that side.

(12) Every electric motor must be controlled by an efficient switch, or switches, for starting and stopping, so placed as to be easily worked by the person in charge. In every place where electric motors are used to drive machines, there must be a means of switching off the motors or stopping the machines if necessary to prevent danger.

(13) Motors, generators and all other apparatus which have dangerous moving parts must be securely fenced or in a safe position.

### *Portable apparatus*

(14) If any portable apparatus is operated by alternating current of any voltage, or by direct current above 150 volts, the flexible wires belonging to it must be connected to the system by permanent joints or by properly constructed connectors.

(15) If the person handling the portable apparatus would be liable to get a shock if the metalwork of the apparatus became charged, such parts must be efficiently earthed. The flexible metallic covers of conductors must also be earthed and must not themselves be used as the only earth connection. (This does not apply to apparatus working below 150 volts DC).

(16) Lampholders of portable lamps must not be in metallic connection with the guard or other metalwork of the lamp. If there is any danger of shock should the metalwork become charged, the apparatus must be earthed.

(17) All portable apparatus working at more than 250 volts must have its metalwork earthed independently of any flexible metal covering of the conductors, and such metal covers must be independently earthed. All such apparatus, and its conductors, must be controlled by an efficient means, suitably located, and capable of cutting off the current.

(18) Dangerous moving parts of portable machines must be guarded.

### *Miscellaneous requirements*

(19) Conductors or apparatus exposed to weather, damp, corrosion, inflammable surroundings or explosive atmospheres must be so constructed or protected as to prevent danger arising from their use in such circumstances. Precautions must also be taken if apparatus is used for any special purpose that might create danger. No one but an authorised person, or someone under his immediate supervision, may undertake any work in which technical knowledge or experience is required to avoid danger.

(20) Any repair, alteration, extension, cleaning or other work which might be dangerous to an inexperienced person, or one without technical knowledge, must be carried out only by an authorised person or a competent adult over 21 years of age working under the immediate supervision of a competent person. Such work must not be carried out by an unaccompanied person. Where the danger to be avoided is under the control of the occupier, the authorized person must be appointed by the occupier. If a contractor is employed and has control of the danger, it is for the contractor to make the appointment.

(21) Instructions for the treatment of persons suffering from electric shock must be posted up in all premises where electricity is used over 250 volts DC or 125 volts AC

The foregoing is an abstract of the clauses in the Electricity Regulations which are most likely to have an effect on paint or resin factories. Considerably more is included in the full regulations and if there is a specific interest in this subject the original regulations should be consulted, It is evident that the Electricity Regulations are sensible, stringent and specific, and the best advice that can be given is to suggest that a qualified expert should always be consulted on these matters.

### The Public Health Act 1961

Section 55 of the 1961 Public Health Act, in conjunction with the Public Health (Drainage of Trade Premises) Act 1937, is the part of this legislation most likely to interest factory management, especially if a caustic soda cleaning plant is in use. "Trade premises" means any premises used or intended to be used for carrying on any trade of industry, and "trade effluent" means any liquid, either with or without particles suspended therein, which is wholly or in part produced in the course of any trade or industry carried on in the trade premises, but does not include domestic sewage. The important points to be noted are listed below.

(1) No trade effluent shall be discharged into a public sewer of a local authority other than in accordance with a written notice served on the local authority by the occupier (known as a Trade Effluent Notice) stating: the nature and composition of the trade effluent, the maximum daily discharge, and the highest rate of discharge.

(2) Such trade effluent shall not be discharged in accordance with such a notice until two months have expired after its serving, or such lesser time as the local authority may agree. The application referred to under (1) shall be regarded as an application for permission to discharge.

(3) The local authority may direct: (a) which sewer the trade effluent is to enter, (b) its nature and composition, (c) the maximum discharge either overall or into any one sewer, (d) the highest rate of discharge under (c) and (e) any other conditions that the local authority may deem necessary.

(4) Upon receipt of an application under (1), the local authority must inform any other interested body (e.g. a local river board) and must not grant permission to the trade premises occupier without prior agreement of any other interested body. Any change in sewers automatically annuls any permission previously granted.

(5) The local authority may levy charges on the trade premises occupier based on: the quantity of effluent discharged, its composition and the cost incurred by the local authority in treating the effluent.

The general procedure is for the trade premises occupier and the local authority to enter into an agreement containing details relevant to items under (3) above (e.g. the pH may be specified, gallons per hour and temperature may also be included). In addition, the factory occupier will have to provide inspection manholes which can be used for sampling, meters for measuring the rate and quantity of discharge and apparatus for testing the effluent on the site. It is obvious that random discharge of effluent cannot meet strict requirements, so that the occupier will have to install some form of chemical and physical purifying plant to treat the effluent before its discharge into the sewer. In this same context, the direct discharge of effluent into rivers or streams is restricted by The Rivers (Prevention of Pollution) Act, The Clean Rivers (Estuaries and Tidal Waters) Act and The Salmon and Freshwater Fisheries Act. Similar restrictions can be applied in coastal waters under the Sea Fisheries Regulations. One other mode of disposal which might be concerned is discharge into the ground; in this case contamination by discharge is controlled by the Water Act, which makes it an offence to do anything to pollute a spring, well etc. which provides water for human consumption, domestic purposes or food manufacture.

Although the foregoing section may seem formidable at first sight, it will be realised after a little reflection that it is all sensible and necessary. Officers of local authorities are invariably extremely helpful in advising how best to fulfil any legal requirements and, once a basis of agreement has been reached, the plant necessary presents no great problems either in operation or maintenance. It may be noted that the effluent from research laboratories may be liable to control but that from laundering operations is exempt.

### Miscellaneous legislation

There is other legislation which is mainly the responsibility of the personnel officer or the company secretary, but it is nevertheless desirable that the factory management should be aware of their implications. Two of these regulations are:

#### *Redundancy payments*

Redundancy payment refers to money owing to an employee when employment is terminated by the employer on the grounds of "no job." As an example of the way in which this can be operated, the motor industry redundancy pay was agreed as shown below:

> 104 weeks' continuous service is necessary to qualify for pay;
>
> for each whole year of service, those between 18 and 24 years of age receive one half week's pay per year's service; those between 24 and 40 receive one week's pay per year and those between 41 and 64 receive one and a half week's pay per year.
>
> The money has to be paid by the employer, who may claim approximately 2/3 of the amount back from the Government.

#### *Industrial Relations Act (1971)*

This is new and, at the time of writing, controversial legislation. It would be inappropriate to consider it at length in this review. However, mention may be made of two useful publications which are obtainable from HM Stationery Office,

> "Industrial Relations. A guide to the Industrial Relations Act 1971", and
> "Industrial Relations. Code of Practice."

## New legislation

When new legislation is proposed, it is usual to publish a draft form of it, known as a "consultative document." This is generally circulated as a confidential document to trade organisations representing those who may be affected by the legislation for comment and, if necessary, modification of the proposed Act. In the case of the paint industry the organisation is the Paintmakers Association of Great Britain Ltd.*

The PA is therefore well aware of most impending legislation and, as most leading British paint manufacturers are members of the association, advice can be obtained from it regarding possible forthcoming regulations. Generally, when it is likely that some form of legislation will be introduced, the association will prepare an explanatory document for the benefit and advice of its member firms. A few of these reports of current interest may be listed:

"A consideration of the regulations governing the use of flammable liquids."

"European Conservation Year. Some of the problems of the paint industry throughout Europe."

"Labelling of dangerous substances."

"Harmonisation of legislation in the EEC and possible repercussions in Great Britain."

"Paints, varnishes etc. in contact with foodstuffs."

## Hydrocarbon duty

For many years hydrocarbon oils that could conceivably be used as a fuel in vehicles were subject to the same tax as is imposed upon petrol. A refund of duty, known as "drawback" was allowed on paints etc. exported. Some years ago the legislation was modified to allow the use of duty free hydrocarbons in products which could not be used as a motor fuel on account of their pigment and/or resin content. The regulations are somewhat complex and this review is not an appropriate place to discuss them, but factory management must be aware of their requirements regarding the use and storage of duty free hydrocarbons. Some high boiling solvents are exempt, but the law is applicable to most hydrocarbons boiling in the range of white spirit and below.

This review of the law as it applies to a factory covers the main requirements, but it is by no means complete. Ignorance of the law is no defence, so that it is highly desirable that all opportunities of extending knowledge of the general law should be taken. In view of the possibility of civil actions arising out of incidents in a factory, the doctrine of negligence should be covered. As already mentioned, a solicitor or other appropriately qualified person should always be consulted before any action is taken which might conceivably be contrary to legal requirements.

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*Prudential House, Wellesley Road, Croydon CR9 2ET.

## APPENDIX: Tables of statutory requirements

*Table 12*

*Intervals at which employees must be medically examined*

| Interval | Job of employee concerned |
|---|---|
| Week | Manufacturing and handling lead carbonate, acetate, sulphate, nitrate.<br>Manufacturing and handling red lead, orange lead, litharge. |
| Month | Paint manufacture involving carbonate of lead or red lead and lead chromate manufactured by boiling. Paint for own use and artists' colour manufacture exempted |
| Three months | Vitreous enamelling of metal or glass.<br>Women and young persons handling lead compounds |
| Six months | Young persons (16-18 years) employed on shift work in special industries, in particular cleaning and repair of road vehicles. (No indication that this affects synthetic resin manufacture—usually young people unsuitable for this work) |
| Twelve months | All young persons not covered above |
| If and when ordered by Chief Inspector of Factories | Persons employed in painting buildings or vehicles with lead paint. (Examinations are not normally required by law, but the Chief Inspector has power to demand them if he thinks it necessary.) All examinations conducted by appointed factory doctor who, under most codes of regulations, has power to vary the interval for any particular employee |

*Table 13*

*Protective clothing required by law*

| Process | Clothing |
|---|---|
| Operation of unfenced machinery | Overalls of approved design |
| Work in confined spaces | Belts, ropes, breathing apparatus, oxygen. Reviving apparatus if dangerous fumes likely to be present |
| Vitreous enamelling | Overalls and head covering |
| Painting of buildings | Overalls for those handling lead paint |
| Bronzing (in printing) | Overalls and, for women, head covering |
| Manufacturing lead compounds | Overalls, head covering and respirators for specified operations. Separate accommodation for outdoor clothing must be provided |
| Processes involving lead compounds | Suitable protective clothing if dust is produced or splashing occurs |
| Lead paint manufacture | Overalls for those working on roller mills |
| Painting of vehicles | Overalls for those using lead paint |
| Processes involving asbestos | Overalls, head covering and breathing apparatus in special cases |
| Cement manufacture | Watertight boots for those standing in slurry, mud, or water. Goggles for those exposed to dust; waterproof coats for those working outside, overalls and head covering for men repairing bags |
| Cleaning and repairing sacks | Suitable protective clothing |
| Chemical works | Breathing apparatus, oxygen apparatus and life belts for those exposed to gas or fumes; eye and hand protection for those likely to be splashed with acid; overalls, footwear, woollen clothing, goggles, gloves and respirators for scheduled operations; non-metallic spades, scrapers and pails for cleaning certain tanks, stills, etc. |

*Table 14*

*Summary of the British Acts of Parliament*

| Act | Enforcement | Other interested bodies | Reminder |
|---|---|---|---|
| FACTORIES ACT 1961 | Factory inspector | Factory doctor. L/A sanitary inspector for toilets. Fire department | Health-Welfare-Safety General Register and special forms to be returned when necessary. Lead Regulations |
| THE OFFICES ACT | Factory inspector | — | — |
| PETROLEUM (CONSOLIDATION) ACT 1928 and subsequent orders | L/A petroleum inspector | Factory inspector. Fire department. Insurance company | Licence to carry on business using petroleum and mixtures thereof. Renewable annually. Notices re duties of employees. Transport-handling-storage-labelling |
| WEIGHTS AND MEASURES BILL | L/A weights and measures inspector | Factory inspector if payment of wages depends on measurement by weight or volume | Accuracy of dispensing apparatus. Labelling with contents quantity |
| FOOD (HYGIENE) REGULATIONS 1961 | L/A sanitary inspector | Ministry of Food | Applies wherever food is sold or prepared—need not be for profit. H & C washing, toilets, protective clothing. Notifiable diseases, cuts etc. |
| ROAD TRAFFIC ACT and ROAD TRANSPORT ACT | L/A and police | Insurance company | Construction of vehicles. Licences to carry goods A/B/C. Drivers' log-books. Road Fund Licence. Insurance Certificate. Petroleum Act affects vehicle construction if petroleum mixtures are carried |
| CELLULOSE SOLUTIONS REGULATIONS | Factory inspector | May introduce petroleum inspector. Fire department. Insurance company | Storage and handling of cellulose derivative solutions flashing at 90°F or below. Notice showing duties of employees. Flameproof equipment |
| CHEMICAL WORKS REGULATIONS 1922 | Factory inspector | Sanitary inspector factory doctor | Maintaining standards of safety and cleanliness |
| ALKALI WORKS REGULATION ACT 1906 | Factory inspector | L/A factory doctor sanitary inspector | Evolution of offensive gases. Discharge of liquids into sewers and drains |

*Table 14—Cont.*

*Summary of the British Acts of Parliament*

| Act | Enforcement | Other interested bodies | Reminder |
|---|---|---|---|
| ELECTRICITY (FACTORIES ACT) SPECIAL REGULATIONS 1944 | Factory inspector | — | Safety factor |
| CLEAN AIR ACT | L/A clean air inspector | — | Boiler etc. chimneys, incinerators and emission of smoke. Ringleman chart |
| PUBLIC HEALTH ACT | L/A sanitary inspector, building inspector | Engineer in charge of sewerage farm. Local river board | Disposal of effluent. Nuisance by noise, smoke etc. to neighbours |
| BUILDING BY-LAWS enacted under 1961 BUILDINGS ACT | L/A buildings inspector | Fire department Insurance company | Construction and safety of buildings, chimneys, drains—and effluent |
| NATIONAL INSURANCE ACT. INDUSTRIAL INJURIES ACT | Local offices of Department of Employment, Ministry of Health and Social Security | For any medical check appointed doctor | Contributions to national health, unemployment and pensions schemes. Accident and occupation disease benefits |
| FINANCE AND CUSTOMS AND EXCISE ACTS | Local officer of Customs and Excise | — | Methylated spirit bond and licence to purchase etc. Inspection of any stills. Light Hydrocarbon Oil Duty repayment or licensing not to pay |
| CONTRACTS OF EMPLOYMENT ACT and REDUNDANCY ACT. SELECTIVE EMPLOYMENT TAX | Department of Employment | — | Notice of leaving or dismissal. Holidays etc. |

*Note:* L/A = Local Authority

*Table 15*

*Intervals at which certain plant must be examined*

| Period | Plant |
|---|---|
| Daily | Transmission belts used in continuous processes |
| Weekly | Scaffolds in building operations. Timbering shoring in building excavations |
| Monthly | Fire alarms. Breathing and reviving apparatus used for workers entering confined spaces |
| Three months | Wire ropes and chains used for unloading barges and ships |
| Six months | Hoists other than continuous or hand operated. All other chains, ropes and lifting tackle. The re-annealing of chains, and chain slings made from ½in bar or less |
| Twelve months | Continuous hoists and hand operated hoists. Derricks and other machinery used in unloading barges, also all other chains used here (i.e. those bigger than ½in) |
| Fourteen months | Cranes and other lifting devices not examined every 12 months. Steam boilers, steam ovens. Annealing of chains not already covered. All apparatus working under pressure or vacuum |
| Twenty-six months | Steam and air receivers |
| Four years | Derricks used on ships and barges—this means complete check as opposed to inspection annually |
| No period given | Railway lines subject to locomotive region |

# Newcastle Section

## Programme 1972-73

All lectures will be held at the Newcastle Polytechnic, Ellison Place, Newcastle upon Tyne, at 3.0 p.m.

### 1972

**Wednesday 8 November**

"Yacht paints" by Mr L. Bennison of The International Paint Co. Ltd.

**Wednesday 13 December**

"Titanium dioxide" by a speaker from Tioxide International Ltd.

### 1973

**Wednesday 10 January**

"Fields of application of synthetic resins" by Dr A. F. Everard of Berger Chemicals Ltd., Resinous Chemicals Division.

**Wednesday 7 February**

A lecture by a speaker from Camrex Ltd.

**Wednesday 7 March**

"The use of water in paints" by Mr B. Ridley of The International Paint Co. Ltd.

# Information Received

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

**Reads & Drums Ltd.** has recently launched a new range of pails in heavy duty polyethylene. Of interest to the paint industry, particularly in respect of water-based paints, these pails are also intended for adhesives, chemicals, foodstuffs, oils and pharmaceuticals.

**National Plastics Ltd.**, a member of the Courtaulds group, is injection moulding the pails for Reads & Drums in three sizes: 1 litre, 2½ litre, and 5 litre; three other sizes, leading up to 25 litres, are planned. The unique feature of the new range is claimed to be the closures on the medium density polyethylene lids available for each size. Since the pails themselves are tapered slightly, the lid closures have been designed so that pressure on the centre of the lid intensifies the closure seal, unlike the domed lids of some other types, which tend to open under central loading. Reads & Drums is also stressing the impact resistance and ease of screen printing of the pails, and claims that a number of smaller paint companies are already using them.

A new edition of "Marketing guide to the paint industry" has been published by **Charles H. Kline & Co. Inc.** The book is mainly concerned with the USA, giving statistical data on the industry as a whole, together with details of companies and services; however, some space is devoted to the European industry also. Copies of the 87-page treatise are available from the publishers at a cost of $30.

**Farbwerke Hoechst AG** has announced a change in the nomenclature of its vinyl chloride/vinyl acetate copolymer based pigment preparations. Previously marketed as *PV* or *PV Fast* pigments *Hostaprint*, the range is now to be known as *Hostaprint*, the *PV* suffixes being deleted; the code numbers, however, are unchanged. Thus *PV Yellow H10G Hostaprint* becomes *Hostaprint Yellow H10G*, etc.

*Progal 777SP* is a new stripper for epoxy powder coatings from **ICI Ltd., Paints Division.** Promoted as the first effective stripper for epoxy powders, the new compound is claimed to remove stoved epoxy powder coatings within ten minutes by immersion at room temperature. It operates by breaking the adhesion between the coating and substrate, and leaves a temporary protective film to inhibit corrosion.

"This is Du Pont", a twenty-eight page colour brochure giving a broad outline of the company's world-wide activities, has recently been published by **Du Pont de Nemours International, SA.**

Improvements in the *Polyox* range of ethylene oxide homopolymers have recently been announced by **Union Carbide Europe SA.** When originally introduced, this series of water soluble resins suffered from being highly viscoelastic in solution, and paints containing them tended to spatter badly during application—this "defect" did, however, lead to their use in textured finishes for special effects. The new grades, which have the designation *N*, have been treated to reduce any viscoelastic tendencies, and are claimed to offer advantages in use as flow modifiers in latex paints and industrial latex paints, and as thickeners in paint removers, as well as in spatter paints. Two viscosity grades in the *N* series are available initially: *Polyox WSR-N-750* (600-1,000 cP) and *Polyox WSR-N-3000* (2,300-3,400 cP).

Full technical data on the entire *Polyox* range, together with suggested formulations, are available from Union Carbide.

A new type of tack cloth for use in paint finishing has been announced by **StarChem Limited.** The *SuperWhite A* range is based on a synthetic fabric, and is claimed to offer much better wear characteristics than conventional cotton-based products.

**Dearborn Chemicals Limited** has recently established the **Dearborn Environmental Services Group,** which will operate as an independent consultancy advisory industry on all problems associated with the industrial environment. Initially the service will be primarily concerned with helping industry control and abate water pollution caused by waste water, in preparation for the strict new anti-pollution legislation due to come into force in 1974.

A new pack has been introduced for the powdered pigment products of **CIBA-GEIGY (UK) Limited.** Cubic in shape, the pack is made of reinforced cardboard, the pigment being contained in a polyethylene bag inside the box, which is itself protected by shrink-wrapped polyethylene cover. The carton incorporates a tear strip for ease of opening, and will fold flat when empty. Advantages of stacking full and empty packs are stressed by the company.

The use of the new packaging techniques has allowed CIBA-GEIGY to achieve considerable automation at its Paisley site, where a sophisticated system of conveyors, sealing machinery, shrink wrapping and labelling equipment has been installed.

The *Omni-Fill* aerosol paint system produced by **Sprayon Products Inc.,** of Cleveland, Ohio, is now to be available in the UK from **Elcometer Instruments Ltd.** This system enables even unskilled staff to fill pre-charged aerosol cans (supplied with the system) with the correct quantity of any type of paint. A hand operated machine, it is intended for retail outlets—particularly where a tinting system is employed—painting contractors, fleet operators (for touching up accidental damage) and similar applications.

The Vehicle Refinishes Division of **Berger Paints** has announced an improved formulation for its *Kemitone* coach enamels, containing polyurethane resin. Another new feature of the *Kemitone* range is a primer undercoat, dispensing with the need to apply both primer and undercoat when refinishing, and thus saving labour costs.

A recent addition to the range of mixers produced by **Silverson Machines Ltd.** is the *Duplex* disintegrator/dissolver. This machine incorporates two separate heads on one frame. The upper head acts as a disintegrator and disperser, acting under conditions of intense shear. The flow pattern produced by the two heads is claimed to lead to more than double the action of a single-headed machine, giving significant increases in high viscosity capability and reduction in processing times.

During the national dock strike in August, 6,000 workers at the St. Austell plant of **English China Clays** formed a protest march against the closing of three local ports, which was threatening the company's operations. ECC, which considers that it has the best industrial relations in the country, has published a leaflet reproducing the press cuttings dealing with the demonstration, illustrating the "family" atmosphere that the company enjoys. Copies of the leaflet, entitled "A family of 6,000", have been circulated to all ECC customers.

Since the publishers of the monthly "Current Index to Conference Papers" (CICP) recently decided to discontinue its publication, it has been announced that the **World Meetings Information Centre** (WMIC), of Massachusetts, is to launch "Current Programs", a current awareness journal dealing with a similar subject matter to CICP.

WMIC previously acted as editorial office for CICP, and "Current Programs", although basically similar, will be structured so as to make it more attractive to the individual scientist or engineer.

**Pamasol Willi Mader** has introduced an automatic valve inserter for aerosol cans which can be adapted for use on almost all medium speed rotary machines. One of the main drawbacks of the space-saving rotary filling machines has been the difficulties of manual insertion of valves, and the new *P2037* machine can now overcome this. Full details are available from Pamasol's UK agent, **D.H. Industries Ltd.**

"The cheapest in the world" is the claim that **Carson Paripan Ltd.** makes for a new paint shaker being offered to its stockists. Manufactured by **Steele & Cowlishaw Ltd.**, the *BM Quickway* shaker is being recommended as an essential part of the Carsons Colours tinting machine system, and is selling initially at an introductory price of £72.

A booklet for safety engineers and health officers, dealing with the safe handling of chlorinated solvents, has been published by **Dow Chemical Company Limited.** Copies are available from Dow on request.

**Vestolen GmbH,** the jointly-owned venture of **VEBA-Chemie AG** and **Chemische Werke Huls AG,** has recently put on stream two new plants for the manufacture of *Vestolen A* (polyethylene) and *Vestolen P* (polypropylene). The increase in annual capacity thus produced is 60,000 tons of *Vestolen A* and 20,000 tons of *Vestolen B.*

A complete range of reverse osmosis water purification systems is announced by the **Elga Group.** The *Elga Intercept* systems reduce the total dissolved solids content of raw water by up to 95 per cent, and have no chemical regeneration or effluent disposal problems. Unlike cellulose acetate membrane systems, the Intercept units can be back-flushed for cleaning, and have longer membrane life, carrying a three-year guarantee.

## *Notes and News*

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

# 25th Technical Exhibition

### 21-24 May 1973

**Over 90 stands allocated**

The Exhibition Committee has now allocated over 90 stands to exhibitors at OCCA 25; a full list of exhibitors will be published in the December issue of the *Journal*.

There will be direct participation from ten overseas countries: Belgium, Finland, France, Germany, Holland, Italy, Norway, Sweden, Switzerland, and the United States of America; six of the companies showing have never appeared at a previous OCCA exhibition and a further 30 did not participate at OCCA 24.

*Information leaflets*

In view of the strong overseas participation at OCCA 25, readers are reminded that the Association has available copies of an information leaflet in six languages (English, French, German, Spanish, Italian and Russian). These will be supplied free of charge to any company, or indeed any individual, that wishes to send them to overseas associates. Please direct all requests to the Association's offices.

*Exhibition Dinner*

In 1973, for the first time, an Exhibition Dinner will be held, taking the place of the customary Luncheon. The Dinner will take place at the Savoy Hotel on the evening of Monday 21 May, and full details, with an application form for tickets, will be included in the *Official Guide* to the exhibition, which will be sent to Members, exhibitors, and others on the Association's comprehensive mailing list early in 1973.

The opening hours of OCCA 25 have also been changed, both because of the dinner and in accordance with the views of exhibitors and visitors. The new times will be:

| | | |
|---|---|---|
| Monday | 21 May | 12.00 to 18.00hr |
| Tuesday | 22 May | 09.30 to 18.00hr |
| Wednesday | 23 May | 09.30 to 18.00hr |
| Thursday | 24 May | 09.30 to 18.00hr |

Non-members wishing to receive copies of the *Official Guide* when available should apply to the Association's offices as soon as possible.

# Optional Professional Grade for Ordinary Members

**First year's figures indicate excellent response to Professional Grade**

The innovation made in introducing an Optional Professional Grade for its Ordinary Members has received extensive support in the first year of the Grade's operation. Following the announcement of the inception of this new scheme of technical qualifications in September 1971, over 350 applications have been received for admission. This response has been very broad-based; as well as Members from all of the UK Sections, many applicants have been Members attached to Sections based in Ireland, South Africa and New Zealand, as well as a considerable number attached to the General Overseas Section and resident in countries as far spread as the United States, Malaysia and Australia, as well as those in Europe.

The Council considers that the interest generated bears out its own opinion that there was a definite and general need for a system of professional qualifications having an educational identity with the paint, printing ink and allied industries.

As might be expected in the launching of such an enterprise, the majority of the early applications have been for the grades of Fellow and Associate. To date, 119 candidates have been accepted for FTSC, 180 for ATSC, and 6 for the grade of Licentiate (LTSC). It will be appreciated that all applicants for the Licentiate grade are required by the regulations to write a full dissertation and to undergo a viva voce examination, and thus at the time of writing, there are ten applicants for this grade awaiting fulfilment of the regulations. Full statistical details of the applications received so far are shown below; a full list of all Members admitted to the Professional Grade will appear in the December issue of the *Journal.*

During the first year's working of the scheme, the Professional Grade Committee has maintained close scrutiny of the initial regulations, and certain changes of detail may now be made. In particular, the regulations regarding sponsorship of candidates by Members of the Association in the Professsional Grade, which were waived for the first year, will take effect as from 1 November 1972.

Further, the Council has recently decided that the fees for the Professional Grade shall be: Fellows £10.00, Associates £6.00, Licentiates £3.00, with effect from 1 January 1973.

| | Applications received | Applications transferred between grades | Successful | Awaiting fulfilment of regulations | Not accepted |
|---|---|---|---|---|---|
| Fellowship . . . . | 160 | less 33 | 119 | — | 8 |
| Associateship . . . . | 186 | add 33<br>less 3 | 180 | 21 | 15 |
| Licentiateship . . . . | 13 | add 3 | 6 | 10 | — |
| | 359 | | 305 | 31 | 23 |

# OCCA Biennial Conference

## towards 2000

### eastbourne 19~23 june 1973

There is now an amendment to the programme published in the October issue of the Journal. The paper by Professor Anderson originally planned for technical session 5, on the morning of Friday 22 June, has been withdrawn, and will be replaced by a paper entitled "Chloride ion diffusion in epoxy polyamide films and the substrate effect," by Dr J. D. Murray of QAD (Mats), Woolwich. A final programme will appear in the December issue, together with summaries of all papers, and it is hoped that biographies of the authors will appear in January.

A full social programme, aimed particularly at ladies attending the conference, has been arranged. There will be a civic reception by the Mayor and Mayoress of Eastbourne, followed by a dance, as well as the customary reception by the President of overseas Members and visitors, and the informal reception for all delegates. Coach tours have been arranged to Bateman's, Burwash, the home of Rudyard Kipling, to Brighton, including the Pavilion, and to Firle Place, the home of Earl Gage. The usual sporting tournaments will take place, and a theatre party will be organised for the Thursday evening.

The fees for the conference will be:

Members of the Association £30.00, non-members £50.00, wives £10.00. Daily registrations will be available only to Members attached to the London and Thames Valley Sections, at £12.00 per day.

The conference brochure, giving full details of both technical and social programmes and accommodation, together with application forms, will be sent to all Members at the turn of the year. Non-members wishing to receive these items when available should apply to the Director & Secretary at the Association's offices.

# Midlands Section

### Ladies Evening 1972

The Annual Ladies Evening of the Midlands Section was held on Friday, 15 September, at the Botanical Gardens, Edgbaston. The Chairman of the Section and his lady, Mr and Mrs A. S. Gay, were pleased to welcome as guests the President and Mrs Blenkinsop, Mr H. J. Clarke, Chairman of the Midlands Section of the Paintmakers' Association, and Mrs Clarke, Mr R. Jukes, President of the Birmingham PVL Club, and Mrs Jukes, Dr and Mrs J. M. Fletcher, a number of Chairman of Sections with their ladies and the Director & Secretary, Mr R. H. Hamblin. An excellent steak dinner was served and, after toasting the Queen, the Chairman officially welcomed the ladies and guests, covering the OCCA notables in witty verse. Mr H. J. Clarke replied and the President's lady said a special thank you for this year's ladies' gift of potted plants.

The main speech of the evening broke with tradition in many ways, being delivered by Dr Fletcher, Lecturer in Political History at the University of Aston, and President of the Black

**At the Midlands Ladies Evening: (left to right) Mr A. S. Gay (Chairman, Midlands Section), Mrs Gay, Mr R. H. Hamblin (Director & Secretary), Mrs Blenkinsop, the President (Mr A. W. Blenkinsop)**

Country Society. Dr Fletcher described the geography, industry, history and dialect of the region in a light-hearted but forceful manner, this region, between Birmingham and Wolverhampton, being famous for iron-working. His view was that Black Countrymen make it, Brummies put it together and people from Solihull talk about it. Among a selection of amusing anecdotes was a poem concerning the night "our Eli captured Hitler," recited in full dialect.

Following the speeches, a pleasant evening's dancing was enjoyed by all.

R.J.K.

# South African Section

## Transvaal Branch

**The newly-elected Chairman of the Transvaal Branch, Mr P. C. Geldmacher (right) is seen receiving the Chairman's badge of office from Mr P. A. J. Gate, a past-Chairman of the Branch**

## News of Members

Mr L. Tasker, an Ordinary Member attached to the General Overseas Section, and an Associate in the Professional Grade, has been appointed general technical and plant manager of Panther Chemical & Industrial Co. Inc., a newly formed company in Abadan. Mr Tasker will be involved in the setting up of a factory under a joint contract between Panther and Walpamur Ltd. Panther will then manufacture Crown emulsions, undercoats, aluminium and road marking paints under licence.

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Mr R. St. C. Burgess, an Ordinary Member attached to the London Section, has been appointed UK sales representative for Synres Nederland NV, and will handle inquiries for all the company's products.

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Mr R. B. Hurley, an Associate Member attached to the London Section, is to relinquish his position as field sales manager for Cabot Carbon Limited, as he is returning to the International Division of Cabot in the USA.

Mr D. K. Naylor, an Ordinary Member attached to the Manchester Section, has been appointed field sales manager in Mr Hurley's place.

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Dr A. R. Pinnington, an Ordinary Member attached to the Manchester Section, has recently left Laporte Industries Ltd. and has joined Pinnington, Dawson & Wood Ltd., who are chemical manufacturers and merchants in Radcliffe, Manchester.

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Mr C. D. Graham, an Ordinary Member attached to the General Overseas Section, has been appointed to the newly created position of regional manager by the Finishes Department of the European subsidiary of E. I. Du Pont de Nemours Inc. Mr Graham will be located in Barcelona, Spain, and his responsibilities will include Southern Europe, the Middle East and Africa.

Simultaneously, Mr Graham has relinquished his appointment as commercial director of Colorquin S3 21 de CV, an affiliate company in Mexico, where he has been located since 1961.

### XIIth FATIPEC Congress 1974

A preliminary announcement concerning the XIIth FATIPEC Congress has been received from Dr H. Rechmann, FTSC, the incoming President of the Federation d'Associations de Techniciens des Industries de Peintures, Vernis, Emaux et Encres d'Imprimerie de L'Europe Continentale.

The theme of the congress will be "New developments in the field of paints, printing inks and pigments," and it will be held at Garmisch-Partenskirchen from 12-18 May 1974.

The Association has been asked to present one of the plenary papers at the congress, and further details will appear in this *Journal* from time to time.

# 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

BARNES, RICHARD GARTH, BSc, 2B Springfield Road, Gatley, Cheshire. (*Manchester*)

BARTRUPP, DERRICK WILLIAM, 436A Longbridge Road, Barking, Essex. (*London*)

BRAGADO PEREZ, AGUSTIN, Urruzola SA, Embajadores 225, Madrid 5, Spain. (*General Overseas*)

CODES BLANCA, FRANCISCO, Montesa 16, Madrid 6, Spain. *(General Overseas)*

FERNANDES, DANIEL, Antonia Ruiz Soro U°37-2B, Madrid 28, Spain. *(General Overseas)*

FRANCISCO DE GUTIERRES, LUIS, Francos Rodriguez 30, Madrid 20, Spain. *(General Overseas)*

FRIAS GIMENEZ, JOSE LUIS, Avenida General Peron, No. 5-6°B, Madrid, Spain. *(General Overseas)*

ELIAS, JOSE LUIS, Parque Lisboa, Torre 2, Esc. Der. 4°A, Spain. *(General Overseas)*

GARCIA GARCIA, JOSE MANUEL, Otero 2-2°D, Madrid 28, Spain. *(General Overseas)*

GARCIA VAZQUEZ, LUIS, Garcia de Paredes 4-3 Izda, Madrid 3, Spain. *(General Overseas)*

GOMEZ, VICTOR LUIS, Costa Rica 7, Madrid 16, Spain. *(General Overseas)*

LIEW, ANN SHING, BSc, 8A Jalan Jim Quee, Johore Bahru, Johore, Malaysia. *(General Overseas)*

MARTIN JORGE, LUIS, Maldonada 54B, Madrid 6, Spain. *(General Overseas)*

MARTINEZ REMIS, FERNANDO, Embajadores 206 Dup, Madrid 5, Spain. *(General Overseas)*

PATTYRANIE, CAREL, MChE, DrTech, Statens Provningstalt, Box 5608, 114 86 Stockholm 5, Sweden. *(General Overseas)*

PEREIRA, SANTIAGO, Paseo de las Delicias 27, Madrid 7, Spain. *(General Overseas)*

RAFAEL, COBO MORALES, Avenida del Mediterraneo, No. 59, Madrid 30, Spain. *(General Overseas)*

SANCHEZ SANCHO, ALBERTO, Sanchez Pacheco 19, Madrid 2, Spain. *(General Overseas)*

SACRISTAN, FERNANDO, Augusto Gonzalez Besada No. 2-1°D, Madrid 30, Spain. *(General Overseas)*

SPICER, LEONARD ALFRED, Gestetner Ltd., Broad Lane, Tottenham, London N17. *(London)*

WHISTON, CHRISTOPHER JOHN CHARLES, BSc, 26 Riverside Crescent, Holmes Chapel, Crewe, Cheshire. *(Manchester)*

ZAFRA, DEMETRIO, Alcantara 35-6°G, Madrid, Spain. *(General Overseas)*

ZARAGOZA DEL RIO, JOSE LUIS, Cuidad Santo Domingo, c/- Castilla, Algete (Madrid), Spain. *(General Overseas)*

**Associate Members**

ZGIBE, GEORGE JOHN, 44 Doddington Drive, Cramlington, Northumberland. *(Newcastle)*

**Student Members**

AINSWORTH, STEPHEN, Walpamur Co. Ltd., Hollins Road, Darwen, Lancs. *(Manchester)*

GREEN, DAVID, Walpamur Co. Ltd., Hollins Road, Darwen, Lancs. *(Manchester)*

PALMER, DAVID, Walpamur Co. Ltd., Hollins Road, Darwen, Lancs. *(Manchester)*

WHITTAKER, DAVID, Walpamur Co. Ltd., Hollins Road, Darwen, Lancs. *(Manchester)*

# Forthcoming Events

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

**Thursday 2 November**

*Newcastle Section:* "Polymeric prognostications" by Mr A. R. H. Tawn of Cray Valley Products, to be held at the Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne, at 6.30 p.m.

*Thames Valley Section—Student Group:* "Corrosion: The vulture of metallurgy and the skeleton in the chemical cupboard" by Dr M. Clark of Sir John Cass College, to be held at the Main Lecture Theatre, Slough College, at 4.00 p.m.

**Friday 3 November**

*Irish Section:* Annual Dinner Dance to be held at the Royal Starlight Hotel Bray.

**Monday 6 November**

*Hull Section:* "Stainless and low alloy steels" by Mr J. E. Truman of Firth Brown Ltd., to be held at the Haven Inn, Barrow Haven, Lincolnshire, at 7.00 p.m.

**Tuesday 7 November**

*Scottish Section—Eastern Branch:* Joint meeting with BPBMA, Northern Section "Marketing in the paper industry" by a lecturer to be arranged. To be held at the Tree Tops Hotel, Aberdeen, at 7.00 p.m.

**Wednesday 8 November**

*London Section:* European Liaison Lecture: "Painting concrete" by Mr B. Lindberg of the Scandinavian Paint & Printing Ink Research Institute, to be held at the South Bank Polytechnic at 7.00 p.m.

*Newcastle Section—Student Group:* "Yacht paints" by Mr L. Bennison of the International Paint Co. Ltd., to be held at the Newcastle Polytechnic, Ellison Place, Newcastle, at 3.00 p.m,

**Thursday 9 November**

*Midlands Section—Trent Valley Branch:* "Durability testing" by Mr E. Oakley of Tioxide International Ltd., to be held at the British Rail School of Transport, London Road, Derby, at 7.00 p.m.

*Scottish Section:* "Trends in major printing processes—role of pigments" by Mr P. Raymond of CIBA-GEIGY (UK) Ltd., to be held at the St. Enoch Hotel, Glasgow, at 6.00 p.m.

**Friday 10 November**

*Manchester Section:* "The scanning electron microscope" by Mr R. J. Williams of BP Chemicals (UK) Ltd., to be held at the Bolton Institute of Technology, Deane Road, Bolton, at 6.30 p.m.

**Saturday 11 November**

*Scottish Section—Student Group:* "Future advantages from North Sea oil" by Mr R. C. Campbell of the Scottish Council—Development and Industry, to be held at the St. Enoch Hotel, Glasgow, at 10.00 a.m.

**Tuesday 14 November**

*West Riding Section:* "Anaerobic acrylics" by Dr Leen of Borden Chemical Co. (UK) Ltd., to be held at the Griffin Hotel, Leeds, at 7.30 p.m.

*London Section—Southern Branch:* "Industrial pollution" by Dr Coleman of Rechem International Ltd., to be held at the Pendragon Hotel, Southsea at 7.00 p.m.

**Friday 17 November**

*Midlands Section:* "New technology furnace blacks as channel black replacements" by Mr N. Scott of Cabot Carbon Ltd., to be held at the Birmingham Chamber of Commerce and Industry, 75 Harborne Road, Birmingham, at 6.30 p.m.

*Irish Section:* "Developments in ink technology" by Mr G. H. Hutchinson of A. B. Fleming & Co. Ltd., to be held at the Clarence Hotel, Dublin, at 8.00 p.m.

**Thursday 23 November**

*Thames Valley Section:* "Car painting requirements of the future" by Mr W. Dabbs of Pressed Steel Fisher Ltd., to be held at the Beech Tree Hotel, Maxwell Road, Beaconsfield, Bucks, at 7.00 p.m.

**Friday 24 November**

*Bristol Section:* "The paint industry and the Common Market" by Mr D. E. Eddowes, of Polymers, Paint and Colour Journal, to be held at the Royal Hotel, Bristol, at 7.15 p.m.

*West Riding Section:* Annual Dinner and Dance, to be held at The Crown Hotel, Harrogate, at 7.30 p.m.

**Friday 1 December**

*London Section—Southern Branch:* Ladies Evening with Buffet Supper "Protection or beauty" an illustrated paper on cosmetics by Mr M. Hand of Max Factor. To be held at the Pendragon Hotel, Southsea at 7.00 p.m.

**Monday 4 December**

*Hull Section:* Details to be arranged.

**Wednesday 6 December**

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

**Thursday 7 December**

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

*Newcastle Section:* "Pollution control" by Mr G. Turner, of ICI Ltd., HOC Division, to be held at the Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne at 6.30 p.m.

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

**Friday 8 December**

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

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

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

**Monday 11 December**

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

**Tuesday 12 December**

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

**Wednesday 13 December**

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

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

**Thursday 14 December**

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

**Saturday 16 December**

*Scottish Section—Student Group:* Joint meeting with Eastern Branch. Works visit to Linwood Plant of Chrysler Scotland Ltd. with a lecture on "Automotive finishes" by Mr J. McQuade.

**Wednesday 20 December**

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

# Oil and Colour Chemists' Association

***President:*** A. W. BLENKINSOP, F.T.S.C.

The Oil and Colour Chemists' Association was formed in 1918, to cover paint, printing inks, pigments, varnishes, drying and essential oils, resins, lacquers, soaps, linoleum and treated fabrics, and the plant, apparatus and raw materials useful in their manufacture. In 1924 it absorbed the Paint and Varnish Society. The stated purpose of the Association is to promote by discussion and scientific investigation the technology of the industries concerned with the above-mentioned products, and to afford members opportunity for the interchange of ideas. This is achieved by the regular holding of ordinary meetings at which papers are presented, and the organisation of annual technical exhibitions, biennial conferences, educational activities and practical co-operative experimental work. Details of these activities are given in the *Journal of the Oil and Colour Chemists' Association*, which is published monthly, and whose pages are open to receive communications and other pronouncements on scientific and technical matters affecting the members of the Association and the industries concerned. The Association's meetings also afford opportunities for members to meet informally and socially.

There are Sections of OCCA in Auckland, Bristol, Hull, Ireland, London (with a Southern Branch), Manchester, the Midlands (with a Trent Valley Branch), Newcastle upon Tyne, Scotland (with an Eastern Branch), South Africa (with Branches in the Cape, Transvaal and Natal), Thames Valley, Wellington, and the West Riding, and these are responsible for the conduct of their own local affairs. There is also a General Overseas Section. There is also a close alliance between the Association, the Fédération of Societies for Paint Technology in the United States, and the Fédération d'Associations des Techniciens de l'Industrie des Peintures, Vernis, Emaux et Encres d'Imprimerie de l'Europe Continentale (FATIPEC). The Association also maintains cordial relations with the Scandinavian Federation of Paint and Varnish Technicians (SLF).

The five Sections previously maintained by the Association in Australia formed (1.1.68) the Oil and Colour Chemists' Association Australia, having the same aims and activities as, and working in close liaison with, the parent body.

Ordinary Membership is granted to scientifically trained persons, and Associate Membership to others interested in the industries covered. An optional Professional Grade, conferring designatory letters, is open to Ordinary Members. Student membership is open without restriction to persons under the age of 21 and to those up to 25 who are following a course of technical study. The annual subscription in each case is £5.25, except for registered Students, whose subscription is £1.05. An entrance fee of 50p is payable by all members. Applications for membership are invited from suitably qualified persons who are engaged or otherwise interested in the industries noted above. Applications, which should be supported by two members of the Association (one of whom must be an Ordinary Member), should be forwarded to the Director & Secretary at the address given below. Application forms and full details of membership may be obtained from the offices of the Association.

## PUBLICATIONS

*Journal of the Oil and Colour Chemists' Association.* Published monthly. Subscription rate to non-members in UK and abroad: £10.00 p.a. post free; payable in advance.

*An Introduction to Paint Technology* (Second Edition with additional chapter). Pp. 187. illustrated, with index, £1.00 (including postage).

*Paint Technology Manuals* (Parts 2, 4, 5 at present out of print).

- Part 1: "Non-convertible Coatings," Second Edition. Pp. 343. £2.25.
- Part 2: "Solvents, Oils, Resins and Driers."
- Part 3: "Convertible Coatings," Second Edition. Pp. 350. £2.50.
- Part 4: "The Application of Surface Coatings."
- Part 5: "The Testing of Paints."
- Part 6: "Pigments, Dyestuffs and Lakes." Pp. 340. £2.00.

Director & Secretary: R. H. Hamblin, M.A., F.C.I.S., Wax Chandlers' Hall, Gresham Street, London EC2V 7AB.


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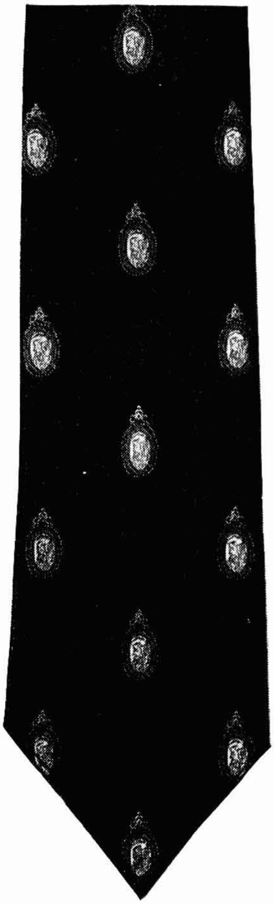

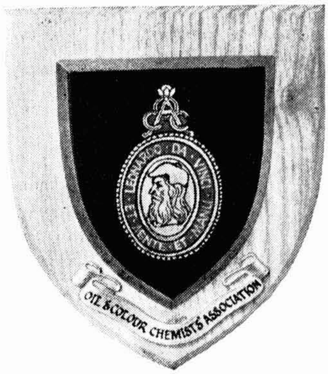

*The tie is blue terylene, with the Association's insignia woven in red and gold silk.*

*The blazer badge has the insignia embroidered in silver and gold wire on a red and blue ground.*

*The plaque has the insignia hand-painted in red and gold on a blue ground.*

*The car badge has the insignia embossed in red and gold on a blue ground, the whole being covered in transparent polypropylene, with a thick chrome surround. Bar and grille fittings are available.*

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**The ties will be supplied from stock; all other items are made to order. Only the tie can be supplied by airmail at an extra cost of 35p.**

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# introduction to paint technology

## second edition with additional chapter

The sales of this Association publication now exceed 16,000, and now includes an eleventh chapter entitled "Recent Development," and incorporates up-to-date information on the latest advances in the technology of the paint and allied industries.

This addition will help "Introduction to Paint Technology" to maintain its position as an invaluable aid to young entrants into the industries and to marketing and other personnel requiring a basic knowledge of the principles and techniques of surface coating production and application.

## new chapter

The new chapter is subdivided into three sections—

### *resins and media*

Including polyester, epoxy, polyurethane resins and developments in water based paints vinyls, acrylics etc.

### *application techniques*

Including electrodeposition, powder coatings, strip-coating, aerosol spraying.

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# CLASSIFIED ADVERTISEMENTS

Classified Advertisements are charged at the rate of 50p per line. Advertisements for Situations Wanted are charged at 12½p per line. A box number is charged at 5p. They should be sent to the Director & Secretary, Oil & Colour Chemists' Association, Wax Chandlers' Hall, Gresham Street, London, EC2V 7AB. Telephone: 01-606 1439.

## SITUATIONS VACANT

# CLASSIFIED ADVERTISEMENTS

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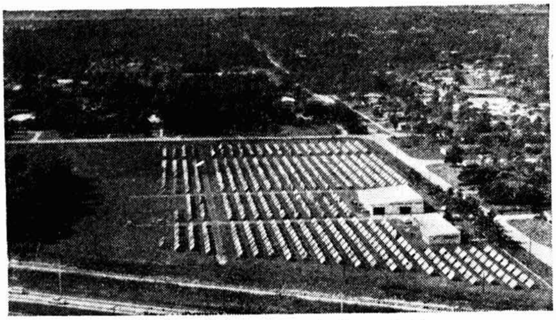

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*Published under the patronage of the French National Federation of Paint, Varnish and Printing Inks manufacturers*

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