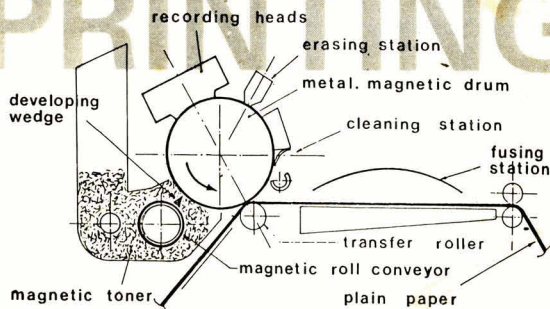
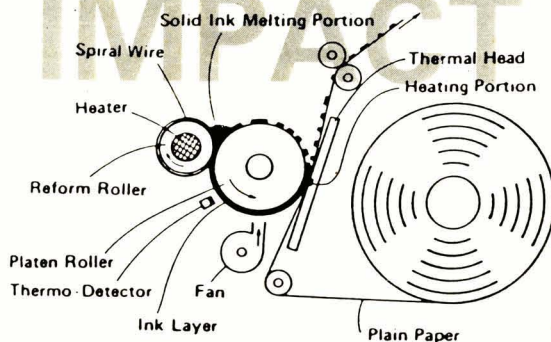
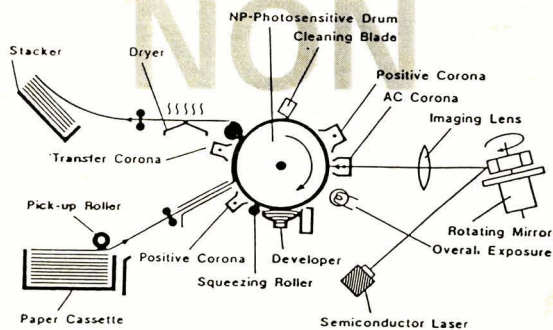








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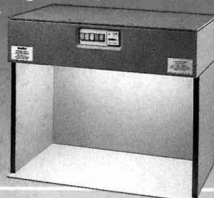
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# Waterborne coatings: A review of basic principles

J. W. Nicholson

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## Abstract

Waterborne coatings are currently the subject of widespread interest, yet it is not a simple matter to substitute water for the organic solvents conventionally used in paints. In this paper, some of the problems involved in waterborne coatings technology are described, and the underlying physical chemistry of aqueous systems is considered. In particular the topics of solubility/dispersibility of polymers in water, the wetting behaviour of aqueous solutions and the drying mechanisms of films of polymer dispersions are reviewed in order to show their importance for the formulation of technically successful waterborne coatings.

## Introduction

It is almost exactly 20 years since the Los Angeles County Authorities introduced their now-famous "Rule 66", designed to limit the emission into the atmosphere of various classes of organic solvent<sup>1, 2</sup>. This event was a turning point in the development of "environmentally friendly" coatings technology, and was crucial in the evolution not just of waterborne, but also of high-solids and powder coatings. It was followed in 1970 by the United States "Clean Air Act", and by 1976, all of the United States had legislation based substantially on the provisions of the Los Angeles "Rule 66".

Such environmental legislation does not, of course, apply to the UK or to Europe, but it has clearly had an impact in these regions, largely because America represents the biggest single market in the free world, and as a result, to a substantial extent, they control technical developments. This is not to say that there is no pressure to move towards reduced solvent coatings in the UK or Europe, but in these regions this pressure has been mainly economic<sup>1, 3</sup>. Organic solvents, being derived from crude oil, have gone up in price in real terms in the last ten to 15 years<sup>4</sup>, and, on the ground of cost alone, it makes sense to put effort into developing alternative systems to conventional, solvent-based paints.

In formulating or using waterborne coatings, three fundamental questions need to be considered, either explicitly or implicitly. These are:

1. What is water like as a paint solvent?
2. What makes paint resins soluble/dispersible in water?
3. What are the film-forming characteristics of waterborne coatings?

In this paper, these three questions will be considered in turn, and some attempt at answering them will be made.

## Water as a paint solvent

Water has a number of attractions as a solvent or carrier for paints. In particular, it is cheap, readily available, non-toxic

and non-flammable<sup>1-3</sup>. Despite these advantages, it is not the solvent universally used in coatings, and this is because it also introduces disadvantages to the finished films, the most significant of which are that dried coatings have a tendency to remain water-sensitive<sup>3</sup> and that humidity affects their drying<sup>5</sup>, so that at high humidity, drying may be so slow as to cause sagging, while at low humidity, it may be so explosively fast as to lead to cratering in the final film<sup>5</sup>.

Water, as a substance, is unique<sup>6</sup>: it is the only inorganic liquid to occur naturally on earth, and it is the only compound which can be found in nature on earth in all three physical states, solid, liquid and vapour.

In its physical properties, too, water is unusual, as the data in Table 1 show.

Table 1

Comparison of water with other paint-solvents

Property	Water	Mineral spirits	Xylene
Molar mass	18	170	106
Boiling point/°C	100	214.5	144
Surface tension/dynes cm <sup>-1</sup>	73	18	30
Latent heat of evaporation/Cal.g <sup>-1</sup> at bp	540	115	94

From this, it can be seen that water has a relatively high boiling point for its molar mass, as well as a high surface tension and a high latent heat of evaporation. All of these point to the very associated nature of the molecules of water. Water itself is a highly polar molecule, and this polarity causes the molecules to form dimers in solution, held together by relatively strong secondary bonds known as "hydrogen bonds"<sup>7</sup>. This polarity is important in considering the next question:

## What makes paint resins soluble/dispersible in water?

The rule for solubility is that "like dissolves like"; in other words, non-polar solvents dissolve non-polar compounds, polar solvents dissolve polar compounds<sup>8</sup>. This means that molecules such as ethanol are soluble in water, but those such as hexane, are not. As far as paint resins are concerned, since these are mainly hydrocarbon in nature, and non-polar, they are generally insoluble in water.

The kind of polymers that are soluble are those which contain highly polar monomers, such as poly(vinyl alcohol), poly(acrylic acid) or poly(acrylo-nitrile). Poly(acrylic acid) is of particular interest, because acrylic acid itself is frequently used as a component of copolymers, to confer water-solubility or dispersibility. Its effectiveness can be

increased, if necessary, by neutralization, for example, with ammonia or sodium. In one study of this topic, it was found that the copolymer of acrylic acid with methyl acrylate (89 mol% acrylic acid) was not water soluble, but became so on neutralizing with sodium<sup>9</sup>.

Although often included to confer dispersibility as a sort of "internal emulsifier", polar units such as acrylic acid are not strictly required in a polymer, in order to disperse it. However, since it is necessary to wet the surfaces of the individual polymer particles thoroughly, it is generally advantageous to include such groups.

So far, the discussion of solubility of polymers has been confined to a consideration of the attractive forces involved. But, if we look at the waterborne polymers of practical use in coatings, we see that they all have hydrocarbon backbones. In the absence of polar functional groups, these polymers would not be water-soluble, so that there is a "hydrophobic" contribution to the overall solute-solvent interaction which needs to be considered. The origin of this hydrophobicity may be explained in terms of thermodynamics<sup>10</sup>.

Measuring enthalpy changes for the dissolution of hydrocarbons, such as hexane, in water shows that  $\Delta H$  is negative; energetically, water and hexane attract each other. However, hexane is not soluble to any appreciable extent, and this lack of solubility is not merely a kinetic effect<sup>6, 10</sup>. The free energy change,  $\Delta G_{\text{solution}}$  is against the process, i.e. is positive.

From  $\Delta G_{\text{solution}} = \Delta H_{\text{solution}} - T\Delta S_{\text{solution}}$ , it follows that the  $T\Delta S_{\text{solution}}$  term (and hence  $\Delta S_{\text{solution}}$ ) must be negative. This, in turn, leads to the conclusion that the entropy of the final state (the solution) must have decreased relative to the initial state (the two separate liquids). In other words, the proposed solution is more ordered than the separate liquids, a result which is attributed to the formation of "cage" structures of hydrogen-bonded water molecules around the non-polar hexane molecule in which the water has fewer degrees of freedom than in pure water itself<sup>6, 10</sup>.

Such hydrophobic interactions, arising on entropic grounds, are significant in solutions of all water-soluble polymers except poly(acrylic acid) and poly(acrylamide), where large  $\Delta H_{\text{solution}}$  terms swamp the effects<sup>6, 10</sup>.

In liquid-liquid phase diagrams, the hydrophobic interaction results in the existence of a lower critical solution temperature, and to the remarkable result that raising the temperature reduces the solubility (Figure 1a). In general, the solution behaviour of water-soluble polymers represents a balance between the hydrophilic and hydrophobic nature of the macromolecule. This often results in closed solubility loops (Figure 1b), in which the lower temperature behaviour and lower critical solution temperature arise due to hydrophobic effects, while, at higher temperatures, the solution behaviour becomes dominated by hydrophilic effects.

These diagrams represent the behaviour of specific polymers in water. For example, aqueous solutions of poly(methacrylic acid) show the behaviour of Figure 1a, while aqueous solutions of poly(ethylene glycols) show that of Figure 1b<sup>10</sup>. Similar behaviour would be expected for the sort of polymers employed in waterborne coatings, for

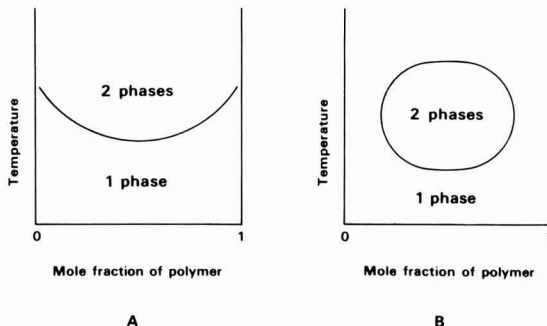


Figure 1. Phase diagrams resulting from hydrophobic interactions.

example, where there is insufficient acrylic acid in a copolymer for a large  $\Delta H_{\text{solution}}$  term to swamp the  $T\Delta S_{\text{solution}}$  term completely. In such polymers, care would be needed to ensure that the polymer remained in solution, and if cloudiness became apparent, indicating some incompatibility of water and solute, the conventional approach of heating the mixture would be inappropriate, since it could well lead to complete phase separation.

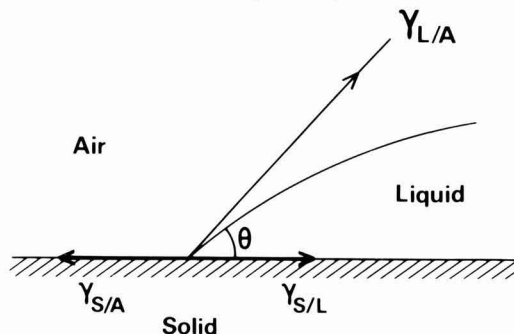
#### Film-forming characteristics of waterborne coatings

To act satisfactorily as film formers, waterborne coatings need to be capable of forming coherent films, substantially free of voids, and to adhere well to the substrate. Film-forming ability depends on the nature of the polymer used: true solutions of polymer readily form films, simply by evaporation of water. Latices, by contrast, form films less readily, depending on the ease with which the polymer particles deform and coalesce. This question of film formation by latices is discussed later in this paper.

Adhesion, which is important in determining the performance of the final film, is generally regarded as depending on the ability of the initial coating to wet the substrate<sup>11</sup>. A large proportion of adhesion failures of coatings have been attributed to the inability of the coating to wet the substrate adequately<sup>12, 13</sup> and it is appropriate to consider this problem in detail.

Classically, the ability of a liquid to wet a solid substrate has been considered in terms of surface tensions and contact angles<sup>11</sup>. When a drop of liquid is placed on a flat, solid surface, it generally remains as a drop having a distinct angle of contact with the solid surface, as illustrated in Figure 2.

Figure 2. Contact angle of a liquid on a solid.





Taking the various surface forces as represented by the respective surface tensions acting in the direction of the surfaces, then equating the forces at the boundary of the solid, gives:

$$\gamma_{S/A} = \gamma_{S/L} + \gamma_{L/A} \cos \theta \quad (1)$$

Finite contact angles arise when the liquid coheres to itself more strongly than it adheres to the surfaces of the solid. In principle, in order for wetting to occur, a contact angle of zero is required. In practice, however, spreading and wetting are found to occur for small finite values of  $\theta$ , generally below  $90^\circ$ .

This is because the theoretical analysis fails to take account of the natural roughness of the solid surface, and it is this which aids wetting at non-zero values of  $\theta$ <sup>14</sup>. The actual value of the contact angle depends on whether the liquid is advancing or receding across the surface, this hysteresis effect being most apparent with impure surfaces. It is also noteworthy that they vary with contamination of the surface, a factor which is particularly important with waterborne coatings, which are sensitive to substrate quality<sup>15, 16</sup>.

If we consider again Equation (1), two things are apparent. Firstly, the solid itself has a surface tension,  $\gamma_{S/A}$ , and secondly, there is a critical value of surface tension for liquids on a solid surface such that the contact angle is zero ( $\cos \theta = 1$ ), and spontaneous wetting occurs.

To determine this value for a solid surface, contact angles for various liquid drops on the surface are measured, the cosines of the angles being plotted against the surface tensions of the various liquids. Extrapolation to  $\cos \theta = 1$  (i.e.  $\theta = 0$ ) gives  $\gamma_c$ . This method, utilizing the concept of critical surface tension, provides a convenient method for assessing surface properties of various solids<sup>13, 14</sup>. Values of  $\gamma_c$  for various substrates are presented in Table 2.

Table 2

Critical surface tensions of selected solids<sup>13,14</sup>

Substrate	$\gamma_c$ /dynes cm <sup>-1</sup> at room temperature
Aluminium	45
Iron-phosphated steel	43
PVC	39
Tin plate	35
Untreated steel	29

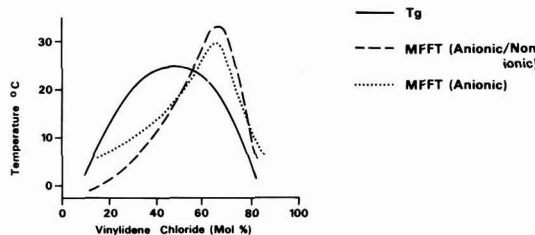
These critical surface tensions are all substantially below the natural surface tension of water. In order to apply waterborne coatings to the typical substrates listed in Table 2, it is necessary to reduce the surface tension, and this is usually done by using surfactants. Care needs to be taken with this, however, since too low a surface tension can lead to severe foaming<sup>17</sup>.

Film formation and drying are more complex for emulsion paints than for paints based on true solutions. Initially, the drying is controlled by vapour phase diffusion as the water evaporates<sup>18</sup>. When this stage is complete, polymer and pigment are left behind, together with minor components of the paint formulation interspersed between them. To form a reasonably continuous film, the polymer

particles need to deform from their essentially spherical and discrete morphology into a flattened and coalesced film<sup>1, 2</sup>. This process must also take place in such a way that the pigment particles also become fully integrated into the coating. In order for both of these to happen, the polymer must deform readily, and this ability depends on both the natural hardness of the polymer and the overall latex formulation, in particular whether or not coalescing solvents are present. Since both polymer hardness and effectiveness of solvents are temperature dependent<sup>19</sup>, it follows that film formation by latices is also temperature dependent, and there is a minimum temperature at which film formation will occur; below this, polymer particles do not coalesce or embody the pigment.

It has been widely assumed that minimum-film-formation temperature, MFFT, approximates to the glass transition temperature,  $T_g$ , of the polymer. This latter temperature is the point at which the polymer undergoes a transition from a brittle, glassy material to a softer, rubbery one, caused by a significant increase in the degree of segmental rotation within the polymer backbone. It is found that  $T_g$  and MFFT are related, and that factors which lead to reduction in  $T_g$  tend also to reduce MFFT, for example, the inclusion of "soft" monomers in a copolymer<sup>1</sup>. However, the relationship is a complex one which varies with copolymer composition, as shown in Figure 3. This illustrates the relationship between  $T_g$  and MFFT for various latices containing vinylidene chloride and ethyl acrylate<sup>20</sup>.

#### Relationship between MFFT and $T_g$



Polymer : Vinylidene chloride/ethyl acrylate

Figure 3. Relationship between MFFT and  $T_g$  for VDC/ethyl acrylate latices.

From Figure 3, it can be seen that MFFT differs quite considerably from  $T_g$ . At low levels of vinylidene chloride, it falls below  $T_g$ , but above about 55 mol%, it comes above  $T_g$ . While the overall shape of the curve for MFFT is broadly similar to that for  $T_g$ , it is not symmetrical, and the maximum occurs at 65 mol% rather than 50%. It is also notable that the values of MFFT depend on the nature of the surfactant, the latex formulated with a mixed anionic and non-ionic surfactant system giving different results from the latex dispersed with an anionic surfactant<sup>20</sup>.

Overall, these results indicate the important difference between MFFT and  $T_g$ , namely that MFFT is a property of the entire latex formulation, while  $T_g$  is a property of the polymer itself.

Determination of MFFT is generally done by applying the coating of interest to a metal platten which can be heated and cooled differentially along its length<sup>21</sup>. The coating is allowed to dry on this platten and the MFFT determined by visual inspection of the resulting film. This is

readily done, since the point along the surface at which the coating first forms an integrated film can be related to a particular temperature. There is now an apparatus commercially available which can be used for carrying out this determination, and this has simplified the procedure<sup>21</sup>.

### Conclusion

In this paper, the various factors affecting the performance and application of waterborne coatings have been reviewed. Due to the environmental acceptability and economic attractiveness of these coatings, they are likely to continue to grow in importance. As a result, it is important to appreciate the influence of water as a paint solvent on the key requirements for coatings systems, namely polymer solubility/dispersibility, substrate wetting and film formation. Although there have been many developments in recent years, much remains to be done. Some of the features identified in this review, notably the problems of substrate wetting, are likely to remain, but others, such as polymer solubilization and improved cross-linking, have scope for significant advances. In view of the amount of research effort currently going into this field, such advances may be confidently expected.

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# Developments in screen inks

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## Summary

This article reviews the use of screen inks in the container market. Recent changes and trends in this sector are discussed.

Whilst we must not overlook the substantial paper and board packaging market, in which screen inks have an important role, the largest packaging sector using screen inks is the container market. Therefore this paper reviews the screen printing of containers, recent changes that have occurred and the trends that appear to threaten the dominance of screen in the future.

During 1985 it is estimated that 700 million PET bottles were used in the UK<sup>1</sup>. Unfortunately none of them was screen printed. This is in stark contrast to the other two main polymers—polythene and PVC. UK consumption of polyethylene for bottles was nearly 100,000 tonnes and PVC over 26,000 tonnes. A large proportion of each was screen printed.

## Review of screen container printing

The screen printing of containers is almost exclusively by the direct decoration technique and has developed into an extremely versatile and sophisticated process. Often, it is integrated within overall bottle manufacture, although a substantial amount of contract printing is also employed. The basic steps involved are flame treatment, ink application and print drying.

The need to flame treat polyethylene, which is the most common polymer, is due to the inert and insoluble nature of the material. To obtain adequate ink adhesion, the surface of the polyolefin must be treated to make it receptive. The universally accepted method of pre-treating of containers is by flame impingement, which occurs only a few seconds before the bottle is screen printed.

The technique varies considerably, and major variables are:

1. Time of exposure to flame (normally 1-2 seconds).
2. Distance of inner flame tips to bottle surface (normally 5-6 mm).
3. Type of flame.
4. Composition of flame (gas/air ratio).

The ink maker has been forced to understand this element of the decoration process because most complaints about poor ink adhesion and product resistance are directly related to poor surface treatment.

Ink application is little different from any other form of screen printing, except that on cylindrical containers the screen moves, driving the container round in contact with a

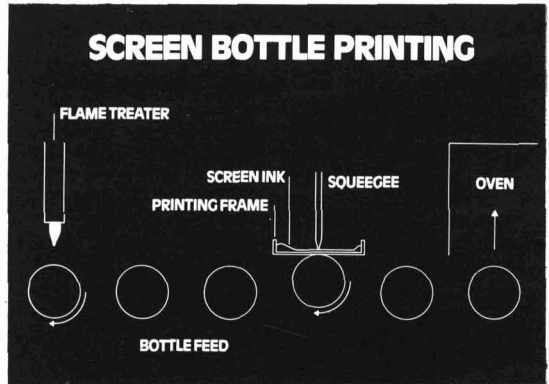


Figure 1. The principle of screen bottle printing.

stationary squeegee. See Figure 1. The choice of squeegee (construction profile), stencil or mesh are all variables the printer must consider and will not be discussed here.

There have been three different stages of ink development in the past:

Oxidation drying systems were the first to be used, and they still offer good adhesion, high gloss and reasonable film hardness. Their limitation, however, is long drying schedules of four to six minutes at elevated temperature or even overnight drying in order that the drying oil/alkyd reacts with oxygen from the atmosphere. As a result, their use has declined in favour of faster drying formulations.

Evaporation drying inks, based on chemically resistant resins dissolved in volatile solvents are able to be printed in a wide variety of different press conditions. Faster or slower evaporating solvents of similar chemical nature can be added to balance the requirements of drying and screen stability. They can be used on hand fed machines where air drying is employed or on the latest multi-colour lines which employ hot air blasting with very short dwells (2-3 seconds) or flame drying. Evaporation drying inks offer good gloss, adhesion and print quality. Their resistance properties are satisfactory for a number of products including motor oils, bleaches and some detergents. They are, however, readily attacked by products which contain solvents (e.g. cosmetics, brake fluid) and for this application catalytic systems are required.

There are two types of catalytic ink generally available. The two pack system, which requires mixing before printing, has resistance to most of the aggressive products including those containing solvents or essential oils. There is a two stage cure, as initial tack free drying is effected by solvent evaporation whilst chemical cross-linking continues over a longer period (2-3 days) before full resistance is achieved. This reaction, however, also continues within the mixed ink, reducing its pot life.

\*Presented at the Manchester Section OCCA Symposium, "Printing Inks and Packaging—Recent Changes and Future Trends", University of Salford, April 1986.

The inconvenience of mixing, and the waste of unused mixed inks which have reacted, encouraged ink makers to produce the conventional "cure-all". A one-pack, evaporation drying, catalytic curing ink was first produced by Coates in the 1960s and is still the industry standard. These inks combine, in essence, the ease of handling of evaporation inks and chemical resistance of the two pack products. The product is stable in the can over a long period and the cross-linking only activated when volatiles are removed by the drying stage.

The need for more technically advanced inks has occurred as a consequence of the demand for faster production and easier usage. In the latest inks, a fine compromise between the need for fast drying and reasonable screen stability during the run, has been reached. Recent development in drying have provided the mechanism for combining the best of both properties.

### Recent changes

There have been two major developments in the last few years which have had an effect on the screen decoration market. These are the emergence of UV Curing as an alternative drying system, and the exceptional growth of PET as a container substrate.

UV chemistry is a relative newcomer to the screen bottle printing market, but has now become a commercial reality. There are a number of advantages which the UV Curing process has to offer:

- Speed of cure
- Ultimate screen stability
- Reduced space requirements
- Lower energy requirements
- Greater design potential (four colour process)

The heightened interest in UV as a drying system for screen printed containers had been established with assistance from the ink maker.

Earlier formulations suffered from a number of disadvantages compared to solvent based inks (for example, poor stability, inadequate cure speed and inferior printability) which have now largely been overcome. In part, this is due to increased experience in use, as machine conditions require careful control.

The technical difficulty of formulating a UV ink for this application is considerable. Whilst the basic components provide almost indefinite screen stability, a compromise of photochemically active materials is necessary to obtain satisfactory cure.

If those which are surface active are present in too high proportions, then poor intercoat adhesion will result, whilst if those which are through film active are predominant, there may be a greasy surface after UV exposure, due to oxygen inhibition of the free radical reaction.

It has also been relatively difficult to select a prepolymer which is sufficiently resistant to all materials packed in polyethylene containers. In order to improve resistance of



Figure 2. Some examples of printed PET bottles.

the cured film, chemical additives have been employed to increase crosslink density. However, recent resin developments have allowed the formulation of a very resistant one-pack UV ink. Further improvements, of increased opacity, cure speed and flexibility are necessary if UV is to realise its full potential.

Early fears regarding the safety in use of UV inks are now not a major concern, as all reputable ink makers who are members of the SBPIM (Society of British Printing Ink Manufacturers) are bound by an agreement to check all potential raw materials for any risk to the user.

In addition, some materials are excluded by members because of their uncertain nature. This can, sometimes, restrict technical performance.

Polyethylene Terephthalate (PET) has, as indicated earlier, become increasingly familiar as a polymer for bottle production. It has been particularly successful in the packaging of carbonated drinks, predominantly for large volume containers where labelling is cost effective. See Figure 2. To date, there have been few attempts at direct decoration, although a number of ideas are currently under review within major packaging groups.

Solvent based inks are technically satisfactory, offering good adhesion and resistance, although PET is a difficult surface to adhere to. The softening point of the PET polymer, however, demands a low temperature in the ovens and thus drying times are unacceptably long. If a faster drying ink is used, screen stability problems are encountered.

This, then, would appear to be an ideal situation for UV inks to dominate. Whilst it is possible to formulate inks which offer acceptable adhesion on certain grades, there are a growing number of PET variations. The universal UV ink for PET has not yet been formulated.

If the market acceptance of PET continues to expand, and as associated developments become established, there is a greater potential for direct decoration which will require satisfactory inks.

### Existing trends

Articles about packaging provide convincing evidence that the use of plastic is increasing within areas traditionally dominated by other materials. This, in turn, is leading to greater competition between decoration techniques, and particularly where large volumes are involved, possibly a potential threat to screen printing on cost grounds.

Shrink labelling and transfer printing are two such methods which, having established themselves for the large run containers, are viable alternatives to screen decoration. Often, however, the film weight deposited by the screen process, and the consequent attractive print quality are still demanded by the print buyer.

In order to satisfy this latter requirement, the possibility of producing both PVC shrink labels and transfers by the screen process have been investigated. As part of this development, the need for new inks is obvious, particularly since the substrates are different, as is the speed of printing (normally on a web).

For PVC shrink labels, a fast drying, solvent based ink is required which will give good print quality at high speeds and offer sufficient flexibility so as to shrink evenly with the film. Because the inks are usually reverse printed (and will be protected once applied) resistance properties are not critical.

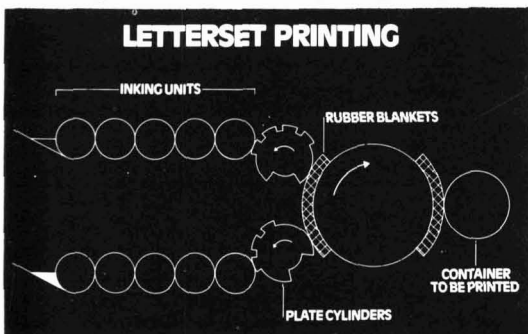
This is not the case for transfers, where, because they are applied to the surface, the inks are liable to be attacked. The release coatings involved offer partial protection but also impair the finish. It is obvious, therefore, that the inks developed for this application are faster drying versions of product resistant solvent based inks.

One of the major markets that has adopted the use of plastic containers is home decorating. Mastic cartridge tubes were made from card until recently but polypropylene is now used to improve storage, handling and appearance. Paint containers, for emulsion paint at least, are already available in polypropylene and work on barrier coatings is in hand to enable gloss paints to be similarly packed.

I know of different packaging companies decorating mastic cartridges by screen and dry offset processes. The latter technique has also been adopted by printers of the plastic paint can, and is, therefore a potential rival to screen printing in developing areas, as it has been in certain fields in the past (e.g. polyethylene bottles).

Dry offset printing is a lot faster than screen, applying a lower filmweight. It is also more cost effective when printing large areas of multi colours and is, therefore, ideal for large containers which are printed in large volumes. It does, however, lack the colour strength and visual appearance which screen printing produces. Also the thinner film applied is more susceptible to removal by aggressive products.

Figure 3. The principle of dry offset printing.



Whilst the inks for both printing processes are broadly similar, in so far as they are either resins in solvent or UV curing systems, there are fundamental differences. Because of the lower film thickness, pigmentation of dry offset is much higher (approximately three times) and the viscosity is completely different. The speed of dry offset printing, in combination with the substrates used, also demands the use of different solvents, whose evaporation rate would be unacceptable in a screen ink.

There are a number of new developments within plastic packaging which may result in new inks required for future decoration. Multilayer containers (e.g. Lamicon 5 layer polypropylene ex Metal Box) offer high performance for the foodstuff market in competition with glass. One of the major advantages claimed is that they are "Squeezy" bottles, enabling easier use. That poses, however, a problem for the ink maker if the chemically resistant inks need to be so crosslinked that sufficient flexibility is difficult to obtain.

New substrates often introduce a further adhesion problem and if nylon or polycarbonate becomes more widely used, there will be new screen inks required which offer the range of properties currently available from the polyethylene inks described previously.

As mentioned earlier, plastics do not usually offer a satisfactory barrier to aggressive materials, particularly solvent. Substantial effort has been devoted by many companies to produce suitable barrier coatings. Air Products has recently announced a fluorocarbon barrier effective against almost all solvents. Fortunately, this is applied inside and should not impair adhesion of the current polyethylene inks. Other barrier coatings however, may be surface applied and may therefore, affect adhesion.

The increased use of plastic will require the development of new screen inks to maintain the important role this process has within the packaging industry.

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# Liquid ink developments\*

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## Summary

Liquid ink developments are more and more becoming affected by:

1. New printing press designs.
2. Environmental pressures.

Advances have been made in flexographic printing with the attainment of higher press speeds, the use of ceramic rollers, the use of photopolymer dates, half-tone printing, the use of add on gravure units for adhesive/protective lacquer application and a more recent advance has been seen with the application of the technique to newspaper printing.

The decline of gravure printing would appear to have been halted with the introduction of cheaper cylinders and the application of the offset gravure printing process.

With these changes in printing press designs and the increasing interest in environmental pollution and health hazards which influence both the material content of inks, and material handling and manufacture, considerable changes in liquid ink technology has taken place and this paper seeks to introduce some of the more recent developments.

## Introduction

Printing ink manufacturers have the basic motivating force common to all successful industrial suppliers, in that they try to provide their customers with the products they want to buy and use. In meeting this demand we have seen considerable development in liquid inks for packaging and in this afternoon's talk I will aim to concentrate on these developments whilst outlining my thoughts on future areas of development. Before I discuss the actual ink developments I feel it would be beneficial to outline the factors (discussed in the following sections) which typically influence the course of liquid ink developments: Economic climate, health and safety/environmental factors, ink manufacturing techniques, printing process advancements, packaging methods, substrate changes.

## Economic climate

Like most industries today we are in the midst of a recession and with intense competition, both the packaging converters and ink manufacturers must study the cost effectiveness of both current and new formulations. Note the use of the term cost effectiveness as opposed to cost reduction or low cost, since the important factor is the total cost of the package rather than the individual components, e.g. formulations of an alternative package without an overprint varnish using inks 10% more expensive than the original set may still prove cost effective by:

1. The achievement of higher press speeds.
2. Many cold seal pack designs utilise all the available units on the press due to the conventional practice of applying a cold seal release lacquer as well as the cold seal adhesive. Thus the omission of the overlacquer will facilitate

the application of the spare unit for an additional colour which can be advantageous for special offer flashes.

## Health and safety/environmental factors

Over the last few years changes in many liquid ink formulations have been prompted by the increased attention given to health and safety/environmental factors.

## Reduction in hydrocarbon solvents

The use of systems based on hydrocarbon solvents has diminished considerably over the last few years and still continues to do so. The major reasons are press room odour and tighter specifications by the end user, on odour and taint characteristics. This has caused difficulties in gravure formulations due to inferior wiping characteristics and elimination of resins which have previously been necessary to achieve optimum gravure print quality.

## Glycol ethers and their derivatives

Recent years have seen a reduction in TLV values of certain of these solvents and presently their application within the ink industry is minimal, alternatives being adopted wherever possible.

## Plasticisers

With the increasing attention given to health and safety standards, comments have been made on the following:

1. toxicity of certain phthalate plasticisers
2. toxicity of diethylene glycol recently removed from certain films

Whilst there appears to be little foundation for the toxicity of certain phthalate plasticisers, such comments nevertheless emphasise the enormous potential effect that health and safety legislation could have on the ink industry.

## Abolition of cadmium and lead based pigments

Whilst these have been successfully phased out this has still presented problems. Cost of heatfast/lightfast yellows has risen significantly whilst the change to organic pigments in the case of the dark colours has resulted in inferior lay.

## Solvent emissions

Unlike the USA, the UK as yet has not experienced any legislative pressure regarding solvent emission, but should this situation change it most certainly would have a marked effect on the packaging industry namely:

1. A move to apply solvent burning techniques

\*Presented at the Manchester Section OCCA Symposium, "Printing Inks and Packaging—Recent Changes and Future Trends", University of Salford, April 1986.



2. A move to waterbased inks
3. A move to solvent recovery

1 and 2 (above) are indicative of the direction the USA packaging converters have taken.

In Italy where the bulk of liquid ink printing is by gravure we have seen a move to single ester based solvent systems in order to facilitate solvent recovery. Regarding the UK such a move is highly improbable as the flexographic printing process is still widely used.

### **Pigment dust**

Regarding future health and safety considerations, pigment manufacturers are attempting to produce low dust pigments by manufacture of pelletised pigment particles. Unfortunately to date such pigment particles have considerable dispersion problems associated with them and often require specialised equipment in order to achieve the required dispersion.

### **Ink manufacturing techniques**

The last decade has seen a change in liquid ink manufacturing techniques with the introduction of pressurised bead mills. These are available in both the horizontal and vertical forms and produce a better quality dispersion than the older traditional bead mills or other types of dispersion equipment such as ball mills.

For the ultimate in transparency the chipping process has remained, but in recent years there has been considerable development by pigment suppliers in the production of "easy dispersible pigments". These pigments are specially treated so as to disperse simply by high speed stirring into the appropriate vehicle.

Despite this ease of dispersion and the subsequent lower manufacturing costs such easily dispersible pigments may not be adopted by the ink maker since in many cases their raw cost can be considerably higher than the standard pigments to the point of outweighing any reduction in manufacturing costs.

### **Printing process advancements**

Whilst the basic processes of flexo and gravure have remained substantially unchanged, the degree of sophistication in press design and ancillary equipment have advanced significantly.

### **Flexo**

*Higher press speeds* have been attained whilst retaining the quality and performance of print.

*Ceramic anilox rollers* have been introduced to provide a more durable cylinder to the conventional chrome plated anilox rollers which can be irretrievably damaged long before their useful life has ended.

*Photopolymer plates* have been available for many years, but only recently have they been adopted on a widespread scale. The major disadvantage in their use from an ink makers point of view is the limitations placed on the ink solvent systems.

*Half-tone printing.* This has continued to rise and fall in application and there are many different schools of thought on the subject. The general consensus of opinion is that good print quality can be obtained provided the proper hardware is available. The economics, however, with longer press set up times are less favourable compared to traditional flexo printing. The final decision of flexo half-tone versus gravure is therefore highly dependent on the equipment and skills available.

*Use of add on gravure units.* These units are placed on the final unit in order to, for example, apply cold seal adhesives in patterned design in register to the face design. Flexo application of these additives has not in the main proved successful.

*Reverse angle doctor blade.* This application is a recently adopted, if not recently developed, flexographic technique and is worthy of some discussion.

The conventional method of controlling ink film thickness is the combination of the metering action of the duct and anilox rollers and also the screen size of the anilox. The duct roller transfers ink from the duct to the anilox, the pressure between the two being capable of alteration to suit the ink viscosity and press speeds required. With such a two-roll arrangement for ink metering, certain disadvantages are apparent.

Demand for higher levels of productivity has meant the building of modern presses, suitable for printing at high speeds on wider web widths. Consequently as the working width of the press increases so the anilox and duct rollers become correspondingly longer. With this increase in roller length we get an increase in the so called "hydraulic wedge" effect caused by fluid pressure forcing the rollers apart. Thus we get a variation in ink film thickness from centre to edge which produces an unacceptable variation in colour density across the web.

Doctoring the ink off the anilox was seen as the answer to the previously mentioned hydraulic wedge problem and specifically reverse angle doctoring as the most suitable for the flexo press. Such reverse angle doctoring is converse to normal doctoring as the blade is positioned to oppose the direction of rotation.

To the ink maker the adoption of the reverse angle doctor blade with its superior wiping characteristics, meant modification of the previously adopted flexo inks. For example:

1. The ink film thickness is reduced hence stronger inks were required.
2. Reduction in the ink film thickness also tends to result in lower gloss, therefore a high solids/low viscosity ink system was required, to enable sufficient resin solids to be deposited to maintain gloss.
3. A closer study of wettability of inks in relation to aniloxes, printing plates and substrates was necessary to ensure sufficient feed up of ink through the roller train and the formation of a sharp dot on contact with the substrate.

One example of where the application of the reverse angle doctor blade is vital is the area of high quality half-tone and type work on flexo packaging. Without precise control on the amount of ink deposited on the relief dots which form the illustration, any excess ink will end up in the

valleys between the dots, causing dirty print. Similarly too little ink application and the dot will not print out completely, either way tonal variation will occur.

### Gravure

Changes in the gravure process have tended to be less dramatic but factors affecting the ink maker are:

1. Higher press speeds.
2. Use of Helioklischograph engraving, giving a different cell structure to conventional and acigraph process.
3. In line lamination facility on the same press.
4. Increased use of the final unit for PVDC coating and cold seal adhesive applications.
5. Extended drying hood to cure acid catalysed lacquers.
6. Offset gravure.

### Offset gravure

Offset gravure is by far the most recent gravure development and as such I will discuss it in some detail.

In conventional gravure printing the ink is deposited from the engraved cell directly onto the substrate. The ink laden cell being evacuated by the partial vacuum created at the impression nip, where the substrate and engraved cylinder are brought into contact under pressure.

In contrast with offset gravure printing, the image is first printed onto a rubber plate or 'blanket', which is then brought into contact with the substrate on which it is intended to print.

The modern approach to offset gravure uses a flexo press configuration enabling certain significant differences between offset and direct gravure to be exploited for particular sectors of the packaging market.

The factors which might lead a converter to select the offset gravure process are as follows:

1. Increasing demand for detailed illustrations on short run length packaging, where the cost of full gravure origination is not justified.
2. Necessity to print designs embodying process work where the pack size or design format changes frequently, e.g. when special offers, competitions, etc. are printed on the pack.

The possibility of combining on a single press, offset gravure units for process work and flexo units for line work, means that, providing a standard illustration is acceptable, several different pack sizes can be printed by merely changing the line work which is printed flexo.

If necessary sections of the gravure design can be omitted simply by cutting away the blanket in the appropriate area, thus enabling special offer flashes to be inserted using flexo plates.

Finally the flexo configuration of the press means that the web path between first and last print unit is shorter than on a conventional gravure machine. This means that register is more rapidly achieved than on a multi-unit gravure press, the net result being a decrease in the amount of film wasted each time the press is stopped and started. Furthermore surface tension properties of the inks must be studied to ensure optimum cell evacuation and optimum dot retention

on the blanket.

Despite its limited application offset gravure may well grow in usage since it offers the smaller converters close to gravure print quality without the substantial investments required for direct gravure equipment.

From a technical point of view the main differences between direct gravure and offset gravure lie with the following:

1. *The engraving of the gravure cylinder.* In the offset process, cell evaluation is more efficient by virtue of the better pliability and receptivity of the rubber blanket compared to most substrates. Thus for a given cell volume more ink is delivered by offset than when printing by the direct method. The engraver may therefore consider it necessary to reduce cell depth or use a finer screen in order to compensate.
2. *Ink technology.* The presence of the intermediary transfer roller means that the ink must remain "open" longer than is the case with direct gravure. To the ink maker this has called for careful attention to the solvent balance of the ink, in order to produce the correct drying rate at the printing stage, whilst not impairing the solvent release characteristics when solvents have to be removed in the drying hoods.

### Packaging methods

Packaging serves two fundamental purposes:

1. To promote an attractive package to the potential customer
2. To provide an effective means of storage for the goods

The increase in turnaround in modern day supermarkets has decreased shelf life requirements and this, together with the effects of oil prices, and the general economic climate, has caused many packages to undergo a change of style and more often than not a change also in substrate.

Examples of such changes are particularly apparent in the area of snack foods and confectionery goods.

### Flow wrap process

Traditionally heat seal techniques were employed but due to the faster packaging speeds required, cold seal has superseded it.

### Corrugated board paper

Recent years has seen the adoption of two distinct types of corrugated packaging.

1. The traditional corrugated transit pack with minimum print area which can be stacked, stored and then discarded after individual products are displayed.
2. The more recently produced quality corrugated pack primarily used for transit protection, but also to attract the customer at the point of sale. This pack will conform to both the high standards of presentation required by retailers and at the same time be an effective advertisement for the contents of the pack.

In the second application, reels of coated liner are printed on a reel to reel flexo press which in turn are

laminated on a corrugator to the base kraft flute. This process provides the facility of improved graphics compared to flexo printing direct on sheets of corrugated board. With the increased adoption of this type of package, waterbased inks specifically for the pre-print market have been given much attention by the ink maker, and this is discussed later in this article.

### **Date stamping**

With legislation making it compulsory for all perishable goods to bear a sell by date, converters and ink makers have investigated to the full, various date stamping techniques, namely:

1. *Laser beam.* A technique which uses a CO<sub>2</sub> laser attached to a microcomputer which burns through the ink, but not the substrate, leaving a reversed out image of the sell by date. Generally speaking this method is not adopted due to the high capital expenditure required in setting up.
2. *Ink design.* Ink lift off for example was the adopted method for original Mars bar wrapper on brown glassine, where the red ink is lifted from the gold ink by a hot die, leaving the date as shown in gold lettering. For this method the red ink must be very brittle in order to facilitate easy removal from the hot die prior to the next impression. A second method is available which also relies on a similar hot dye stamping process. In this case we get no cleaning of the hot die prior to the next impression, thus it is necessary for the ink to be soft in nature in order to be pushed to one side without sticking to the hot die.
3. *Ink printing.* Relief printing uses a raised image printed by a crude flexo process and for the older members of the congress my superiors inform me is akin to the old John Bull printing kits. Jet printing facilitates the use of different coloured dye based inks applied in the packaging process.

It should be noted that both the laser beam and ink design methods involve no ink application at the time of packaging and as such the product runs no risk of contamination by residual ink. However, for reasons such as financial and ease of application, converters are today tending to adopt the ink printing methods, particularly the relief method.

For such a technique to be successful the ink maker has to take care in ink selection in order to render the print date stamp receptive, whilst still meeting all the other desired properties. For example where inks are required to give cold seal release the traditionally applied polyamide inks require modification in order to accept a date stamp administered by the previously mentioned relief process.

### **Flexible packaging substrates**

Flexible Packaging Converters use many different types of substrate, some of which are as follows:

1. Paper (coated/uncoated)
2. Board
3. Aluminium foil
4. Cellulose film (NC coated/PVDC coated)
5. Polypropylene films (PVDC/Acrylic coated)
6. Polyethylene
7. Polypropylene (co-extruded/orientated)

8. Polyester
9. Nylon
10. PVC
11. Polystyrene
12. Metallised substrates.

The discussion will concern those substrates which have seen the greatest change in terms of usage and in ink advancements, namely:

- Regenerated cellulose acetate films
- Coated/treated polypropylene films
- Metallised films
- Paper (pre-print)

### **Regenerated cellulose acetate films**

The cellulose film market has suffered greatly over the past decade due to the high energy costs in its manufacture, and has been replaced in many areas by various polypropylene grades available at lower gauges. Despite the fact that the polypropylene films are dependent on oil feedstocks for the basic materials, the energy requirements for conversion are considerably lower and hence for the same weight it is a much more economical proposition.

### **Coated/treated polypropylene films**

The co-extruded polypropylene film market has probably been the largest growth market in the late seventies, particularly in the snack food business.

So far the eighties has seen substantial growth in the printing of opaque/pearlised polypropylene films coated and uncoated. Such materials have the unique property of being able to prevent fat "show through" where the product and film are in direct contact. This property has led to their adoption on numerous biscuit and chocolate confectionery goods, either as heat sealable materials in their own right or as bases for converter applied cold seal and PVDC lattices.

Developments are tending towards lower density materials than are currently available. Whilst these materials may give similar protection there could be some difficulty experienced in sealing at the ever increasing packaging machine speeds required by the industry. However, as will be discussed later this sealing problem could be overcome by the application of cold seal adhesives.

### **Metallised films**

Whilst metallised films are currently being used in both single web and laminate forms for the packaging of snacks, crisps, confectionery goods etc., the growth has been modest even though longer shelf life performance has been proven. The reasoning behind such a modest growth rate is that variation in the nature of the surface is observed on ageing.

Causes for this change are:

1. Migration of additives from the base film to the metal surface.
2. Oxidation of the aluminium.
3. Poisoning of the aluminium by the back of the film or paper.

Despite improvements in metallised film stability the ink

maker still cannot give a binding guarantee that the properties of the printed material will not deteriorate on ageing or that variation will not be seen from reel to reel of a particular metallised film.

## Paper

As mentioned earlier in my lecture the change in the construction of the corrugated box has seen considerable growth in the area of pre-print paper. The advantage being in the quality of the print resulting, due to the superior registration/graphics by printing prior to lamination and corrugation.

## Liquid ink developments

I have indicated previously how packaging methods have changed over the last few years, so now I will discuss the areas which I feel have seen the greatest development or are in the process of development, namely:

1. Cold seal adhesives
2. PVDC overlacquer/heat seal inks
3. Waterbased pre-print inks
4. Waterbased inks
5. UV inks/lacquers
6. Newspaper inks

### 1. Cold Seal Packaging

Packaging methods in the area of confectionery goods has seen the application of glassine, paper in general, polythene coated paper, paper backed foil, foil and heat seal films for wrappers.

In general three methods of sealing were available to the converter, namely:

*Heat seal.* Whilst heat sealing satisfied the requirements for flow wrap packaging the demand for higher quality and cost reductions created a few problems.

1. When the filling line stopped, chocolate near the heat seal jaw was damaged.
2. Such heat seal machinery was complex and often prone to break down.
3. Packaging speeds were limited due to the dwell time required for heat sealing.

*Glue Seal.* For obvious reasons the glue seal has the requirement of being applied at the packaging stage and thus packaging speeds are limited.

*Dead Fold.* Limits both packaging speeds and, by virtue of its non-sealing characteristics, runs a high risk of contamination and so limits its application to certain confectionery goods.

Unlike the previously mentioned sealing techniques, cold seal is applied at the printing stage so invariably faster packaging speeds are obtained than with the standard methods. Cold seal adhesives are normally applied by the gravure process, although flexo printing has been employed. The adhesive is applied in line on the reverse side of the printed film before re-reeling.

A modern cold seal adhesive formulation would generally comprise of:

Natural rubber latex  
Synthetic resins  
Stabilisers  
Defoamers  
Wetting agents  
Preservatives

the combination of which creates an adhesive with sufficient adhesion to the substrate, but still retaining enough of the latex properties to seal to itself.

Note many grades of cold seal are available today, ranging from "hard to soft" as depicted by their inherent tack. This variation in tack is important when one considers the ink/lacquer release properties required.

Indeed cold seal applications give the ink maker a few problems to face, namely:

1. The ink/lacquers must not set off in contact with the cold seal and must allow for easy unwind.
2. Additives from the ink/lacquer must not migrate into the adhesive and hence cause loss of bond strength on sealing.
3. The lacquer must protect the base substrate as this will cling strongly to the adhesive.
4. Metallic pigments will react with the adhesive and cause poisoning of the cold seal, hence their protection by application of cold seal release lacquers.
5. Care must be taken to prevent contact between cold seal and dye based inks as dye bleed could result.

In order to overcome some of these problems, the ink systems traditionally used have utilised a polyamide release lacquer, the major problem being the odour developed by the interaction of the lacquer and adhesive. Fortunately such problems have been eased both by lacquer developments and on certain designs by omission of the lacquer altogether, by building release properties into the ink itself.

### 2. PVDC overlacquer/heat seal inks

For many years the use of PVDC coated films or the application of PVDC overlacquers has enabled the converter to achieve the end result of a heat sealable package. Indeed PVDC overlacquer facilitates the adoption of a variety of seals, namely:

1. The end seal where a bunch seal is often adopted, which can comprise of any or all of the following seals, that is A to A, A to B or B to B.
2. The lap seal where the film overlaps itself so that we get an A to B seal.
3. The fin seal where the film seal is a B to B seal sometimes with an additional A to A tack down seal.

This facility to produce a low pressure seal is the primary reason for adoption of two sided PVDC coated wrappers for biscuit applications, where the products are delicate and often given rise to a series of high and low points.

Having discussed the applications of PVDC coatings it is worth mentioning a very recent development which involves the use of heat sealing inks with the elimination of the PVDC overlacquer. The inks are specially formulated to give good ink to ink bonds as well as good seal integrity to the film coating, which may be acrylic or PVDC based. Such an ink system requires a careful balance of skill in the



formulation, since as well as heat sealability, good heat resistance is also essential. High gloss inks are also imperative to achieve a similar visual appearance to a PVDC coated pack.

The advantage of such an ink development is that it can eliminate a process if the PVDC is applied by a separate air knife coating operation. Alternatively even where PVDC is applied by the gravure in-line process, it eliminates this relatively difficult application which normally will also reduce the maximum press speeds obtainable.

### 3. Waterbased pre-print inks

In the last few years improved print quality has been demanded by the corrugated case buyer as point of sales cases for many household products. The quality standards have been achieved by the combined efforts of all those involved in the flexographic process, namely the press maker and the plate maker and last but not least the ink maker.

To the ink maker the growth of the pre-print market has meant the following parameters have had to be met:

*High solids.* Where waterbased inks are printed on stocks with low ink absorbency or penetration, inks higher in resin and pigment solids are applied. This allows a thinner ink film to be applied and thus reduces any drying problems that may have been experienced.

*Inks to be non-flammable.* Printers involved in printing corrugated cartons have always used waterbased systems, hence equipment is non-flameproofed.

*Inks must have good heat resistance and rub resistance.* In order to pass through a corrugator without marking.

*Inks must possess good gloss.* Since the pack will be displayed at the point of sale an attractive package is essential.

As far as the post market of pre-print liner is concerned in 1984 the usage of liner was estimated to be around 72m. sq.m of board which is equivalent to 12,000 tonnes of liner (see table below).

	M.S.M. Liner	% Change
1979	2.5	
1980	4.0	+ 60.0
1981	10.0	+150.0
1982	18.0	+ 80.0
1983	40.0	+122.0
1984	72.0	+ 80.0

Regarding the future market for pre-print liner the table below shows forecasts as given by Mr M. Palmer at the 1985 Torquay Corrugated Conference and indicates that the UK liner usage could show significant growth.

	M.S.M.	% Change/Annum
1984	72.0	
1985	115.0	+60
1986	150.0	+30
1987	175.0	+17
1988	200.0	+14
1989	220.0	+10

With this predicted grown (M. Palmer, Intl. Pap. Board Ind. May 85) in pre-print work will undoubtedly come greater demands on the ink maker and printer alike.

### Waterbased inks

#### Why waterbased inks?

There is no doubt that legislative pressure in the UK, Europe, the USA and elsewhere, will bring about demand for inks which will give a reduced level of organic solvent emission to the atmosphere. Admittedly, waterbased inks are not the only option available, some converters in the USA minimise such organic solvent emission by employing the use of burners, alternatively others adopt solvent systems in combination with suitable solvent recovery systems.

In theory, the advantages for the waterbased inks approach are:

1. Low odour
2. No retained solvent
3. No fire hazard
4. Economies may be obtained by using water as a reducer and cleaning solvent both for price and availability
5. No solvent attack on stereotypes
6. Improved press stability

In practice waterbased inks can show some press instability. The reason behind such a statement is that despite the minimal solvent evaporation loss from the ink duct, amine loss may cause similar problems to those experienced by solvent systems. This is because many of the acidic waterbased resins are rendered water soluble by the addition of a volatile amine, and on loss of such an amine the resin begins to precipitate and problems with ink stability and print quality can be observed.

From an economical point of view waterbased inks can arguably prove more expensive than some solvent based inks due to the limited number of quality waterbased resins and pigments available and hence their premium price. This is likely to remain the situation until such time that demand for waterbased inks is equal to that of their solvent counterparts. In fact without this pressure and with the continuation of the present depressed economic circumstances it could be argued that there is little incentive for printers and converters in the UK to investigate alternative products, at least in the near future, unless real technical advantages can be offered.

So let's examine where waterbased systems can, and in some cases have been, used in the UK and take a look at the reasons why it is desirable.

1. *Lacquers.* This has been the greatest area of penetration in the UK. Gloss single pack systems are in regular use on paper for chocolate wraps, where previously a polyamide lacquer was adopted. Advantages are:

- Higher gloss
- No rewetting of the base inks
- Lower retained solvents
- Low odour of finished print

Polyamide overlacquers possess a characteristic odour and prints on such lacquers often give rise to oxidation odours. However, with waterbased inks, by careful selec-

tion of the resin used, we can reduce this initial odour and totally eliminate the problem of oxidation odours with the final print.

Another development presently in use is that of water-based acid catalysed lacquers. They are now available and have the advantage of eliminating the aromatic hydrocarbon present in the corresponding solvent systems. The main problem with such a system is that it is essential to remove the water before cure takes place, otherwise "blistering" will occur. This is where the curing system cross links, only to have the surface structure penetrated by escaping water. Hence dwell times can be longer than those required for solvent systems.

Despite the development in microwave or the less costly Radio Frequency drying techniques, to date their application to waterbased inks has proven unsuccessful. The main reason is that for printability purposes, modern waterbased inks contain a small percentage of alcohol. Thus on the application of RF drying techniques we not only run the risk of ineffective drying but also of solvent flashing. Similarly the presence of some metallic pigments and carbon blacks have been known to cause arcing. In my opinion superior drying techniques revolve around:

"Improving the hot air circulation by modification of the presses to reduce moisture build up, thus improving both interunit and final drying".

2. *Inks for absorbent stocks.* Gloss and rub resistant inks are available for flexo printing of absorbent stocks and these have been used to a limited extent in production in place of solvent inks. The quality of the result is, as with solvent inks, dependent on the stock.

3. *Inks for film.* On film, waterbased systems again have been used primarily flexo on reverse print designs where gloss is of no importance. If a complete waterbased system is adopted, slower press speeds are necessary and hence the use of a single layer of waterbased inks with the remaining inks solvent based being preferred.

This latter approach can be usefully adopted for lamination work where waterbased inks and solvent based adhesives are used, the combination of which results in minimal ink rewetting, and hence lower retained solvent levels and thus higher laminating bonds. Despite my indications that waterbased inks have most certainly progressed over recent years, I feel it is fair to state that progress is slow in comparison to the USA due to the lack of commitment from the UK printing ink industry.

#### UV inks/lacquers

One of the major alternative means of solventless systems is UV curing. In order to show the advantages and disadvantages of such a move it is worth taking a typical lithographic ink and comparing it with a flexo/gravure system. The litho ink generally is made up of the following:

- Pigment
- Oligomer
- Diluent
- Photoinitiator
- Additives

The diluents normally used are considerably higher in viscosity than a normal flexo/gravure ink thus a true diluent in the form of a monomer is necessary. However, for com-

parable print quality the UV ink can, provided its flow out is satisfactory, be run at higher viscosities due to its very good press stability. This press stability is not a feature of flexo and gravure inks where the viscosity of the ink as it leaves the stereo or etch is considerably higher than the pre-press viscosity.

The major problems with the concept of UV curing on flexible packaging substrates are:

1. In achieving such low viscosities by the addition of a true curing solvent, for example monomer, with its much lower molecular weight, the cure rate is considerably reduced due to the difference in photoreactivity between the UV resin and the monomer.
2. The degree of crosslinking is lower with the presence of monomer and there is the possibility of monomer remaining uncured and trapped in the ink giving rise to 3.
3. Odour and taint are increased.
4. Toxicity and handling becomes a cause for concern.
5. Wet on wet printing—the standard litho printing process relies on tack differences between the two layers of inks for printability prior to curing. However, with the application of low viscosity UV inks or lacquers printed wet on wet, ink rewetting and ink pluck off would occur.
6. Ink flow out is often inferior to conventional flexo/gravure inks.


As far as the future of UV coatings for flexible packaging substrates is concerned I believe the anticipated route to be one of conventional flexo/gravure inks overprinted with UV lacquers.

#### Waterbased newspaper inks

Currently most development work is performed abroad, for example in the USA, Italy and Germany, where printing press developments are making the greatest advancements. Admittedly development work in the UK is in its infancy, with ink makers investigating novel ways of manufacturing inks which meet the following basic requirements:

- High press speeds
- Low cost
- High strength
- Good ink penetration/ink drying
- Excellent rub resistance

I have no doubt that by next year there will be more developments in this area.



**OCCA CONFERENCE 1987**

Details of the lecture programme for this important OCCA-sion are given later in this issue. Further copies of the registration brochure can be obtained from Priory House. Photostats of the registration form (both sides) would be accepted but must be accompanied by the appropriate remittance.

# Non-impact printing technologies, an overview\*

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## Summary

During the last few years significant advances have been made in the technology of non-impact printing. This paper seeks to describe the five competing processes, outlining their method of imaging and underlying technology. A brief description is given of the latest equipment on the market. Inks and toner requirements for each of the processes are discussed.

Non-impact printing is classified into five areas—ink jet, thermal, electrographic, electrophotographic and magnetic printing. Of these systems ink jet stands unique; in that in this process only the ink makes contact with the substrate. It is less than ten years since a marketable ink jet printer was made available by IBM. This was the 6640 continuous jet printer for the OS-6 Word Processor. In 1985 more than 50 companies were known to be concerned with ink jet development. There are two main types of ink jet printer; the continuous jet and the drop on demand.

In the continuous jet water based liquid ink is forced at high pressure through a small nozzle. The stream of ink breaks up into small droplets. The droplet stream passes through a charging field which imparts a charge on each droplet. The stream of charged droplets passes between high voltage deflection plates. By varying the voltage on the plates the stream of droplets is steered onto the substrate into the desired shape or pattern. The unused droplets are caught and recirculated (see Figure 1).

The drop on demand or impulse jet uses Piezo electric transducers to stimulate a uniform drop system. The Hewlett Packard "Think Jet" uses thermal excitation through 12 nozzles to print a dot formed character. The print head is replaceable and will print 500 A4 pages of text at 150 characters per second. The replaceable print head costs £8 (see Figure 2).

Ink jet can be used to print any information stored in a digital form, text, illustrations, charts and graphs in black and white or colour.

An example of a colour ink jet printer is the Hitachi Koki microdot printer. This is a four colour device which has a resolution of about 430 d.p.i. Hitachi also has an experimental 1,000 dot per inch version.

Applications other than hard copy output from computers include—textile printing, carpets, posters, wall coverings and ceramics. If one looks at the colour reproductions produced by Cambridge Consultants Ltd., one can see that ink jet has potential as a colour proofing output from Electronic Page Composition systems. This is seen in the Iris Graphics 2024 colour ink jet printer which is designed to produce high resolution pre-press proofs in the four standard colours. This is a continuous jet system 240 d.p.i. producing an image in full colour at a rate of 1 square inch per second. A 34 x 44 inch page takes between eight and 30 minutes depending on the resolution required. The

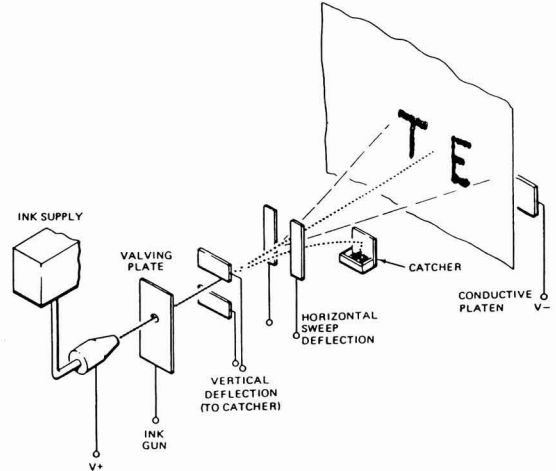


Figure 1. Ink Jet Continuous; Winston (Teletype Inktronic) system.

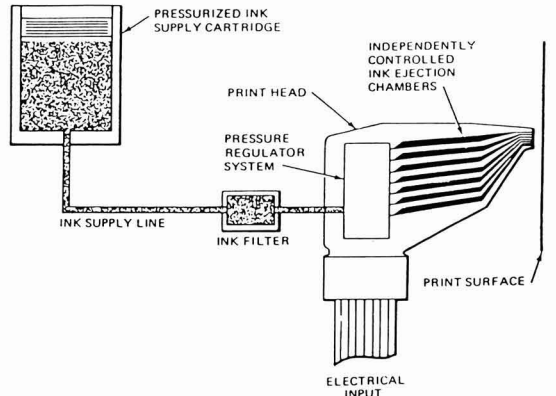


Figure 2. Ink Jet Drop on Demand; diagram of a Silonics printer. cost however is in the region of £85,000. This machine will be available in the U.K. later this year.

Thermal printing is a rapidly developing technology, almost everyone is familiar with thermal printers which use heat sensitive paper. Over the past few years, however, transfer systems have been developed using heat sensitive ribbons. The ribbon is between the plain paper and the printhead. Heat is generated at the printhead by a pulsed electrical charge, which melts the ink on the ribbon, the ink then transfers to the paper. The IBM quietwriter uses a resistive ribbon which itself is the heated element. The thermal head is replaced by a current conducting stylus array. Current from the styli pass through the resistive layer causing localised heating which melts the ink allowing it to

\*Presented at the Manchester Section OCCA Symposium, "Printing Inks and Packaging—Recent Changes and Future Trends", University of Salford, April 1986.

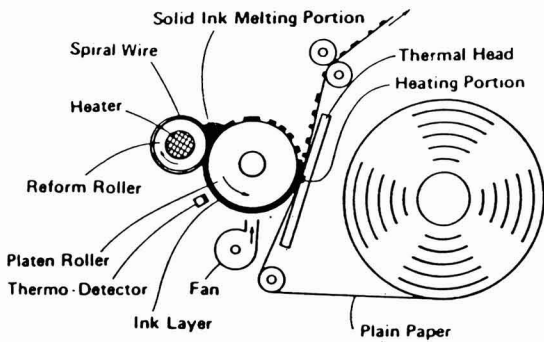


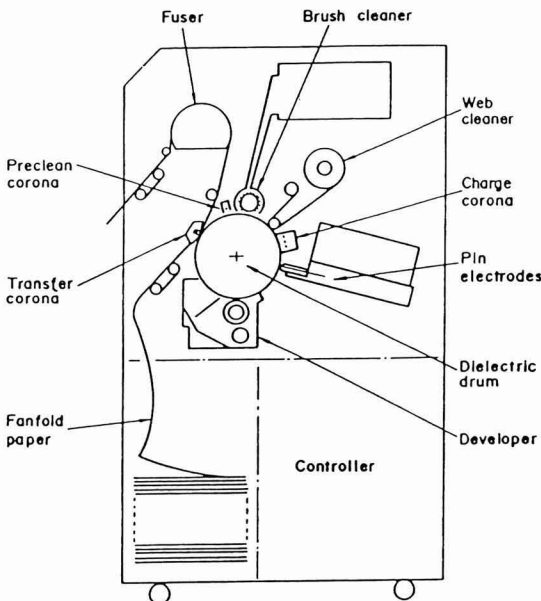
Figure 3. Thermal transfer; cross-section of thermal ink transfer printing mechanism.

transfer to the paper. Printing speeds are approximately the same as drop on demand ink jet. Colour printing is also possible by thermal transfer with machines manufactured by Mita, Mavica, Matsushita, Sharp, Minolta and Oki Electric (see Figure 3).

The Mavica "Mavigraph" was developed to produce colour prints from the Mavica electronic camera, future applications include Teletext and Facsimile colour printers for transmitted data. The high resolution machine announced by Matsushita in May of last year has a resolution of 400 dots per inch on a print line length of ten inches. This machine will produce an A4 page in full colour in under two minutes. Oki Electric's colour printer incorporates a system for re-colouring the ribbon thus giving a continuous process. The claim for this printer is 220 d.p.i. producing an A4 page in 50 seconds.

The Mita TP-7000 thermal transfer printer prints with 4 colours on plain paper at 50 seconds/A4 page, using a three or four colour ribbon.

Figure 4. Electrostatic; Fujitsu 3,000 line/minute plain paper electrostatic printer, Fujitsu FY-3.



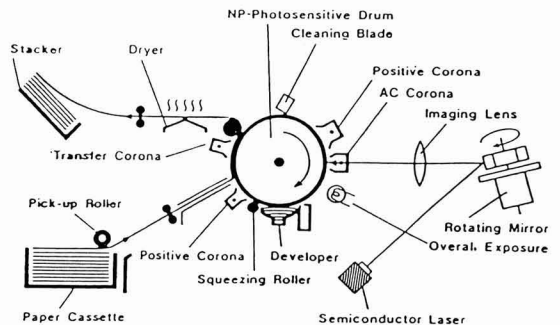
Electrographic printing is the non-impact process which produces graphic images directly from electrical input without changing the input into another form of energy (see Figure 4). The Versatec colour plotter writes an electrostatic latent image onto a dielectric paper, this image is then toned. A 30 x 40 inch four colour plot with a resolution of 200 d.p.i. takes two minutes 45 seconds. Benson recently introduced a plotter that will produce a 36 x 30 inch four colour plot in one minute 40 seconds.

Calcomp has introduced a colour electrostatic plotter in competition to these two. It can produce drawings up to 500 feet long with a plot time of five to nine minutes and a possible 1,024 colours. It uses a four pass process which places black registration marks along one edge during the first pass when black plot data is also recorded. This differs from Versatec, who use a preliminary pass to put registration marks along both edges, and the Benson system which plots registration marks followed by all four colour data recording in a single pass.

The ion deposition method used in the Delphax machine has an ion projection system which produces an image on a dielectric drum. This electrostatic latent image is developed by a toner from a magnetic brush. The image is transferred and fused to plain paper by a high pressure nip. Printing speeds vary with "print engines". The C-Itoh 30 page per minute unit is an office printer, with a resolution of 300 d.p.i. and is designed to be connected to a P.C. such as the IBM. Xerox (who, incidentally have a 50% share in Delphax) have just announced a 60 page per minute machine. Up to 120 ppm have been claimed on web fed machines. IBM announced a new development at Print '85 in April in Chicago. From a multilayer material on a Mylar base the IBM 4250 electrographic printer will produce, by an electro-erosion writing process, a negative suitable for making litho plates. This foil negative may also be used as a short run offset plate without further treatment. This direct step from the computer to the offset machine must be of interest for on demand publishing.

Electrophotographic printing has developed directly from the office copier so well known to all. Everyone in our industry has "laser printer" in their vocabulary. The basic configuration of an electrophotographic printer is a photoconductor (either drum or belt) corona chargers, an image forming device which may be a CRT, light switching array, scanning laser beam, LED or LCD array, a toner and a fusing unit (see Figure 5). The laser LED and LCD machines are full page printers with output speeds varying from 6-8 ppm, for the low cost machine, up to 60-80 ppm at the very high cost end.

Figure 5. Electrophotographic.





It is being argued that phototypesetting as we know it today may not survive through the 1980's. Plain paper typesetting is here now. Tegra's Genesis front end systems controlling an LBP 5-480 produces camera ready copy.

Data Recording Systems (DRS) have developed laser-scribe, and output device for connecting to existing R.I.P.'s 15 ppm (8.5 x 11 inches at 400 d.p.i.) is the proof output speed but is capable of producing camera ready A3 pages at 800 d.p.i. in 32 seconds.

Xerox has two new laser printers for in-house or on-demand publishing. The 4045 Laser CP. Its specification is impressive—300 d.p.i., 10 ppm, two type fonts, 36 optional from plug in cartridges and a further 90 downloadable fonts. Its selling price in the USA is \$4,995. The upmarket printer selling at \$29,995 has an output of 24 ppm at 300 d.p.i. A 10 mb Winchester font store links to other Xerox front end systems via ethernet.

Colour by electrophotographic printing is quite a problem but considerable research is taking place in this area. Toshiba announced a prototype plain paper three colour printer in May of last year. The heart of the system is a three layer photosensitive drum exposed by three semiconductor lasers to create three latent images. A non-magnetic toner is applied in a three stage cycle of exposure, toner, fuse. A commercially available colour laser printer is the Colorocs printer which has a resolution of 300 d.p.i., four colour toner development, four pages per minute in full colour mode and the price is between \$15,000 and \$19,000. An input scanner is expected to be offered as a companion piece allowing the printer to act as colour copier. A number of companies announced colour electrophotographic printers at the CeBIT Fair in Hannover last month.

Also at CeBIT Panasonic displayed a laser printer with a new micro magnefine toning process which is capable of resolutions of up to 500 d.p.i. (the highest yet achieved by this process) via video signal communication.

Clearly, the laser printer offers a logical output system for networked information.

Magnetic printing has been slow to develop due to manufacturing problems. The making of high density writing heads has been a difficult problem to overcome. The technology has a number of points in its favour the use of magnetic recording, which is a well understood technology, coupled to the fact that it is possible to create the image over a wide time scale. (Photoconductors have only a limited image retention capability) and, finally, thousands of copies can be printed at high speed from a single magnetic image.

Bull Peripheriques have recently (June 1985) announced a magnetic printer which has an output speed of 50,000 lines per minute. This means 500 pages per minute. When this machine comes onto the market it should make a significant impact on computer driven printers (see Figure 6).

The ink used in an ink jet printer has to adhere to a number of strict requirements. In formulating the ink the following conditions must be achieved. The ink must dry quickly after the printing process but not in the printing apparatus or in flight. The surface tension and viscosity must be well controlled due to the fluid dynamics of the

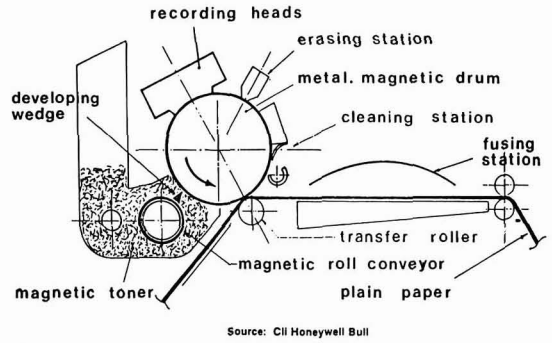


Figure 6. Magnetic; CII Honeywell Bull printer cross-section.

system. The result must be light fast. In some products the ink must be electrically conductive and of a stable electrical conductivity.

In achieving these conditions the following requirements must be borne in mind. Any solid impurities or particles must be very small compared to jet, nozzle and orifice size. Any other activity, either chemical or biological must not be allowed to clog the jets. No air bubbles can be allowed to form. The ink formulation must be compatible with materials used in construction of the product to avoid corrosion and/or ink contamination.

A typical ink formulation will consist of a suitable vehicle, a colour additive, a bactericide, a fungicide, a humecant and an additional acid or alkali for a pH adjustment. When printing on non-absorbent material it is usually necessary to employ an alcohol vehicle, however when printing on paper a water based vehicle is normally used.

For a continuous ink jet system recirculation of ink is likely to occur about 40 times (i.e. 2% of the ink is deposited, 98% recirculated). Therefore, a comprehensive filtration system is necessary and filter clogging has to be minimised to maintain constant flow rate. Possible causes of clogging are dye solution instability as pH drops, due to absorption of carbon dioxide from air, biological growth due to constant exposure to air and contamination due to corrosion of parts and dust particles. The first two of these can be overcome by the use of suitable additives, while the last one can be minimised by careful design.

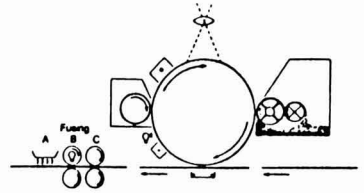
In drop on demand systems no recirculation takes place and the main problem is clogging at the printhead due to evaporation which occurs when the system is not in use. This was found to be more of a problem with water based inks. Oil based inks as well as being non-volatile are rapidly absorbed into the paper giving better dot shape, however, their disadvantages are low surface tension and high viscosity.

The hot melt inks and the equipment for using them have aroused a great deal of interest. These inks, solid at room temperature and heated to fluidity for use, "dry" or "solidify" very quickly on paper. Excellent dot shape, contrast and edge definition have been achieved with these inks.

In direct thermal printing a coated paper material is heated to produce a colour change. The coating contains a

Two-component dry toning process is the standard bearer for units made by Xerox, IBM and a host of others. It operates with most plain papers, and is known for generally excellent copy quality and good maintenance characteristics. Its name derives from the fact that it utilizes two chemicals to make a copy—a toner and a developer.

cles to the paper; (5) toner particles are fixed to the paper in the fusing station using one of the three methods shown; and (6) the PC is cleared of untransferred toner particles and discharged of any leftover electrical charge, so the cycle can begin again for the next copy.



The process begins much like LTT technology: (1) an electrical charge is applied to the photoconductor; (2) latent electrostatic images are formed by exposure of the original onto the PC through an optical lens system. The charge remains only on the "image" areas of the PC; (3) the photoconductor rotates to a magnetic brush developer station where toner particles migrate from the brush to charged areas of the PC; (4) as the PC rotates, the paper passes between it and the transfer corona which transfers toner parti-

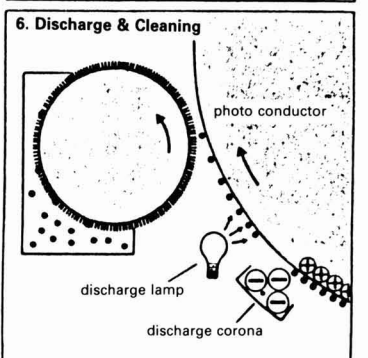
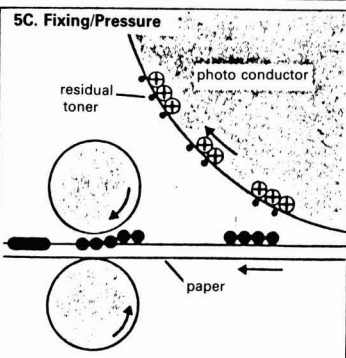
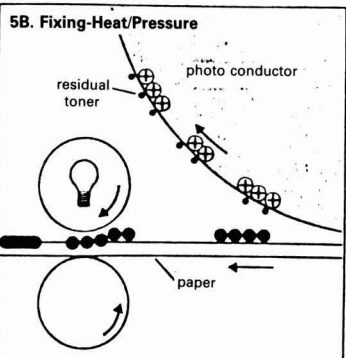
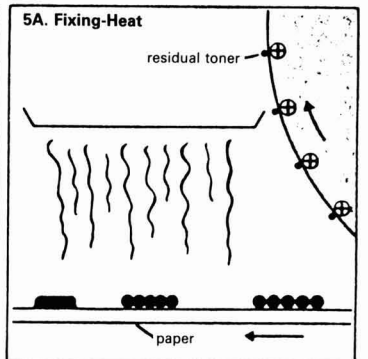
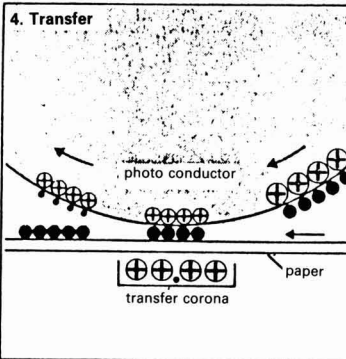
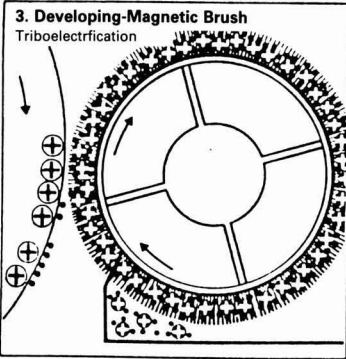
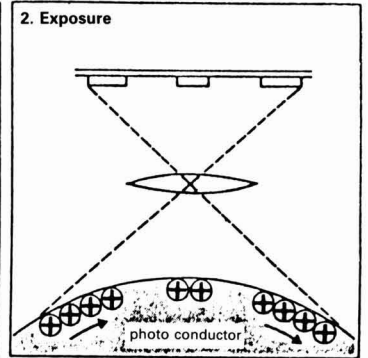
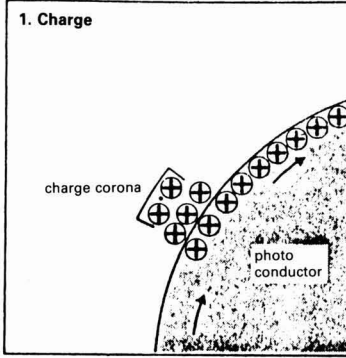


Figure 7. Two component dry toning process.

dyestuff and a phenolic colour former suspended in a solid binder. At a critical temperature the binder melts allowing the two components to flow together thereby creating a colour change through chemical reaction between the two components. In thermal transfer the coating components are basically the same as in direct thermal printing.

Electrographic, electrophotographic and magnetic

printers all use toners to produce the final image. The toner particles in magnetography are not so tightly held on the media and have a slightly different composition.

Three kinds of toning process are in use today. Liquid, dry two component and dry mono component. Liquid systems employ a dispersion of fine (0.1 to 1.0 micron) particles in a dielectric liquid, such as the petroleum

Mono-component dry is one of the newest toner technologies—and may offer longer term solutions for providing a simple and reliable method for plain paper copying. The system offers the potential for more consistent copy quality than two-component toning systems.

The technology employs the same seven basic steps as in the dry two-component process except it utilizes no separate developer component: (1) an electrical charge is applied to the photo conductor; (2) latent electrostatic images are formed by exposure of the original onto the PC through an optical lens system. The charge remains only on the "image" areas of the PC; (3) the photo conductor rotates to a magnetic brush development station where toner particles migrate from the brush to charged areas of the PC; (4) as the PC rotates, the paper passes between it and the transfer corona which transfers toner particles to the paper; (5) the toner particles are fixed to the paper by either pressure or heat and pressure; (6) the PC is cleared of untransferred toner particles in the cleaning station and discharged of any leftover electrical charge, so the cycle can begin again for the next copy.

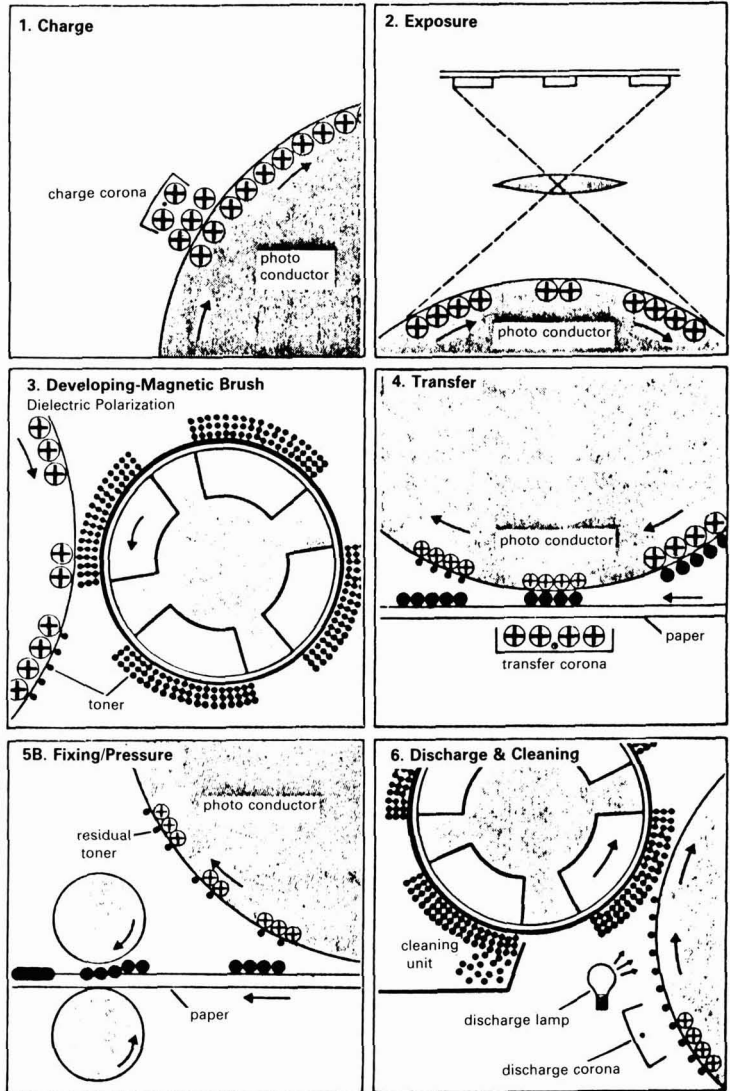
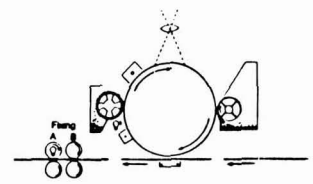


Figure 8. Mono component dry toning process.

derivative known as "isopars". The particles are an agglomerate of carbon with polymeric material and they are charged by including a special charge agent in the formulation. The surface bearing the charge pattern is passed through a tank of the liquid developer and the oppositely charged toner particles are attracted to the image area, a squeegee roller then removes excess liquid and then the image is transferred to paper by the transfer corona.

In dry two component systems the developing material is made up of the toner powder and a carrier, the latter being spherical beads which are much larger than the toner particles. The toner particles will usually constitute about one per cent by weight of the mixture. One function of the carrier is to charge the toner particles by triboelectrification. The carrier beads are coated with a material which is selected to promote charge transfer. They become coated with a monolayer of toner particles, due to

electrostatic attraction. The coated carrier is brought into contact with the charged image carrier where the toner breaks free from the carrier beads and adheres to the image pattern, it is then transferred to paper (see Figure 7).

The most recent developing system to become available is the single component magnetic brush. In this system there is a toner powder but no carrier. The simplification is achieved by using a different method for charging the toner particles. Charge is induced in them by the electric field of the electrostatic image charge. This is made possible by using toner with a relatively low, controlled electrical resistivity. The conductivity and magnetic permeability required are attained by incorporating ferrites in the toner powder. When a brush of such powder is suspended by a

grounded magnet over a charged latent image pattern, the toner at the tip of the brush is charged inductively then attracted to the charged areas of the pattern (see Figure 8).

The technology of NIP is developing at a furious rate. Non-impact printing has, to some extent, met with the market barriers. However, it is known that the European Commission is examining the effect of noise in the workplace. It is a widely held opinion that new legislation will be enacted, making a noise level of 55 db, the maximum allowable by law. The average impact printer emits between 63-65 db, almost 10 times above the projected noise limit. This may encourage the market to look more closely and favourably at NIP.

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## next month's issue

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The Honorary Editor has accepted the following papers for publication in the February issue:

**The formulation of high durability exterior varnish stains** by *K. O'Hara and L. Newton, Cray Valley Products, Farnborough, UK.*

**Accelerated drying techniques** by *D. Pelling, Wallace Knight Ltd, Slough, UK.*

**Computer assisted match prediction and quality control** by *J. Morgan, J & C Printing Ltd, Manchester, UK.*

**What can we do when things go wrong in the printing processes** by *J. T. Guthrie, Department of Colour Chemistry, Leeds University, UK.*

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# OCCA Conference 1987 Eastbourne

Enclosed with each copy of December 1986 issue of JOCCA was a brochure describing the Technical and Social Programme for the Association's Biennial Conference which will take place at the Grand Hotel, Eastbourne, Sussex, England, 17-20 June 1987, under the title "Advances and application of science and technology in surface coatings". Eastbourne, which is a seaside resort easily reached by rail or road from London, has been a popular choice of venue for many Association Conferences and has attracted many overseas visitors. Further copies of the brochure can be obtained from the Association's offices. The summaries of some lecturers and biographies of lecturers appeared in the December 1986 issue and the full list of lecturers and further summaries and biographies are given below.

## Lecture Programme

The Technical Sessions will take place in the Devonshire Suite at the Grand Hotel on Thursday and Friday, 18 and 19 June. The Honorary Research and Development Officer (Mr J. R. Taylor) has arranged the following lectures for the Conference:

### THURSDAY, 18 JUNE

#### Session I (9.00 a.m. — 12.15 p.m.)

Chairman: Mr J. R. Taylor (Honorary Research and Development Officer, OCCA)

Speakers: Address of Welcome by the President, F. B. Redman

Keynote Address by Ing. Arja Saloranta (President, SLF)

Dr A. Wilson and Dr J. W. Nicholson (Laboratory of the Government Chemist) — "Preparation of Ionomers for Coatings from Water Soluble Polymers"

Mr R. H. E. Munn (Cray Valley Products) — "Novel Polyamide Type Epoxy Curing Agents"

Mr Thor Fjeldberg (Dyno Industrier AS Norway) — "Alkyd Emulsions, Properties and Applications"

Dr H. Warson (Solihull Chemical Services) — "Recent Advances in Crosslinking and Curing Applications to Surface Coatings"

#### Session II (2.00 p.m. — 4.30 p.m.)

Chairman: Mr G. W. Fowkes (Vice-President, OCCA)

Speakers: Ilkka Sarvimäki (Tikkurila OY) — "A Novel Water-Based Coating System for Wet Areas" (*Paper presented on behalf of SLF*)

Mr J. Spauwen (Dow Chemical Co Ltd) — "New Propylene Glycol Ethers for Water Borne Coatings"

Mr D. S. W. Dargan and Mr J. Hemmings (Kirklees Chemicals) — "High Binders in Decorative Emulsion Paints"

Mr L. Cutrone and Mr D. V. Moulton (Tioxide Ltd) — "The Reliability of Durability Testing"

Mr A. C. D. Cowley (ICI Organics Division) — "Improving Dispersion of Pigments with Hyperdispersants"

Mrs N. Usman (Paint Research Association) — "Development of Novel Driers for Paint"

### FRIDAY, 19 JUNE

#### Session III (9.00 a.m. — 12.15 p.m.)

Chairman: Mr J. Bernie (Director, Paint Research Association)

Speakers: Keynote Address by Mr G. Phillips (Managing Director, Ault and Wiborg PLC)

Dr W. G. Erskine (Domino Amjet Ltd) — "Advances in Ink Jet Printing and Ink Jet Inks"

Mr P. C. Stievater (NL Chemicals Inc) — "Advances in Environmentally Acceptable Polyurethanes"

Professor Mengies (Loughborough University) — "Rapid Electrodeposition Systems for Metallic Coatings"

Mr P. Fallon (Johnson and Bloy Ltd) — "Advances and Changes of Ink Technology in Cold Seal Packages"

#### Session IV (2.00 p.m. — 4.15 p.m.)

Chairman: Mr G. J. Gough (President, Birmingham Paint, Varnish and Lacquer Club)

Speakers: Dr H. Robinson (Taylor Woodrow Engineering Ltd) — "Durability of Anti-Carbonation Coatings"

Mr M. Leclercq (Société des Mines et Fonderies de Zinc de la Vieille Montagne) — "Production of Zinc and Zinc Alloyed Dusts by Fine Atomisation"

Dr B. L. Kaul (Sandoz Huningue SA, France) — "Advances in the Science and Technology of Pigments"

Dr N. Henwood (Dow Chemical Co Ltd) — "Membrane Separation for the Production of Nitrogen Enriched Inert Gas"

Mr I. Tonini (Walter Maeder AG) — "Technical Progress of New Ecologically Safe Paint Systems and Application Technologies" (*Paper presented on behalf of FATIPEC*)

Below, further summaries of the papers and the biographies of their authors are presented, Eight summaries/biographies appeared in the December issue of the *Journal*.

## Keynote Address Day 2

**G. Phillips**

### Biography

Gordon Phillips is the Group Managing Director of the Ault & Wiborg plc. He has given various papers to OCCA sections including a paper at the Torquay OCCA Conference. Prior to joining the Ault & Wiborg Group, Gordon Phillips spent 10 years in the American chemical industry. His final post before returning to the UK was as Director of Research for the Industrial Paints Division of the SCM-Glidden Corporation. He has also worked for the Distillers' Company and the UKAEA.



**G. Phillips**

## Improving dispersion of pigments with hyperdispersants

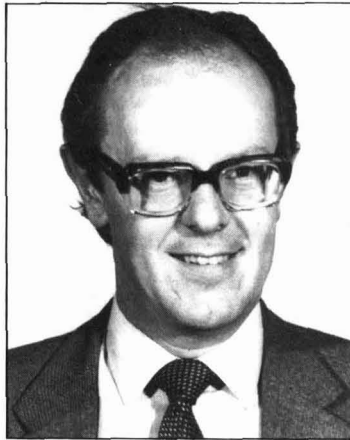
**A. C. D. Cowley**

### Summary

Hyperdispersant technology represents a new scientific approach to the dispersion of pigments in non-aqueous systems resulting in significant economic and technical benefits to the paint and printing ink industries.

The efficiency of pigment dispersion is a key factor influencing the ultimate profitability of paints and printing inks. With the rising costs of both pigments and energy, it makes economic sense to ensure both are used efficiently; it is desirable to achieve maximum tinctorial strength per kilo of pigment and to use minimum energy in achieving this effect.

Over the years the pigment manufacturers have attempted to produce pigments which are easier to disperse by using either flushing or chipping techniques or surface treatments. More



**A. C. D. Cowley**

recently hyperdispersants have been developed specifically for the purpose of improving the dispersion of pigments in non-aqueous media. This new technology offers the paint and ink industries a unique approach to the production of stable non-aqueous dispersions. It is now possible to double the organic pigment loadings in millbases and often obtain 20% increases in tinctorial strength when using hyperdispersants.

The purpose of this paper is to consider traditional methods of producing stable dispersions, to describe the innovative design of hyperdispersants and finally to highlight some of the practical benefits which the paint or printing ink formulator is likely to derive from using hyperdispersants.

### Biography

Alan Cowley is a Senior Technologist in the Dispersants Group of ICI Organics Division, in Manchester, UK. He is responsible for providing technical service on hyperdispersants to the paint, printing ink and plastics industries. His first job, with Goodlass Wall and Co Ltd of Liverpool, was as a formulation chemist working with decorative paints and later with automotive paints. He then joined ICI Organics Division in 1965 to work in the Pigments Section on product development before transferring to the Dispersants Group. He is a member of OCCA and presented the UK plenary paper to FATIPEC in 1984. He also serves on the Technical Committees of the British Colour Makers Association and the Ecological and Toxicological Association of Dyestuff Manufacturers and is a past Chairman of the European Manufacturers of Lead Chromes.

## Recent advances in crosslinking and curing applications to surface coatings

**Dr H. Warson**

### Summary

Surface Coatings have been improved from time immemorial by taking advantage of the fact that the macromolecules, using modern terminology, have been cured by a crosslinking process which involves forming a three dimensional structure, the original being the air crosslinking of linseed oil.

The current art may be divided into two major sections, viz, the crosslinking of addition or "vinyl", polymers, formed essentially by addition polymerisation and a subsequent secondary action, and the crosslinking of other macromolecules including epoxides, polyurethanes, phenoplasts, aminoplasts and modifications in the more traditional types such as alkyds. The use of silanes will also be considered.

A distinction must also be made between reactions which take place at ambient temperatures, and those which require heating, mainly for industrial finishing. This lecture is not intended to discuss the finer technical details and requirements, but present the general principles. It will include both solvent based and water based products.

Vinyl polymers may be cured or crosslinked by the controlled inclusion of monomers with multi-double bonds. Of interest is the use of monomers with multi-allyl bonds, and (meth)acrylic esters of unsaturated alcohols which impart air-drying properties. Alternative

**Dr H. Warson**



developments include the presence of various reactive groups such as amide, carboxyl, and epoxide in the polymer and also unsaturated siloxanes. These may self react on film formation, or require an external additive such as an aminoplast. Various developments with epoxides, polyurethanes, alkyds, drying oils, silanes and newer products will also be summarised.

## Biography

Dr Henry Warson is well-known both home and abroad for the technology and science of emulsions and he obtained his BSc degree at Queen Mary College in 1938 and his PhD degree at the Battersea College of Technology, University of London in 1963. The subject of his thesis was on "The Initiation of Vinyl Polymerisation by means of Diozonium Salts". He attained Associateship of the then Royal Institute of Chemistry in 1934, becoming a Fellow of the Royal Society of Chemistry and Chartered Chemist in 1948.

His industrial experience covers a wide range of topics with the Explosive Division of ICI during the 1939/45 war and extensive experience of research in polymerisation of emulsions with Vinyl Products Co Ltd, and Dunlop Special Products Ltd. He has been an Industrial Tutor to students of Leicester Polytechnic in Coventry and is now Polymer and Chemical Consultant and Managing Director of the Solihull Chemical Services (International Polymer and Chemical Consultants). His company has an association with the Sinclair Laboratories of Lehigh University in Bethlehem Penna, USA. He has had a great many publications associated to his name including books, reviews, short monographs and symposium papers. He has at least 34 patents both British and foreign to which he was either inventor or co-inventor on the subject of emulsion polymerisation for the production of vinyl latices.

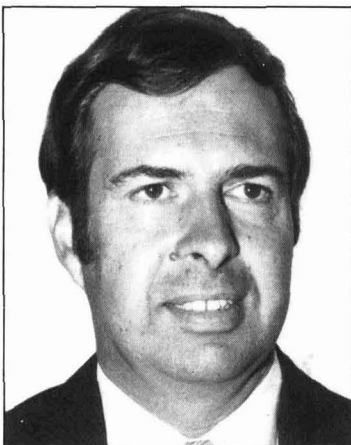
## Advances in environmentally acceptable polyurethanes

### P. C. Stievater

#### Summary

The versatility of urethane chemistry allows for the synthesis of a variety of polymer compositions useful for the manufacture of surface coatings. Environmental considerations have influenced the direction of research and development of urethane resins and led to the development of new products with reduced solvent and lower VOC levels.

A review of basic urethane chemistry



P. C. Stievater

and the property/structure relationships of common compositions is presented. The evolution of the more environmentally acceptable waterborne, higher solids and single package high performance versions of various urethane types is discussed and contrasted to older technology. Coating formulations and performance of old and new technology systems are compared and associated end use discussed.

#### Biography

Paul Stievater received his BS degree in Chemistry from Canisius College in Buffalo, New York, in 1957. He also studied Chemical Engineering at Massachusetts Institute of Technology. He was formerly employed by Cadet Chemical Corporation, now a division of Noury Corporation, as a research chemist working on the development of organic peroxides. He joined Spencer Kellogg in 1961 as a chemist in the technical service laboratory, was made Group Supervisor of special projects, specialising in application and development of urethane resins, and served as Manager of the technical service department from 1969 until 1980. He was Technical Sales Manager until 1985, and was named Applications Manager in 1986, his present position, after the acquisition of Spencer Kellogg by NL Chemicals, Inc. He is a member of Buffalo Paint and Coatings Association, the Isocyanate Committee for the NPCA, and the American Society for Testing and Materials (ASTM).

## Development of novel driers

### N. Usman

#### Summary

This paper describes the investigation

carried out by Paint Research Association into possible alternatives to the conventional cobalt/lead/calcium drier systems used in oil-based paints.

From 1978-1979 a research programme was carried out for the Paintmakers Association to identify possible alternative paint driers to those based on cobalt and lead. At that time cobalt supplies were seriously threatened by disorders in Central Africa and the use of lead was under attack by environmentalists especially in the United States. This investigation led to the conclusion that a combination of manganese driers with 2,2<sup>1</sup> dipyrindyl could be an effective and economically acceptable alternative to the usual cobalt/lead driers in air drying paints.

This work was then followed by a full technological evaluation of manganese/2,2<sup>1</sup> dipyrindyl in over 30 primer, undercoat and topcoat formulations supplied by the Paint RA member firms. It was concluded from this work that although the manganese/2,2<sup>1</sup> dipyrindyl system could not be regarded as a universal replacement for paint driers currently in use, there was a significant proportion of commercial paints where it could be utilised without detriment.

Following the voluntary agreement between the Paintmakers Association and the Department of the Environment that "lead driers will cease to be used in decorative paints after June 1987" a wide range of materials were evaluated as alternative driers at the Paint RA. The materials investigated were metal driers, metal amines, oxygen carriers, one-electron oxidising agents and enzymes. This work showed that it was difficult to dry undercoats under adverse conditions in the absence of lead, and copper naphthenate could be regarded as the most attractive option for replacing lead in paints. Loss of dry on storage could be a problem with this material.

Recently the Paint RA has been looking

N. Usman



into the mechanism of driers in air-drying paint films. This would give a better understanding and control of the way in which air-drying paint films dry and the influence of the choice of driers and external conditions.

## Biography

Najma Usman (Mrs) was educated at the University of Karachi (Pakistan) where she obtained her BSc followed by a Master's degree in Organic Chemistry. She began her career as a Research Chemist at Polyalloys Ltd in 1969 where she worked for five years. She joined Paint RA in 1977 and at present is working as a Senior Research Officer for the Environmental Group. Her main research interests include, development of novel driers for decorative paints and mechanistic studies of biodegradation of cellulose ethers in emulsion paints.

## Advances in the science and technology of pigments

### B. L. Kaul

#### Summary

The organic pigments industry has been faced with new challenges and opportunities owing to the expansion of the plastics, paints and coatings, printing and writing inks and man-made fibres industries, coupled with the growth of the transportation industry, over the past three to four decades. New substrates and novel technologies, initially introduced because of aesthetic and durability reasons and more recently due to ecological and toxicological concerns, have led to the development of new high-grade, non-toxic organic pigments of good to excellent fastness properties and to the improvement of existing classes of pigments. The objective of this paper will be to discuss some of these developments. The subject matter to be presented is by no means a complete analysis of organic pigments and will particularly concentrate on novel azo, heterocyclic and metal complex pigments, where the lecturer's research interests lie. Whilst describing the characteristics of these novel pigments, it is intended to discuss the formulations based on these products rather than the properties of the individual products. Specific attention will be given to unsolved problems in this field.

#### Biography

After studying at the University of Bombay and the National Chemical Laboratory of India in India, at the Swiss Federal Institute of Technology (ETH) in Zürich (Switzerland), and at the California Institute of Technology (Caltech) in Pasadena (USA), Dr Kaul joined (1970)

Sandoz in Basle, where he is now Head of Research and Development: Pigments, Pigment Preparations and Solvent Dyes, operating from Sandoz Huningue, France.



B. L. Kaul

## Durability of anti-carbonation coatings

### Dr H. L. Robinson

#### Summary

The highly alkaline concrete environment surrounding embedded reinforcement, aids the formation of a passivating oxide layer on the surface of the steel. The stability of this layer is dependent on the surrounding concrete media maintaining a pH of about 12.5.

The reaction between atmospheric carbon dioxide and calcium hydroxide hydration product, progresses through the concrete as a 'Carbonation front', which if unchecked, will eventually reach the reinforcement, lowering the concrete pH in the process. The passivating oxide layer is then no longer stable, at which point reinforcement corrosion may occur.

By applying a suitable coating to the surface of the concrete, the carbonation process can be halted which in turn protects against possible corrosion, thus extending the lifetime of the structure.

Such coatings primarily need to be impermeable to carbon dioxide diffusion, whilst allowing sufficient levels of water vapour to pass out of the structure. This study reports a method for evaluating the gas barrier properties for a range of different generic types of coatings.

The method, emphasises the choice of a suitable substrate, sample application, curing conditions and reproducibility of test results. Measurement of carbon dioxide diffusion through a coating is carried out by means of a diffusion cell, interfaced to a Gas Chromatograph with a

data handling facility.

The durability of concrete coatings is a key issue and this is evaluated for a range of coatings by examining the effect of artificial weathering on their gas barrier properties.

#### Biography

Dr Howard Robinson studied for his BSc degree and PhD degree at the University of Leicester and obtained the latter degree in 1984 on the "Spectroscopic studies of solvation in aqueous and alcoholic media". After leaving University he joined Taylor Woodrow Construction Ltd, in the Design and Research Laboratories and is currently a Design and Development Scientist engaged in repair and protection of concrete structures, protective coatings and failure analysis. He has lectured frequently on methods of the prevention of breakdown of concrete including to OCCA (Thames Valley Section) and the Royal Society of Chemistry, Industrial Division. He has written several publications for the Journal of the Chemical Society, Faraday Transactions and the Proceedings of the 2nd, International Colloquium, Materials Science and Restoration, West Germany.



Dr H. L. Robinson

Further biographies and summaries will be published in the February issue of the *Journal*.

## OCCA Ties

OCCA ties are now available from the Association's offices, with a single Association Insignia on either a blue or maroon background.

The price is £4.25 each (including VAT) and orders (by prepayment) to Priory House should state clearly the number and colour(s) required.

## Manchester Section

### New developments in inverse emulsions

A lecture on the subject of Inverse Emulsions was presented on 3 November 1986, to the Manchester Section by Dr A. Chaudhry of Scott Bader at the St James's Club, Manchester. The lecture was attended by 55 members and guests.

Dr Chaudhry initially discussed what was meant by an emulsion, and hence the two types:

#### Oil in Water

Dispersed phase — Oil  
Continuous phase — Water

#### Water in Oil

Dispersed phase — Water  
Continuous phase — Oil

and that it is the water in oil type that are known as "Inverse Emulsions".

Usually emulsions of both types are milky liquids, but recent developments in inverse emulsions are almost transparent, and Dr Chaudhry went on to explain the physical differences between the two types. The lecturer continued by describing the basic manufacturing process, and the different monomers used in inverse emulsions. The polymer types and rheological characteristics were outlined, and these were illustrated by a short practical demonstration.

The lecturer concluded his presentation by discussing the mechanism of acrylic thickeners and their practical uses, which were mainly associated with the printing field.

After an interesting question and answer period a vote of thanks was proposed by Bill Borrell and those attending were able to participate in a buffet courtesy of Scott Bader.

*M. G. Langdon*

## Midlands Section

### Colour dispensing systems/Solvent recovery systems

The first lecture this session of the Midlands Section was held on 16 October 1986, at the Clarendon Suite, Stirling Road, Edgbaston, Birmingham.

Members and guests listened to two talks given on behalf of OBS Machines Ltd. The first was by Mr C. Moenaert entitled "Colour Dispensing Systems". The speaker said that production of small batches of paint in the factory was an expensive and time consuming process unless they are made from a base mixing scheme. The EuroTinter is a fully automated dosing-dispensing unit which is ideal for producing small batches of paint quickly and cost effective. The machine, which is of modular design, is fitted with positive displacement pumps controlled by a computer. It can handle container sizes from 0.5 to 10.0 l and other sizes are available for factory use. The pump can dispense as little as 0.3 mls or up to 0.8 l per minute. The computer will store up to 20,000 formulae.

Mr Moenaert concluded his talk saying that the use of this type of machine can reduce paint stocks held at retailers also it can improve the quality of colour matching by removing the human error.

The second talk was given by Mr A. Cluvinage and was entitled "Solvent Recovery Systems". The speaker said that there were three main recovery systems to be considered.

1. A jacketed vessel with anchor type stirrer and scraper. Here the walls of the vessel quickly become coated with resin and therefore loses efficiency.

2. Steam stripping. This is more efficient than the jacketed vessel but water contamination occurs in the final product and is unsuitable for water miscible solvents.

3. Thin film evaporator. This is the most efficient of the three processes but ends up with a liquid sludge that still contains inflammable solvents.

The speaker then described the Sussmeyer SRP process which combines the advantages of the previous ones. This is a direct heat transfer process which uses the solvent vapour itself as the heat transfer medium. The solvent vapour is superheated to a few degrees higher than the liquid solvent boiling point, the accumulated heat is then transferred to the dirty solvent causing it to boil. A fan draws the solvent vapour through the condenser from where it is collected. The recovered solvent is free from water and because the heat transfer is by direct solvent vapour no loss of efficiency occurs. The sludge is easily removed at the end of the day or shift in a dry state.

The numerous questions asked after the end of each talk reflected the interest shown by the audience. The meeting closed with a vote of thanks proposed by Mr B. Rushton and endorsed by the audience in the usual manner.

*B. E. Myatt*

## Midlands Section — Trent Valley Branch

### New solvents for coatings

The second meeting of the current session of the Trent Valley Branch was held on 30 October 1986, at the British Rail School of Engineering, Derby, when two papers were presented by Dr Zain Dawoodi and Mr Alan Sheen of BP Chemicals Ltd under the title of "New Solvent Systems for Coatings—Computer Aided Formulation".

Solvent usage in Western Europe is now in excess of five million tonnes per annum with the surface coating industry forming a significant part of the consumption. Complex solvent mixtures are used in surface coatings to achieve satisfactory solvent power and evaporation characteristics at the lowest cost.

Mr Sheen outlined the properties required in the design of the solvent system, the crucial properties being balanced



to give the lowest cost. Considerable resources may be expended to achieve an optimum balance when labour intensive trial and error methods are used to produce optimum blends and coating chemists are usually reluctant to change from tried and tested formulations without good reason. Today, as a result of increasing costs and new legislative restrictions the coating chemist is under pressure to reformulate. Mr Sheen described how they have developed a comprehensive computer-based solvent optimisation technique and how these programmes enable BP Chemicals not only to predict the behaviour of different solvents and their blends, but to propose alternative cost-optimised systems which will match or even improve on current performances.

Mr Sheen entered a formulation into the computer and allowed it to run through its programme whilst Dr Dawoodi discussed the toxicological problems encountered with certain solvents which could be eliminated or minimised using the same programmes.

With the aid of slides, comprehensive comparisons of the properties of the alternative solvent formulations were discussed and, in particular, ethoxypropanol, methoxypropanol and methoxypropoxypropanol blends have been examined as alternatives for ethyl glycol ether in a typical coating system. Of these only ethoxypropanol has emerged as a direct weight for weight replacement for ethyl glycol ether. Methoxypropanol suffers as a result of its fast evaporation rate while its blends with methoxypropoxypropanol show little improvement in evaporation rate and can confer significant defects in the quality of the coating films.

A comparison was also made between two propylene glycol ethers as potential substitutes for ethyl glycol acetate in a range of surface coating applications. Ethoxypropyl acetate has emerged as a very close match for ethyl glycol acetate allowing its use on a direct weight for weight basis. The use of methoxypropyl acetate can, in some systems result in acceptable performance, although costly reformulations will usually be necessary. In other systems, however, the performance drop is so marked that even substantial reformulation is unlikely to prove of any real benefit.

In the meantime the computer had produced a closely matching, lower cost, equal performance solvent blend to the original mixture.

After a most enlightening evening a vote of thanks was given by Mike Hannah appreciating the professional manner in which the papers were presented and the technical advances made but at the same time not wishing to lose the human touch completely. Thanks were also expressed to BP Chemicals Ltd, for providing a generous buffet and totally sponsoring the evening.

*J. C. Ellis*

## Newcastle Section

### Carbon blacks for inks and coatings

Thirty members and guests attended the second meeting of

the 1986/7 session on 6 November 1986, to hear Mr J. McKeown of Cabot Carbon Ltd talk on the "Selection of carbon blacks for inks and coatings".

He began by reviewing the various market sectors of carbon black usage: vehicle tyres (30%—the main sector), printing inks, paints, plastics (recording tapes, anti-static cable covers, EMI shielding). The need for jetness, flow and gloss, makes paint blacks generally more expensive. Channel blacks were popular for paint, but environmental problems from channel black production resulted in many plant closures and users are switching to other types. For practical storage/handling reasons most blacks are made in pelletised (beaded) form.

Mr McKeown illustrated the type of plant and processing variations used for making furnace blacks. Flame technology is the basis; furnace residence times from as long as 10 seconds at 2,200°C to as short as 0.008 seconds at 3,000°C are typical, longer times allowing more particle growth, agglomeration and secondary structure. Particle sizes of 13-15 µm are common for very high quality paint blacks, 25-60 µm for many ink blacks/tinting/plastic cable blacks; 130-140 µm for plastic grades; all very much smaller than other common paint pigments.

Mr McKeown discussed the various properties of significance in choice of carbon black by the user: particle size, structure, surface area, surface chemistry. Finer grades are best for jetness and tint strength but are difficult to disperse and require more binding resin: they also have a brown undertone in tints, whereas larger particle size blacks have a blue/grey tint undertone. The continued demand for lamp blacks as tinting pigments results from their blue/grey undertone, and similar particle size furnace blacks are being offered as substitutes. Structure affects binder demand and dispersibility, e.g. higher structure results in higher oil absorption but easier dispersibility.

Surface chemistry dictates the wetting characteristics of carbon blacks. Chemisorbed oxygen in the form of hydroxyl, carboxyl, phenolic, lactonic or quinonic groups may be present, depending on process conditions or after-treatment. Generally, surface-active blacks produce low pH values when slurried with water. Mr McKeown illustrated the interplay of surface chemistry, particle size and structure with printing ink blacks, finally showing how specific ink faults, such as "scumming" or "strike through" could be overcome.

The properties of fluffy and pelletised grades were discussed with regard to storage, handling and dispersion, before Mr McKeown closed with an illustration of the wide variation of choice by users for what is apparently the same coating application.

Question time afterwards included subjects such as loading/viscosity, conductive coatings, surface treatments, "oily black" equivalents for paint, dispersion of beaded blacks and flotation.

The vote of thanks for an excellent lecture was given by the Chairman, Mr R. G. Carr.

*J. Bravey*

## Scottish Section

### Forensic Science

The Scottish Section held a joint meeting with the Society of Dyers and Colourists on 13 November 1986, at the Hospitality Inn, Glasgow. The guest speaker for the evening was Mr Keith Eynon—Deputy Principal Scientist with Strathclyde Police Science Authority who gave a lecture on Forensic Science. The subject matter for this lecture proved to be very popular as there was an excellent attendance.

Mr Eynon illustrated with the aid of slides the many areas of police work that his department are involved in. This ranges from checks re the level of alcohol in blood to drugs including analysis of drugs confiscated to determine type and strength. Although fingerprints are often a vital clue in tracing a criminal it is surprising how often they continue to leave such evidence. Footprints also are often used as evidence that a person has been at the scene of a crime. Less common perhaps is a fragment of tooth knocked off in a struggle which when matched up has been used as conclusive proof that a person was involved in a break in.

The speaker explained how modern technology can help to solve crimes, it is possible to pinpoint where a hijacked lorry has deposited its load by scrutinising the vehicle tachograph in conjunction with an ordnance survey map. Also with present day technology fibres transferred from an attacker to a victim's clothing can be used to trace the item of clothing and ultimately the criminal involved.

Mr Eynon also explained that traces of paint left by a car damaged at the scene of a crime can often provide the necessary evidence to convict a criminal. Car manufacturers now supply details to police regarding paint used on new cars. This information is stored in a central computer thus enabling the police to identify the make and year of manufacture of a car from a sample of paint. If they also know the area a suspect lives in then they can obtain a list of names and addresses of owners of a particular make, colour and year of car for that area. Naturally this is a very welcome aid in the detection of crime.

Following a question and answer session a vote of thanks was proposed by Mr J. Dodds.

*R. A. Hunter*

## Thames Valley Section

### Coatings formulation using three component contour plotting

The second lecture of the Thames Valley Section was held on 16 October 1986, at the Crown Hotel, Amersham. Members and guests heard Mr Luigi Cutrone give a talk on "Coatings Formulation Using Three Component Contour Plotting".

Mr Cutrone commenced by outlining the problem which confronts the user when studying multi-component systems, and the difficulties in assessing the effects of the

mixture variables. He introduced the three component contour plotting whose operation is greatly simplified with the help of a computer and suitable software available from Tioxide UK Ltd.

The lecture continued with a simplified explanation of the theoretical considerations necessary for the proposed analysis of mixture data; the most frequently used is the special cubic equation derived from the Taylor's series.

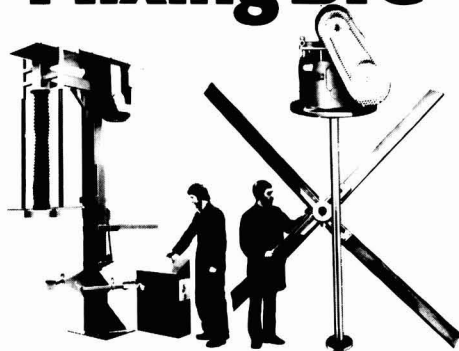
Most helpful was Mr Cutrone's review of the method employed to plot on trilinear co-ordinate paper and gave as an example a three component systems using ten samples, comparing each individual component blend with its corresponding response. Much of the lecture was devoted to the exploration of various latex paint formulations where physical properties such as gloss, opacity, scrub resistance and ASTM porosity were considered.

In conclusion it was demonstrated that the application of response surface contour plots has been found very useful and time saving in developing new and optimising existing coating formulations. The value of such a technique is that, with a relatively small number of samples, a formulator by super-imposing the desired properties can optimise or develop new products.

A vote of thanks was given by Mrs Christine Morrell who also thanked Tioxide UK Ltd for sponsoring the buffet.

*J. A. Gant*

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**Brent Chemicals acquires Blancomme Inks**

Brent Chemicals International, the speciality chemicals group, has agreed to acquire for FFfr. 26 million the business and fixed assets of the packaging inks division of Blancomme SA, a privately owned French company. Blancomme Inks is the largest privately controlled supplier of flexographic and gravure inks to the French packaging market. This acquisition together with those of Winnetts in 1985 and Joachim Dyes in 1986, will establish Brent as a major ink supplier to the North European packaging industry.

**Exxon expands MEK production**

Exxon Chemical is increasing the capacity of its MEK Fawley plant—the largest in Europe—from 75,000 to 90,000 tonnes per annum. Construction work on the multi-million dollar project is underway and completion is scheduled for July 1987.

**Macpherson agreement with Glidden**

Macpherson plc, a leading UK paintmaker has signed a long term licence agreement which allows Glidden of Ohio, USA, to use an advanced paint technology in in-mould coatings developed by Macpherson in the UK, throughout North America. The new system is novel in that the paint is applied in-mould prior to plastic (polyurea or polyurethane) injection. The resultant moulded component is chemically bonded and ready for use. Because in-mould coatings are truly bonded to their substrate to form a single cohesive mass and problems of paint chips and abrasion are eliminated in the conventional sense, this feature is especially important to automotive components like bumpers, wheel arches and spoilers. The system eliminates surface preparation, priming and post-painting of a moulded plastic part.

**BJN headquarters move**

Berger Jenson & Nicholson Ltd, the international surface coatings group, are moving their headquarters from Berkeley Square to Hoechst House at Hounslow.

**Europe's first Vapocure-line**

Vapocure Ltd of Australia has started its first conveyerised painting line in Europe, (UK). The new line is dedicated to contract painting for UK customers using Vapocure's rapid room temperature curing process. The vapocure process uses a specific catalyst to accelerate the reaction between NCO and hydroxyl groups to form a urethane or urea bond or one of the variations of that chemistry between two polymer molecules.

The Vapocure process offers the advantage that heat sensitive substrates like plastic products, electrical

components, timber, etc, can all be coated at room temperature with 4-12 minutes from spraying to touch dry. The new line is fully conveyerised and technical support is given by an attached paint laboratory.

**Hammersmith Bridge gets a centenary facelift**

More than 2,000 litres of paint have been used to restore London's Hammersmith Bridge to all its Victorian splendour, with a £140,000 facelift to celebrate the centenary of its reconstruction. The project was completed using Crown paints trade undercoat and gloss products. The work included the repainting of the main structure and included painting 10,000 stars on the sides of the structure.



Hammersmith's Crown jewels

**products**

**Extension to Berger's Plastisol Range**

Berger Industrial Coatings of Dagenham, one of the largest producers of paint systems for the coil-coating industry has introduced a new version of one of its popular coil-coatings. Weathering tests on this new cadmium-free *Plastisol* has shown improved UV resistance, heat resistance and mould resistance.

Reader Enquiry Service No. 35

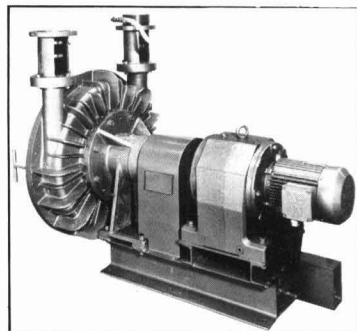
**Sheenstick**

Sheen Instruments of Teddington has introduced a new industrial/laboratory instrument called a *Sheenstick* which measures pH, temperature, humidity/temperature and conductivity. The first Sheenstick to be marketed is the micro-processor-based model 1610 pH meter. The new pH Sheenstick covers the full range of pH1 to 14 and -30° to 150°C, and 0 to ±199 mV. The instrument is powered by a 12 volt battery and has dimensions of 120 × 35 × 22 mm<sup>3</sup>.

Reader Enquiry Service No. 36

**SSP's difficult media pump**

SSP Pumps Ltd of Eastbourne has added



SSP's Rosewater peristaltic pump

the *Rosewater Peristaltic Pump* to its range of positive pumps. This heavy duty, valveless and glandless peristaltic pump can cope with extremely difficult media including thick, abrasive sludges, slurries and corrosive materials. The reinforced hose provides smooth, full bore positive transfer with delivery pressure up to 15 bar. Nominal bore sizes range from 40 to 100 mm diameter and flow rates extend to 50m<sup>3</sup> per hour.

Reader Enquiry Service No. 37

**New epoxy curing agent**

Thomas Swan & Co Ltd of Consett, has introduced a new curing agent called *Casamid 417*. This is an epoxy curing agent with reduced toxicity based on aromatic amines.

Reader Enquiry Service No. 38

**literature**

**Transport of dangerous substances by road**

New safeguards for transport by road of dangerous substances in containers such as drums, bottles etc, are contained in regulations recently laid before Parliament by the Minister for Transport. The Road Traffic (Carriage of Dangerous Substances in Packages etc) Regulations 1986 (PGR) comes into force on 6 April 1987. They cover both manufacturers and suppliers of specified dangerous substances as well as vehicle operators and drivers. The document on these regulations SI 1986 No. 1951 is available from HMSO, price £2.90.

**BSI Publications**

BS 4X 17 Specification for varnish for aerospace purposes. This gives revised requirements for a water-resistant varnish suitable for application to wood used for aerospace purposes. Priced at £10.30 copies are available from: Sales Department, BSI, Linford Wood, Milton Keynes MK14 6LE.

Also the following BSI publications are on sale from the above address:

BS 3761: 1986, Specification for solvent-based paint removers.

BS 5082: Specification for water-borne priming paints for woodwork (Revision).

BS 5358: Specification for solvent-borne priming paints for woodwork (Revision).

BS 3900: Part D8: 1986, Determination of colour and colour differences: principles.

BS 3900: Part D9: 1986, Determination of colour and colour differences: measurement.

meetings

**TankCon 87**

The Road Haulage Association's Tanker Convention and Exhibition, 1987, called TankCon 87, will be held at the Norbeck Castle and Norcalympia, Blackpool, on 17 to 19 June 1987. TankCon will be of interest to customers in the petroleum and chemical industries who use tanker vehicles for the road transport of bulk materials. At the exhibition the latest tanker equipment and vehicles will be on display. For further information contact: TankCon 87, Road Haulage Association Ltd, Roadway House, 104 New Kings Road, London SW6 4LN.

**Wood Coatings Seminar**

Coatings for wood substrates will be discussed at an FSCT Seminar scheduled for 1-2 May 1987 in Seattle. For further information contact: FSCT, 1315 Walnut Street, Suite 832, Philadelphia, PA 19107, USA.

people

**Arno L. Baltzer** succeeds Dominik von Winterfeldt as Chairman and Chief Executive of Hoechst UK. At present Managing Director of Hoechst South Africa, Mr Baltzer has been with the Hoechst organisation for 25 years.

OCCA news

**Report of council meeting**

A meeting of the Council took place at 1.30 pm on Wednesday 29 October, at the Great Northern Hotel, King's Cross, London N1. The President (Mr F. B. Redman) was in the Chair and there were 25 members present.

The President welcomed to the meeting Mr D. W. N. Clayton and Mr B. E. Myatt who had been elected at the Council meeting in July.

Reports were received on the sale of publications, the preliminary work for the council's Annual Report, the Open Tech project, the arrangements for the technical sessions and the social programme for the Eastbourne Conference, 17-20 June 1987, the next Surflex Exhibition (Harrogate, 15-16 June 1988) and the fees for the Conference were agreed. It was planned to include the Conference Brochure in the December issue of *JOCCA*.

The first half year accounts and estimates for the second half year were tabled and agreed.

An illuminated address for presentation to the Paint Research Association to mark its 60th anniversary was shown to the council and approved.

The President reported on his visit to the FATIPEC Congress held at Venice in September and the visit by both him and the President Designate to the South African Division's Conference in October.

The Association would be represented at the FSCT Paint Show and Convention, to be held in Atlanta, Georgia, in November, by Mr D. W. N. Clayton.



Photo: PPCJ

**The President, Mr F. B. Redman addressing FATIPEC Congress, Venice, on behalf of the visiting Presidents.**

As a result of a request from M. Roire at the International Liaison Committee meeting at Venice for contacts in China who might help with his history of paint manufacturers, Mr W. Borrell, the newly appointed Honorary Overseas Secretary, had been able to supply helpful information. Other matters discussed referred to OCCA International, the present organisation of the New Zealand Division, the Professional Grade, computerisation of membership and *Journal* subscription records, appointment of a successor to the Director and Secretary who would retire in 1987, papers for the *Journal*, monographs, the Jordan Award and the preliminary arrangements for the Association's Conference to take place at Chester in 1989.

There being no other business, the President thanked members for their attendance and declared the meeting closed at 4.05 pm.

**Eastern Branch—  
Scottish Section**

**Annual Skittles Match**

On 3 October 1986, the Annual Skittles Match was held at the Murrayfield Indoor Sports Club, Edinburgh, with 21 members/guests in attendance.

The Chairman and Committee thanked the Scottish Chairman, Tioxide, Alex Fergusson & Co, Ciba Geigy plc and Craig & Rose plc for donating prizes for the evening.

Both sides playing for the Newton Cup (team event — Scottish Section) were evenly balanced with five novice players each and this was further shown by both captains scoring the same number of points. Tom Kirkwood was given the added responsibility of captaining the West side for the first time, in the absence of Simon Lawrence. The scores at the interval were close with the East trailing by 12 points but after further refreshments and sandwiches the West led by Tom achieved their 'Hat-Trick of Wins' over the East as the score difference increased to 58 points. Both teams were ably supported and supervised by non-players, Ron and Irene Barrett and Geoff Flood. Individual prizes were awarded to Louise Kirkwood (first lady, West) with 160 points and to Phil Rudden (first gentleman, East) with 223 points.

Ron Barrett and Tom Kirkwood expressed thanks to Nigel Baird and Tom McMahon for their organisation of another successful and enjoyable evening.

N. D. Baird

## Midlands Section

### Ladies' Night

The Midlands Section Ladies' Night was once again held at the Penns Hall Hotel, Walmley, Sutton Coldfield, on 31 October 1986.

The Chairman of the Midlands Section, Dr G. J. Lewis, in his speech to welcome the guests said that he was pleased to see that some had taken the advantage of it being Hallowe'en to come in fancy dress. Among the guests welcomed by the Chairman was Mr F. Redman, President of OCCA and his wife, Mr R. Hamblin, Director and Secretary of the Association, Mr M. Prigmore, Chairman of the Bristol Section and his wife, Mr T. Wright, Chairman of the West Riding Section and his wife and Mr G. Fowkes, President of the Birmingham Paint Varnish and Lacquer Club and his wife. In his speech Dr Lewis thanked the committee, especially the Social Secretary Mr K. Chater and the Treasurer Mr A. Eades, for the hard work they had put in to ensure the evening was a success.

In response the President thanked the section for inviting him for a second time and spoke of his visits to other overseas sections especially South Africa.

After the speeches dancing commenced to the "Take Five" Group who carried on the theme of Hallowe'en. During the band interval the audience were entertained by an illusionist "Tony Shelley and Elizabeth" who at one stage had Richard Devenish thinking he had lost a fiver but all ended well. The dancing continued till 1 o'clock when all were wished a safe journey home by the Chairman.

B. E. Myatt

### News of members

C. N. Finlay, (President 1983-85) has been appointed Technical Product Manager of Durham Chemicals Ltd.

### new members

The sections to which new members are attached are shown in italics together with the country, where applicable.

#### Ordinary members

Adriaanse, G., BSc (*General Overseas — Holland*)  
 Burns, D. (*Newcastle*)  
 Fielden, R. E. (*Manchester*)  
 Griffiths, G., BSc (*Cape*)  
 Jordens, P., MSc (*Natal*)  
 Kathirgamathamby B., BSc (*London*)



At the Midlands Section Annual Ladies' Night held on Hallowe'en. Back row (left to right): Mr G. Fowkes (President, BPVL Club), Mr F. B. Redman (President), Dr G. Lewis (Chairman, Midlands Section), Mr M Prigmore (Chairman, Bristol Section), Mr T. Wright (Chairman, West Riding Section), Mr R. H. Hamblin (Director and Secretary). Front row (left to right): Mrs Fowkes, Mrs Redman, Mrs Lewis, Mrs Prigmore, Mrs Wright.

### OCCA International Liaison



The photograph shows (standing) Mr D. W. N. Clayton who presented a paper and represented the Association at the FSCT Convention in Atlanta, Georgia, in November 1986. Seated (left to right): C. E. Dorris (FSCT President-Elect), W. Mirick (FSCT President), D. R. Pawsey (FSCT Treasurer).

Key, M. G. D. (*Midlands — Trent Valley Branch*)

Lee, W. (*General Overseas — Hong Kong*)

Manley, F. (*Manchester*)

McMillan, E. (*Midlands*)

McTaggart, A., BSc (*Newcastle*)

Newman, A. C. (*Bristol*)

Proudlock, K. (*Newcastle*)

Rayner, P. H., BSc (*Cape*)

Schofield, J. F., BSc (*Manchester*)

Wood, R. J., PhD (*Manchester*)

Wright, T. (*Manchester*)

#### Associate members

Ball, A. (*Manchester*)

Healy, M. A. (*Ireland*)

#### Registered Student

Davys, P. B. C. (*Manchester*)



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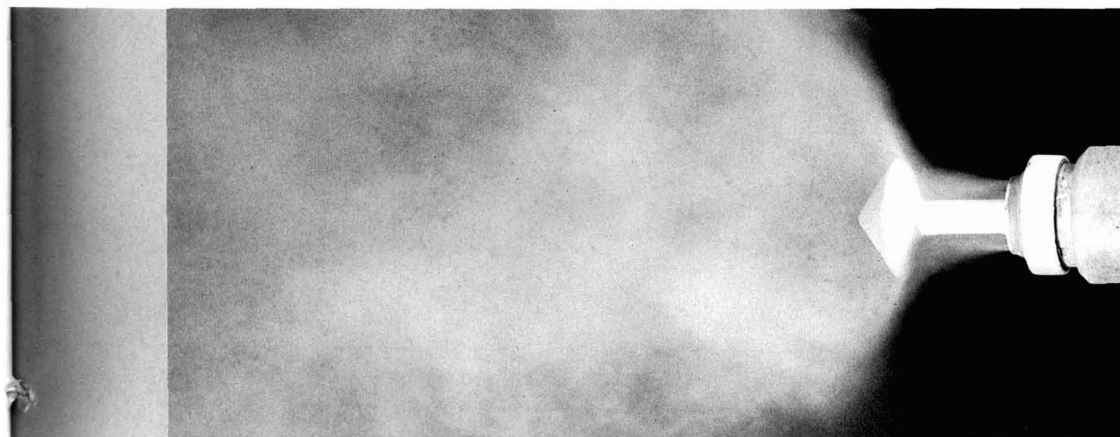
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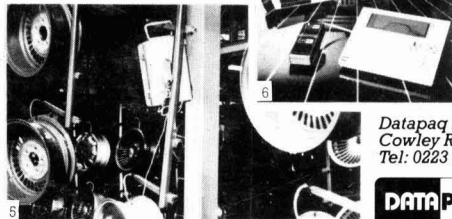
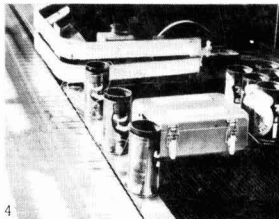
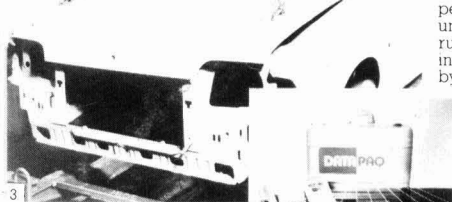
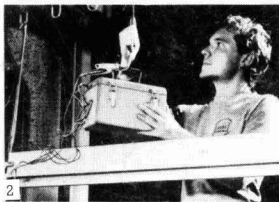
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# Painting by Numbers.



1. The Datapaq Tracker in operation at Ford Halewood
2. Photograph courtesy Birmingham Powder Coaters
3. Photograph courtesy Ford Halewood
4. Photograph courtesy Metal Box Co., Carlisle
5. Photograph courtesy GKN Kent Alloys
6. The complete Datapaq/Tracker system.



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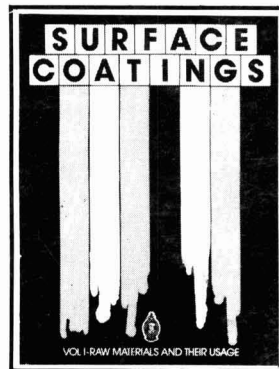
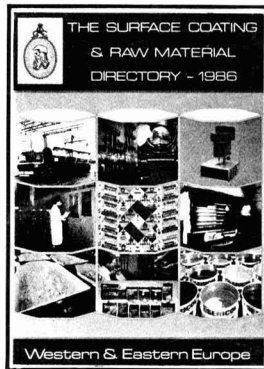
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