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OIL AND COLOUR CHEMISTS' ASSOCIATION

Vol. 47 No. 6 **June 1964**

TRANSACTIONS AND COMMUNICATIONS

ASSOCIATION'S ANNUAL GENERAL MEETING
WEDNESDAY 17 JUNE

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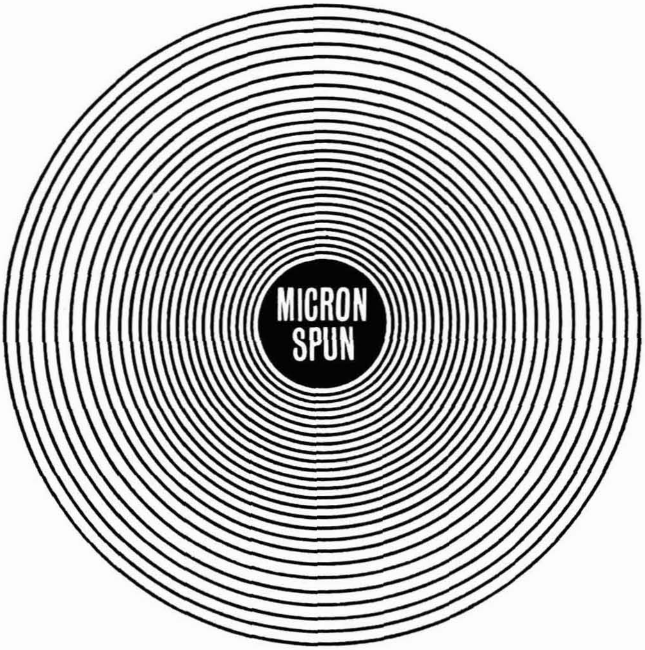
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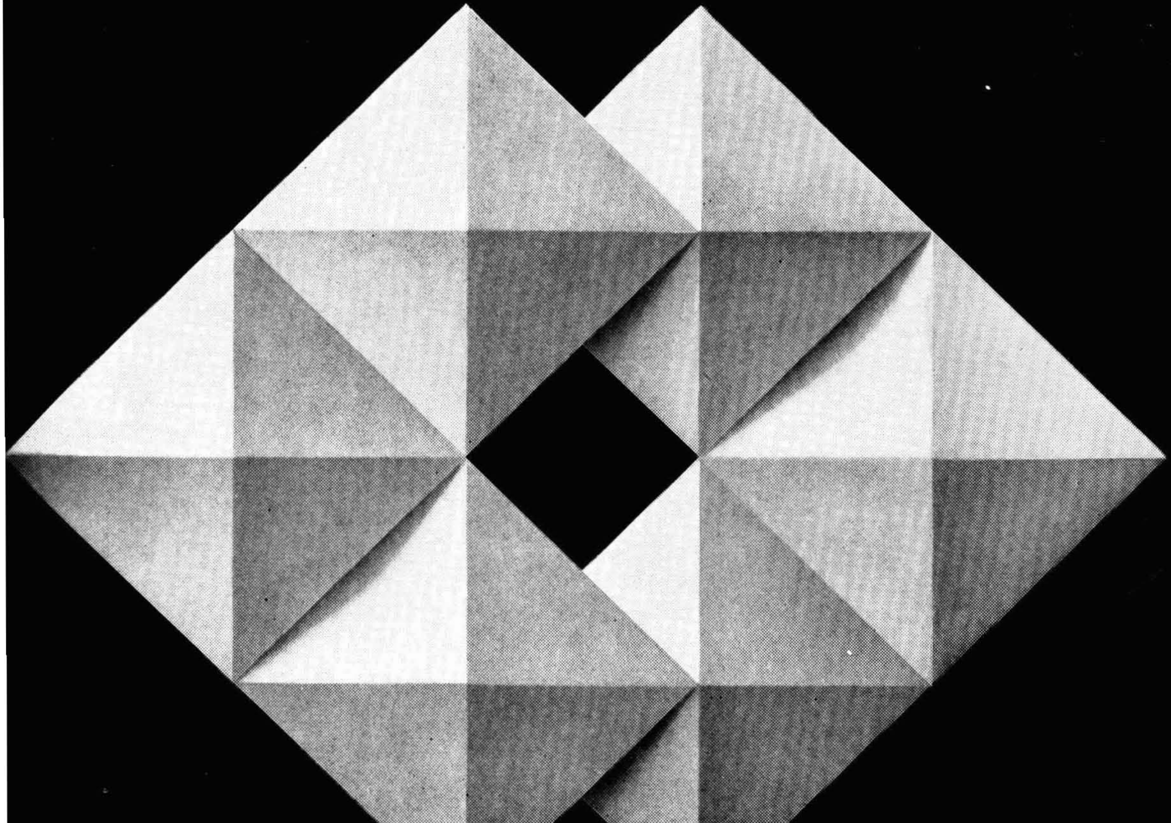

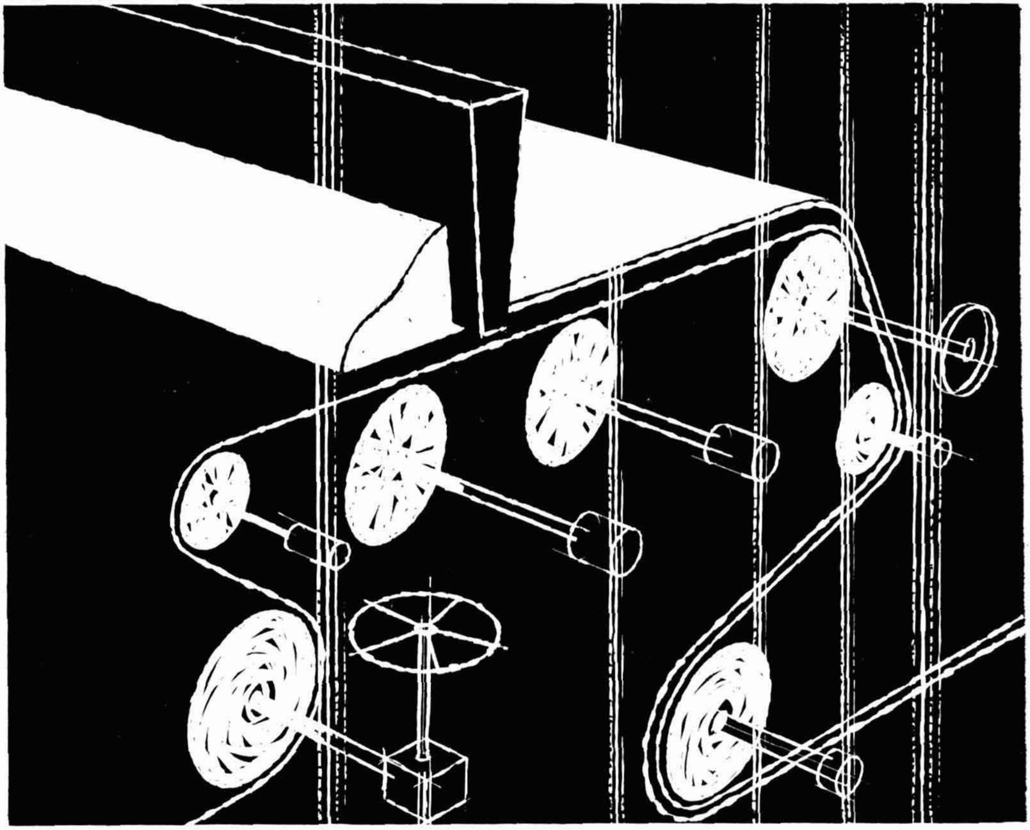


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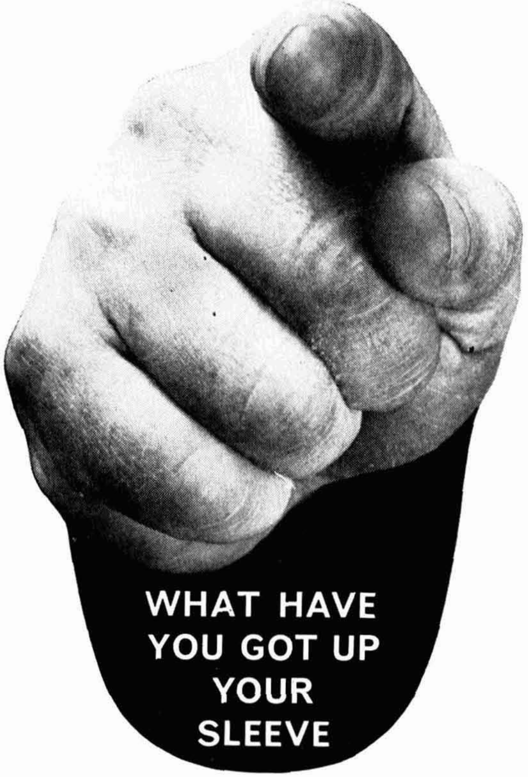
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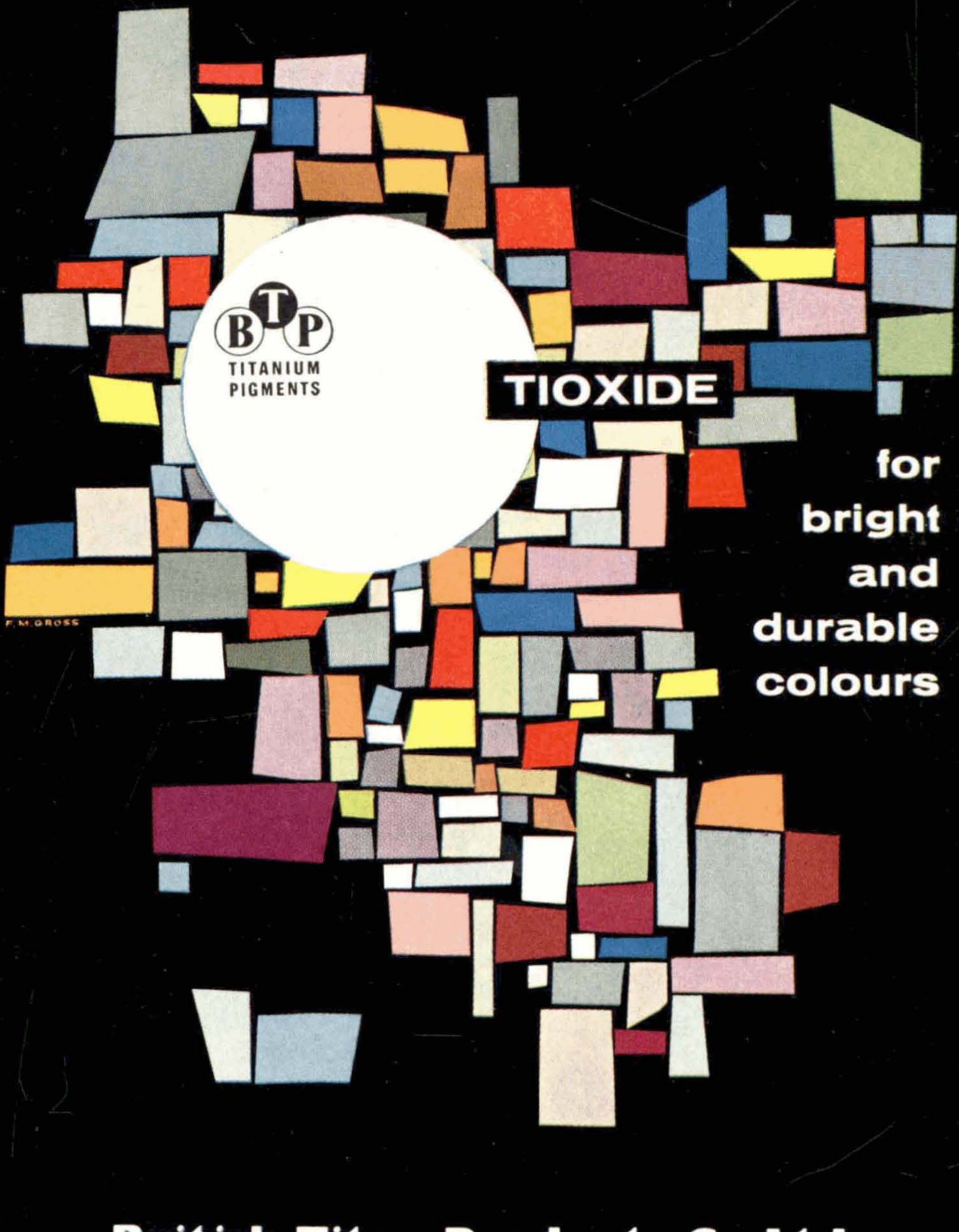

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JOURNAL OF THE OIL & COLOUR CHEMISTS' ASSOCIATION

Vol. 47 JUNE 1964 No. 6

TRANSACTIONS AND COMMUNICATIONS

Plastic Coatings: A Challenge to the Paint Industry*

Summary

The extrusion coating process as applied to polyolefines is described. After melting in an extruder, bonding to the substrate is accomplished by means of laminating rolls and normally no adhesive is needed. The main exception to this is in preparing coatings on rubber. The commonest substrate is kraft paper on which the polyolefine provides a chemically inert coating with extremely good chemical resistance and low moisture vapour transmission. The main application is the coating of the inner-ply of multi-ply paper sacks. Printing on the polyolefine surface requires pre-treatment.

Recent developments in the field of dispersion and solution technology of polyvinyl chloride coatings are described. Pvc pastes have recently been developed which adhere tenaciously when stoved in contact with metal and other substrates. They may be applied to clean metal by conventional painting techniques in some cases without primer or even pre-treatment. Such pastes are being used increasingly in those applications where erosion and corrosion protection are required such as the coating of wire mesh and roofing sheets, steel pipes, tanks, and steel floor plates. Coatings have excellent mechanical properties which enable coated sheet and strip to be drawn and formed into complicated shapes without impairing the coating. Pvc solution paints are also described for use on clean metal surfaces.

The advantages of dip coatings over sprayed or painted coatings are described for both liquids and fluidised powders. Increasing use and versatility of thermoplastics have made the use of fluidised powders attractive and an outline is given of methods of fluidising, including control of air flow and the feasibility of mechanical agitation. Practical methods and problems arising in dealing with various plastics are described together with the effects of various polymers on the finished articles and on production rates. The possibility of mass production and automation in this type of work is also discussed and an outline given of the comparative costs for various operations.

Finally, the use of epoxy resins in surface coatings is described in relation to their more recent development as powder coatings. Methods for preparing " B-stage " and " one-component " systems and the apparatus required by the formulators are discussed.

The advantages and disadvantages of various epoxy coatings are discussed and the properties of their cured films are compared to other coatings. Application is by fluidised bed, flock gun, flame gun, or electrostatic gun, and the apparatus for each technique is described. Particular factors affecting the performance in each process are discussed.

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*A Symposium held on 9 October 1963 in Manchester.

Extrusion Coating and Polyolefines

By C. D. Wells

Shell Chemical Company Limited, Carrington Works, Urmston, Manchester

INTRODUCTION

The polyolefines are rapidly becoming important coating materials because of their excellent chemical resistance and mechanical properties. They can be applied to various substrates, usually kraft paper, paperboard or metal foil, by several techniques. The commonest of these is extrusion coating which will be dealt with in some detail later.

Other processes are sometimes used, but are of lesser importance for polyolefines. These are :

(*a*) The production of a molten film of a polyolefine between heated rolls and the subsequent application of this film on to a substrate between laminating rolls.

(*b*) The application of an emulsion of low molecular weight polyethylene by a doctor blade technique.

(*c*) Flame spraying polyolefine powder on to metal surfaces, and coating metals in a fluidised bed of hot polyolefine powder. This last technique is gaining in importance, and is similar to that used for epoxy resin powders.

TYPES OF POLYOLEFINES

The polyolefines consist of polyethylene, polypropylene, polybutylene, etc. The first two are thermoplastic materials in current commercial use. The polyethylenes are produced by two main methods, one using high pressure techniques and the other using special catalyst systems. The first method produces branched chains of lower crystallinity having densities in the range 0.915 to 0.930.

The second method, which comprises several types of catalyst system, (mainly the Ziegler and the Phillips types) produces linear polymers having much lower branching and higher crystallinity. These products have densities in the range 0.940 to 0.965. As the density or crystallinity of polyethylene increases, so the tensile strength rigidity, surface hardness and softening point increase. At the same time, the impact strength decreases but even the high density polyethylenes have good impact strength when compared with the more brittle types of plastic, such as polystyrene.

It is important to note that, while the tensile strength of polyethylene varies linearly with its density, the rigidity of the material varies logarithmically with density ; this is illustrated in Figs. 1 and 2.

In addition to variations in density, a considerable range of molecular weights is available. As the molecular weight increases, the impact strength, tear strength and resistance to stress cracking increase but the melt flow decreases.

The higher molecular weight polymers are thus more difficult to process but give better performance in service.

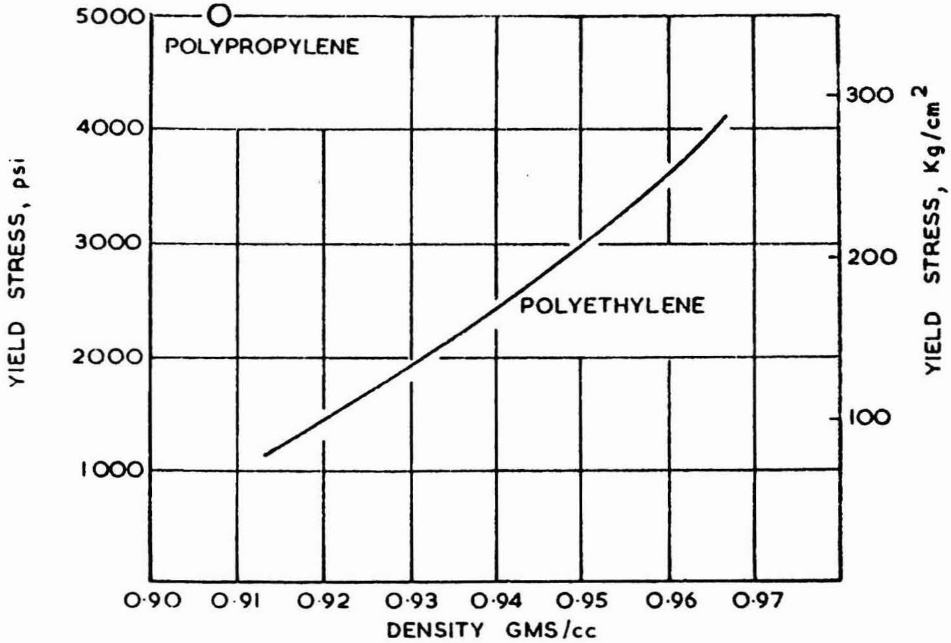

FIG. 1. THE EFFECT OF DENSITY ON YIELD STRESS

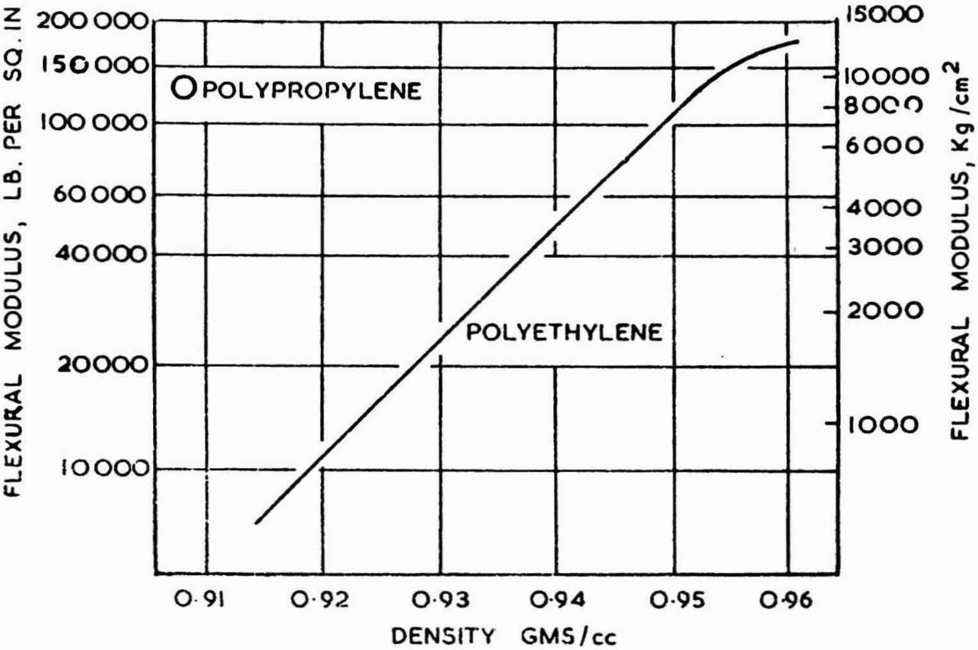

FIG. 2. THE EFFECT OF DENSITY ON STIFFNESS
(Flexural Modulus ASTM D747-50)

Polypropylene differs from the polyethylenes in having higher tensile strength than the high density polyethylenes, better resistance to stress cracking, a higher softening point, a harder surface and higher gloss. It is, however, somewhat less stable to ultra-violet light and ageing at elevated temperatures. Points are included in Figs. 1 and 2 to show how the tensile strength and stiffness of a typical polypropylene compares with those of polyethylenes.

The higher polyolefines are of limited commercial value as far as thermoplastics are concerned.

Table I lists the properties of typical polyolefines which are of interest in coating applications.

TABLE I

SOME PROPERTIES OF TYPICAL POLYOLEFINES

Property	Units	Low density polyethylene	High density polyethylene	Polypropylene
Price (bulk deliveries) ..	shillings/lb	1/7-1/8*	2/2-2/4*	2/4½-2/5½*
Density	g/cc	0.918	0.950	0.908
Tensile strength at yield	psi	1,700	3,500	5,000
Stiffness (rigidity) modulus	psi	10,000	100,000	130,000
Hardness	Shore " D " scale	50	65	75
Impact strength (notched bars)	ft lb/in	>18	5	3
Softening point (Vicat method)	°C	90	120	150
Crystalline melting point	°C	100	130	160
Stress cracking in non-ionic detergent at 50°C	Hr to failure of 50 per cent of specimens	4	30	>1,000
Specific heat	Cal/°C/gm	0.55	0.55	0.46
Thermal conductivity ..	10^4 cal/sec/ cm^2/1°C/cm	8	11	3.3
Moisture vapour permeability of film†	gm/m^2/24 hr	2.0	—	1.4

*Depending on grade.

†This can be compared with regenerated cellulose film (coated to give improved moisture resistance) which gives figures between 5 and 30 gm/m^2/24hr.

EXTRUSION COATING

The extrusion coating process consists essentially of producing a plastic melt in a heated barrel (using a screw to melt and convey the polymer), forcing this melt through a slit die, and laminating on to a substrate under light pressure. Generally, no adhesive is used, the plastic material retaining enough mobility to give a good mechanical bond with the substrate. Diagrams illustrating the process are shown in Figs. 3 and 4. The extruder screw has a length/diameter ratio between 15:1 and 25:1. This screw has three zones :

(*a*) A melt zone, where the polymer granules are melted. (*b*) A compression zone, in which the profile of the screw changes to compress the polymer and drive back any volatile constituents, and (*c*) A metering zone, which delivers a constant volume of plasticised (i.e. molten but highly viscous) polymer to the die.

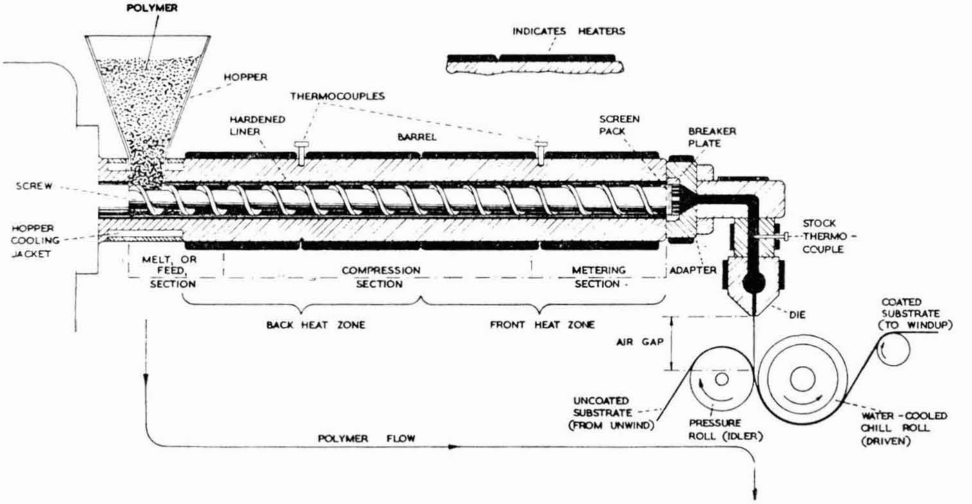

FIG. 3. DIAGRAMMATIC CROSS-SECTION OF AN EXTRUDER

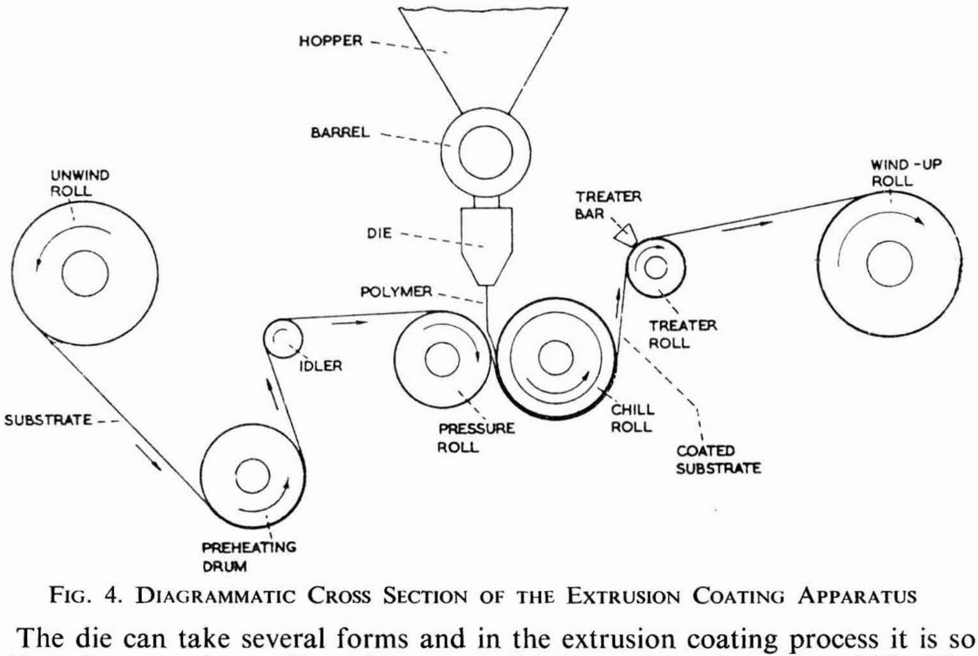

FIG. 4. DIAGRAMMATIC CROSS SECTION OF THE EXTRUSION COATING APPARATUS

The die can take several forms and in the extrusion coating process it is so adjusted as to give a film of constant thickness throughout its width. The molten film is bonded to the substrate by means of laminating rolls which are maintained at a given temperature by internal water circulation. The temperature of the polymer is higher for the extrusion coating process than for most other extrusion techniques, being usually in the region of 250-300°C. This is necessary to give a good mechanical bond to the substrate. The melt must be thoroughly homogeneous, i.e. there must be no high molecular weight particles, which cause marks in the film known as "fish-eyes." For best adhesion the melt should strike the substrate one quarter to three eighths of an inch before entering the nip. The substrate should be pre-heated before coating, again in order to obtain good adhesion.

When the film flows from the die, some lateral shrinkage occurs. This is referred to as "neck in," which is the difference between the melt widths at the die and at the line of contact with the substrate.

AFTER-TREATMENT

For many applications, no after-treatment is required. However, if the polyethylene coating is to be printed, it must be treated in order to make it ink-receptive. Polyolefines are hydrocarbon materials containing no polar groups and ink has very poor adhesion to such surfaces. The treatment process to render the surface ink-receptive is generally carried out electronically by a high voltage discharge in the case of polyolefine films or coatings. This produces sufficient oxidation on the surface of the polyolefine to give adhesion to the ink.

Printing should be carried out within a few days of treating. The effectiveness of the treatment is commonly measured by the "Scotch tape" test. In this test, a sample of film or coating is printed, a piece of transparent adhesive tape is pressed on to it, and the tape then pulled sharply away. If the treatment has been carried out effectively, the print remains intact.

THE SUBSTRATE

The most usual substrate in the United Kingdom is kraft paper, although other types of paper are frequently used. Paperboard (cardboard) is becoming increasingly used as a substrate ; it has a coarser fibre than kraft paper and is more rigid.

In addition, metal foils such as aluminium can be used. In this case the main object is not to produce a moisture-vapour resistant sheet, since the metal foil is adequate in this respect, but to obtain a "heat-sealable" film, i.e. one which can be stuck to itself by heating to a temperature between 150° and 200°C.

Another substrate which can be used is rubber. In this case, a different technique is employed, since an adhesive is required to produce a bond between the polypropylene and the rubber.

The use of fabrics as substrates is increasing but little published work is available on this subject.

CHOICE OF POLYOLEFINES FOR COATING

By far the most widely used polyolefine material in coating is low density polyethylene. This is due to its low price, good flexibility and adequate properties for many applications. Where higher mechanical strength is required, high density polyethylene and polypropylene are used, although the former has only found limited application at present. Polypropylene, which has better mechanical properties than high density polyethylene, withstands higher temperatures and is in some cases easier to process, is gaining ground as a coating material. Its application is still in its infancy, but it is expected to grow steadily.

APPLICATIONS

Multi-wall Paper Sacks

Products which are damaged by picking up moisture can be safely stored in sacks with an inner-ply of polyethylene-coated paper. Also, agricultural products such as fertilisers retain moisture at the desired level when packaged in sacks containing polyethylene-coated liners.

Milk and Juice Cartons

The non-leaking and non-flaking properties of polyethylene are superior to those of paraffin wax and account for the growth of this application. Other advantages are high gloss, heat sealability and, in the case of treated coatings, good printability and gluability.

Polyethylene-coated board is increasingly used for bakery and meat trays, and other dish and tray stocks, including frozen foods. Grease resistance and release characteristics are the major factors for this application.

When applied to aluminium foil, polyethylene effectively seals any pin-holes and its flexibility prevents fracture on flexing of folding. Coated foils are being increasingly used in heat-sealable decorative packaging.

Polyethylene/cellulose film laminates combine the desirable properties of both, such as the low gas permeability of cellulose and the low moisture vapour permeability and good low temperature flexibility of polyethylene.

Polyethylene is also coated on to fabrics, both to impart moisture resistance and to serve as a quick release surface in such applications as conveyor belts.

Rubber/polypropylene laminates have been developed recently as a joint project between three companies, representing the rubber, plastics and chemical plant industries. These laminates are used as tank linings for acids and other corrosive liquids, the rubber providing elasticity and adhesion to the metal tank and the polypropylene providing the chemical resistance.

THE MARKET FOR POLYOLEFINE COATINGS

In the United States, most of the polyethylenes used in extrusion coating during 1962 went into paper-board. Of a total of 72,000 tons of polyethylene consumed in extrusion coating, 45,000 tons (roughly 60 per cent) was used in this application. In terms of board itself, some 325,000 tons were coated in 1962. This is mainly due to the growth of plastic-coated milk cartons, which have almost entirely superseded wax-coated cartons in the United States.

This tonnage of polyethylene represents a tenfold growth in the past eight years and the consumption is expected to double by 1965. The reasons given for this growth are the properties of polyethylene, the economics of the process and the ease of application of the material[1].

In the United Kingdom approximately 6,000 tons of polyethylene are at present used in paper coating. The majority of this is employed for the inner liners of multi-wall paper sacks. Other outlets are small at present but are growing rapidly.

CONCLUSIONS

The extrusion coating technique is now well developed and takes its place among other better-known techniques. Polyolefines are enjoying a tremendous growth rate as coating materials and, in general, they are not replacing other materials (except possibly paraffin wax) but are rather leading to the development of new applications and markets.

REFERENCES

1. " Progress in PE Extrusion Coating, Part 1—Applications and Markets " (Editorial). *Modern Plastics*, May 1963, p. 84.

DISCUSSION

DR. H. A. HAMPTON commented that the lecturer had referred to the low water vapour permeability of polyethylene comparing it with water-proofed cellophane. He thought that it was fairly well known that the resistance to water vapour penetration in a coated cellophane was largely due to the wax that was incorporated in the lacquer which was put on as a proofing medium. He asked whether there was any means of replacing wax in this type of application by polyethylene and perhaps producing a paint which would have very much greater resistance to water penetration. As the lecturer had also mentioned how easy it was to release static from polyethylene, Dr. Hampton asked whether it could be incorporated in some way into a standard paint to give a paint surface on which dirt would not collect so easily or could be more easily removed.

MR. WELLS considered that it would be extremely difficult to incorporate polyethylene into a standard paint. There was a firm in the United States which made a low molecular weight emulsifiable polyethylene and he believed they made it in emulsion form in the same way as a pva emulsion. However, it was not very compatible with other materials, mainly because of its lack of polarity. He did not think any work had been done on incorporating polyethylene into other types of paint, although he felt it would be possible. Very low molecular weight polyethylene would have to be used, in view of the limited solubility.

DR. K. W. HUMPHREYS said he assumed that the prices quoted were those for unpigmented plastic and, as the lecturer had stated that pigmentation was difficult, asked if he could give some idea of the price increase when pigmented polyethylene was required.

MR. WELLS replied that the price of pigmented polyethylene was usually 6d. per lb more than the natural material because it was necessary to tumble mix and then re-extrude and re-granulate. Moulders quite often mixed their own colours by tumbling pigment with polyethylene and then feeding into the hopper of an injection moulding machine, but this did not give very good dispersion. A better method was to make up a master batch of about 30 to 40 per cent pigment with a small amount of the polyolefine, extrude this master batch and then let down to a final 2 per cent concentration of pigment in the hopper of the extruder. This only gave a small price premium since it was only necessary to make up enough master batch to blend in with the rest of the material. Pigmentation was always a problem in that extrusion was necessary. It was not possible to tint the polyethylene in the same way as a paint ; if the shade obtained was wrong it was necessary to re-extrude.

DR. W. CARR said it was obvious from the lecture that one of the major applications of this film was a packaging material and this was normally a very interesting field for the printer from the point of view of decorating, advertising and labelling. He asked whether there were any problems in printing on plastic films and laminates by conventional printing processes.

Mr. Wells answered that apart from the major problem of surface pre-treatment, which had now been largely overcome, he did not think there were any particular difficulties. He had not studied the various types of printing on such surfaces, but one had only to look at household bottles—bleach bottles, detergent bottles, etc.—to see that it was possible to print by ordinary methods. Ink makers did produce special inks for polyolefines, but he did not know if it was possible to use all types of ink for printing on them.

Mr. J. Miles inquired whether Mr. Wells could give the coating rates of the polyolefines with reference to his Table I (p. 410) where some moisture vapour penetration rates were quoted and asked how these compared with the cellulose types of coating.

Mr. Wells explained that the polyolefine films were not coated, but were 0.001 in films made by the blowing process, whereas the cellulose film was made by the cast process in which the extrudate passed on to a roll and gave a 0.001 in film of cellulose. He regretted he had no figures for polyethylene-coated paper. It was found that if a coating of less than 0.0005 in was used, problems with pinholing could occur and this explained why 0.0005 in was the standard.

Mr. H. D. Brearley asked if Mr. Wells would discuss the possibilities of paper coating using emulsion techniques with low density polyethylene. He said it would seem that this process would require less capital outlay.

Mr. Wells replied that this was correct. He had no details, but as far as he knew the doctor blade method of coating the emulsion had been used in the United States. It did not seem to have been developed in this country. There would be the problem of having to pass the web through an oven to obtain the necessary flow out in a continuous film and it might be difficult to achieve an even and well-knit coating.

Mr. J. N. McKean asked whether the incorporation of pigment necessitated casting a thicker film to avoid the possibility of pinholing in a film of 0.0005 in due to large particle size.

Mr. Wells said it should be unnecessary because pigment particles of about 0.1 to 2 microns were used. With a coating of 0.0005 in one did not seem to run up against problems of poor pigment dispersion. He pointed out that only a low concentration of pigments, about 2 per cent, was used.

Dr. L. Valentine asked whether Mr. Wells could comment on the possibility of polyolefines being a real challenge to the paint industry in terms of coatings for buildings purposes, e.g. laminates for systematised building structures. He also inquired whether the photochemical stability of polyolefines was suspect, and whether this would restrict competition to such materials as *Tedlar* (polyvinyl fluoride film) laminates.

Mr. Wells thought Dr. Valentine was right. The main field in which polyolefine coatings were going to challenge the paint industry would be in tank linings, etc. Again, he said, there was the problem of poor adhesion to metals, etc., but with the laminates which were currently being developed, such as polyethylene/rubber laminates and polyethylene/polyester/glass-fibre laminates, the sandwich construction provided a key to the metal and, being resilient, might relieve the vibrations. He did not feel that such coatings would be a serious challenge to paints in buildings.

Mr. J. K. Rankin asked Mr. Wells to comment on the low temperature stability of polyolefines.

Mr. Wells stated that there was no problem of low temperature stability. The brittle point of both polyethylene and polypropylene was about −70°C. The flex properties were extremely good down to those temperatures. In fact, it was possible to mould a hinge of polypropylene by having the right molecular orientation and the right die design ; tests had shown as high as 70,000 flexes before failure at −70°C. On the other hand the impact strength of polypropylene was not so good below 0°C, under freezing conditions polypropylene being more brittle in impact although satisfactory in flexure. Polyethylene could be taken down to sub-zero temperatures both in flexure and in impact without any likelihood of failure.

Pvc Metal Coatings

By M. R. Day

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INTRODUCTION

Pvc is the most versatile of the common thermoplastics. It can be compounded with a variety of ingredients to give material which may be moulded, extruded, and calendered ; it may be used in latex, solution, powder, or dispersion form. This paper will deal mainly with recent developments in the field of dispersion and solution technology, and outline their place alongside both conventional painting techniques, and the traditional methods of applying pvc coatings.

ESTABLISHED METHODS

Pvc may be hot compounded with a variety of ingredients including plasticisers, pigments, heat stabilisers, and fillers, to produce a compound suitable for extruding and calendering. The amount of plasticiser included in the compound controls the softness of the product. The traditional methods of processing thermoplastics depend upon shaping them while they are in the semi-molten state, and cooling them so that they retain that shape at ambient temperatures.

Calendering

A calender is essentially a sophisticated hot " mangle " which squeezes hot pvc compound into a uniform foil or film which may subsequently be embossed or printed. A full size calender costs about £100,000.

Special grades of calendered foil have been developed which can be laminated to metal sheet and strip. Bonding takes place at high temperatures, and the equipment for this process is much less expensive than the calender needed to produce the foil.

It is only practicable to coat one side of the metal, and for this reason, when steel is used as a substrate, it is often galvanised in order to afford some protection to the back and edges of the product. Since the pvc foil applied to the metal in this manner may be printed and embossed, a product is obtained which is ideal for domestic and decorative use, but which tends to be rather expensive for widespread general industrial use. The laminates may be readily drawn and formed into complicated shapes.

Extrusion

Hot pvc compound may be extruded. This process is rather akin to syringing cake icing through a nozzle, the nozzle being called a die in the case of extrusion. Since another paper will deal with extrusion coating in greater detail, mention will only be made of two methods of extrusion coating which have a bearing on the techniques discussed later in this paper.

Wire Coating

Pvc compound may be extruded on to wire. The familiar green chain-link fencing is made from steel wire which is coated in this manner and subsequently woven. The wire may be coated at about 600 ft/min on equipment costing approximately £7,000. There is no adhesive bond between the wire and the metal.

Contractile Tubing

There is a patented process whereby a pvc tube is extruded, cooled, and subsequently re-heated and inflated to increase its diameter. When again re-cooled over a rod or tube of any material, it shrinks to its originally extruded size, to provide a close-fitting protective coating. As in the case of coated wire, there is no adhesive bond to the substrate, unless the metal is first treated with an adhesive.

Dip Coating with Pvc Paste and Powders

Pvc pastes or plastisols are dispersions of a polymer in a liquid plasticiser. When heated, these liquids undergo an irreversible physical change in which the pvc particles are dissolved by the plasticiser to give, on cooling, a product which is the same as the plasticised pvc compound already mentioned ; this process is called gelation. One important application for pvc paste is to spread it on to fabric, gel by passing through an oven, and subsequently emboss the coating to produce the pvc coated fabrics which upholster the majority of motor cars.

Metal items may be coated by heating, dipping into pvc paste, removing, and allowing to drain, followed by gelation of the coating in an oven. The object of dipping the items into the pvc paste while they are hot is to allow them to pick up some of the pvc which semi-gels in contact with the hot metal. It is also possible to dip-coat metal items in beds of thermoplastic powders made fluid by blowing air through them. Finely ground pvc compound may be used for this purpose.

The main point in introducing this subject, since it is being dealt with in another paper, is to stress that no adhesion of the pvc to metal is obtained with dip coatings, unless the metal is primed.

NEW MATERIALS AND METHODS

Until recently, it was necessary to prime metal substrates in order to obtain an adherent coating of gelled pvc paste.

Metal Adherent Pvc Paste

Pvc pastes are now available which, when stoved in contact with metal, adhere tenaciously. This paper will not discuss in detail the constitution of these materials, but rather their application, costs, and uses, since it is these factors which offer a challenge to the paint industry. Several systems are available, and they all involve the chemical cross-linking of some of the paste ingredients. This cross-linking takes place when the paste is heated and gelled. These new pastes tend to be two-pack systems or, if one-pack, then of limited shelf life by normal pvc paste standards.

The cross-linking produces hard durable coatings with good chemical resistance, particularly to inorganic chemicals, good weathering characteristics, and good wearing properties. They may be modified to produce coatings of different softness by varying the amount of plasticiser. The table below shows the effect of plasticiser additions to " *Welvic* " M1/24C paste. The plasticiser used is di-nonyl phthalate.

Welvic M1/24C Paste

Percentage w/w di-nonyl phthalate added	0	3	7	10
B.S. softness number	15	20	25	30
Shore " A " hardness number	97	96	94	92
Pencil hardness	4H	3H	2H	H

With this paste, the bonds obtainable to grit-blasted mild steel are of the order of 25 lb/in. In the case of steel and iron, no pre-treatment is necessary, provided that all scale, rust, and grease are removed, while pre-treatment is usually necessary in order to obtain good bonds to galvanised steel, aluminium, and zinc. The adhesion to copper and brass is poor, and it is best to use a primer and conventional paste in order to coat these materials.

Metals coated with metal adherent pvc pastes may be formed and drawn, since the coatings are plastic.

Application and Costs of Metal Adherent Pastes

Metal adherent pastes may be obtained in the 100 per cent solids form which means that, when heated and gelled, all the components will change into a solid material. Volatile diluents can also be included as thinners, but are not normally used to give a solids content below 70 per cent.

Typical diluents are xylene, toluene, and ethylene glycol monobutyl ether. The pastes are dispersions, not solutions, so that ketones or chlorinated hydrocarbons must not be used, since they act as solvents for the pvc particles. The effect of adding a solvent is to swell the pvc particles and thicken the paste.

The diluents mentioned reduce the viscosity of pvc pastes to a remarkable extent and, in any case, only a small amount is required because pastes can be sprayed on conventional paint spraying equipment at higher viscosities than would be employed for conventional paints. For example, *Welvic* M1/24C paste, containing 8 per cent of titanium dioxide pigment, and thinned to 100 sec (Ford No. 4 cup, Series B) with 10 per cent of a 2:1 mixture of xylene and toluene, sprays satisfactorily with a 70 p.s.i. pressure on the line and 15 p.s.i. pressure on the reservoir. Using a fairly large air cap and fluid tip on the spray gun, an 0.010 in coat is obtained with one application of this paste.

When diluted, the pastes may be applied electrostatically on conventional equipment. They can be applied by single roller coater, without any diluent, to produce an attractive ribbed finish on metal sheet. If this ribbed finish is undesirable, then it can be smoothed with a second doctor roller running in the reverse direction.

In the diluted form the pastes may be applied by a curtain coater and reverse roll coater. They may also be applied to wire or narrow width steel strip by simply passing the wire or strip through a bath of paste, and then through a sizing die.

Stoving of the pastes to gel and cross-link them is carried out at between 160°C and 250°C, for a time, which depends on, (*a*) Temperature, (*b*) Thickness of coating, (*c*) Amount of diluent added to paste, (*d*) Thermal capacity of substrate.

The best conditions are soon established by trial and error. Clearly, on a continuous coating plant it is desirable to stove quickly at a high temperature, in order to avoid the necessity for inordinately long ovens. Stoving times vary between 2 and 30 minutes, depending on the above factors.

It is possible to build up very thick coats, i.e. greater than 0.03 in, by applying several coats of paste and semi-gelling between each coat, so that the pvc is solid enough to be handled, but not completely gelled and cross-linked. The complete gelation can be carried out when the last coat has been applied. This is the technique normally adopted to coat large tanks, etc., for chemical plant.

Over-stoving results in a charring of the pvc coating while under-stoving gives a film which is weak and one which does not adhere to its substrate.

One disadvantage of these materials is that they fume on stoving, although this may be reduced by using polymeric plasticisers to make up the pastes ; these plasticisers are more expensive than those normally used.

The cost of these pastes is about 40-50s per gallon ; that is for 100 per cent solids material. They are normally sold by weight, and there are approximately 13 lb in one gallon. One gallon of paste will cover 380 ft^2 with an 0.005 in coating, assuming no losses on application.

Metal Adherent Pvc Lacquers

Parallel to the development of pvc pastes for metal coating, is that of pvc solutions for the same purpose. The solutions are air drying, and do not require stoving like the pastes. They may be used as mastics or lacquers to touch up damaged pvc paste coatings or as coating materials in their own right. The air-drying materials will be more expensive than the pvc pastes ; they will be below 40 per cent solids, and are, of necessity, based on copolymers of vinyl chloride and vinyl acetate, which are more expensive to produce than the simpler vinyl chloride polymers used in pvc pastes. The solvents used are ketonic. Further development of these systems will show more clearly their potential role in the surface-coating field.

End Uses for New Materials

The materials described are already being applied, mainly to steel, by a variety of methods, to give products which are finding uses in many fields.

The constructors of chemical plant are well served with products that are coated with pvc paste. Custom coaters are now able to apply pvc pastes by spraying. This method of coating offers advantages over the traditional dipping method, and is more economical than rubber lining or lining with rigid pvc sheets. Spraying is not limited to the size of a dipping bath, and enables economical coatings of any colour to be applied, provided that a large enough oven is available to stove the coated item. Figure 1 shows a tank lined with *Ensecote* P/L, based on *Welvic* pvc paste, by *Ensecote Ltd.*, a Newton Chambers Company.

Industrial steel floorplates are available which are coated with pvc, and which incorporate grit, by a patented process, to give them non-slip characteristics; the pvc can be applied in any colour.

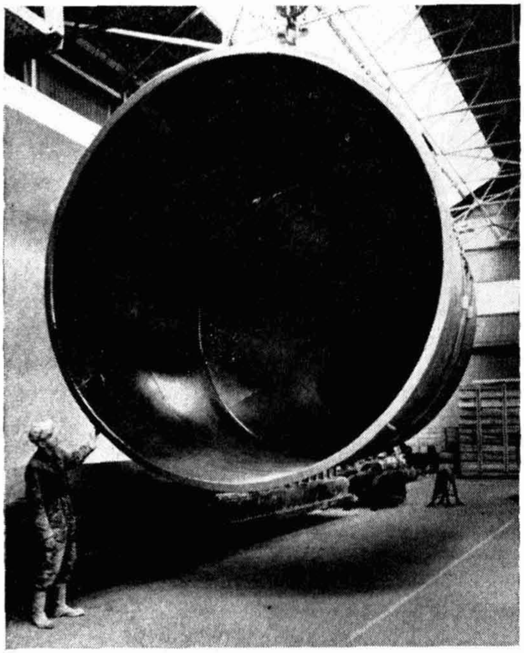

FIG. 1. A TANK LINED WITH ENSECOTE P/L, BASED ON "WELVIC" PVC PASTE, BY ENSECOTE LTD., A NEWTON CHAMBERS COMPANY.

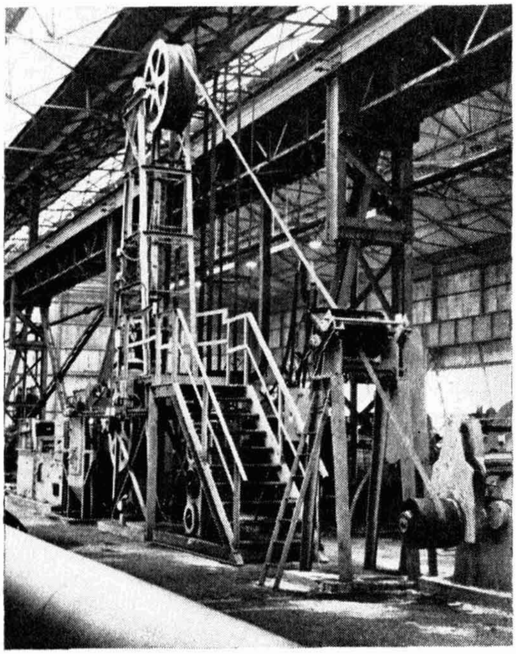

FIG. 2. PART OF A PLANT FOR COATING NARROW STEEL STRIP AT CONSETT IRON CO. LTD.

Coated and lined steel pipe is now on the market ; the coatings and linings are applied to pipes up to 26 in in diameter and 40 ft long, to give a product which has the strength of steel and the erosion and corrosion resistance of pvc. Such pipes are particularly suitable for carrying corrosive slurries. The good erosion properties are particularly impressive and pvc pastes are now being used to coat rollers which move conveyor belts in gritty environments. It must be remembered that plasticised pvc is an excellent material for shoe soling, which gives an indication of its wear performance. Pvc coated steel goods for chemical plant are complementary to the unplasticised pvc products which are increasingly finding their way into this field. They are used where the strength of the unplasticised pvc is insufficient for any particular purpose.

There are considerable possibilities for pvc coated steel goods in the building field. Steel sheets are being coated with pvc paste by a single roller coater to yield a product which is coated on both sides, and at the edges. This product is available at prices which compare very favourably with the pvc steel laminates which are only coated on one side. The sheets may be corrugated and used for roofing and curtain walling, in place of the traditional galvanised and painted sheets. The pvc coated sheet should have a considerable life, and is available in a range of attractive colours which can be made into building panels.

Narrow steel strip is being coated with pvc paste and subsequently formed into sections for the manufacture of beams and joists for building systems. Figure 2 shows part of a plant for coating narrow steel strip at *Consett Iron Company Limited.* The coated product is being coiled on the right of the picture.

There is considerable interest in the coating of wide steel and aluminium strip with pvc paste on a continuous basis. It is being done abroad with conventional pvc pastes applied over a primer ; metal adherent pastes should offer an advantage for this application. The coated strip can be cut, formed and drawn, thus obviating pre-treatment and painting operations at a fabricator's works.

Pvc paste has been applied electrostatically to tubular steel furniture to provide a tough durable coating which should appeal to the manufacturers of office and school furniture. Figure 3 shows a section of the renovated Wembley Stadium. The steel seat frames have been coated with *Welvic* pvc paste by *Cox of Watford Limited.*

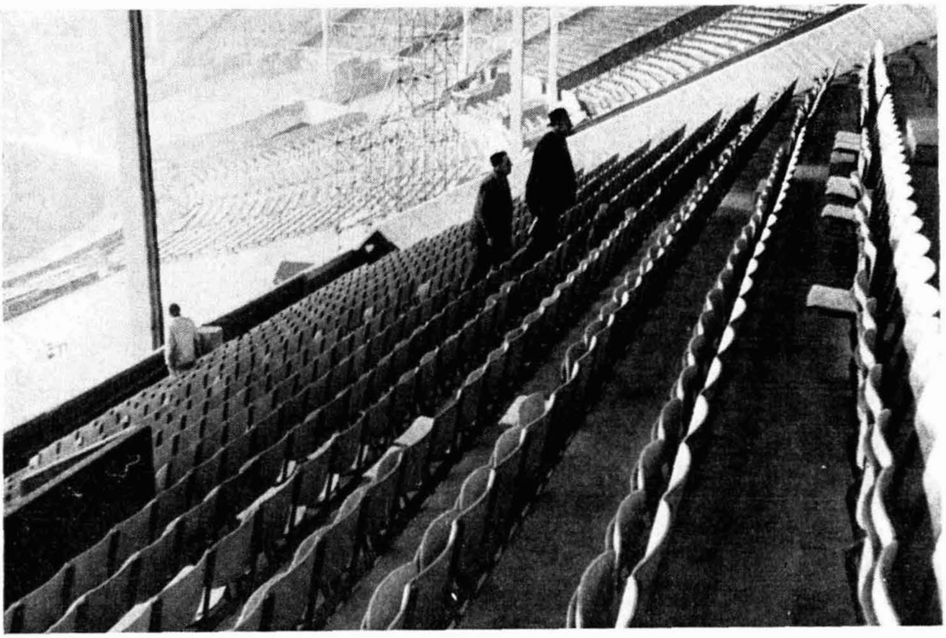

FIG. 3. STEEL SEAT FRAMES COATED WITH " WELVIC " PVC PASTE BY COX OF WATFORD LTD.

The electrostatic method offers an ideal way of providing coatings between 0.005 in and 0.02 in on large welded wire mesh sections ; the traditional dipping method requires a large bath and gives coatings which are too thick for many purposes.

An elegant application involves the coating of mounting plates for electrical switchgear control boxes. Figure 4 shows slotted backing plates coated with a fairly heavy coating of *Welvic* pvc paste by *Associated Electrical Industries Limited.* Formerly, the plates were not slotted, and had to be drilled and grommeted in order to mount and wire the components. The pvc coating provides a durable insulating coating with no sharp edges to damage the wire insulation.

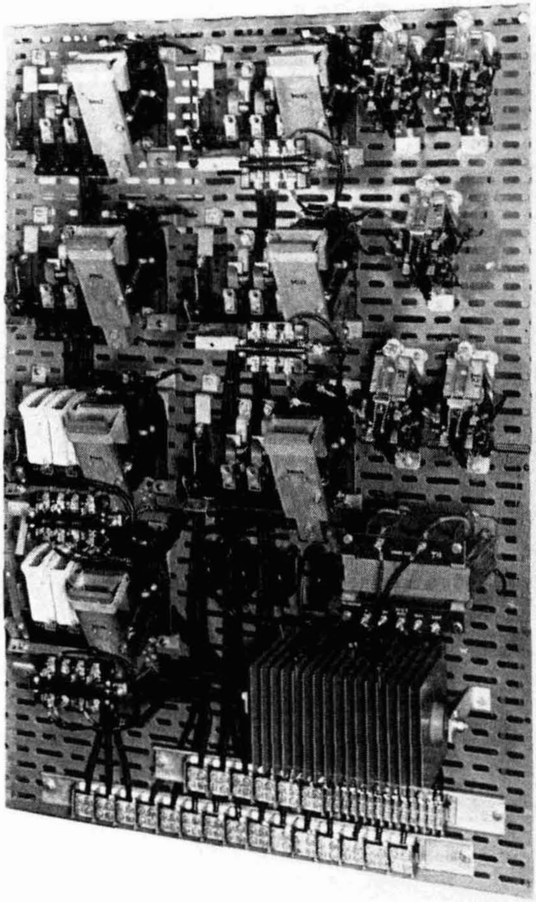

FIG. 4. SLOTTED BACKING PLATES COATED WITH "WELVIC" PVC PASTE BY ASSOCIATED ELECTRICAL INDUSTRIES LTD.

Wire may be coated continuously by passing it through a bath of pvc paste and then through a sizing die. The coated wire then passes through an oven before cooling and feeding to a weaving machine. In order to match the output of an extrusion coating arrangement, many wires can be coated simultaneously, so that the limitation imposed is the cost of the fairly expensive haul-off and tensioning equipment. Wire is now being produced by this technique which may have an advantage over the extruded product in that the coating adheres to the wire, whereas there is no bond between the pvc and metal when the extrusion process is adopted.

CONCLUSION

While the traditional methods of applying pvc coatings by extruding, laminating calendered foil, and dipping, will continue to grow, a further challenge to the paint industry comes from metal adherent pvc pastes and solutions.

[*Received* 13 *August* 1963

DISCUSSION

MR. W. G. TOPHAM commented that the performance of the newer solution type of pvc coating was stated to approach that of the heat-cured finishes. He asked the lecturer whether this comparison applied to solvent resistance, and whether unconventional solvents were necessary.

MR. DAY said pvc coatings were not particularly solvent-resistant. He did not think people usually offered pvc coatings for solvent-resisting applications. Certainly he would not recommend the pvc pastes for that sort of application and he would be even less willing to recommend the solution-borne ones—it was mainly for inorganic environments that both were being offered. Mr. Day said he realised he had not really said much about the solutions. They were rather new, at least as far as his company were concerned.

MR. C. D. WELLS asked whether the lecturer could give an indication of the outdoor life of, say, a pvc paste-coated gate.

MR. DAY admitted this was the " 64,000 dollar " question. It was difficult to say, but the experience gained on all forms of pvc suggested that such a coating would certainly last ten years if it was black. This was the sort of figure that was being mentioned, and while some people were quoting even longer lives on the basis of accelerated tests, it must be remembered that these did not always correlate with actual usage.

MR. C. L. LEWIS asked if it was correct that adhesion of pvc plastisols to metal varied considerably with choice of stabilisers and plasticisers.

MR. DAY thought that this was so, but if a ready-made system was used, this was taken into account. He thought that the adhesion obtained with the sort of systems he had been discussing was something of the order of 25 lb per in (peel). Using systems based on di-allyl phthalate a lower adhesion was obtained, but such systems had certain advantages in respect of shelf life.

MR. ARMITAGE confessed that he did not quite understand the reference made by Mr. Day to the " challenge " to the paint industry by the development of pvc solution coatings, plastisols and organosols, and would have thought that coatings such as those described were made by the paint industry and had been made for the past 15 years, and he asked in what sense was any special challenge involved.

MR. DAY said he did not believe that it had been possible to coat metal with pvc without the use of a primer in the last 15 years, but admitted that he might be wrong.

MR. H. GRIMSHAW inquired whether in the continuous coating of steel strip and wire with pvc paste as described in the paper it was necessary to pre-heat the wire and strip.

MR. DAY explained that this was being done cold at the present time. He saw no reason why strip or wire should not be pre-heated provided it was passed through a relatively small bath of paste, whose contents were continuously being replenished. He felt that a lot of work remained to be done, but until now most of the work had been done on cold wire. He admitted that pre-heating might lead to shorter stoving times.

MR. P. WHITELEY asked if the lecturer could say more about the method of manufacture of beams and joists from coated strip. In particular, if bolts were used, he asked how these were protected. He also asked if it was possible to give a comparison of cost of galvanising and pvc coatings.

MR. DAY agreed that on the question of making beams and joists the questioner was quite right in that there were ways of overcoming these difficulties by touching up local spots. Touching up could be carried out in two ways : by applying the solvent-borne, air-drying material, or applying the pvc paste and gelling it by local heating with infrared or other method.

Replying to the second half of the question he said that pvc coatings were more expensive than galvanising except possibly in the case of wire ; nevertheless it was a technique that was being taken up by galvanisers. Some firms who were traditional galvanisers saw pvc coating as a challenge and were therefore entering the field.

MR. J. F. J. RULE requested a little more information about the two-pack systems and asked what the other pack was and on what principle did it work.

MR. DAY regretted that he could not divulge this information.

DR. H. A. HAMPTON asked how the two-pack system affected the thermal plasticity of the finish. He presumed that with the same plastisol a certain degree of thermal plasticity was obtained, but asked how cross-linking would affect the result. He suggested that this would achieve a greater solvent resistance.

MR. DAY answered that cross-linking slightly reduced thermal plasticity and improved solvent resistance, but not to the point where the latter property was good enough for use in contact with common solvents. Use of the two-pack system hardened the film considerably ; being cross-linked it appeared to contain less plasticiser than, in fact, it did.

MR. RULE asked what would be the effect of a burning cigarette end.

MR. DAY replied that comparing the coatings with conventional pvc compounds the heat distortion temperature did not alter a great deal, and that the flammability of the coatings was controlled by the same factors which controlled that of conventional pvc compositions.

MR. LAND said he would like to ask Mr. Day whether in his experience the coating on the sheeting exhibited was actually giving corrosion resistance. He asked if the lecturer had any experience of what happened to such coatings if, on a building after erection, it was then damaged and whether there would be corrosion creep under the film.

MR. DAY answered that his experience suggested that if such coatings were scored and then allowed to corrode, the corrosion did not creep as much as it did in the case of a laminate. The product was also cheaper than a laminate. It was coated on both sides and the edges, while a laminate was only coated on one side. This was the sort of product that was going to break into the industrial field for roofing, etc.

MR. R. F. BOWLER requested Mr. Day to enlarge on the process of electrostatic coating to which he had referred.

MR. DAY explained that this was a technique whereby liquid droplets were charged, and allowed to " home " on to an earthed object. A large number hit the earthed object—at least 80-90 per cent—and so there were only small losses. This process was particularly useful for coating open structures such as slotted angle, or chicken-wire in the woven form. The demonstration which would be seen later on would illustrate the technique for the application of powders, but the same principles applied in the case of liquid droplets.

MR. A. T. S. RUDRAM commented that most of the applications described were for new work. He asked how these coatings performed as recoating films in absence of curing procedure.

Mr. Day said that he did not think these coatings would deteriorate apart from possible slight changes in colour. They could, if required, be repainted with ordinary gloss paint, but there seemed little point in this. In response to Mr. Rudram's further comment that the paint would, therefore, make good the deficiency of the pvc, Mr. Day said he did not think this would be necessary.

Dr. L. Valentine inquired whether Mr. Day was able to speculate on the reasons why cross-linking one of the paste ingredients should lead to an increase in adhesion.

Mr. Day replied that the nature of adhesion was little understood, despite the fact that several theories had been advanced.

Dr. H. A. Hampton commented, amid laughter, that no one understood that better than Dr. Valentine.

The Factory Application of Dip Coatings

By E. W. FOLEY

Plastic Coatings Ltd, Winsford, Cheshire.

INTRODUCTION

Plastic coatings were originally applied to metals to protect them against corrosion. This is still one of the major uses, but the field has now widened to embrace cushion coatings to prevent damage, for electrical insulation purposes and as decorative finishes in their own rights. In the chemical field the engineer is making increasing use of specific plastics for protection against an ever-increasing combination of compounds which attack mild steel and also very often stainless steel. The automotive industry has a very large number of carrying jigs coated with a resilient grade of pvc to prevent chrome plated components from being scratched and instruments from being jolted during movement in the factory ; dish drainer and dishwasher inserts coated in pvc, *Polythene* and *Nylon* serve very much the same purpose for domestic and industrial kitchens ; electric drills have their handles coated inside and outside to provide a pleasant feel and to ensure electrical insulation ; more and more tubular steel furniture is being coated in pvc and particularly *Nylon* to provide highly durable non-chip decorative finishes.

DIP COATING

The dip coating process depends on the fact that at some time during the heat cycle of the polymers there is a thermoplastic phase that can be used. It is true that there are cold-dipping grades of pvc available, but it is the intention in this paper to restrict observations to processes in which preheating and post-sintering are used. These can be used either together or singly.

PROCEDURE

There are four major stages in the dip coating operation, (*i*) metal preparation, (*ii*) preheat, (*iii*) the dipping operation, (*iv*) the stoving, sintering or curing operation.

Metal Preparation

Metal preparation usually begins before the articles that are to be coated reach the plastic-coating factory.

Design

To be really successful, coating should be considered as part of the basic design of the article, and the designer should bear four important points in mind :

(*a*) The surface contours should be smooth ; sharp edges and corners should be avoided for thermoplastics tend to contract on cooling, and, as a corner or sharp edge is always coated more thinly than a flat surface, the coating is made thinner when cooled. For this reason it is essential that all corners and edges should be made to a minimum radius of $\frac{1}{16}$ in, but if possible $\frac{1}{8}$ in.

(*b*) There should be as little difference as possible between the gauge of metal used. To take an extreme case, a 1 in × 1 in mesh fabricated from 18 swg and attached to a $\frac{3}{4}$ in thick metal plate of 18 in diameter with a boss of a further 1 in thickness would be amost impossible to coat satisfactorily. (Faced with such an item the skilful operator can often achieve a surprisingly high degree of success.) In the preheating process, it takes the thick piece of metal considerably longer to be raised to the required temperature than the mesh, and once removed from the preheating oven the mass will retain its heat considerably longer than the mesh, which will lose its heat almost immediately.

(*c*) The mass of the metal must also be considered and this is particularly true of castings at one end of the scale and very fine mesh at the other. In the case of castings the mass should be kept as low as possible since the preheat time becomes excessively long, and the heat from the casting emitted during the actual dipping operation could cause the plastic to run, particularly where, for reasons of weight, water quenching cannot easily be carried out. In the case of the mesh, it would be almost impossible to coat satisfactorily a 22 swg 1 in × 1 in mesh, whereas the same gauge in $\frac{1}{4}$ in × $\frac{1}{4}$ in mesh over a $\frac{3}{16}$ in frame could be coated with comparative ease. This is probably because the effects of radiation from wire to wire are sufficient to retain the heat long enough to allow transfer from the oven to the dipping medium.

(*d*) The fabrications or castings must be as free from porosity as it is possible to make them. In the case of mild steel fabrications this applies particularly to the welds; these must be reasonably well ground, continuous, and free from porosity. The welds need not be quite as well ground as is necessary to produce a first-class painted surface since normally the thickness of the plastic applied during the coating operation is sufficient to mask any large surface unevenness. Porosity will cause the coating to bubble, and if water quenching takes place, will also allow water to pass, often defeating the object of coating. If pores are obvious they should be weld filled before the coating operation is undertaken. Plastic metals and similar fillers are not in practice suitable for this work.

Metal Cleaning

The second stage in metal preparation is the removal at the factory of all forms of oxidation. This is carried out by the conventional means of shot blasting, pickling or chemical rust remover. When this has been completed an adhesive primer is generally applied, partly to prevent further oxidation and partly to provide a satisfactory adhesion between the thermoplastic and the substrate ; this can be applied either by dipping or spraying.

Preheating

The article is then preheated at a temperature and for a period of time both of which can only be predetermined by experience, so that, when the article is dipped, it is emitting sufficient heat from its surface to gelate (in the case of a plastisol) the pvc on to the metal, or, in the case of a fluidised powder, to melt the particles so that they will flow over the surface and form a *homogeneous* film.

The sources of heat can vary considerably ; recirculating ovens are generally found to be the most efficient, because an even temperature can be more easily maintained throughout. They are not necessary, however, and surprisingly good results can be achieved with quite crude ovens.

Radiant heaters are also used quite extensively, but these can cause trouble where a variety of metal surfaces is encountered, since the reflective ones may be impossible to heat sufficiently or may take up costly time and fuel in attaining the required temperature.

Induction, resistance heating and direct flame heating can also occasionally be used, but are generally severely limited either by the intrinsic shape of the article or inability to control the end temperature.

Operating costs can vary considerably depending upon the efficiency of the heating system and the fuel used. It is a question of balancing time and consumption, but it is worth considerable investigation to ensure that the methods used are the most efficient.

Dipping

The article is dipped for a sufficient length of time to enable it to be coated to the required thickness. In the case of a pvc plastisol, a useful guide to the maximum thickness which can be deposited is to use the gauge of metal itself up to a limit of $\frac{1}{4}$ in. For example, a $\frac{1}{8}$ in mild steel plate would be expected to take up a maximum pvc deposit of $\frac{1}{8}$ in. Up to this maximum the thickness is directly proportional to the period of the dip. There is also a minimum thickness—this is essentially dictated by the shortest dip period to ensure a complete film formation ; it is dependent on the design of the component.

Drips are the commonest drawback to an acceptable appearance on pvc paste dipped articles. They can rarely be completely eliminated from this method, but by slow withdrawal from the paste and by using proprietary electrostatic de-tearers their occurrence can be reduced. They can be completely eliminated by use of the fluidised-bed technique, which is discussed below.

Pvc is the only material which is generally deposited from the liquid form. Other polymers such as *Nylon*, *Polythene*, *Penton*, cellulose acetate butyrate, acrylonitrile butadiene styrene, epoxides and polypropylene could be applied by solvent dipping, but the cost would be excessive because of the solvent loss or expenditure on recovery plant, and the many precautions needed for factory handling.

To overcome the above limitations the fluidised-bed method is used. In this technique the material to be used is ground to a powder of a particle size which will ensure that, when a large volume of air is passed through the powder at low pressure, the powder will be lifted and behave in a similar manner to a fluid. Filtered air at a pressure of about 21 in of water is passed into a chamber at the bottom of the container in use. The rate of flow is in the order of 10 to 15 ft^3/ft^2 of surface/min, and careful control has to be exercised over the way in which the air is led into the chamber so that its flow is even over the whole of the surface of the container, thus the design of the inlet manifold is of considerable importance. The air then rises through a microporous substance, such as a ceramic tile, so that it is evenly diffused before passing through the powder in the container. A very even diffusion of air is essential to a well-fluidised container. The sides and corners of the container must not hold " dead " powder (i.e. which has not been fluidised) or full use cannot be made of the whole capacity of the container. Equally, without satisfactory diffusion there is a tendency for air to concentrate on a small area and push up the powder in a manner very similar to a water spout so that the surface of the powder erupts in volcanic spurts. Ideally, the surface of the powder will look like simmering water.

Not all powders will fluidise with equal ease. The two factors which appear to influence the ability to fluidise are the mesh size and the density of the material. The following table gives typical data for these materials in factory use. The precise technologist would probably wish to determine these factors more exactly, but it is fairly certain that, within the limits shown in the table, it is possible to fluidise the powder to a degree which will permit production by dipping. It is known that any excessive straying from the range of mesh sizes shown will result either in excessive fines being liberated and causing a considerable amount of dust, or, at the coarser end of the scale, quite lumpy formations will sink to the bottom of the container, ultimately blocking the air flow completely.

Material	*Mesh Size*	*Particle Shape*
High density *Polythene*	80—200	Angular
Low density *Polythene*	50—100	Conical
Nylon 11	80—200	Angular
Penton	80—200	Angular
Pvc powder	50—100	Angular

The dipping operation itself is carried out either by hand or by use of hydraulic and pneumatic ram equipment or often on the camel back principle of a continuous conveyor dipping through the fluidised powder.

It is usually necessary to agitate the article when dipping in powder to prevent the formation of occluded pockets of air and ensure intimate physical contact of metal with the powder. With liquids this is not necessary since the flow will fill most cavities if the dip is carefully controlled. Considerable care must be taken in both powder and liquid when coating the inside of tanks. These must be dipped upside down to allow surplus raw material to flow out on withdrawal from the dip, and in this position there is a tendency for a pocket of air to be trapped. This is overcome if a bleed hole for the air can be provided.

The thermoplastic, which is either gelated or fused on to the metal, acts as a heat insulant with most normal fabrications so that there is a limit to the thickness which can be applied. The next table shows what these thicknesses would normally be for a $\frac{1}{8}$ in plate of mild steel.

Material	Maximum Thickness in inches
Pvc plastisol	0.125
Pvc powder	0.030
Low density *Polythene*	0.035
High density *Polythene*	0.030
Nylon	0.025
Penton	0.025

In the case of heavy castings where the thermal retentivity of the metal far outweighs the insulating properties of the plastic greater thicknesses will be picked up, and, unless immediate steps are taken to cool the item, sagging of the film will occur.

Post-Sintering and Stoving

When the dipping operation is complete, the plastisol coating has to be cured to ensure that the polymer takes the predominant position in the compound, thus obtaining maximum physical properties ; and for the powder coating to be sintered, thus ensuring that any unfused particles of powder are fused, giving a uniform, homogeneous film over the article. This is done in a similar way to the preheating process, but using temperatures only slightly above the melting point of the thermoplastic. The sintering completed, the items are then generally water quenched to speed up handling and in some cases to impart a high gloss to the surface of the plastic.

Fig. 1 shows a flow chart for a typical installation and this can be taken in conjunction with Fig. 2, which illustrates an automatic plant for the coating of some 4,000 articles per shift at its maximum output.

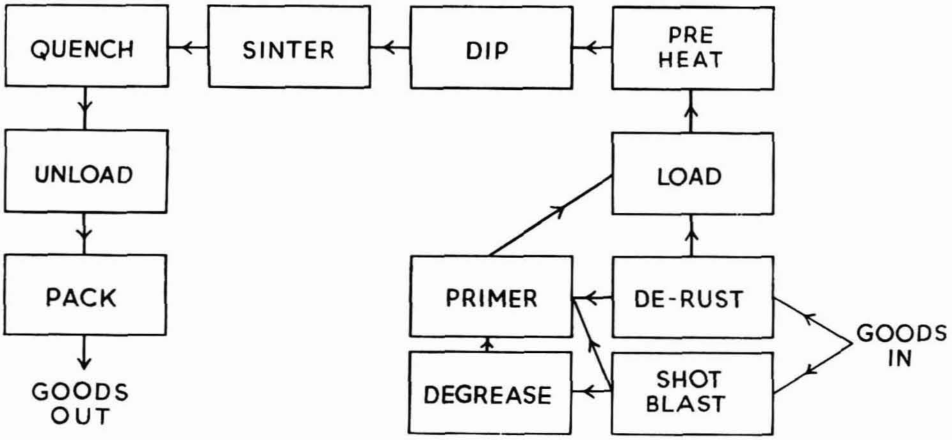

FIG. 1

A typical operating cycle for wirework articles coated in polythene (for example, refrigerator shelves or clothes airers) would be as follows :

(*i*) Preheat temperature ..	400°C.
(*ii*) Time	1½ min.
(*iii*) Dip	2 dips each of 5 sec with a delay of approximately 30 sec between dips.
(*iv*) Sinter	3×1½ min stages at 150°C rising to 180°C.
(*v*) Water quench	1 min.

The machine illustrated is highly automatic. If a run of sufficient length and an article of correct design is used, there is no reason why such a process

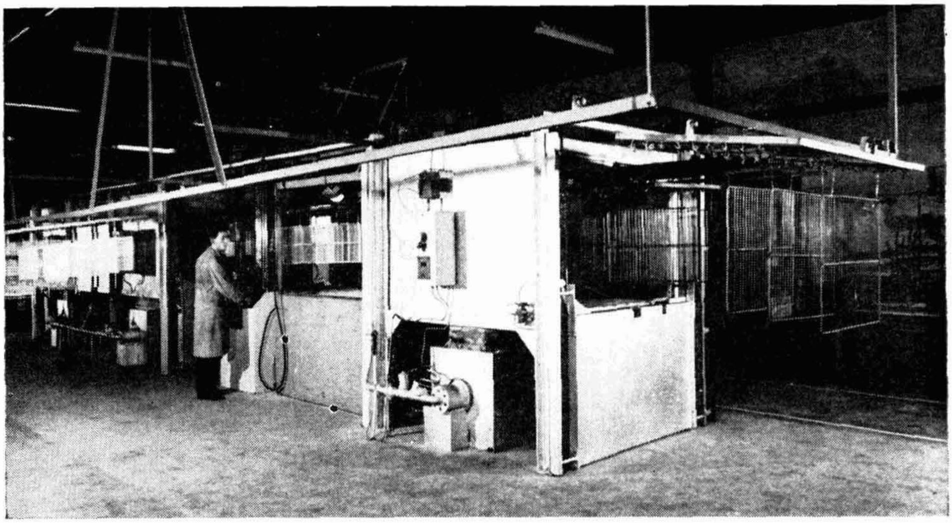

FIG. 2. A HIGHLY AUTOMATIC DIP COATING PLANT DESIGNED TO HANDLE UP TO 4,000 ARTICLES PER SHIFT.

could not be fully automated. Conditions of dipping can be determined empirically, and once determined they can be measured in terms of temperature, time and weight. Given these measurements, electronic control should be possible to make the coating operation self-adjustable to any variation in the production line.

Economics

The dipping tank in the illustration measures 5 ft 6 in × 3 ft × 3 ft, a total of approximately 50 cubic feet. Filled with *Nylon*, this takes approximately 600 kilos, and with the market price of *Nylon* powder (type 11) being approximately 32s. per kilo, the cost of stocking one container of this size is £1,056. To ensure continuity of production the same quantity is required as a stock-holding figure. These indications of tied-up capital will explain why only a narrow range of colours is available in *Nylon* coatings for large articles. The largest tank held by the author's company for *Nylon* dipping measures 7 ft × 4 ft × 3 ft ; this requires £1,772 worth of raw material to fill.

Polythene is a lower priced raw material and a tank measuring 5 ft 6 in × 3 ft × 3 ft holds 600 lb, which at approximately 3s. 6d. per lb requires an outlay of £105 in order to fill it, and, of course, the same amount to be held in stock. Fortunately this enables a wider colour range to be provided. The same sized box filled with *Penton*, the chlorinated polyether, would hold 1,840 lb with a total value of £2,484. Fig. 3 makes an interesting comparison on the cost per cubic foot of four materials used.

Size is one of the most limiting factors for this type of work, since the capital outlay for extra capacity rises rapidly. The preheat oven must be designed to fit the required size ; dipping capacity and the size of the curing oven must then correspond, and, of course, the additional services such as shot blasting, pickling, primer spraying, handling equipment and general room for

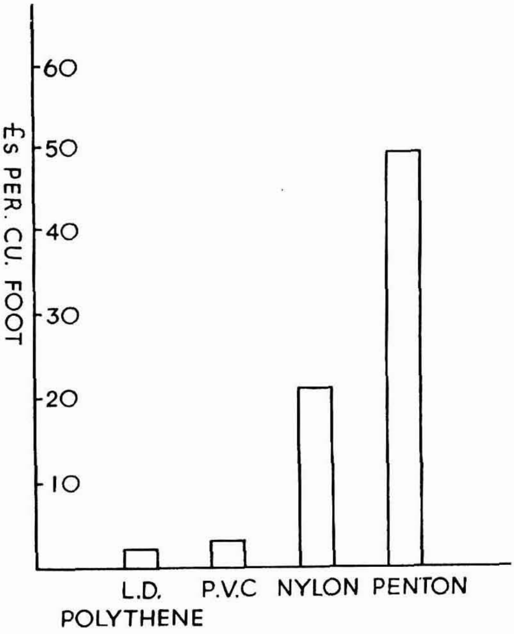

FIG. 3.

manoeuvrability must all be added to the outlay on basic raw materials. The process fortunately is such that handwork is reduced to a minimum and there is little cost involved in demurrage as compared with some other types of metal protection where processing is slower.

CONCLUSION

The great asset of the dip coating operation is that a homogeneous film can be formed, virtually encapsulating the whole of the item, although if areas are required to be left uncoated this can be done, either by subsequent trimming, or preferably by a development of special masking tools for which the customer is normally invited to share the cost. An unusually thick deposit can be achieved by a single dipping operation and, particularly in the case of the fluidised bed coatings, there is a lack of drips on the finished item. When there is also a guarantee of freedom from microporosity where this is required, and a speedy turn-round, the rapidly increasing interest in this type of finish is easily explained.

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The Versatility of Techniques Available for Applying Epoxy Powders

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Summary

Powder coatings have a number of advantages over conventional coatings due to the elimination of solvent. Epoxy-based powders are particularly useful as they can be applied and cured at temperatures as low as 100°C.

Four general techniques are now available for the application of powder coatings—flock gun spraying, flame gun spraying, fluidised bed dipping and electrostatic techniques. The first of these are limited in use to the coating of relatively large objects, while a fluidised bed is only capable of handling objects whose size is small compared with the size of the bed. The electrostatic methods appear to be the best general powder-coating techniques available at present.

INTRODUCTION

Solvent-free coatings based on epoxy resins were introduced some four years ago[1] and have now been accepted by the paint industry as an extremely useful member of the range of coatings available. Their outstanding chemical resistance, adhesion and physical properties are advantages which they hold in the industrial field over the more conventional coatings. They have two principal disadvantages however, (*a*) their high viscosity makes them difficult to apply, particularly by spraying techniques, (*b*) they are not easily adaptable for use in continuous processes.

In order to produce a system which overcomes the handling problems of the solvent-free coatings while still maintaining their advantages, the epoxy powder coatings have been developed. Techniques are available which make these materials usable in continuous processes and on production lines. Thermoplastic powder coatings such as polyethylene and polyvinyl chloride have been in use for some time, but they are not altogether suitable because of the application temperatures required (see Table I).

ADVANTAGES OF POWDER COATINGS

Powder coatings in general contain no volatile components. This gives them a number of important advantages over conventional solvent-containing systems.

(*i*) Costly solvent extraction apparatus is not required.

(*ii*) The loss of large quantities of solvent to the atmosphere is eliminated, giving a financial saving. Solvent recovery is only practised to a small extent at the moment among users of paints and this itself costs more money.

(*iii*) Workmen are not exposed to the possible harmful effects of solvents.

(*iv*) The fire hazard attached to the normal paint solvents is eliminated.

(*v*) Heat is not required to volatilise the solvent in the curing oven. This is of particular importance when comparing powders to water-based coatings, which themselves overcome the previous disadvantages of the solvent-based coatings. The high latent heat of vaporisation of water means that considerable heat is absorbed in removing the water, leading to a heavy fuel bill.

(*vi*) A much thicker coating can be applied by a single operation.

(*vii*) There is no danger of solvent being trapped in the film. Trapped solvent leads to reduced film properties, and the possibility of a porous structure.

(*vii*) As no solvents are required, it is therefore possible to apply materials by powder-coating techniques which are not easily adaptable to use in solvent. Many of the thermoplastic materials can only be applied as a powder as they are insoluble to any practical degree in common solvents. Also many of the " B-stage " epoxy powders with long shelf-life would have their life drastically reduced by solution.

The above advantages are not only common to all types of powder coating but also to other solvent-free coatings such as epoxies and pvc plastisols. The epoxy powder coatings are of particular value when compared to thermoplastic powders as they can be made to flow at much lower temperatures.

Table I gives typical values for various types of powder now in use.

TABLE I

Resin	Application Temperature
Epoxy	100—200°C
Pvc	225°C
Cellulose	300°C
Polyethylene ..	240°C
Nylon	280°C
Fluorocarbon ..	360°C

Cure temperatures of as low as 100°C, now available with some epoxy systems, are not possible with any other type of powder coating. Such temperatures cannot be exceeded in certain specialised industries, such as specific sections of the electrical industry, and here such powders are the only ones suitable. However, it is not for this low cure temperature that these systems are of interest to the product finishing industry in general but rather because their high reactivity will allow a cure cycle of 5 minutes or less at more elevated stoving temperatures. This compares favourably with a minimum cure cycle of 20 minutes at 180°C required by epoxy powders previously available. This reduction in cure time is probably the most significant recent advance in the field.

Because of their thermosetting nature the epoxy coatings have excellent stability at elevated temperature, superior to all but the most costly of the thermoplastic systems. They also show better adhesion than most thermoplastic powders and do not require any priming of the substrate.

The detailed formulation of epoxy powders will not be considered here, but information on both the formulation and manufacture of such powders is now available[2]. Considerable powder development is now being undertaken and no doubt formulations will change considerably in the near future to suit the market requirements.

In all the aspects described so far, the epoxy powders are considered to be complementary to the epoxy solvent-free systems. The powders have the disadvantage that room temperature cures are not possible by the very nature of the system. They cannot therefore be used for *in-situ* application on large structures where chemical and corrosion resistance are required. This has become the major field of application for solvent-free coatings.

APPLICATION TECHNIQUES FOR POWDERS

There are four main techniques now being used to apply powder coatings, (*a*) flock gun spraying, (*b*) flame gun spraying, (*c*) fluidised bed dipping, (*d*) electrostatic techniques.

The powder required by each of the above methods will differ in particle size. To obtain the best results therefore it is not possible to use one batch of powder for more than one technique. The recommended particle sizes and the corresponding British, German and American Specification mesh sizes are shown in Table II.

TABLE II

Method of Application	Particle Size of microns	Recommended Mesh Size		
		BS 410	DIN 1171	ASTM E11-39
Fluidised bed .. Flock spray gun	Less than 350	Passing 44	Passing 20	Passing 45
Flame spray gun ..	100—150	Passing 100 Resting 150	Passing 40 Resting 60	Passing 100 Passing 140
Electrostatic spray gun	Less than 75	Passing 200	Passing 80	Passing 200

Apart from the different particle sizes required by each method of application, it will also be found necessary in most cases to vary the formulation to achieve successful results. For example if a powder is to be applied to a cold object by electrostatic spray, the conditions under which it will later be required to flow will be very different from those existing when a hot object is dipped into a fluidised bed. In the one case the temperature of the powder will be raised slowly, while in the other a sudden rise in temperature will occur. It is recommended therefore that less fillers and extenders be used in powders for cold application than for techniques requiring a heated object.

Having obtained the correct powder for the technique to be used, it is then necessary to ensure that the conditions under which it is used are suitable to obtain the best results.

From the operator's point of view it is necessary that adequate ventilation and extraction apparatus is installed to maintain a powder-free atmosphere around him. To this end, more careful air extraction will be required if a spraying technique is used than if a fluidised bed method is adopted.

With any of the techniques described below, it is important that the operator has some handling experience before being called upon to coat articles for production. Similarly it will always be necessary to perform trial runs on the coating of a newly developed article in order to obtain some idea of the optimum pre-heat temperature, dip or spray conditions, cure cycle and so on. Once these variables have been satisfactorily fixed further production runs should proceed smoothly.

Flock Spray Gun

The normal type of flock gun used to spray chopped glass and other fibrous materials can be used to spray powder coatings. This consists of a reservoir full of powder into which a jet of air is blown. The air-borne powder is then blown out through a nozzle of wide orifice towards the object to be coated. The object must be heated to above the melting-point of the powder, so that the powder impinging on the surface will adhere to it and flow out to give a continuous film. The object is then reheated in an oven under the conditions recommended to cure the particular powder.

This method requires apparatus which is cheap to buy, and is useful for those manufacturers who anticipate occasional use of powder coatings on large objects. Even here, however, some degree of skill is required to obtain an even coating over large surfaces. On small objects there is considerable overspray due to the very diffuse jet of powder produced by the flock gun.

Only surfaces which are visible to the operator are coated as no " wraparound " occurs by this technique. It is therefore difficult to spray into cavities without putting too thick a coat on to the outside surface.

The problem of overspray is of course one which arises with all the spraying techniques available. Theoretically, it is a simple matter to collect the overspray on a vibrating surface from which it falls through a funnel and back into a reservoir. In practice this creates problems because dust and other foreign particles, which may also be collected and recycled with the epoxy powder, are likely to lead to defects, particularly cissing in the coating. It is therefore important that either spraying takes place in a room where the air is dust-free, or overspray is not recycled. As the first possibility is costly to achieve, then the flock gun, with its excessive overspray becomes uneconomic, except as mentioned earlier, for the coating of a small number of large objects of reasonably simple shape.

Flame Gun

Epoxy coatings can be sprayed through the standard type of flame gun that could be used to apply metal powders. The powder is carried to the nozzle by air and it is then sprayed through the centre of the flame. As it passes through the flame the temperature of the powder particles is raised above the powder's melting point. On striking the object to be coated, which may be cold or preheated, the molten particles adhere to the surface and coalesce to form a continuous coating. If a cold object is sprayed a continuous coating may only be formed after the object has been placed in the curing oven.

Epoxy coatings are normally sprayed through butane/oxygen or propane/oxygen flames, though an oxyacetylene flame has been used successfully. The quantity of gas passing through the gun must initially be determined on trial runs. This will vary from powder to powder, and also may be affected to some extent by the substrate. A pre-heated object will require a smaller flame than a cold one. The gun is normally held near enough to the object to heat it during spraying.

An experienced operator is required to make a success of this technique as there is little allowable variation in the spraying variables. During its passage through the flame the powder reaches a high temperature, and can achieve a considerable degree of cure during application. This is a valuable asset under correct control, but it can lead to lack of flow on the coated surface.

The flame gun gives a more concentrated directional jet of powder than the flock gun, and therefore gives much less overspray. The oversprayed material that is produced is waste, as it will have advanced too far during spraying to be usable again. It will, of course, no longer be in powder form either and can lead to considerable build-up on the spray booth.

This technique has the advantage of being capable of coating cold objects, which are more easily handled in the factory than the hot objects required for flock gun spraying. The electrostatic technique can also be used with cold objects, but there is more chance of accidentally removing powder in this case than of removing resolidified resin applied by flame gun. This point is worth bearing in mind particularly when a heavy object is to be coated and then moved into a curing oven.

The apparatus required for flame-gun application is much more expensive than the flock gun, but it is not as costly as electrostatic equipment. Electrostatic methods, however, lend themselves much more to automation.

Probably the most important disadvantage of this technique is the degree of skill required of the operator, which is probably higher than with any of the other techniques discussed.

At the present time, in fact, this is still very much a development process, and it is envisaged that some redesign of the gun and reformulation of the powder is required before it becomes a practical and economic technique.

Even less developed than the flame gun is the plasma gun, now used to spray metals and ceramics and of considerable interest for use with plastics. In principle, an electric arc is struck in argon, an inert gas. In the arc the gas is ionised to the so-called " plasma " form. During the ionisation process the gas can achieve temperatures of around 15,000°C and is accelerated towards a nozzle from which it emerges as a very intense " flame " some 2 inches long. This is not a true flame as no oxygen is present and no combustion takes place. The powder is injected into the " flame " using argon as a carrier gas, and is immediately melted and propelled towards the object to be coated.

As no oxygen is present this technique produces no charring of the particles, an advantage over the flame-gun.

Techniques have already been developed in the United States to apply epoxy powders by the " plasma " method and a development project is now under way in this country to ascertain the limits of the various application variables.

Fluidised Bed

The fluidised bed technique has been discussed in some detail in an earlier paper[3], and many other articles have been written describing its use with all types of powders (see for instance Sharretts[4], Richart[5], and Cleave[6]). Practical details of the technique will not therefore be discussed here, though the advantages and disadvantages will be mentioned in order to complete the overall picture and allow the method to be compared with the others described.

It is much simpler to obtain an even coating over a small object by dipping. If larger objects are used however a definite thickness gradient will be obtained, the bottom of the object spending more time in the powder. It is necessary to devise double dipping techniques to eliminate this problem.

Articles to be coated need to be preheated. This is a simple matter on a production line with most objects. Difficulties arise however with objects of particularly high or low heat capacity. In the case of the former it is difficult to limit the thickness of the coat applied, in the case of the latter it is almost impossible to immerse it in the bath at all before it has cooled below the application temperature. It is therefore necessary to heat fine wirework to as high as 400°C to achieve a suitable coating. Articles of high heat capacity can best be coated by one of the previous two methods, while those of low heat capacity are most efficiently handled by the electrostatic methods to be described next. Perhaps a more serious drawback to the dipping of large objects than the high heat capacity is the possibility of upsetting the fluidisation by covering too large an area of the bed surface. This would then lead to an uneven coating and probably no coating at all on the upper surfaces.

Masking is a problem which must be overcome when an article is to be only partially coated. This problem also exists when the article is to be spray coated by flock gun or flame gun. Here careful spraying can help, though masking is always required when a sharp demarcation is needed.

The fluidised bed technique is however easily adopted to production lines and mass production methods. The apparatus required is comparatively cheap and robust, and can be used on production lines now employing liquid dipping processes without too much further modification.

Electrostatic Techniques

The electrostatic spraying of powder coatings was introduced into this country about 18 months ago by *SAMES (Great Britain) Limited* when their *Stajet Gun* was introduced[7]. Though the apparatus required is costly to install, it has a number of advantages which make it extremely important in the development of powder coating techniques.

In principle, a high voltage is applied to the nozzle of a powder spray gun when the gun trigger is pressed. The powder spray produced is of low velocity and receives a strong negative charge on passing through the nozzle. The object to be coated is earthed and so attracts the charged powder. Thus the powder is attracted *to* the surface rather than being sprayed *at* it. (See Fig. 1.) As all parts of the object are earthed the powder will envelop it completely and not just coat the visible surfaces.

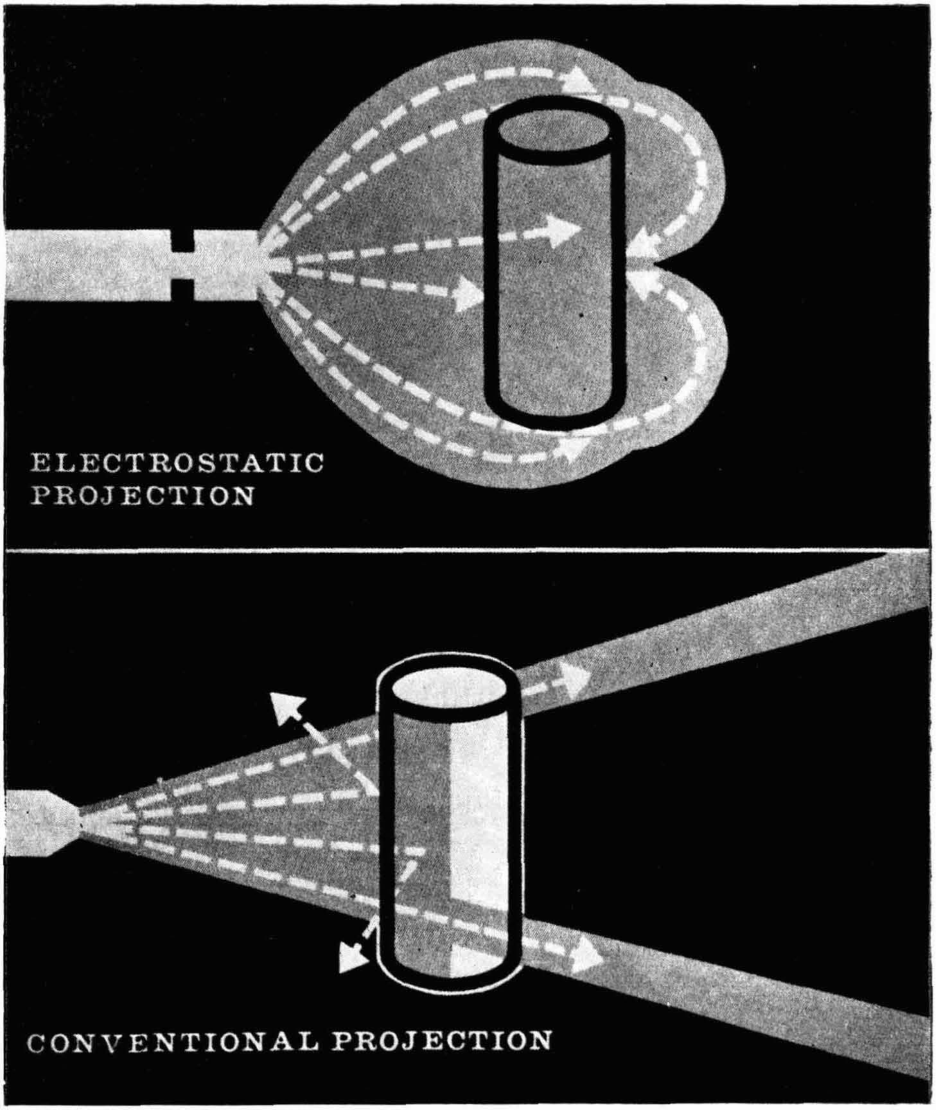

FIG. 1. THE PRINCIPLE OF THE ELECTROSTATIC SPRAYING TECHNIQUE

The voltage is supplied by an electrostatic generator which is supplied together with the gun. Guns are available to spray 10, 40 or 100 lb of powder per hour.

As this method is similar to normal paint spraying techniques, production lines can change over to powder spraying at low cost because no change need be made other than a direct replacement of the guns.

No masking is required as articles are normally sprayed cold. It is then a simple matter to remove powder from those sections which are not to be coated.

There is very little overspray because powder particles are all attracted to the article being coated. Normally a film thickness of only 0.005 in can be achieved by this method, because of the mutual repulsion between the powder particles. The film thickness can possibly be increased by lowering the powder resistivity by the use of anti-static agents. It must be remembered however that the powder only sticks to the surface by virtue of its charge, so that the powder will tend to drop off the surface again if too much anti-static character is built into it. An increase in film thickness can also be achieved by spraying a warm article, as resistivity decreases rapidly with rise in temperature.

Theoretically it should be impossible to spray into cavities by this method, but in practice this is not altogether true. Nevertheless it is difficult to coat deep cavities, such as the narrow slots in the rotors and stators of electric motors.

Electrostatic spraying is ideal for intricately shaped articles which cannot easily be handled by flock gun, and whose heat capacity is too low for an adequate coating to be applied by fluidised bed. Such articles as wire trays, wire mesh are examples.

A still more recent development in electrostatic methods was the introduction this year of the *Stafluid*. This combines the principal advantages of both the fluidised bed and the electrostatic spray techniques. It consists of an array of electrostatic elements on the bottom of a shallow bed. A small quantity of powder is placed on the elements and fluidised by the normal method. The fluidised powder is then given a strong negative charge. Fluidisation is not used here as a means of providing a powder bed into which the object to be coated can be dipped, but only as a way of producing mobile charged particles. The earthed article is then held above the powder surface when the charged particles of powder jump out from the bed and envelop it. The velocity of the powder is now due entirely to electrical attraction and is therefore travelling more slowly when it impinges on the surface than when an electrostatic spray gun is used. Consequently a thicker film (50 per cent greater) can be achieved by this means than the gun. It also seems to be easier to coat the inside of cavities by this technique than with the gun.

This method is of course admirably suited to automatic production lines, and can be used to coat continuous sheet efficiently and evenly, which would perhaps be its major outlet in the future.

A great advantage over normal fluidised bed is the small amount of powder needed for operation. A fluidised bed requiring 50 lb of powder can be replaced by a *Stafluid* bed needing only 5 lb. This means that manufacturers who want to use a range of formulations and colours need not carry large stocks of powder. The tray carrying the powder in the *Stafluid* can be removed as a unit and replaced by another colour, thus cutting down the time taken to change over and leading to a saving in overheads.

A disadvantage of the system, however, is the limitation in the depth of objects which can be coated. This is about 4 in at the moment, and although this can be increased by the use of higher voltages, a definite thickness gradient will always exist with a simple *Stafluid* bed. This can probably be improved by a change in design, but has not so far been achieved.

Useful Range of Each Technique

To summarise, the useful range of application for each of the techniques :

Flock Gun

Medium sized objects with smooth surfaces and large objects which can easily be handled when hot.

Flame Gun

Again objects with large flat surfaces and possibly continuous sheets. The inside surfaces of piping and tanks when hot-air cure is possible.

Fluidised Bed

Articles of intricate shape, the size being limited by the size of the bed.

Electrostatic Gun

Articles of low heat capacity or other objects which would receive too thick a coating by other techniques.

Electrostatic Bed

Intricately shaped objects, and again those of low heat capacity, continuous sheets.

FUTURE DEVELOPMENTS

Of the techniques described only the fluidised bed technique is used to any extent at the moment for the application of epoxy powders. The other techniques —flame gun, plasma gun and electrostatic methods are still in their infancy. Their present limitations are known to the manufacturers and to overcome these, close collaboration is required between the powder manufacturers, the apparatus manufacturers and the end users. In this way new techniques of tremendous value to the end user will be developed, and many of his problems overcome.

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APPENDIX

THE MANUFACTURING PROCEDURE FOR EPOXY POWDERS

Formulation 1

A Powder Based on a Solid Aromatic Amine Curing Agent

This example and the following one provide powders with the high temperature and chemical resistance characteristics of aromatic amine-cured epoxy systems. In this case *Araldite Hardener HT* 972 is used. For maximum properties the following formulation is recommended :

Araldite GY 260	100 parts w/w
Hardener HT 972	27 parts w/w

This mix, however, has a poor storage life and the small sacrifice of properties caused by the partial use of a solid *Araldite* resin is more than offset by the increased storage stability of the resulting powder. It is recommended therefore that a mixture of *Araldite* 6100 (70 w/w) and *Araldite GY* 260 (30 w/w) be used instead of *Araldite GY* 260 alone, the amount of curing agent being reduced to allow for the drop in total epoxide content.

This basic formulation will of course be modified by the addition of suitable pigments, extenders and additives to suit the individual needs of the manufacturer. A typical powder for fluidised bed application would have the following formulation :

	parts by weight
Araldite 6100	70
Araldite GY 260	30
Hardener *HT* 972	17.5
Titanium dioxide	5
China clay	60

An adduct is first prepared by melting the Hardener *HT* 972 at 100°C and slowly stirring in 5-6 parts w/w *GY* 260 preheated to 50-60°C. Melt the *Araldite* 6100 into the remainder of the *GY* 260 in a Z-bladed mixer at 80-100°C, cool the resin mix to 60-70°C, then add the pigment and extender, continuing to mix at 50°C until they are thoroughly dispersed. Add the hardener adduct at 50-60°C and mix for 10-15 minutes. Discharge the mix into trays in layers not more than 1 in thick and allow the compound to advance to the B-stage for 24-36 hours at normal room temperature. Break, crush and powder the compound, then sift to the required mesh size.

Formulation 2

A Powder Based on a Liquid Aromatic Amine Curing Agent

As with the solid amine in formulation 1, this gives a system of high temperature and chemical resistance. Again the best properties are obtained using a liquid resin, the following being the best ratio :

	parts by weight
Araldite GY 260	100
*Araldite X*83/169	34

where *X*83/169 is a stable liquid aromatic amine.

It is again recommended that, for general use, some solid resin should be used to give a more adequate storage life.

The manufacturing procedure is essentially similar to that in formulation 1, but as the hardener is liquid it is not necessary to make an adduct from it. The *Araldite* 6100 is melted into the *Araldite GY* 260 in a Z-bladed mixer, at 80-100°C. The pigment and extender are added at 60-70°C and thoroughly dispersed. The mix is then cooled to room temperature before the hardener is added and mixed in for 10-15 minutes. The mixture is discharged into trays to a depth of not more than 1 in and allowed to react for 5-7 days at normal room temperature. The process can be accelerated by keeping the mixture at 40°C when it takes $3\frac{1}{2}$-$4\frac{1}{2}$ hours and should be stopped just before the compound becomes hard at that temperature. Break up, crush and powder the resin, then sift to the required size.

Formulation 3

A Powder Based on an Aliphatic Amine Curing Agent

Normally aliphatic amines cure epoxy resins at room temperature and therefore cannot be stopped at an intermediate stage. A curing agent has now been formulated, however, which will form a B-stage powder. It is a low viscosity colourless liquid which aids processing. The recommended ratio of resin to hardener is :

	parts by weight
Araldite GY 260	100
*Araldite X*83/171	23

This can be formulated to give the flow and other properties required by the manufacturer. Mixing is simpler than with the previous two systems due to the low viscosity of the resin/hardener system.

Disperse the required pigments and extenders in the *Araldite GY* 260 in a suitable paint mill. Ensuring that the temperature is below 25°C, add the *X*83/171 and disperse thoroughly. Discharge the mix into trays in layers not more than ¼ in thick and cover the surface with a moisture-impermeable sheet. Allow the compound to advance to the B-stage at a temperature not exceeding 25°C for 24-36 hours. Break up, crush, powder and sift the resin to the required size.

Formulation 4

A Powder Based on a Latent Amino-containing Curing Agent

This group includes dicyandiamide and certain substituted melamines such as diallyl melamine. A typical formulation in this group is :

	parts by weight
Araldite 6200	100
Dicyandiamide	5

The *Araldite* 6200 can, however, be replaced by a mixture of *Araldite* 6300 with *Araldite* 6100 or *Araldite GY* 260, when powders with more suitable flow properties for a particular application may be obtained.

Using *Araldite* 6200, the resin must be melted in the Z-bladed mixer at 130-140°C and maintained at that temperature while the required pigments, fillers and other additives are mixed in. It is cooled to 100°C before the hardener is added, then stirring is continued for 15 minutes before the mixture is discharged, cooled, broken up, then powdered and sifted to the required size.

Formulation 5

A Powder Based on a Boron Trifluoride Complex

Boron trifluoride itself is a gas which reacts with epoxide groups at an uncontrollable rate even at room temperature. It does, however, form a large number of complexes with amines, which are stable at room temperature and only react above their decomposition temperature. By choosing the correct complexing agent therefore, suitable hardeners for a range of curing conditions may be obtained. Most of these complexes are solid materials, although two liquid hardeners are now available—Curing Agent 1040 (Anchor Chemical

Company) and *Araldite X*83/170. The optimum recommended formulation for both curing agents is :

	parts by weight
Araldite 6200	100 w/w
Boron trifluoride complex	10 w/w

The comments under formulation 4 on the use of other epoxy resins are equally relevant here, while the manufacturing procedure described there can also be used for this formulation. It should be noted, however, that the temperature of the mix should be no higher than 85°C when *X*83/170 is added, while a temperature limit of 95°C is recommended with Curing Agent 1040.

Milling and Sifting of Powders

The solidified epoxy compositions should be roughly broken by hand, then passed through a suitable mechanical crusher to reduce them to the size required for feeding into a comminuting mill. Any comminuting mill which does not become hot when running is suitable for this purpose. Cutter mills, hammer-mills and pin disc mills have been found to be suitable. Present experience has shown a pin disc mill to be the best machine. For large-scale production of very fine powders fluid energy mills may be found to be advantageous.

The sifting of the milled powder may be carried out in any suitable machine, such as gyratory sifter or turbo sifter. For the large-scale production of fine powders, turbo sifters are likely to be the most successful, although other methods of separation based on air flotation may be useful.

GENERAL DISCUSSION

DR. M. E. D. JARRETT, as Chairman for the General Discussion, said the meeting had heard four most interesting and excellently presented papers on the use of plastics for surface coatings and on methods of application employed. The picture presented by the four lecturers, he felt, might have lacked some of the grey tones and perhaps even dark clouds which might well develop with further experience in these new fields, but nevertheless it did show quite clearly that birth had been given to a new challenge to the paint industry. Whether this challenge would grow to a maturity of any stature remained to be seen and on that point he was sure each and every member of the audience would have his own opinion. For a decade or two, or maybe longer, many people in the paint industry had regarded plastics as a kind of Damocles Sword, but until a few years ago, say, about 1957, when pvc-coated steel strip was first introduced on the market in this country, that was just prognostication and not fact. Now things were rather different because plastics were actually being applied o surfaces which previously had seen only paint.

It was interesting to observe that the methods of application, with the exception of fluidised-bed dipping, were not new to the paint trade, and that many of the film-forming materials were familiar enough, at least in closely related forms. Moreover, as one contributor had already pointed out, solventless coatings such as plastisols and 100 per cent epoxies had already been adopted by the paint industry, perhaps because they were fluids, and consequently the methods and equipment needed to handle them were familiar. When it came to the use of powders as paints, Dr. Jarrett felt that was rather a big step for conservatism to take. It was true that some paint companies were looking into the use of powders as surface coatings, but he suspected that this was more as an insurance rather than from any great enthusiasm. On the other hand he said he felt equally sure that the barrier of conservatism which had been seen so often in the paint industry would soon disappear and that the paint industry would adapt plastics, in the widest sense of the term, as part of its armoury and would make its own particular contribution to the development of this new field, with the great technical and commercial potential it offered, a potential which he thought the lecturers had succeeded very well in putting across.

Dr. Jarrett then invited those present to put questions to the lecturers, individually or collectively, or on the other hand to make any contribution relative to the subject of the Symposium that they might wish.

MR. J. K. RANKIN asked Dr. Humphreys about the commercial aspects of the drying of Stage B of epoxy resin. Such formulations would be unacceptable by manufacturers due to the large areas involved. He asked whether alternative methods were available.

DR. HUMPHREYS explained that at the moment all that had been done was really to look at the chemistry of these powders and develop powders that worked. Further work had to be done on the production techniques for this advancement. He thought it might be possible ; certainly a hot method must be developed. It might be that if the mix itself, rather than the powders, were initially made in a calender at a reasonably high temperature, then this might well, by accurate control, give the required advancement very quickly. Also, if a co-kneader was used, then there were various areas which could be accurately controlled by the screw thread. By finding the right conditions it should be possible to get a mixture coming out of the end which was sufficiently advanced in cure for use. He said that his Company, as resin manufacturers, naturally had no great expertise in the use of such machines which were simply used as suggested by the machine manufacturers. They had been so far only used to give the mix. He considered that this aspect must be looked into further, either by the manufacturers of the machines or by the paint maker who would want to turn out quantities of these powders, or even by the resin manufacturers.

MR. J. R. MCCAIG asked if it was not a fact that the addition of an adhesive to a dipping bath of pvc plastisol could result in gelation.

MR. FOLEY agreed that the stage had not yet been reached where this improvement was possible. He thought that chemical manufacturers should work along the lines of trying to develop this possibility and, theoretically at any rate, he felt it should be feasible. There was probably some compound in existence which could be added which would not decrease the pot-life of the bath. The great virtue of the dipping technique was, of course, that by the cold technique it could be put in the bath and virtually left there ad infinitum. At the present time there would be a very serious risk in such additions, but he thought this improvement would come in time.

MR. H. GRIMSHAW said that Mr. Foley had described and illustrated the dip coating (and dip moulding) of objects of large heat capacity. Since pvc paste slowly thickened when heated, he asked whether thickening of the paste in the dipping tanks due to the repeated dipping of large hot objects was experienced. He said he would imagine that the viscosity properties of the paste would change, causing thickening and coating problems with later objects.

MR. FOLEY confirmed that the questioner was correct and this problem had to be overcome somehow. The method, generally speaking, was to keep the tank fluid circulating as far as possible so that fresh surface was continually being presented to the air surface to let the heat go out of it. The other aspect was, of course, that the thermoplastic itself also acted as a heat insulant so that the actual heat loss into the rest of the bath was small, and once the gelated film was on the object and began to be taken out again the actual heat loss into the rest of the bath was minimal. There was a danger definitely, and it was essential to keep it circulating since it had been known for a complete bath to glue up. In fact, his Company insured against it happening, but it was most rare.

Dr. L. Valentine pointed out that the paint industry had to be prepared to make a very wide range of colours and to maintain very close tolerances in colour matching. He said he would be interested to learn the views of the speakers on the possibilities of the various systems with regard to the colouring problem.

Mr. Foley replied that with dip coating, as could be seen from his slides, the question of stockholding presented a very big problem indeed. For large articles it was a case, like Mr. Ford, that the customer could have any colour as long as it was black! With smaller articles, his Company were, in fact, prepared to match almost any colour within the limits of the physical possibility of doing so. In these cases it was not too bad because the actual stockholding required to dip a large number of small items was not great. If it was a highly repetitive run it would be accepted ; if it was a larger object, or something simply with a small turnover, it had to be one of a standard range of colours and, for very big stuff, black only.

Dr. Humphreys commented that for powders made from solid resin this was quite a problem and again each batch could be coloured, but it was rather difficult to match it to the colour of the previous batch unless it was one of the simple colours. With the liquid system he thought it would be rather easier as the problem was to pigment the liquid resin to match the colour. It might be necessary to cure off a standard from each batch and colour match and then vary the pigmentation to get the right colour. How accurately this could be done he did not know ; he was not a paint man and he left this for the paint industry themselves to judge.

Mr. Day, replying to the same question, commented on the fact that Dr. Humphreys had suggested in his paper that the plastics industry was going to sell powders and cut out the paint man. He personally felt it could not possibly do this because of the colour and supply problems involved. In fact, large suppliers were tending to sell compound, in the unpigmented form, for paint manufacturers to make into usable paints.

Mr. Wells added that with a thermoplastic system such as polyolefines, you had a water-white material to start with which was not transparent but was translucent. There was really no problem of colouring, but a problem of colour matching. It was simply a question of using a range of master batches to get the colour required and his Company made over 2,000 such colours.

Mr. L. R. Dowsett at this point asked if he might do a little advertising for the Plastics Institute. There was to be a Symposium in Manchester in May 1964, at which a series of papers would be given on the colouring of plastics, and he suggested that those interested should make a note of this.

Mr. J. C. Barford commented that fluidised bed coatings of pvc were not very satisfactory for exterior applications because they were based on copolymers. He asked first whether the " team " could comment on the use of pvc homopolymers for sinter coatings, since such materials were currently available from the United States. His second point was that *Nylon* coatings undoubtedly gave some of the finest finishes, but were expensive. Many people had hoped that polypropylene coatings would give similar properties, but, in fact, there were difficulties in degradation of the plastic during the freezing stage. He asked whether there were any signs that polypropylene would eventually be suitable for powder coating.

Mr. Foley confessed he did not know the answer to the first part of the question. He had heard of homopolymers in the United States and thought perhaps that Mr. Day might know something about them in this country. On *Nylon* and polypropylene he considered that as soon as the polypropylene manufacturers could supply something which was sufficiently stabilised to form a good film coating, then his Company were " raring to go." The application was tremendous. One of the big applications involved the question of flex life where it might be practicable to coat a tin all over and still have the lid flexible. At the moment this was a complete anathema, a moving part, and it simply could not be done. He would certainly like to have a suitable polypropylene.

MR. DAY said that he had also heard of the pvc homopolymers, but had not unfortunately been able to obtain much information and certainly no samples. He suspected they might be low molecular weight, in which case they might suffer from the same sort of faults as copolymers, from the weathering point of view. On the polypropylene question, many of the problems involved in the development of the technology of polypropylene had been concerned with heat stability, which was still not good enough for sinter coatings at present.

MR. WELLS added that it was possible to get a polypropylene moulding which would stand 150°C for 30 days if well stabilised, but with powders there was the problem of the very large surface exposed to the air. There had been significant improvements already and he felt sure this would go on.

MR. J. N. McKEAN inquired whether low molecular weight homopolymers of pvc would be more applicable as solution coatings.

MR. DAY replied that he did not think they would dissolve in the commonly-used solvents as readily as copolymers, although a tendency to use the homopolymers in less common solvents was developing.

MR. J. P. M. DENNY commented that an examination of the performance figures for formulation 3 in Dr. Humphreys's paper would indicate that the performance of this particular system was not as good as that of a cheap alkyd/MF system. He asked why Dr. Humphreys had particularly commended this system to the meeting.

DR. HUMPHREYS answered that this formulation was recommended because it was felt to be probably one of the best coatings for this type of application and the paint industry so far seemed to agree with this view.

MR. J. K. RANKIN commented that the formulations given in Dr. Humphreys's paper were based on the same basic epoxy resin, but varied in catalyst. Different properties had been mentioned which could be attributed to the degree of cross-linking. He asked if Dr. Humphreys would comment on this statement.

DR. HUMPHREYS said he was not quite sure. He thought that anything containing the urea type of molecule would tend to be susceptible to acid. The urea group was an amide and these were broken down by acid. As far as the formulation 3 was concerned, it was formulated to be fully cross-linked and to give the optimum properties. Whether the fact that the cure was taking place in two stages meant that the cross-linking did not go completely was a possibility, but he could not be really certain about this. He felt that the system was reasonably cross-linked and that the lowish properties shown were merely due to the thickness of the coating. Epoxies did tend to be brittle and in a 0.015 in coating he did not think that anything very much better could be expected. Epoxies were not thermoplastics, they were thermoset and in any thermoset system a rather brittle product would be obtained. Methods of flexibilising powders were being investigated, but it was rather difficult because flexibilisation for the same degree of linkage obviously lowered the softening point of the system. As recommended in the lecture, these formulations tended to soften or melt around 80-90°C and if this was brought down very much at all it would be almost impossible to handle in a grinder and therefore flexibilisation was something of a problem. He understood that in the United States flexible powders already existed, but he did not think there were any available in this country at the moment.

MR. L. R. DOWSETT inquired whether Mr. Day's two-pack system gave a harder coating than could be obtained by the use of a primer or a paste of the Rigisol type, and whether the advantage therefore was only one of adhesion or elimination of the primer coat.

MR. DAY replied that he did not think this was so. The main feature was that it was possible to obviate the priming stage which was an expensive and tedious process involving the use of volatile inflammable materials. It was easy enough to make a hard coating without employing a Rigisol, by using xylene or another diluent as a replacement for part of the plasticiser. The normal technique of producing a Rigisol by incorporating a granular polymer into the paste mix gave rise to a " gritty " surface on surface coatings.

MR. F. ARMITAGE said that he understood Mr. Day to say that pvc coatings generally did not have very good outside durability. In fact pvc solution-type coatings at 0.001 per cent to 0.0015 per cent on aluminium had exceptionally good durability and he presumed that Mr. Day was thinking of pvc coatings on steel or galvanised iron.

It seemed that of the four papers, perhaps only one process—that of the use of powder by either fluidised bed or electrostatic spray—could be considered to be any kind of challenge to the paint industry. He recalled that the fluidised bed process was about 15-20 years old already and felt it was pertinent to ask what was the total amount of resin currently used by this method of application and what ultimate potential was envisaged. One other well-established item which he felt might have received attention was the use of paper—melamine formaldehyde or polyester resin laminates which were replacing paint or varnish in a number of places, such as the furniture industry, in railways and in the home.

Mr. Armitage added that an interesting development of recent years was the BISRA method of applying pvc powder directly on to hot-primed strip steel and reducing this to the molten state by the pressure of a roller which served to distribute the material evenly over the surface. He understood that this might be considerably cheaper than applying a plastisol or organosol over a primed surface. He asked Mr. Day whether he could say anything about this process.

MR. DAY replied that on the weathering aspect he was afraid that he must have misled Mr. Armitage because he agreed with him that the weathering of pvc was excellent and most of its applications involved exterior use.

He said he knew little about the cost of the BISRA process, but that in terms of raw materials it should be cheaper than paste coating, although he did not know what processing costs were involved.

MR. FOLEY said he did not have any figures on the total consumption of polymers which were being used in either the plasticiser or the fluidised bed process.

He thought Mr. Armitage was probably right on the question of laminates and this was a serious challenge to the paint industry. The paint industry was in on this development to some extent with the polyurethane paints, but this was another similar sort of challenge as a finishing medium. Architecturally speaking, although at the moment there was very little evidence to be seen, he thought that over the next 15-20 years the use of either laminated coatings, pvc or a similar sort of thing, would affect quite considerably bulk sales to the engineering trade as such. Certainly his own industry was making, by its own standards, big inroads into the architectural trade. Compared with the total of paint sales he realised that quantities were negligible, but he felt it was symptomatic of the sort of growth. From the number of inquiries which came in regularly from the architectural field he said that he would put the rate of growth in the order of 5 per cent.

MR. ARMITAGE said he was under the impression that a great volume of plastisols and organosols were made and applied already by the paint industry.

Mr. Foley replied that this was true, but he had been talking about his own particular sphere.

Mr. Armitage asked how Mr. Foley's particular sphere differed.

Mr. Foley explained that it differed in the sense that an article generally speaking came into a factory and was coated before erection. This was the sort of line he had been thinking along, but it was not fair to be too categorical about this. One of the things which, at the moment, was becoming more and more popular was plastic-coated balustrading, fencing and that type of end-product. He realised that this did not present a very large surface area and so, in terms of tonnage, it might not be very much, but he thought that before very long, unless there was a big improvment in paint technology, it would be the plastic coaters, as such, who would be doing the majority of this work. This might be stretching it a bit, but was the sort of line he had been thinking along.

Mr. Day agreed with Mr. Foley on this point and said that he felt the trend was developing.

Mr. Barford asked if he could add something to the question about the BISRA sheet steel pvc coating process. This process used a pvc dry powder premix, that is, a mixture of pvc polymer, plasticiser, stabiliser, etc. dry blended in a high-speed mixer. This powder was applied by rollers to give a thin coating of high quality. The cost of a normal powder premix was similar to a pvc extrusion compound and could, therefore, in theory, be expected to be cheaper than a pvc plastisol. In practice, he understood that polymeric plasticisers were preferred for the best results and that these might increase the price above plastisols.

Mr. Day was of the opinion that on the basis of the information at present available it was difficult to decide which process was most costly.

Dr. Jarrett intervened at this point and suggested that this aspect had better be left to discussion after the meeting.

Mr. A. T. S. Rudram made the point that the paint industry had always sought to have its products applied in controlled conditions before they met the environment. Unless the applier processed and compounded the material he applied he was still a user of the products of the paint industry.

Mr. Foley remarked that it was nice to hear this but he could not say he agreed at all. He did not think frankly that the paint trade as a whole would consider that something that was dipped in a polythene bath could be looked on as application of paint on to metal. Whether, in fact, the applier did anything at all with the polythene seemed quite immaterial. This was definitely a challenge to the paint industry. It might be felt that it represented only the merest digit but it was there nevertheless.

Mr. J. Ashley asked Dr. Humphreys if he thought that a 2-3 months' shelf life for an epoxy coating powder was adequate and whether six months would not be a more practical shelf life to aim for.

Dr. Humphreys pointed out first that these materials, of course, would be sold to people who had apparatus for dealing with powders and who had gone into this in a reasonably big way—if they were going into powders at all—and therefore he thought that it was quite reasonable. He thought that their turnover rate should be less and 2-3 months was a figure to use at the moment as a safety margin. He felt that if a powder which was quoted as having three months' shelf life was kept for six months it would probably still be usable, but doubted whether such a powder could then be applied quite so easily by cold application. On to a heated object he considered it would still be quite usable. He added that if refrigeration conditions were available the shelf life went up very quickly. In England storage was far more likely to be at 10°C than at 20 or 25°C on which the quoted shelf lives were based.

He thought that any of the powders suggested would last six months, but it was necessary to play safe in case someone asked for £10,000 damages!

MR. T. E. JOHNSON drew the meeting's attention to the fact that the title of the Symposium was " Plastics Coatings : A Challenge to the Paint Industry," and he observed that generally the discussion so far had taken place on only the first two words, " Plastics Coatings," and the technicalities thereof. He added that he would therefore like to draw the meeting's attention to the sub-title, as it were, " A Challenge to the Paint Industry."

The Chairman, Dr. Jarrett, in his philosophical discussion at the beginning of the General Discussion period, which he hoped would be fully reported, had referred to the conservatism of the paint industry and its reluctance to use powders.

Mr. Johnson said that in the capitalistic society under which we lived it was a truism to say that every company or business had a dual object. First, to supply a consumer want or need, and secondly, to do so at a profit. The second object was usually a matter of simple mathematics to determine whether one was making a profit or not, but he had one or two accountant friends who seemed to be making very heavy weather of this! Nevertheless, if a company failed in either of these objects, it would go to the wall.

With regard to the consumer want, this was not so easy to define and merely to sell one's output was not enough. To give an illustration of what he meant, Mr. Johnson said that from the thousands of tons of detergent which are sold weekly (spelt with a double " e "), it would be imagined that this was evidence of a basic consumer want, but, in his opinion, this was not so.

Fundamentally, what the housewife wanted were clothes and linen which did not soil. This at the present time was not possible, although he knew full well that someone somewhere would be working on this principle of making clothes that did not soil. Failing this happy day, the housewife was willing to settle for an easy method of cleaning clothes and the best compromise at the moment was a washing machine and a detergent—hence the demand for detergent.

Mr. Johnson said that the other week he had read in the *Observer* that *Proctor and Gamble Co. Ltd.*, probably the largest manufacturers of detergents in the world, were now prepared to manufacture and market an ultrasonic washing machine that needed no detergent. This illustrated what he meant. Such people knew that in a lot of cases they were not supplying a basic want and their business could be threatened by anyone giving satisfaction nearer to, if not the actual, basic need itself.

For too long, he felt, the paint industry had been limited in its outlook. For too long the paint industry had accepted as inevitable that it must sell a liquid, and that this liquid must change to a solid on the surface, and this vital transformation must take place under the control of the consumer. For too long the paint industry had not realised that, in spite of the demand for paint, the industry was not supplying a basic want. He asked the question as to who really wanted to buy paint which was, in fact, a nasty-smelling, inflammable, messy material. He was sure that what the consumer wanted was decoration or protection, or electrical insulation, or fire-retardance, or the suppression of biological properties on the surface, and these were things which the consumer would go for whether the paint industry supplied them or not.

Mr. Johnson went on to take another example—the tanners. The tanners had been guilty of tying themselves to a single product and a single process and one could see what had happened to the tanning industry. On his way to the meeting he had passed three empty tanneries. He felt it was interesting to speculate on the resemblance between the tanning industry and the paint industry. Both had been old-fashioned conservative industries and at one time family-dominated with the weaknesses of hereditary management. The paint industry had successfully overcome these handicaps, and he could only hope that it would realise the present danger in time.

DR. JARRETT, from the chair, felt that these ideas should have stimulated further questions, and Mr. Foley suggested these should all be directed to Mr. Johnson!

MR. BAXTER said he took strong exception to the suggestion that the paint industry had been conservative. Since he had come into the industry, some 20 years previously, he would have thought that it had been the very opposite, and the developments both technical and scientific, in the production of new resins and new techniques, and in many cases some of the resins themselves had started in the paint industry. He had only to mention co-polymers, thermoplastic acrylics and thermosetting acrylics. These had all been developed by paint companies and many new techniques of application had also come from paint companies, and he took the view, on the contrary, that the paint industry had not been conservative and would not be so in the future.

MR. FOLEY wondered if the answer on this point was that so much of the industry was tied up with the petrochemical industry anyway. It was a sort of mother industry which was so much greater than either the plastics or the paint industry. This great mammoth petrochemical industry was really the star, the star in the firmament at the moment, which dictated whether other industries stayed conservative or became liberal with a little " l."

MR. BAXTER said that it was in his opinion the consumers who dictated more than the basic raw materials of the manufacturer—consumers such as the car industry.

MR. DAY commented that it was, he thought, Mr. Baxter who had so readily dismissed all the exhibited pvc coated articles and he wanted to know why. Possibly it was because such things had been in existence for some years in a modified form where they would have been galvanised and primed, but these were not; they were coated by one application of plastic. This gave a technically satisfactory product at the right price.

MR. BAXTER pointed out to Mr. Day that the term " plastic " was a difficult one. The paint industry had been using and making resins which could easily come under the general term " plastic " for 40-50 years and, so far as the plastic manufacturer was concerned, he would continue to sell epoxy powders. He added that the chances were that the paint industry would in future probably make epoxy powders as it had made many other resins in the past.

DR. JARRETT, from the chair, intervened to ask speakers to avoid discussing definition of terms and to keep to the subject of the Symposium.

MR. I. S. MOLL inquired, first, whether the electrical properties of a pigment had a noticeable effect on the electrostatic spraying operation. Secondly, he commented that Formulation 3 appeared very good for nearly all properties, but gloss was given as only 21 per cent. He asked whether this was typical and how far it would restrict the future usage for household equipment where good gloss was essential.

DR. HUMPHREYS, dealing with the second point, agreed the figure was low, but said that the gloss on the panels he had passed round was rather better using the same formulation. Work so far had not attempted to devise powder coatings which would be good paint, but had been focused on the chemical aspects and then left to the paint industry. He felt quite sure the paint industry would get a far better gloss out of any of the formulations shown.

With regard to the first part of the question, he thought that if organic pigments were used there would be no problem. The only possible problems might arise from the use of carbon black in black coatings. Inorganic pigments could be a problem. There had been no trouble with the colours which had been tried, but not many had been looked at so far. Most of the work has been based on whites.

MR. MOLL asked whether coloured powders could be blended to give a homogenous effect on electrostatic spraying.

DR. HUMPHREYS replied that this gave a beautiful speckled effect to the coating. To the further question on whether the effect had been patented, he replied, amid laughter, that the discussion constituted prior publication.

DR. JARRETT suggested that presumably for the electrostatic spraying of powders the electrical resistance of the powder must be an important factor as it was with paint. He said he would like to know whether any technique had been developed for measuring the electrical resistance of the powder or whether at the moment it was just a case of try it and see. He went on to ask to what extent the particle size and shape of the powder impinged on its suitability for electrostatic spray applications. He said he would imagine that, everything being equal, the maximum surface area per unit weight of powder was wanted. This was a general question on the electrostatic spray side.

Dr. Jarrett said he would also like to put a question on fluidised-bed coating. He presumed (it was so obvious that it must have been tried) that attempts had been made to avoid the need for pre-heating articles by using what might be described as a " sticky primer " to which the coating would adhere and then would cure with the coating during subsequent stoving. In this way he felt that it should be possible to get a coating thick enough to meet most requirements. For example, dealing with spherical particles of 200 microns diameter, if these were all lined up in rows like soldiers, then if his calculations were correct, a film thickness of around 100 microns would be obtained.

DR. HUMPHREYS answered that the film volume surface resistivity of the powders had some effect but he had done no work on this. He mentioned that a paper had recently been published on the mathematics of electrostatic spraying of powders, such as talc, in which the resistivity was related to the thickness of coating obtainable. As to the shape, he thought that probably the nearer the particles were to spherical the better.

MR. FOLEY said that with regard to the second part of Dr. Jarrett's question he did not know whether it had been tried but he could imagine that there would be certain disadvantages. The first which sprang immediately to mind was that the time needed to fuse the coating through, as opposed to having it already beginning to fuse through from the pre-heating, would probably outweigh the advantage of not having to pre-heat anyway.

He said he would disagree to some extent with a point made in Dr. Humphreys' lecture where he stated that an article could be put in cold and, whether in fact the mass of metal was 1½ in thick or whether it was wire gauze, it could be put in and cured with equal facility. He was afraid this was simply not true and anybody who had tried it would know only too well that the mass of the substrate had to be taken into account whether it was being coated from cold or from hot. It might be a little easier but it simply had got to be taken into account.

He went on to say that he did not know the answer to this question from the other side but he felt there would be a problem to get an even coating to start with and an even greater problem, unless something were strictly of an even gauge of metal, to get an even coating at the end of the curing cycle. He added that Mr. Chatt had been in the industry longer than himself and might have come across this before.

Mr. Chatt said that this method of eliminating pre-heating had been tried many years ago. Whilst it could be done, it slowed down the curing and on pure economics it was easier to pre-heat in the normal way.

Mr. Barford commented that it was interesting that pvc powder when electrostatically sprayed gave a heavier build than, say, polythene. This was because of the polar nature of pvc and showed that the electrical properties of the powders were of significance.

Dr. Humphreys added that it was possible to get a much thicker coating with polythene by using the right antistatic agent at the blending stage.

Mr. A. G. Pendleton expressed his interest in the size reduction and the sifting of epoxy resins after they had been ground. A number of paint manufacturers were obviously also interested, and this particular field of powder technology was probably one with which they were not very familiar. As a result there was at present a tendency for the trade to quote ideal particle size specifications when, in fact, exact size fractions were extremely difficult to obtain.

It could be seen in the pre-prints that for the fluidised bed technique ideally a particle size range between 44 BSS and 150 BSS was to be preferred. In practice, equipment to reduce the epoxy resin to this size had to be obtained and, whatever type of grinding mill was used, it was impossible to avoid the creation of some undersize powder. Also, as he saw from the pre-print, even if these fines were segregated by sifting some formulations might not be suitable for electrostatic spray work afterwards. This being the case, the inference was that undersize powder should be rejected as waste and he was trying to suggest that in the size reduction operation there was a greater degree of wastage than probably had been supposed. At this stage, however, he believed that experimental work had only been carried out using small fluidised beds and it would be interesting to discover if in practice the presence of the below 150 BSS particles in the epoxy powder was undesirable.

Another important point concerned the reduction of epoxy resins of low softening point for electrostatic spraying. Dr. Humphreys mentioned the application of a fluid energy mill in this respect since less heat was generated when material was ground in this type of equipment than in a conventional mechanical grinder. It must be said, however, that with a fluid energy mill a large number of particles very much smaller than 300 BSS size were going to be created, which Dr. Humphreys had again mentioned as being probably unsuitable for this process and a potential explosion risk.

To sum up Mr. Pendleton stressed that the practical difficulties should not be overlooked in the final stage of preparing epoxy resin powders.

On a point of information he could state that it was possible to use a nylon sieve, with a sifter of the correct construction, at 200 BSS size.

Dr. Humphreys thought that Mr. Pendleton would agree that the use of fluid energy mills nevertheless led to a much narrower band width in the particle size of the powder that came out and probably could be used at the coarser end for electrostatic application. He felt that it should be possible to get a narrower band width of particle size distribution which would have very few fines in it. It was possible to get a very much narrower band at 200-300 mesh.

Mr. Pendleton said he would agree with the first point that the spread of particle size could be controlled much more readily. He would not be dogmatic about the possibility of confining this to 200-300 mesh. In practice he thought that this depended a lot on the friability of the resin and also the costs were considerably greater using this method of production rather than mechanical.

MR. FOLEY asked on this point whether it was possible to use some of these " coarse " fine particles in the electrostatic or the new *Stafluid* process.

DR. HUMPHREYS replied that there was a problem in that to get the correct flow a rather different formulation was needed. These were less fillers, etc. in the electrostatic powders than in the fluidised bed powders because they were being applied usually to a hot object which encouraged an even flow, whereas in application to a cold object followed by heating a slow temperature rise was involved. If flow was not rapid enough, cure would take place before flow resulting in orange-peeling. This could be overcome to some extent by using radio-frequency heating.

London Section

CROSS-LINKS BETWEEN PLASTICS, PAINT AND TEXTILE POLYMERS

The eighth meeting of the session on 24 March 1964 at 14 Belgrave Square, S.W.1, was held jointly with the Plastics and Polymer Group of the Society of Chemical Industry, with Dr. J. J. Staudinger, the Chairman of the Group, in the chair. Dr. L. Valentine, Director of the Paint Research Station, presented a paper on " Cross-links Between Plastics, Paint and Textile Polymers."

Dr. Valentine said that there was a common scientific basis to a number of different branches of the polymer industries, e.g. textiles with crease resisting cotton, permanently pleated wool, thermosetting plastics, wet strength paper and various examples from the paint industry, which all involved some form of cross-linking process for building up polymer molecules. Unfortunately the same type of reactions were often involved in degradation and embrittlement.

Measurement of the amount of cross-linking occurring in a polymer presented some difficulties. In some cases it was possible to make measurements from solvent swelling, provided that there was an independent method of measuring the polymer/solvent interaction. Where this was not possible, measurements could be made of the elastic properties of unswollen or swollen polymer. A third measurement was of the sol fraction of a polymer. Each of these methods enabled M_c, the molecular weight between cross-links, or the number of cross-links to be determined, and studies on a radiation cross-linked polyamide illustrated the reasonably good agreement obtained between these three methods.

By the assumption that all the primary polymer molecules being cross-linked were of uniform length, it was possible to simplify the expression relating sol fraction to cross-linking to $-\ln S\ (1-S) = M/M_c$, where S was the sol fraction and M was the primary molecular weight. This approach was illustrated by studies with thermosetting acrylic polymers of the glycidyl methacrylate/acrylic acid type. In a series of resins an approximately constant value of about 1,500 was obtained for the molecular weight between cross-links, M_c. This approach, which was on a firm theoretical basis, could be applied to a number of resin systems of interest to the paint industry.

An analogous topic was the interaction between polymers and pigments or fillers. Kraus had used similar techniques to investigate interactions between rubber vulcanisates and filler particles, and the possibility of extending such techniques to paint films was attractive. Thus it had been shown by infrared spectroscopy that in some cases carboxylic species were ionically bonded to pigment particles, while in other cases hydrogen bonding occurred. It might be possible to differentiate between such adsorption mechanisms of differing strength by such techniques. By analogy with the pretreatment of glass fibres with bonding agents for use in unsaturated polyester resins, it might be appropriate to carry out similar pretreatment of pigments and extenders for use in paint systems.

Evidence of reaction between amino resins and alkyds to form cross-links had been provided by recent work on water-based systems. Thus dimethylol ethylene urea does not become insolubilised on stoving, but when stoved with a water soluble alkyd, e.g. one based on trimellitic anhydride, adipic acid and neopentyl glycol, a solvent insoluble film resulted, although the alkyd stoved alone was completely soluble. Increasing proportions of amino resin increased the inextractable content and improved water resistance. An interesting fact was that many alkyd-amino systems were generally formulated in such proportions as to give a nearly stoichiometric equivalence of methylol groups in the amino resin on the one hand and reactive hydroxyl and carboxyl groups in the alkyd on the other.

In the textile field, water soluble resins had been used for many years, and there was an enormous literature covering the field. Originally acid catalysed urea and melamine formaldehyde resins were used, but some of the more important materials recently developed included compounds with a reactive methylol group attached to an active nitrogen atom (e.g. dimethylol ethylene urea, triazones), epoxy compounds and ethylene imines. As an example, the development of sulphonium cross-linking agents was described. Divinyl sulphone was found to react rapidly with cellulose, but had unpleasant lachrymatory effects, and so divinyl sulphone release agents were developed, which would release the agent only under curing conditions. Later compounds were prepared in which the vinyl groups were activated by a positive sulphonium cation, and these were even more reactive than divinyl sulphone, whilst having much improved application properties.

The paper was followed by a lively discussion, in which Dr. M. H. Dilke, Dr. S. H. Pinner, Dr. H. Warson, Dr. M. Gordon, Mr. M. J. Zissel, Dr. J. J. Staudinger and Mr. R. F. Ingleby took part. In proposing the vote of thanks, Mr. M. R. Mills, Chairman of the London Section, said that the lecture had been of interest to a large audience representing many widely different fields of polymer chemistry.

V. T. C.

Midlands Section

SOME DEVELOPMENTS IN COATINGS, MATERIALS AND METHODS

On 20 March, at James Watt Memorial Institute, Birmingham, the Midlands Section held a joint meeting with the Midlands Section of the Plastics Institute, the Institution of the Rubber Industry and the Birmingham Paint, Varnish and Lacquer Club. Mr. H. Everard, Chairman of the Midlands Section of the Plastics Institute, introduced the Chairmen of the visiting Societies, Mr. N. H. Seymour representing OCCA on this occasion, and then invited Mr. G. Barnett to give a paper entitled "Some Developments in Coatings, Materials and Methods."

Mr. Barnett said that in this country the consumption of resins in surface coatings was about one-eighth of total polymer production. After classifying coatings according to structure and method of application, he went on to describe some of the more important developments made in recent years.

In the field of phenolic resins, diphenolic acid and polymethylene polyphenol had been introduced to improve flexibility. New materials for alkyds included isophthalic acid, dimethyl terephthalate and the glycidyl ester of *Versatic Acid* 911. Cyclo-aliphatic and acyclic epoxide compounds, which did not contain glycidyl ether groups, had been developed and a special technique of preparing epoxide esters from liquid epoxide resins gave improved flexibility. By incorporation of reactive unsaturated compounds the adhesion of pvc organosols and plastisols had been improved. With unsaturated polyesters better air-dry had been obtained by incorporating allyl ethers, and photopolymerisation catalysts permitted ultra-violet curing. Thermosetting acrylic resins incorporated acrylamide, carboxyl groups or β-hydroxy ethyl groups as sites for cross-linking and a number of polyurethane resins had been developed, based on reaction of isocyanates with hydroxyl compounds. Other new resins were based on polyhydroxy ethers and on diphenyl oxide.

Turning to newer methods of application, he described water-thinned paints and electrophoretic coating, powder coating, electrostatic spraying, curtain coating and continuous strip coating. He thought that the trend would continue towards elimination of solvents and towards application of coatings by continuous methods. He also foresaw an extension of application of the plastisol principle to resins other than pvc.

After a lively and good-natured discussion by members of the four Societies present, Mr. S. T. Harris proposed a vote of thanks.

L. R. S.

West Riding Section

WATER THINNABLE ALKYD MEDIA

The sixth technical meeting of the session was held at the Great Northern Hotel, Leeds, on 10 March 1964, when Mr. R. A. Brett, of the Paint Research Association, gave a paper entitled " Water Thinnable Alkyd Media."

Mr. Brett said that the work covered in the lecture was part of an extensive programme of study being carried out at the PRS on water solubility. Included in the definition of alkyds, he said, were maleinised oils formed by the reaction of oils with maleic anhydride. These were reacted until just soluble in a volatile base in order to preserve some unsaturation in the oil and thus preserve the ability to dry by cross linking. However, it was found that the acidity of the products was less than the calculated value and this was attributed to difficulty of hydrolysing the anhydride and partly to loss during the reaction. By using fumaric acid especially with conjugated oils such as tung oil no loss of acidity was observed.

With alkyds which were not modified with oil it was found that water solubility could be achieved in three ways :

(*i*) By introducing ether groupings which were hydrophilic, but had the disadvantages of producing water sensitive films.

(*ii*) By introducing polyfunctional alcohols such as pentaerythritol which were an improvement over the previous compounds.

(*iii*) By introducing acids of high functionality such as trimellitic and pyromellitic.

The latter gave the best results probably due to good distribution of carboxyl groups in the polymers.

Although the films produced from maleinised oils were good they had the disadvantage of severe yellowing during oxidation in the ovens. This was attributed to the presence of ammonia or other nitrogen containing bases, and thus these systems had to be confined to use in priming coats or dark colours. The non-oil modified alkyds dry not by oxidation but by removal of ammonia followed by esterification at temperatures up to 200°C for 30 minutes.

To try to achieve a compromise and reduce the temperature to effect a cure of non-oil modified alkyds, amino compounds were added. Three systems were studied : TMA/adipic acid/diol ; TMA/capric acid/diol, and TMA/castor oil/diol, all modified with a melamine condensate. However, none of the systems had satisfactory flexibility and water resistance and substrate wetting characteristics.

It was then decided to try to improve the water resistance by use of a melamine formaldehyde resin modified with 2-methoxyethanol or better hexamethoxy-methyl-melamine. It was found that this compromise did give good flexibility and water resistance together with good storage stability.

Mr. Brett then considered the mechanism of the curing reaction. Free acidity, he said, played an important part in the curing, and experiments were carried out to find the rate of loss of volatile bases by determining the nitrogen content of the film at various stages during stoving. With low viscosity alkyds from 20-30 per cent remained. Rate of loss of different bases was studied and it was found that the rate declined with increase of molecular weight of the base. It had been thought that ammonia may be retained in the film as amide and this was going to be followed up by experiments using radioactive trimethylamine.

Problems associated with water thinnable alkyds were discussed. These included fall of pH, clouding, anomalous viscosity characteristics and application defects. By studying simple polyesters it was found that the lower the number of ester groups present, the less the pH dropped, possibly due to less hydrolysis of the alkyd, also that glycols with secondary hydroxyl groups particularly were associated with clouding and a fall of pH. Anomalous viscosity results had been found when diluting these alkyds and this had been attributed to chains having terminal hydroxyl groups. If branched chains or chains terminating with carboxyl groups were used then the anomalies were lessened. The main application defect was bad wetting and cratering. This appeared during stoving as a little gel-like material in the middle of a very thin film. The addition of solvents such as benzyl alcohol or ethyl lactate or centrifuging helped to partially overcome this problem, the answer to which still was obscure, but may be due to stresses within the film due to different drying rates at different levels.

In opening the question time, Dr. Hargreaves asked whether the wettability of the substrate had any connection with the wettability of pigments, and secondly, could air drying systems be made from water soluble alkyds. In reply, Mr. Brett said that the pigment did not appear to have much effect on wettability. To the second question he said that the maleinised oils would dry in 4-5 hours, but tended to be water sensitive. However, work was being carried out to develop glossy emulsions using water thinnable alkyds as a minor component.

Mr. Heason asked if reactive pigment such as zinc oxide aided solubility of the resin and did this assist the cure. The speaker answered by saying that poor storage stability was observed due to the formation of zinc soaps which were thrown out of solution. In fact a certain amount of pigment selection had to be done to make sure of paint stability.

Mr. Haigh referred to the TMP/adipic acid/diol/methoxylated melamine system and to the fact that there was a low rate of cure except in the presence of acid. Was there, he asked, any parallel with acid cured alkyd/melamine organic solvent systems. Mr. Brett replied that in this connection reference was made to the effect of acid on the rate of cure in the context of the acid present as a reaction product of the resin components and its release on stoving and resultant acceleration of cure not addition of, say, sulphonic acids since the acid values of water soluble alkyds are already high.

The vote of thanks was given by Mr. D. R. Gray.

L. J. W.

Information Received

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

We have received the latest booklet describing their rubber-based hydrocarbon resins from SURFACE COATING SYNTHETICS LTD. The brochure describes the properties and uses of *Surcoprene 1000* and *1100.*

A brochure received from CRODA LTD. describes a number of new chemicals produced by the company. Most of the chemicals mentioned are described as emulsifiers for the cosmetic industry, but one, *Amilan*, is recommended as a pigment dispersant and wetting agent.

BRITISH PAINTS LTD. are expanding their overseas interests. A new company to be known as BRITISH PAINTS (GUYANA) LTD. has been registered and a factory is to be built on the Ruimveldt Industrial Estate, Demerara and is hoped to be in production by the end of the year.

JACOBSON VAN DEN BERG & CO. LTD. have marketed Tetrachlorobisphenol A from the DOVER CHEMICAL CORPORATION of the United States. This raw material is recommended for producing fire retardancy in epoxies, polycarbonates, polyesters, and polyurethanes. It comes in fine white flakes and is reported to be soluble in the more common organic solvents.

COLUMBIAN INTERNATIONAL announce that they have become the sole United Kingdom agents for the products of HERBERT SMITH & COMPANY ((GRINDING) LTD. and BARKER & ASPREY LTD. The arrangement relates to the range of ball mills, high speed mixers, etc. manufactured by these two companies.

From the SIERRA TALC COMPANY of the United States we have received a booklet describing the use of their talcs in surface coatings.

A new domestic paint based upon a marine finish has just been introduced by A. SANDERSON & CO. LTD. The paint is a polyurethane and is reported to give an indestructible, brilliant gloss finish. It is stated to withstand considerable thermal shock and to be unaffected by bleach, concentrated detergent, spirits or grease.

HARDMAN & HOLDEN LTD. have introduced a new paint drier *Cozirc 69.* The drier which contains both cobalt and zirconium is recommended as a replacement for the conventional cobalt and lead naphthenate driers. It is stated that *Cozirc 69* is compatible with alkyds, linseed stand oil and most oil soluble hard resin media.

A buyer's guide to the Indian paint and printing ink industry has just been published by PAINTINDIA. It consists of the following sections : (*i*) raw materials, including a resin index ; (*ii*) raw material manufacturers ; (*iii*) raw material distributors ; (*iv*) paint and printing ink manufacturers ; (*v*) who's who. The guide is comprehensive and well written and should prove of interest to European importers.

A new synthetic resin for printing inks has been introduced by ICI LTD. (DYESTUFFS DIVISION) under the name *Bedesol 899*. It is reported to be a low viscosity, solvent free drying oil modified alkyd of the long oil type. The main use of this new resin is though to be in blends with higher viscosity alkyds in the formulation of heat set lithographic inks. It is stated that the poor scuff resistance of most inks based on low viscosity resins has been overcome in the case of *Bedesol 899* by its hydrophobic character.

THE WALPAMUR CO. LTD. have just marketed a new fire-retardant paint system, *Retaflam*. Protection is afforded, the manufacturers state, by the creation, under conditions of fire hazard, of a cellular foam which effectively insulates the inflammable surface. It is claimed that when the fire is extinguished the surfaces are usually sound enough for repainting after satisfactory preparation by scraping, etc.

Two new thermosetting acrylic resins, *Scopacron 1550* and *Scopacron 1575*, have been introduced by STYRENE CO-POLYMERS LTD. for use in the automotive finishing field. The reported properties of films based upon these resins are : hard films of high solvent resistance, high build together with gloss and colour retention, which are maintained on severe overbake, excellent corrosion resistance, and easy repair of minor defects incurred during trim assembly and other operations.

ASSOCIATION DINNER AND DANCE, 1964

The above photograph shows (*left to right*) Professor H. J. Emeléus and Mrs. Emeléus, Mr. F. Sowerbutts (*Honorary Treasurer*) Mr. E. L. Giles (*Master, The Worshipful Company of Painter-Stainers*) and Mrs. Giles, Mr. R. H. Hamblin (*General Secretary*) and Mrs. Hamblin

The Biennial Dinner and Dance of the Association was held at the Savoy Hotel, London, W.C.2, on Friday 10 April 1964, and although this was the latest date on which this function had been held at the Savoy Hotel, the previous attendance figure of 400 members and guests was maintained. The President, Dr. J. E. Arnold, and Mrs. Arnold received the members, guests and their ladies before dinner.

The guests of the Association were Professor H. J. Emeléus, C.B.E., F.R.S. (*President of the Royal Institute of Chemistry*), and Mrs. Emeléus, Mr. G. H. Carnall, F.C.I.S. (*President of the Society of Dyers and Colourists*), and Mrs. Carnall, Mr. A. P. Low (*President of the Paintmakers Association*) and Mrs. Low, Mr. C. E. Tinsley (*President of the Society of British Printing Ink Manufacturers*) and Mrs. Tinsley, and Mr. E. L. Giles (*Master of the Worshipful Company of Painter Stainers*) and Mrs. Giles.

It was particularly gratifying to note among those attending the Dinner and Dance the presence of several Past Presidents : Dr. H. W. Keenan (1944-47), Dr. L. A. Jordan (1947-49), Mr. H. Gosling (1953-55), Mr. C. W. A. Mundy (1955-57), Mr. N. A. Bennett (1957-59) and Dr. H. A. Hampton (1961-63) and their ladies. Vice-Presidents of the Association who were present were Mr. C. Allsop, Dr. S. H. Bell and Mr. A. W. Blenkinsop, with their ladies, and the Chairmen of the

Manchester and West Riding Sections, Mr. J. Smethurst and Dr. K. Hargreaves, respectively, with their ladies, were also present.

The " Toast to the Association " was proposed by Professor H. J. Emeléus. In a humorous speech he drew particular attention to the link between the Association and the Royal Institute of Chemistry. He was gratified to note that in addition to Dr. J. E. Arnold, no fewer than 12 of the Association's Past Presidents were or are Fellows of the Royal Institute of Chemistry. He expressed the opinion that since the Association was founded in 1918 it had achieved its object to bring science more into the industries concerned and he congratulated the members on the high standard of their research.

Dr. A. P. Low (*President, Paintmakers Association of Great Britain*) and Mrs. Low in conversation with Mrs. C. E. Tinsley, who together with her husband, the President of the Society of British Printing Ink Manufacturers, was a guest of the Association

In reply, Dr. Arnold thanked Professor Emeléus for his flattering remarks, and went on to say how happy he was to have the opportunity to thank him publicly for the great help which the Royal Institute of Chemistry had given to the Association, and also to the Paintmakers Association, in helping to formulate proposals concerning technical qualifications. As had already been announced, the Licentiateship of the Royal Institute of Chemistry with a surface coating endorsement had been adopted by the industry and this was a result of the activities of the Technical Education Committee of the Paintmakers Association on which the Oil and Colour Chemists' Association had been represented.

The President pointed out that he had now completed almost one year of his term of office, and in saying how much he had enjoyed it he referred to the wonderful opportunity it afforded for visiting the Sections and meeting many of the members at annual functions. He felt it was only after doing this that one could appreciate just how vigorous and enterprising was the Association. As a matter of interest, he had computed that the President, during an average term of office, travelled at least 10,000 miles, although there had been two exceptions to this when Mr. L. O. Kekwick (1951-53) and Mr. P. J. Gay (1959-61) during their years as Presidents had travelled round the world and visited the Sections of the Association overseas. On this basis he estimated that the Presidential medallion, since it had first been worn by Dr. L. A. Jordan in 1948, had travelled some 150,000 miles.

In welcoming the guests, the President said it gave him great pleasure to have with him Professor H. J. Emeléus and Mrs. Emeléus, and Mr. G. H. Carnall, President of the Society of Dyers and Colourists, and Mrs. Carnall. He took the opportunity of offering Mr. Carnall congratulations on the occasion of the 80th anniversary of the Society of Dyers and Colourists, and said how pleased the

Mr. H. Gosling (*President* 1953-55) and Mrs. Gosling

TOP (*right to left*) Dr. J. E. Arnold (*President*), Mrs. Arnold, Professor H. J. Emeléus (*President, the Royal Institute of Chemistry*), Mrs. Emeléus, Mr. G. H. Carnall (*President, Society of Dyers and Colourists*), Mr. Carnall

BOTTOM (*right to left*) Mrs. Sowerbutts, Dr. H. A. Hampton (*Immediate Past President*), Mrs. Hampton, Mr. A. T. S. Rudram (*Honorary Research and Development Officer*), Mrs. Rudram

Also attending the Dinner were Dr. H. W. Keenan (President 1944-47) and Mrs. Keenan (*top left*), Dr. L. A. Jordan (President 1947-49) and Mrs. Jordan (*top right*), Mr. C. W. A. Mundy (President 1955-57) and Mrs. Mundy (*bottom left*), Mr. N. A. Bennett (President 1957-59) and and Mrs. Bennett (*bottom right*)

Association had been to be able to include an appropriate display on one of the information bureaux at the recent Technical Exhibition. The President also welcomed Mr. A. P. Low, President of the Paintmakers Association, and Mrs. Low, Mr. C. E. Tinsley, President of the Society of British Printing Ink Manufacturers, and Mrs. Tinsley, as well as Mr. E. L. Giles, Master of the Worshipful Company of Painter Stainers, and Mrs. Giles.

The President added that he had also hoped to welcome on this occasion M. Jean Petit, the President of FATIPEC, Mr. C. D. O'Sullivan, President of the Research Association of British Paint, Colour and Varnish Manufacturers, and Dr. J. E. Garside, President of the Institute of Metal Finishing, but at the last moment these gentlemen had, unfortunately, been prevented from attending. The President of the Federation of Scandinavian Paint and Varnish Technicians, Mr. H. Furuhjelm, had not been able to accept the Association's invitation to this function, but Dr. Arnold was happy to be able to read to those present a telegram he had received from Mr. Furuhjelm wishing everyone a successful and enjoyable evening.

While including the ladies in the " Toast to the Guests," the President said that he always thought of them as honorary members of the Association ; they did not pay a subscription, but they made their influence felt and certainly gave service to the Association by allowing their husbands to give so much of their time to the Association. He then asked the members of the Association to join him in drinking a toast to the " Ladies and Our Guests."

Mr. G. H. Carnall responded to the toast on behalf of the ladies and guests in a witty fashion, and said how sorry he had been about the heart-breaking circumstances with which the Association had been faced at the recent Exhibition, but at the same time he expressed admiration at the forthright terms in which the President had castigated those responsible during the preceding luncheon. In particular he also thanked the Association for incorporating on one of their stands the display in recognition of the 80th anniversary of the Society of Dyers and Colourists.

In conclusion, Mr. Carnall expressed the hope that members of the Association and the Society who were present would always keep in mind the ultimate object of scientists dealing with practical application both in the field of applied science and technology, and that their endeavours rested on human relationships.

After the speeches, dancing continued until 1 a.m., with a break at 11.30 p.m. for refreshments, after which an excellent cabaret entitled " The Gayetimers " entertained the company.

London Section

ANNUAL GENERAL MEETING

The 26th Annual General Meeting was held on 23 April 1964 at the Criterion-in-Piccadilly, preceded as usual by an informal dinner. About 53 members attended.

After adoption of the minutes of the last Annual General Meeting, Mr. R. N. Wheeler proposed the adoption of the Annual Report. He mentioned that there had been a full session of technical meetings (8), most of which had been well attended. This session there had been a series of six lectures for junior members, arranged by Mr. Pooley. Although these lectures had been well attended, the support by junior members had been poor. The future of this form of activity would be considered by the Committee in the coming session. He was also very pleased to welcome the inauguration of a " new channel " of activities, the TV Branch, following on the success of the Southern Branch. In seconding the proposal, Mr. C. A. Carey congratulated the London Section on their enthusiasm, and joined Mr. Wheeler in welcoming the formation of the Thames Valley Branch.

Mr. Carey then spoke about the Southern Branch report. He wished that Mr. F. W. Davies had been able to be present, as he was one of the founders of the Branch, and expressed the appreciation by the Branch of the support and assistance given by the officers of the London Section. Membership was growing gradually, and the Committee had ideas about approaching other industries and societies in the area to lead to an extension of their activities.

Mr. W. J. Arnot then referred to the formation of the Thames Valley Branch. They had an enthusiastic group of members and a hard-working Committee, and they had made a good start. Their headquarters for the coming session would be the White Hart at Beaconsfield. He wished to thank the officers of the London Section and Mr. R. H. Hamblin (General Secretary) for their invaluable assistance in the formation of the Branch.

In commenting on the report, Dr. S. H. Bell said that he had referred on previous occasions to junior membership, and he would like to say "well done" for the work undertaken this session for the juniors. He knew well that it was not easy, and a considerable effort had been needed to get junior activities going in London. A large amount depended on the stimulation and encouragement the juniors received from senior members in their firms. Mr. H. C. Worsdall asked whether there were any juniors coming into the industry as a result of the lectures.

The Chairman, Mr. M. R. Mills, commenting on the proposed scheme for exchange lectures with continental societies, said that favourable replies had been received from France and Holland, and it was hoped to get the scheme started fairly soon. The Council had allocated a grant of £50 per annum for these activities. The meeting then unanimously approved the adoption of the report.

Mr. J. E. Pooley proposed the adoption of the Financial Report. This covered the year ending in December, during which there had been nine technical meetings and three junior meetings. There were also the activities of the Southern and Thames Valley Branches, which together accounted for the increase in expenditure on printing. The cost of the hire of rooms was greater this year due to the meeting held at the Institution of Electrical Engineers in December. The increased cost of refreshments was attributed to the additional junior group activities. Mr. F. R. W. Chitty seconded the adoption of the report and commented that the Ladies' Night had paid for itself in 1963, compared with the loss in 1962. After comments on the report from Mr. G. F. Jones and Mr. Newnham, the report was adopted unanimously.

The Chairman then paid a tribute to Mr. C. R. Pye's services to the Section over a number of years, and expressed his regret at the circumstances which had made it necessary for Mr. Pye to retire from office. He expressed the thanks of the Section to him for his invaluable work, which had included the task of reporting each year on the Technical Exhibition. He then proposed the election of the Hon. Officers for the year 1964-65 as follows:

Hon. Secretary ..	Mr. R. N. Wheeler
Hon. Treasurer ..	Mr. J. E. Pooley
Hon. Publications Secretary ..	Dr. V. T. Crowl
Hon. Programmes Officer	Mr. A. R. H. Tawn
Hon. Auditor ..	Mr. W. H. Campbell

Mr. I. C. R. Bews endorsed Mr. Mills's comments regarding Mr. Pye's services to the Branch and his work on the Publications Committee, and wished to record his gratitude to him for his assistance during his (Mr. Bews's) period as editor of the *Journal*. The nominations were approved unanimously by the meeting.

Mr. R. F. G. Holness then proposed the re-election of Mr. M. R. Mills as Chairman. The election of a Chairman was a task which must be taken seriously, since the Chairman leaves his mark on the Section, and Mr. Mills had impressed the Committee with his ability to lead and inspire their activities. In seconding this proposal, Mr. H. C. Worsdall said that he was very pleased to see Mr. Mills nominated for a second period of office and hoped he would have a further happy and successful year. The proposal was carried unanimously with acclamation, and Mr. Mills acknowledged his re-election, expressing his thanks to the Committee for making his task easy.

Mr. Mills said that the members were very glad to have with them at the meeting Mr. A. J. Gibson and Mr. T. Hedley-Barry.

After a slight delay, the Chairman announced the result of the election of the three members to fill the vacancies on the Committee, Mr. J. R. Berry, Mr. K. D. C. Bruce and Mr. D. E. Eddowes being elected. The meeting was then closed and followed by a talk by Mr. O. M. H. Jackson, of the Shell Chemical Company, entitled " Public Relations, Does It Exist ? "

Mr. Jackson, in an extremely interesting talk, pointed out that public relations was an activity that occurred anyway, irrespective of whether it was organised. It was not the private province of a few professionals, but was involved in every activity of the organisation. A medium-sized or lage company needed to have a PRO, since the press liked to have a focal point as a source of information. In some cases these activities could be handled by an outside consultant. The PR department was essentially a two-way link, explaining the company to the outside world and the opinions and views of the outside world to the company. The latter aspect sometimes involved opinion and attitude research, which might result in the policies of the company being modified. There was a clear distinction between PR work and advertising, although advertising policy was one of the activities which fell into the sphere of PR work. One definition of PR work was that it was the deliberate fostering of good will towards the organisation : this involved the function of explanation and interpretation, and the presentation of the most favourable case for any activity. It could be described as " good behaviour and good reporting."

The talk was followed by a lively discussion, which reflected the interest with which the members present had followed the speaker.

V. T. C.

Manchester Section

ANNUAL GENERAL MEETING

The 40th Annual General Meeting of the Section took place in Manchester on 17 April 1964, with Mr. J. Smethurst in the chair.

After the minutes of the last AGM had been approved, the Annual Report of the Committee and the Financial Report were discussed and adopted.

Officers were then elected as follows :

Chairman . .	Mr. H. F. Clay
Vice-Chairman . .	Mr. I. S. Moll
Hon. Secretary . .	Mr. H. G. Clayton
Hon. Treasurer . .	Mr. S. Duckworth
Hon. Publications Secretary . .	Mr. W. F. McDonnell
Hon. Research and Liaison Officer . .	Dr. F. M. Smith
Hon. Programmes Officer . .	Mr. K. W. G. Butcher
Hon. Social Secretary . .	Mr. M. J. Heavers

A ballot was held to fill three places on the Committee from four nominations received. As a result, Mr. T. Graham, Mr. J. J. Kavanagh and Dr. G. A. Wolstenholme were elected. The meeting re-elected Mr. L. Bowden and Mr. F. A. Walker as Hon. Auditors.

The Immediate Past Chairman, Mr. J. Smethurst, thanked all the Officers and Committee members as a team for the excellent way in which they had worked with him during his two years of office.

Dr. H. A. Hampton spoke of the outstanding way in which Mr. Smethurst had conducted the affairs of the Section. He had brought new ideas and improvements into being, such as running extra meetings for outside lecturers of international repute, putting a highly topical symposium into the 1963 programme, and, more recently, setting out to define the essential functions of Officers more clearly. The meeting endorsed Dr. Hampton's vote of appreciation most wholeheartedly.

After the meeting a hot-pot supper took place, and, at its conclusion, Mr. Smethurst presented Mr. R. McDowell with a canteen of cutlery from members as a recognition of his past services as Hon. Secretary. He said that Bob McDowell's hard work and sincere efforts would long be remembered, and hoped that the gift would always remind him, and his wife, of their association with the Section. Mr. McDowell thanked sincerely all those concerned.

The remainder of the evening was spent in entertainment, during which Markey and Dunn provided songs and stories, ably assisted by Mr. J. J. Kavanagh, who was in charge. Expected talent for storytelling was displayed by several members of Committee, and later, when inhibitions had been suitably submerged, a group of four gave an enthusiastic but confused rendering of a well-known war-time ballad.

Clearly the evening was enjoyed by all.

I. S. M.

Scottish Section

ANNUAL GENERAL MEETING

On Friday 3 April 1964, at St. Enoch's Hotel, Glasgow, the Annual General Meeting of the Scottish Section was held under the chairmanship of Mr. A. S. Fraser.

The Chairman, Honorary Officers, Committee Members and Honorary Auditors were elected and the business of the meeting completed in an efficient manner. Mr. A. S. Fraser warmly thanked his Committee for the assistance they had so willingly given throughout his term of office, which, he said, had been an enjoyable one. On taking over the chair, Dr. D. Atherton expressed gratitude for the honour which had been bestowed on him and hoped that he would be able to carry out his duties as efficiently as Mr. Fraser had done.

At the conclusion of his remarks, Dr. Atherton referred to the sudden deaths of Mr. R. Blackadder and Mr. J. Milligan, which had unfortunately occurred during the session. Both of these gentlemen, he said, would be greatly missed.

For the new session the Chairman, Honorary Officers, Committee Members, etc., were elected as follows :

Chairman ..	.. Dr. D. Atherton
Vice-Chairman	.. Mr. I. S. Hutchison
Immediate Past Chairman	.. Mr. A. S. Fraser
Hon. Secretary	.. Mr. W. W. Horsburgh
Hon. Treasurer	.. Mr. T. B. Hannah
Hon. Publications Officer ..	.. Mr. A. MacLean
Representative on Council ..	.. Mr. H. Gibson
Hon. Research Liaison Officer	.. Mr. G. H. Hutchinson
Hon. Education Officer ..	.. Mr. A. MacLean
Student Group Liaison Officer	.. Mr. D. M. Stewart
Hon. Auditors	.. Mr. J. D. W. Davidson and Mr. L. Hopwood

Committee :

Mr. A. Mawer, Mr. G. Anderson, Mr. A. McGuire, Mr. P. Birrell, Mr. D. Rowley and Mr. W. M. Young.

The business being completed, the meeting was closed.

ANNUAL SMOKING CONCERT

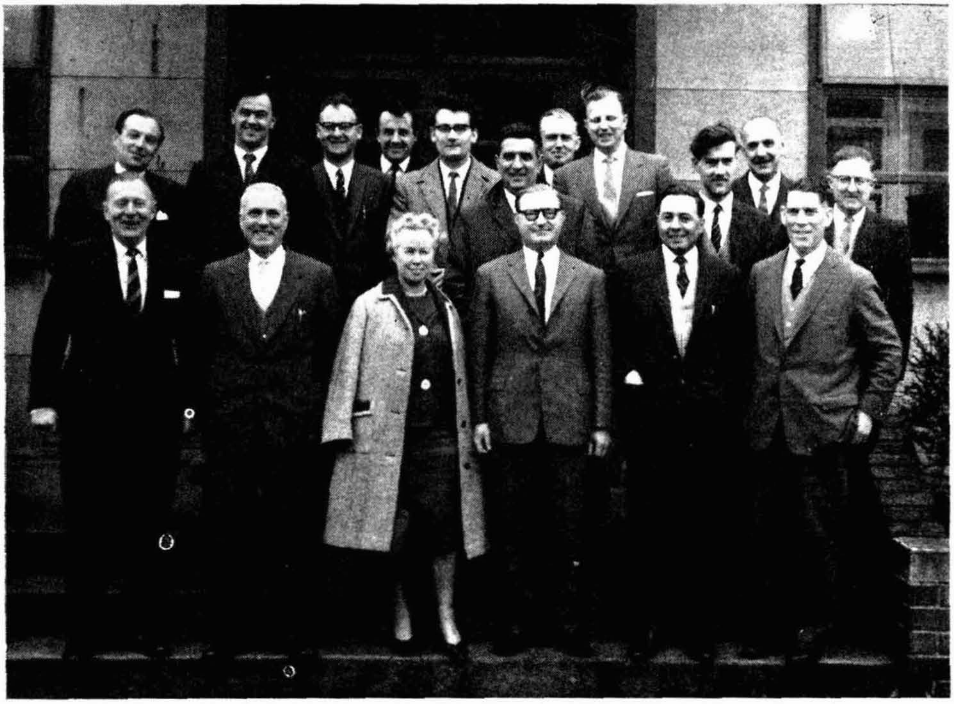
Following their Annual General Meeting in St. Enoch's Hotel, Glasgow, on 3 April 1964, the Section met as usual for their annual Smoking Concert, held this year in the Eglinton Arms Hotel, Eaglesham.

Just before the meal the Chairman, Dr. D. Atherton, presented an attractive pen and pencil set to Mr. A. S. Fraser—Immediate Past Chairman—as a memento of his tenure of office. Thereafter the members enjoyed high tea and the concert proper began. Two professional entertainers set the mood for the evening and, as usual, as the members acquired increasing courage they too showed their talents—some surprisingly outstanding.

In all it was a very successful evening and thanks are due to the members of the Entertainments Committee, who were responsible for all arrangements made.

T. B. H.

West Riding Section



MEMBERS OF THE WEST RIDING SECTION AT THE METAL BOX CO. LTD.

ANNUAL WORKS VISIT

As a follow-up to the February lecture on "The Printing and Decorating of Metal Containers," 13 members of the Section visited the Oddiscroft works of the *Metal Box Company Ltd.* at Sutton-in-Ashfield on Wednesday 15 April.

On arrival the visitors were welcomed by Mr. Mellor, the general manager, Mr. Lott and members of the Oddiscroft staff. Whilst the visitors were enjoying a very welcome coffee, Mr. Mellor gave a brief history of the works and outlined the course of the visit. It appeared that the tin box industry in the Mansfield area was started in 1840 by a mustard miller called Barringer, who decided to pack his product in tins and made them himself. The idea took on so successfully that hand-made tin box making became a new industry in the area. By 1893 the firm took on new partners to become Barringer, Wallis & Manners, which moved from Mansfield to Sutton-in-Ashfield in 1897. Here the tins were litho printed and the Oddiscroft works still does the printing for the Mansfield factory.

The tour commenced with a visit to the reproduction department, where the designs from the customers were translated by skilled artists and photographers to a form suitable for making printing plates even though the design may be severely distorted during fabrication. From there the party moved to the cacophony of the highly mechanised aerosol body and tin can making section. The general impression was of noise and writhing streamers of cans as they moved at phenomenal speed on belts from machine to machine during the different stages of fabrication. It was stated that up to 15 million containers could be made per week and that the biggest problem was despatching the finished articles.

The party was then shown the railway siding sheds where conveyor belts were bringing the tins direct from the fabricating machinery into the railway vans.

After an excellent lunch the party next visited the litho platemaking department and the lacquering and printing factory. Here a wide variety of designs for every conceivable type of container is printed. A small exhibition of examples of work done was shown, which also included tins made as long ago as 1880.

The final section to be visited was the extrusion department, where we were shown the process of making aluminium containers from a slug of aluminium through to lacquered and printed finished products.

Finally over a very welcome sit-down and cup of tea the group was invited to ask questions of the various departmental managers on any part of the process that had not been clear.

L. J. W.

BRITISH SOCIETY OF RHEOLOGY

The British Society of Rheology will be holding a meeting at the University of Exeter on 28-30 September 1964, when papers will be presented on the subjects of rheometry and the teaching of rheology. Further details of this meeting can be obtained from Dr. M. F. Culpin, 8 The Broadway, Pontypool, Monmouthshire.

Register of Members

The following elections to membership have been approved by Council. The Sections to which the new members are attached are given in italics :

Ordinary Members

APPS, ERNEST ARTHUR, B.SC., A.M.I.O.P., 26 South Drive, Ruislip, Middx. *(London)*

ARMSTRONG, JOHN EMERY, 41 Milton Road, Bentley Heath, Solihull, Warwicks. *(Midlands)*

BLAND, HENRY HORSFALL, B.SC., A.R.I.C., 38 Burn Bridge Oval, Harrogate, Yorks. *(West Riding)*

BRIGGS, FRED, B.SC., PH.D., F.R.I.C., The Walpamur Co. Ltd., Darwen, Lancs. *(Manchester)*

BUTTERS, GORDON, A.R.I.C., 15 Wordsworth Place, Walton-le-Dale, Preston, Lancs. *(Manchester)*

CAMERON, DENIS B., B.SC., 9 Thornhill Terrace, Sunderland, Co. Durham. *(Newcastle)*

CUMMINS, WILLIAM HENRY, B.SC., c/o Meggitt Ltd., Box 199, PO Parramatta, New South Wales. *(New South Wales)*

DORST, WILLEM, Chemisch Technisch Adviesbureau, Dr. J. Rinse & W. Dorst, Zijlweg, 340-342, Haarlem, Holland. *(Overseas)*

FARRELL, LAURENCE, 35 Heyburn Road, Liverpool, 13. *(Manchester)*

GRUNDY, JAMES, A.I.R.I., R. W. Greeff & Co. Ltd., Royal Exchange, Manchester, 2. *(Manchester)*

HUDDART, WILLIAM ERNEST, F.R.I.C., Hoechst Chemicals Ltd., Regency House, 46 Wellington Street, Leeds, 1. *(West Riding)*

JARVIS, MICHAEL BENNET, B.SC., 5 Cromwell Avenue, Rose Hill, Marple, Stockport, Cheshire. *(Manchester)*

KAPADIA, KIRIT MANUBANI, M.SC., c/o Dr. K. G. Gandhi, Nava Pura, Karva Road, Surat, India. *(Overseas)*

LAWRENCE, FREDERICK RICHARD, 38 Garden Street, Box Hill North, Victoria *(Victorian)*

MILES, EDWARD JOLLASSE, B.SC., F.R.I.C., Izal Ltd., Thorncliffe, Nr. Sheffield. *(West Riding)*

MORRIS, DAVID, 7 Stockham Lane, Halton, Runcorn, Cheshire. *(West Riding)*

NAGIANATHAN, S., B.SC., Room No. 9, YMIA, Armenian Street, Gokhale Hall, Madras, 1, India. *(Overseas)*

ROWE, ALLAN WINSTON, B.SC., 58 Yeend Street, Merrylands, New South Wales. *(New South Wales)*

RYATT, AJIT SINGH, Paint Research Station, Waldegrave Road, Teddington, Middx. *(London)*

SCOPES, HERMAN MARCUS, B.SC., ICI Ltd., Ship Canal House, King Street, Manchester, 2. *(Manchester)*

SLADE, HAROLD AITKEN, B.SC., A.R.I.C., 79 Pinner View, Harrow, Middx. *(London)*

STRANG, WILLIAM RITCHIE, M.SC., Shell Oil NZ Ltd., PO Box 698, Wellington, New Zealand. *(Wellington)*

VICKERSTAFF, TREVOR STANLEY, 32 Athlone Crescent, Lower Hutt, Wellington, New Zealand. *(Wellington)*

WAGLE, PRABHAKAR NARAYAN, B.SC., B.SC.(TECH.), 2A Ramaprasad, Dadyseth Road, Bombay, 7, India. *(Overseas)*

WATSON, BRUCE MAUGER, 71 Reynolds Street, Cremorne, New South Wales. *(New South Wales)*

WEBB, LAURENCE, A.R.P.S., 181 Turner Bridge Road, Tonge, Bolton, Lancs. *(Manchester)*

WILSON-MATTALON, ROBERT, 3 Avenue des Scarabees, Bruxelles, 5, Belgium. *(Overseas)*

WREN, DAVID MICHAEL, Smith & Walton Ltd., Haltwhistle, Northumberland. *(Newcastle)*

WRIGHT, KATHLEEN A., Para Plastics Pty. Ltd., 165 Islington Road, Croydon Park, South Australia. *(South Australian)*

WRIGHT, ROBERT, Para Plastics Pty. Ltd., 165 Islington Road, Croydon Park, South Australia. *(South Australian)*

Associate Members

CAFFREY, VINCENT E., Anderson & Martin, 23 Anglesea Street, Dublin, 2. *(Bristol)*

COCIANCICH, ROMEO, Via Vodice 14, Milan, Italy. *(Overseas)*

PALFREYMAN, BRIAN RICHARD, Flat 3, 60 Blaxland Road, Ryde, New South Wales. *(New South Wales)*

SCAGLIONE, FRANCESCO PAOLO, 77 Broderick Road, Johnsonville, Wellington, New Zealand. *(Wellington)*

SIMS, SIDNEY HAROLD, Micafine Ltd., Raynesway, Derby. *(Midlands)*

Junior Members

BAXENDALE, FRANCIS REGIS, The Walpamur Co. Ltd., Darwen, Lancs. (*Manchester*)
BLYTHE, KENNETH, 18 Cecil Street, Hawthorn Avenue, Hull, E. Yorks. (*Hull*)
FRANKLAND, PETER, 13 Rustenburg Street, New Bridge Road, Hull, E. Yorks. (*Hull*)
LEGO, JOHN ROBERT, 16 Muriel Avenue, Epping, New South Wales. (*New South Wales*)
MASON-JONES, GEOFFREY, 59 Guildford Road, Surrey Hills, E.10. Victoria. (*Victorian*)
SAUNDERS, MICHAEL, 13 Donald Road, West Croydon, Surrey. (*London*)
SLADE, RICHARD HARCOURT, 8 Nicholsdale Road, Camberwell, Victoria. (*Victorian*)
TAYLOR, ROBERT, Brolite Pty Ltd., 42 Meaden Street, S. Melbourne, Victoria. (*Victorian*)
WRIGHT, MATTHEW H., " Avondale," St. Ann's Road, Prestwich, Lancs. (*Manchester*)

Forthcoming Events

(*Note: Details are given of meetings in the UK up to the 15th of the month following publication, and in South Africa and the Commonwealth up to the 15th of the second month after publication.*)

Wednesday 3 June

Scottish Section—Eastern Branch. Works Outing to BP Refinery, Grangemouth.

Saturday 6 June

Midlands Section. Golf Match with the Birmingham Paint, Varnish and Lacquer Club, to be held at the Broadway Golf Course at 10 a.m.

Wednesday 17 June

OCCA Annual General Meeting at the Painter Stainers' Hall, London, E.C.2, at 6.30 p.m. Followed by the Foundation Lecture and Dinner. The Lecture will be given by Dr. R. R. Myers (Paint Research Institute, USA).

Friday 19 June

Golf Match, Manchester Section *v.* the West Riding Section, at the Hazel Grove Golf Club, Stockport, at 5 p.m.

Wednesday 1 July

OCCA Council Meeting.

Oil and Colour Chemists' Association

President : J. E. ARNOLD, B.SC., PH.D., F.R.I.C., A.INST.P.

The Oil and Colour Chemists' Association was formed in 1918, to cover paint, printing inks, pigments, varnishes, drying and essential oils, resins, lacquers, soaps, linoleum and treated fabrics, and the plant, apparatus and raw materials used in their manufacture. In 1923 it absorbed the Paint and Varnish Society. The stated purpose of the Association is to promote by discussion and scientific investigation the technology of the industries concerned with the above-mentioned products, and to afford members opportunity for the interchange of ideas. This is achieved by the regular holding of ordinary meetings at which papers are presented, and the organisation of annual technical exhibitions, biennial conferences, educational activities and practical co-operative experimental work. Details of these activities are given in the *Journal of the Oil and Colour Chemists' Association*, which is published monthly, and whose pages are open to receive communications and other pronouncements on scientific and technical matters affecting the members of the Association and the industries concerned. The Association's meetings also afford opportunities for members to meet informally and socially.

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

Ordinary Membership is granted to scientifically trained persons, and Associate Membership to others interested in the industries covered. Junior Membership, which is intended primarily for students, is open without restriction to persons under the age of 21 and to those up to 25 who are following a course of technical study. The annual subscription in each case is three guineas, except for Junior Members whose subscription is 10s. 6d. An entrance fee of 10s. is payable by all members. Applications for membership are invited from suitably qualified persons who are engaged or otherwise interested in the industries noted above. Applications, which should be supported by two members of the Association (one of whom must be an Ordinary Member) should be forwarded to the General Secretary at the address given below. Application forms and full details of membership may be obtained from the offices of the Association.

PUBLICATIONS

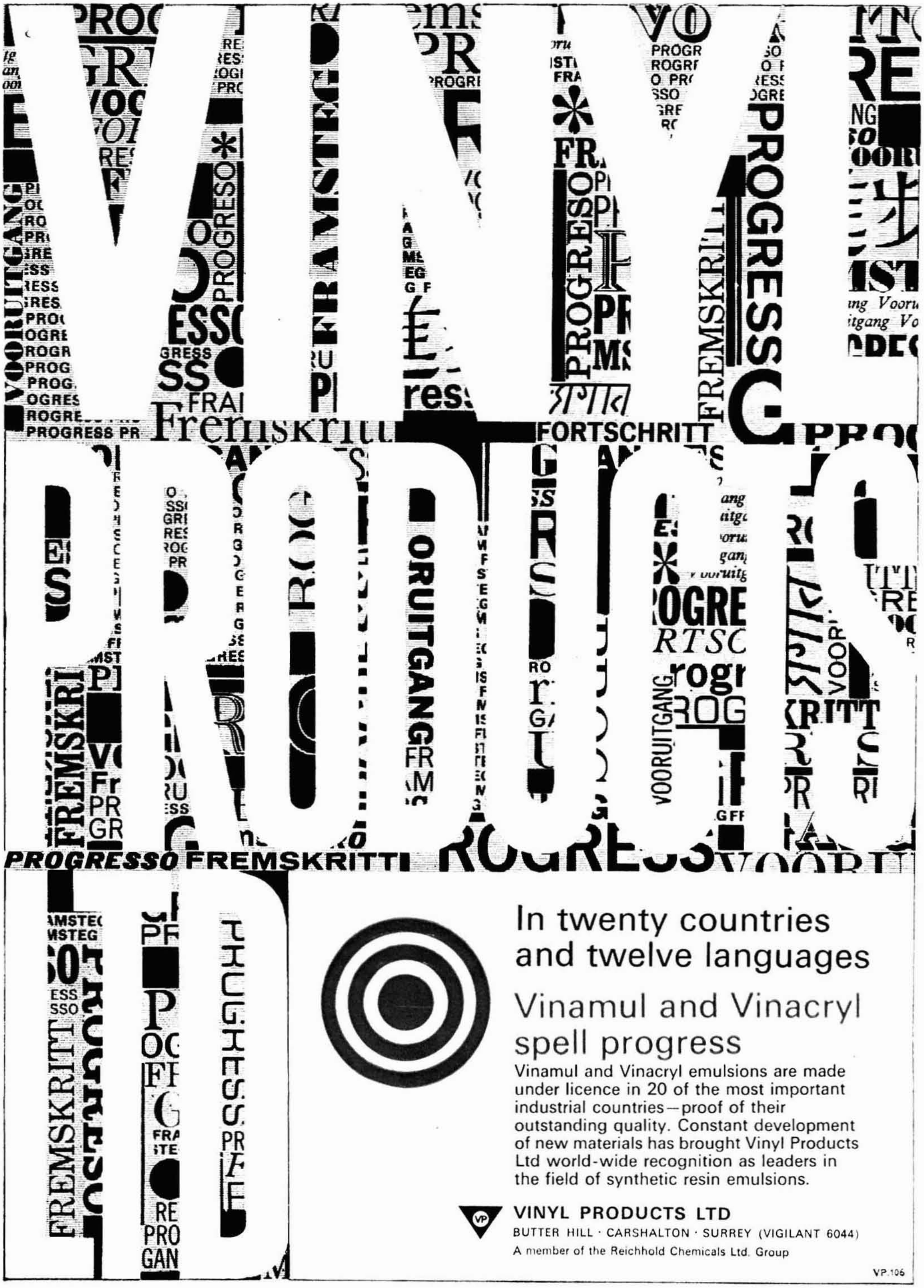
Journal of the Oil and Colour Chemists' Association, Published monthly. Subscription rate to non-members in UK, £5 p.a. post free ; abroad, £6 p.a. post free ; payable in advance.

An Introduction to Paint Technology (Second Edition). Pp. 187, illustrated, with index, 15s. (including postage).

Paint Technology Manuals

Part 1 : " Non-convertible Coatings," Pp. 326, 35s.
Part 2 : " Solvents, Oils, Resins and Driers," Pp. 239, 35s.
Part 3 : " Convertible Coatings," Pp. 318, 35s.

General Secretary : R. H. Hamblin, M.A., F.C.I.S., F.C.C.S., Wax Chandlers' Hall,
Gresham Street, London, E.C.2.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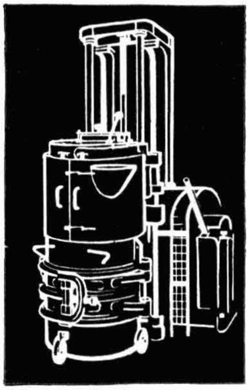

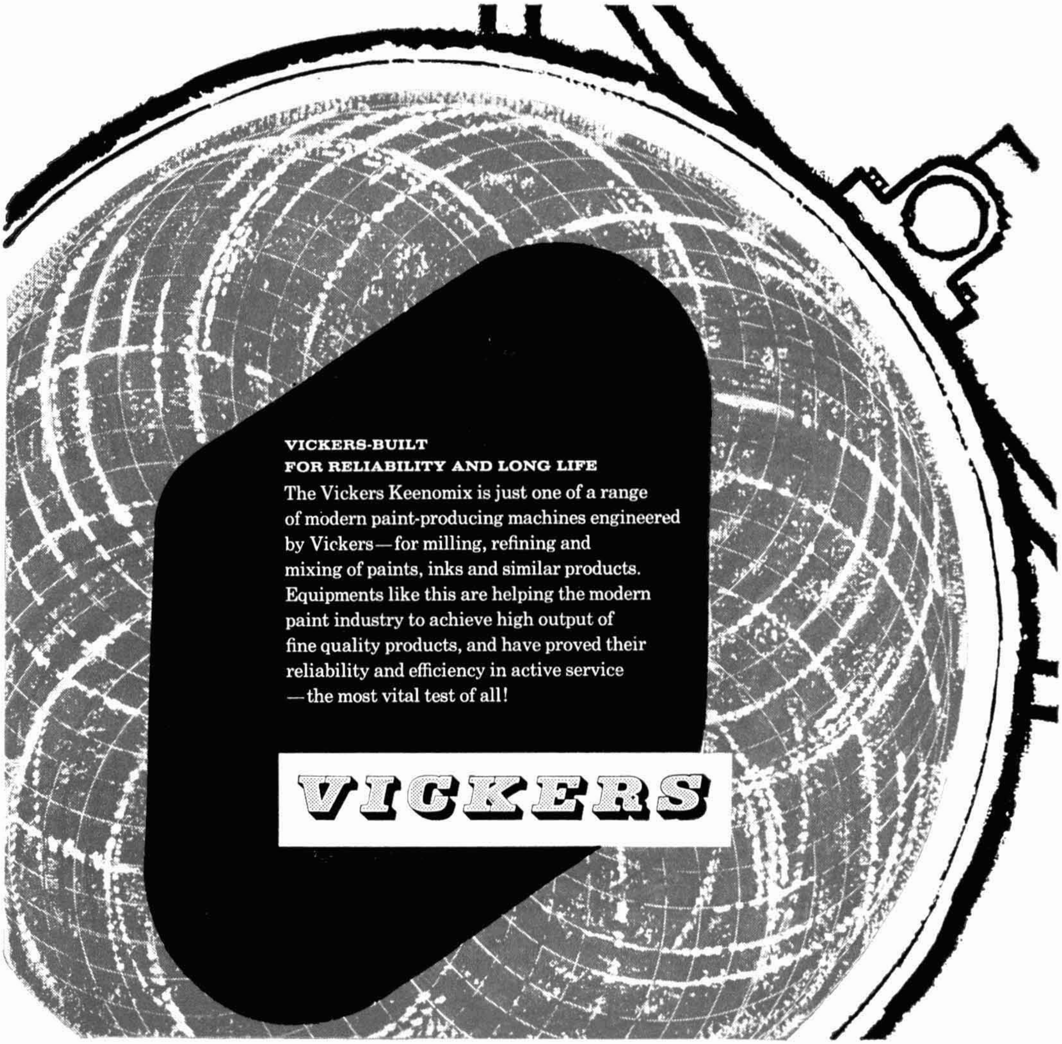


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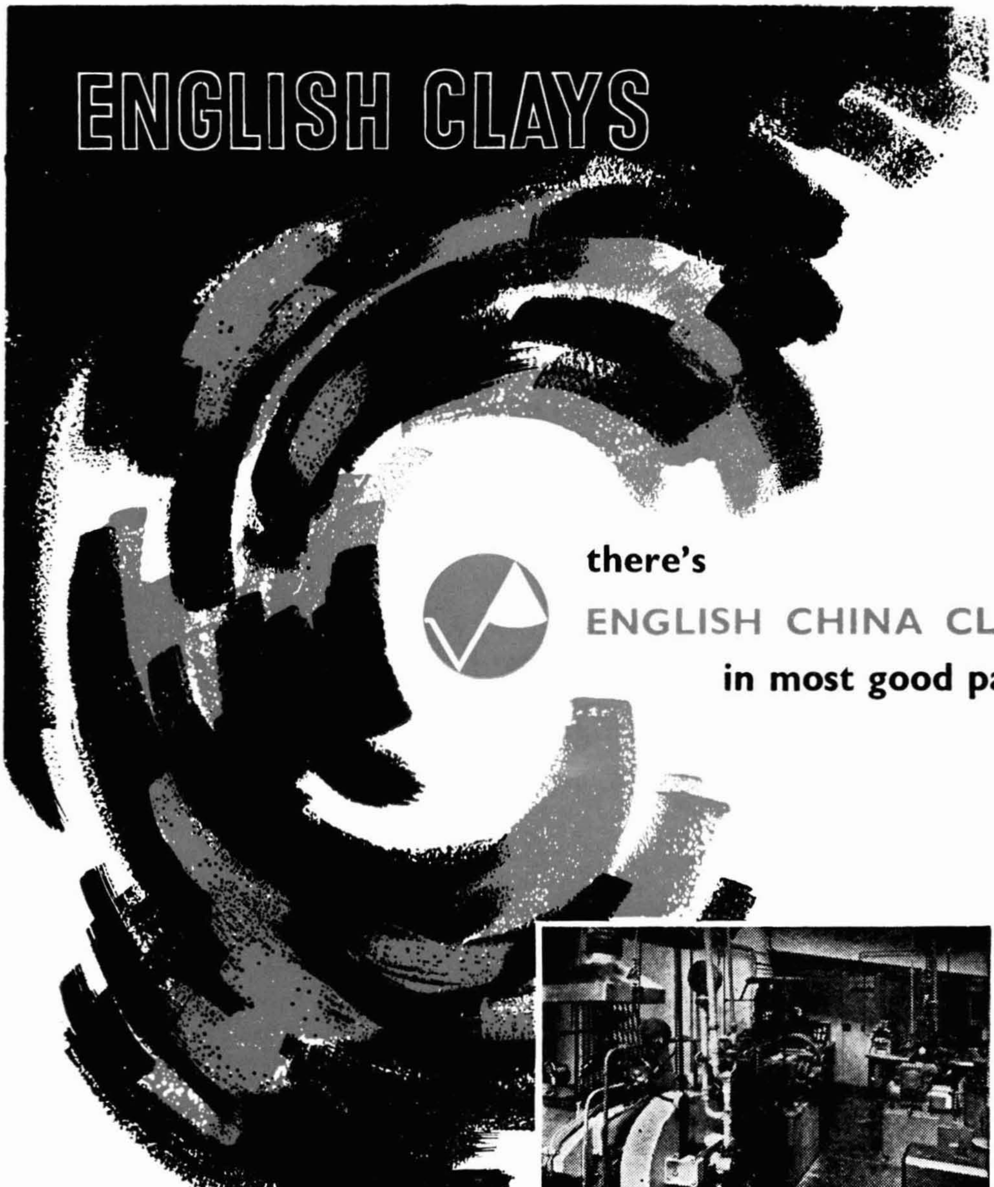

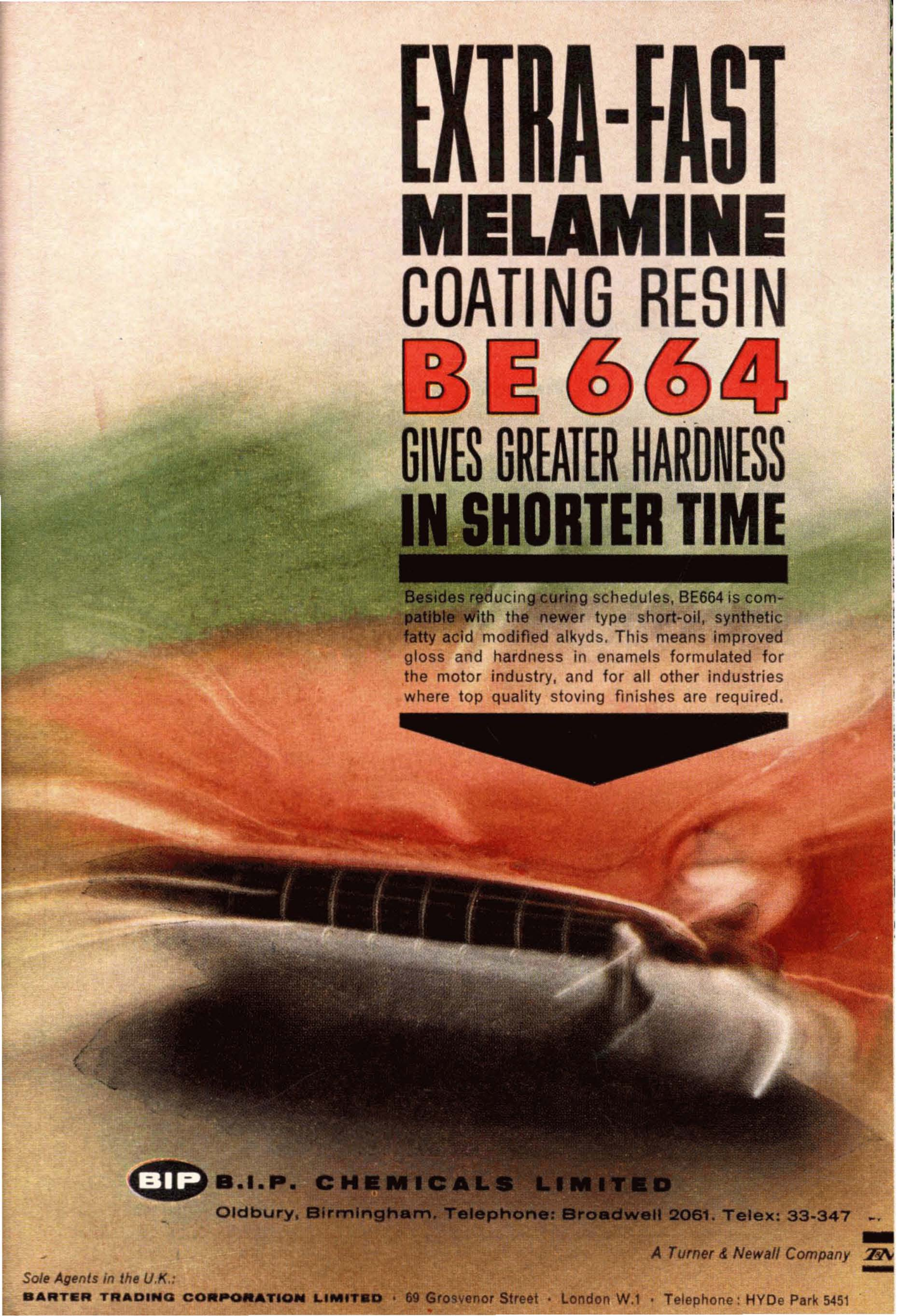

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