JOURNAL

OF THE

OIL AND COLOUR CHEMISTS' ASSOCIATION

Vol. 51 No. 9 **September 1968**

Commemorative Lecture

Science and society *Lord Todd*

Transactions and communications

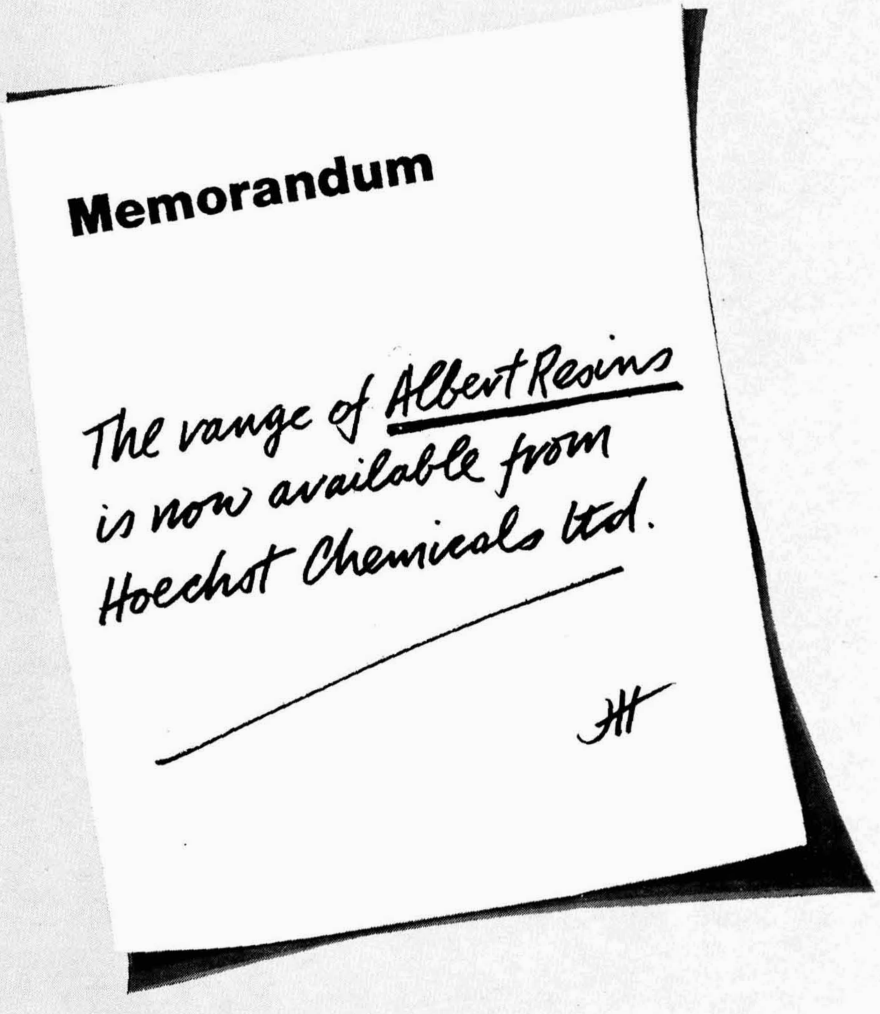
The electron-beam curing of coatings *A. R. H. Tawn*

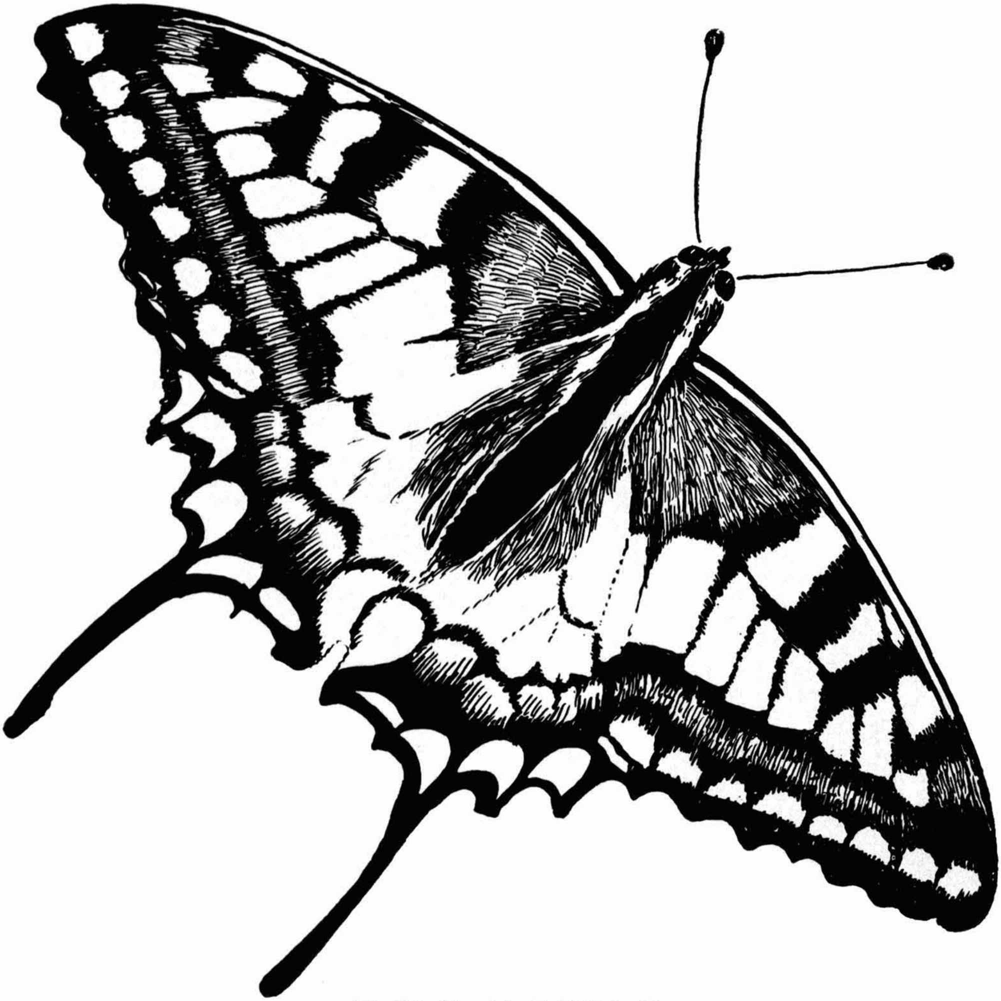
Prefabrication primers for structural steelwork: Part II
D. A. Bayliss and D. C. Wall

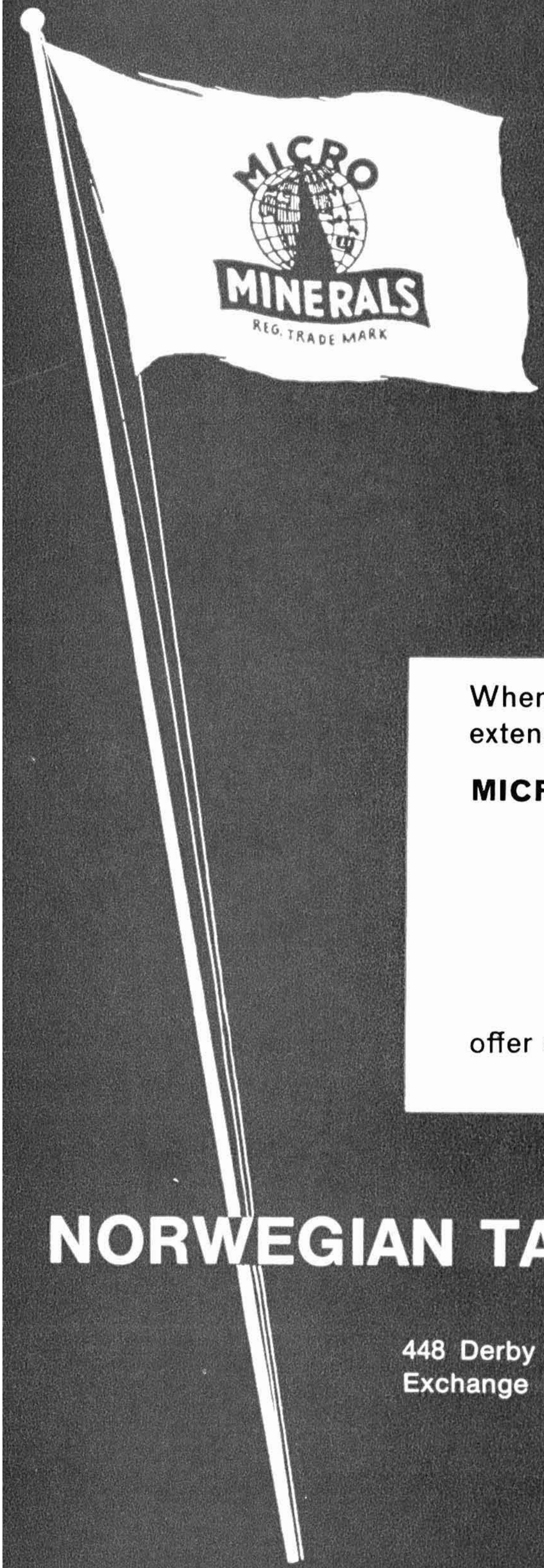
The laboratory preparation and properties of alkyd resin films *E. M. Kinsella and J. E. O. Mayne*

Proceedings of the AGM

OIL & COLOUR CHEMISTS' ASSOCIATION
WAX CHANDLERS' HALL,
GRESHAM STREET, LONDON, E.C.2






MICRO
MINERALS
REG. TRADE MARK

Urea resins for
electrostatic coatings:

DYNOMIN UB-30

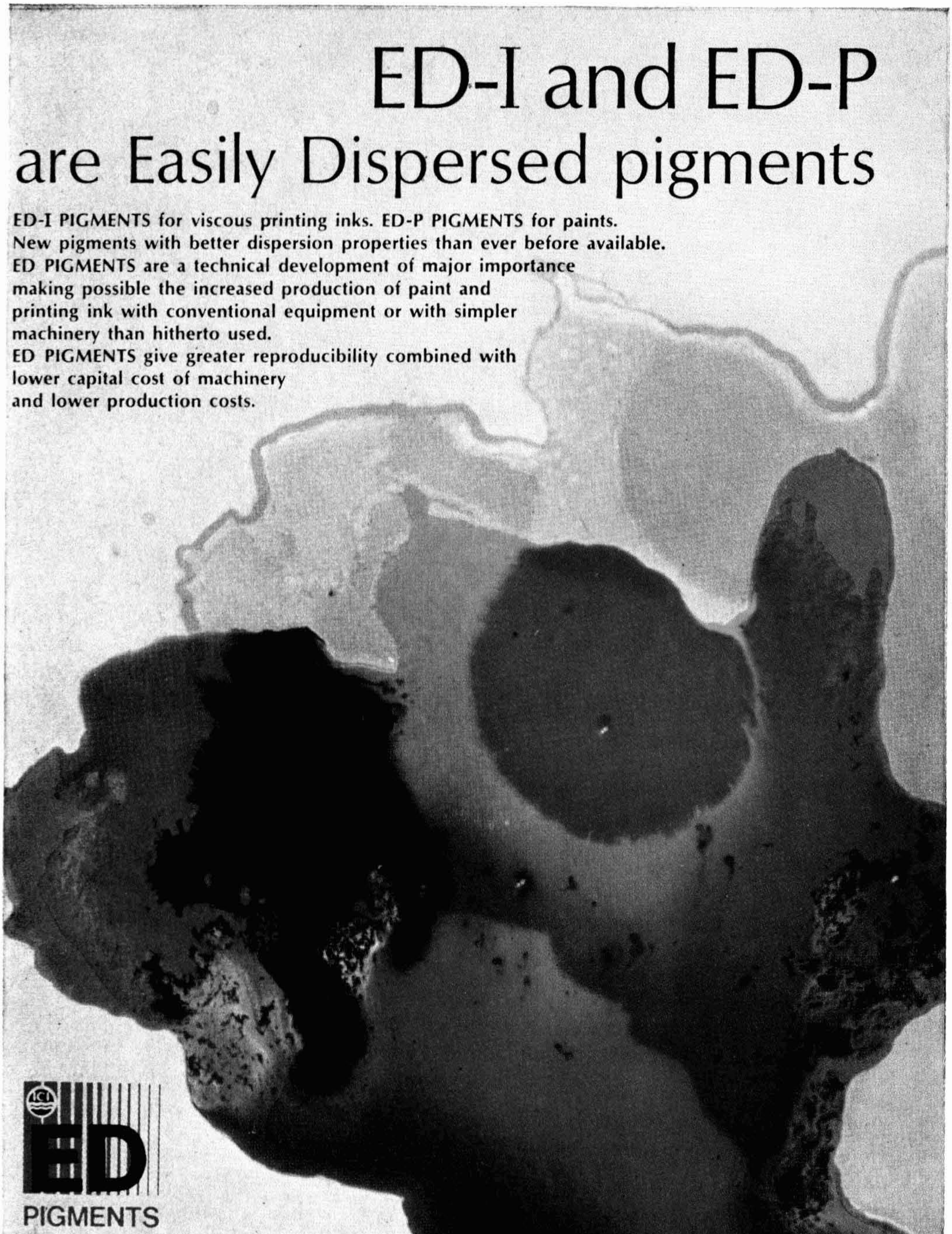
DYNOMIN UI-38

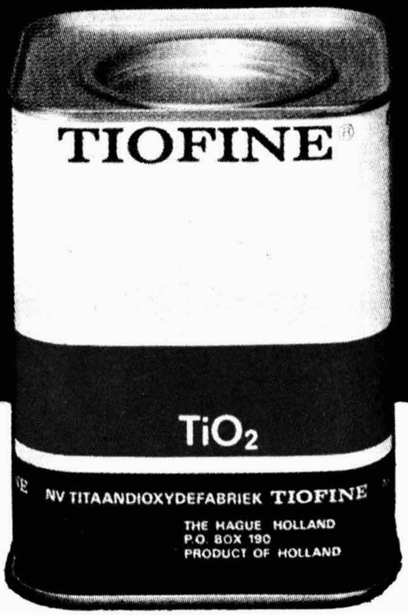
NORSK
SPRÆNGSTOFINDUSTRI A/S
P.O. Box 779 - OSLO - NORWAY

UK Agents:
BARTER TRADING CORPORATION LIMITED
69, Grosvenor Street, London W.1

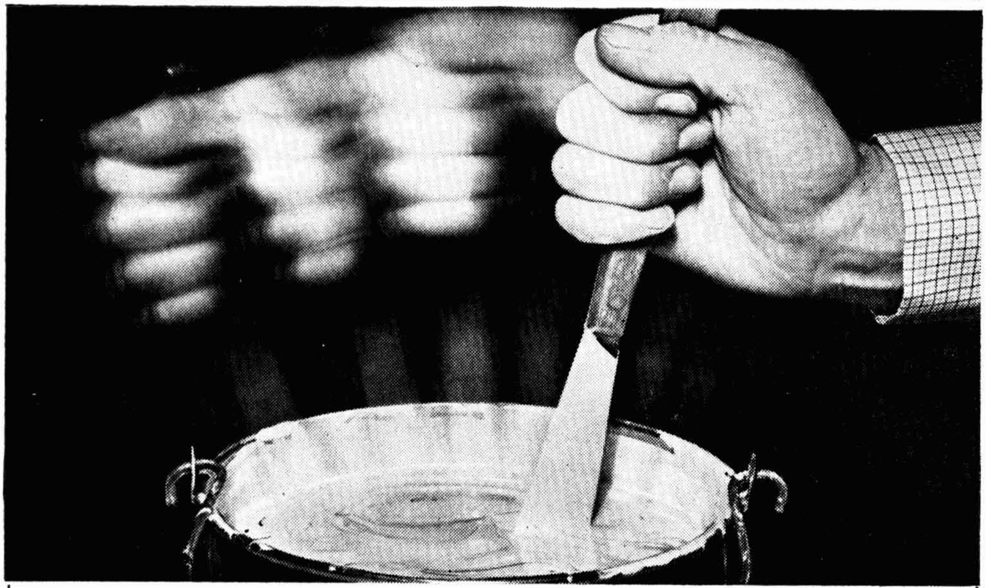
Distributors:
Barter Trading Corporation Limited
69, Grosvenor Street, London W.1

Lonabarc Limited, 110, Cranbrook Road
Ilford, Essex




TIOFINE®
TiO₂
NV TITAANDIOXYDEFABRIEK TIOFINE
THE HAGUE HOLLAND
P.O. BOX 190
PRODUCT OF HOLLAND

tomorrow's paints are today's concern at E.C.C.



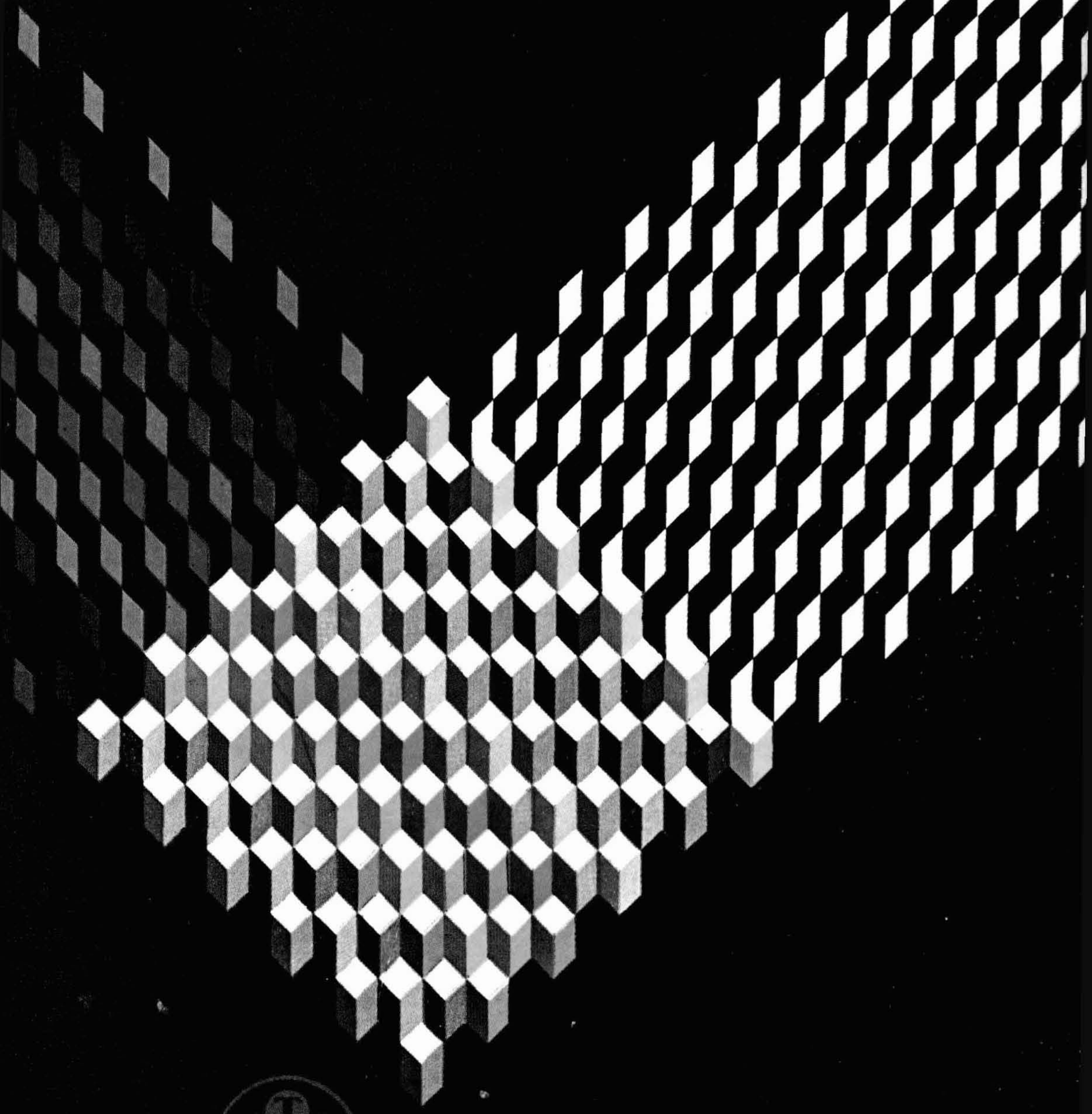
Particularly where service is concerned.
Ours comes three-dimensional: before . . . after . . . way ahead.
With a product like china clay – could we do less? We refine, blend, research, analyse, test and standardise.
We do more than sell you a paint extender – and our man is a whole lot more than just a salesman. He'll be there before you buy. Listening to your technical and handling problems. Coming up with the right answers. And he'll be back – often! Seeing all's well and keeping you in touch with what's new . . . what's different.
Behind him there is a large team of specialists, scientists and research workers. Probing basic requirements. Seeking solutions to your special problems. Meeting the challenge of new techniques and manufacturing processes. Helping you keep one jump ahead of every advance in paintmaking technology.
At English China Clays service is not only concerned with what you need right now, it's all wrapped up in the type of paint that you will be making tomorrow.

Service comes three dimensional from English China Clays.

Full technical assistance from:

English China Clays group

English China Clays Sales Co. Ltd.
Head Office: John Keay House, St. Austell, Cornwall.
Sales Offices in London, Manchester, Newcastle-under-Lyme, Bristol, Edinburgh.
Offices and Representation in most countries throughout the world.



INDEX TO ADVERTISERS

JOURNAL OF THE OIL & COLOUR CHEMISTS' ASSOCIATION

Vol. 51 No. 9 September 1968

Publications Committee

Editorial correspondence should be addressed to the Hon. Editor, *JOCCA*, Cray Valley Products Ltd., St. Mary Cray, Kent.

General correspondence should be addressed to :

R. H. Hamblin, M.A., F.C.I.S., F.C.C.S.,
Director & Secretary,
Oil & Colour Chemists' Association,
Wax Chandlers' Hall, Gresham Street,
London, E.C.2. (Tel. : 01-606 1439)

Assistant Secretary : R. P. Bell, A.C.I.S.

Assistant Editor : R. Wood, B.SC.TECH.

Annual subscription to non-members in UK and abroad £7 10s., post free, payable in advance. Single copies : 15s., post free.

JOURNAL of the OIL AND COLOUR CHEMISTS' ASSOCIATION

Contents **Vol. 51 No. 9** **September 1968**

Commemorative Lecture

Transactions and communications

Published by

OIL AND COLOUR CHEMISTS' ASSOCIATION
Wax Chandlers' Hall, Gresham Street, London EC2

J. Oil Col. Chem. Assoc. 1968, **51**, 773-781

Commemorative Lecture

Science and society*

By Lord Todd

Chairman, Royal Commission on Medical Education; Professor of Organic Chemistry, University of Cambridge; Master of Christ's College

The subject I have chosen for my lecture is a very large one and I can hardly do more than touch on a few aspects of it. It is, of course, clear that in my title "science" includes both so called "pure science" and applied science or technology, for it is technology that exerts a direct influence on society; the influence of science itself is essentially indirect. It is probably fair to claim that technology has always been the basic influence in fashioning human society. Technology—the application of discovery or invention to practical ends—is as old as mankind itself. It began when primitive man made his first tools and weapons to become a hunter and because of it social units based on hunting developed. Later the discovery that one could cultivate food crops became the basis of the ancient agrarian societies. Elements of these two types of society are evident still in the societies of today. And so the story of civilisation goes on. Great empires rose generally through advances in military or administrative technology and they usually crumbled away and vanished in the face of other rival powers with newer and better technology; probably the only exceptions are those in which epidemic disease or natural disasters intervened. One can see this perhaps most obviously in the sphere of military technology—the Roman development of infantry warfare giving way before the longbow and then the crossbow, the development of cavalry warfare by the Mongols, the invention of gunpowder and the development of artillery. All through history such changes were taking place and each of them in its own way influenced the form of society and the slow development from the tribe to the federation, to the city state and finally to the nation state, each change remoulding or modifying the social structure and social attitudes of men and women. The changes were, however, slow and gradual. In the military sphere, for example, the various features I have mentioned each had a long innings lasting hundreds of years, and with this rate of change society could adapt itself reasonably well, although history records many cases of temporary civil strife traceable to the irruption of new technology into a settled society. The fact is that social change and adaptation is—or has been so far—a slow process usually requiring several generations.

The first major break in this process of slow and fairly easily assimilable change occurred with the so-called industrial revolution which began about the end of the 18th century. I shall not discuss this in detail, but would only note that the most important feature of that revolution was the invention of the steam engine, which, for the first time, put controlled mechanical power into

---

*Presented to the Association on the occasion of its 50th Anniversary, 9 May 1968, at Painter-Stainers' Hall.

the hands of man. The consequent development of machinery and the great increase in wealth (aided by the rise of overseas trade and colonial exploitation) threw 19th-century society into a turmoil aggravated by the inevitable rise in population which accompanied it in the western world. The interesting thing to me is that the basis for the industrial revolution was little if at all different in nature from earlier advances in that it rested on chance discovery or invention and the presence of entrepreneurs to exploit it. The invention of the steam engine had little, if anything, to do with science. Science, it is true, had been advancing since the time of the so-called "scientific revolution" of the 17th century when it rid itself of the traditional mumbo-jumbo in which it had been smothered, but it was essentially a cultural pursuit in the hands of amateurs and had little influence either on industry or society at large.

The middle of the 19th century, however, brought a relatively sudden and extremely important change. A new kind of technology made its appearance—a technology based on the application of science and the results of scientific research to the solution of practical problems in industry, medicine, agriculture and military affairs. A number of the more striking early examples are familiar to chemists—Perkin's discovery of mauveine and its industrial application, Graebe and Liebermann's work on the structure and synthesis of alizarin, the industrial development of which totally destroyed within a few years the hitherto flourishing agricultural industry of madder cultivation. This new kind of technology ushered in what I call the second industrial revolution—a revolution which is still in progress and whose end is not in sight. This new phase gathered momentum during the second half of last century and really came to full flower in the present one. Its pace of advance, accelerated powerfully by the two world wars, has been almost frightening and there is no real sign of a slackening. Material civilisation has been fantastically altered—just think of the revolution in communication which has annihilated distance and spread the effect of new technological advances over the entire world. It is probably fair to say that the changes which have occurred during the past half-century exceed in scope all that have occurred in previous recorded history. They have, in fact, occurred too fast for society to adapt itself to them and it is this that accounts for most of the social and political unrest which is all too evident in the world today. This is the central problem of our times.

In the last analysis it is a problem of education. Science and technology today dominate our daily lives and there is hardly an area of human affairs in which major decisions can be taken without science being directly or indirectly involved. Clearly in a democracy such decisions cannot sensibly be reached by a population which is ignorant of science. In Western Europe education from the time of the Renaissance was founded on the study of the ancient civilisations of the Mediterranean basin and in it science had no place. The introduction of science into the system has proved extremely difficult because educational patterns are just as resistant to change as the social attitudes on which they rest. It is of some interest that the two countries which appear to have made most progress in incorporating science and technology into their educational patterns have been the United States and the Soviet Union. In the first of these the educational system developed during the period of the second industrial revolution in a new and expanding country untrammelled by an existing settled social system and in the second it arose in a society from which restrictions had been swept away by violent revolution. In settled communities such as this country the process of change has been and remains difficult and slow, although change is, of course, occurring; our big problem is how to accelerate it.

There has been much agitation in recent years about our need for more scientists and technologists in order to promote industrial innovation and close what has been called the "technology gap" between this country (and Europe in general) and the United States. Now, it is true that without an adequate supply of scientists and technologists our industrial progress in a technological age would be very limited indeed. But we must be careful not to equate progress in industry simply with the number of specialised scientists and technologists we produce. After all, in a recent OECD publication it was pointed out that if one includes (as one legitimately can) the output of our colleges of advanced technology and similar institutions as well as universities, this country actually produces in relation to the number of persons in a given age group as many people with doctorates in pure science, and many more technologists, than the United States. It is probably that neither country really produces enough, but it would seem from these findings that the explanation of the "technological gap" is not to be found in the output of specialised scientific manpower. The problem is much more complex.

The speed and effectiveness with which new discoveries or techniques are applied in industry is affected by the acumen and ability of management and by the readiness with which the labour force will accept changes which may affect social hierarchies within it. There has been much discussion about management training and indeed it is becoming a popular subject, new schools of management having been set up in a number of universities. But it seems to me that the study of management techniques alone is at best only an emergency action. Since the driving forces behind innovation are science and technology it is unlikely that a manager unaware of the basis of science and its potentialities can possibly be fully effective in promoting innovation. This does not mean that management should be in the hands of professional scientists and technologists. True enough, a man may be a good scientist and also a good manager, but the qualities necessary for each of these activities are different and are by no means always found in one man. But there is no reason why everyone should not have the basic knowledge of science which will enable him to appreciate its potentialities and its limitations. In short, science ought to be a normal part of the education of every child and until it is I believe we will continue to lag behind. It has always seemed to me that in our schools science is something of an optional subject. Even where it is given in some degree to all pupils at the pre-school certificate (O level) stage it is still regarded as something "on the side"—something which need only be taken seriously if a pupil is going to specialise in it. This is quite wrong; science should be part of a child's education on all fours with the established subjects—English, history and the rest. After all it is just as much a cultural subject as these others and, moreover, as I have already indicated, it is the central feature of modern civilisation. I have heard it said that science is different from these other subjects in that it requires a special aptitude and does not appeal to the majority of children. I believe this to be nonsense and if, indeed, it appears to be so in schools then it is high time that teaching methods and curricula were drastically overhauled. Given this degree of breadth in school education, later specialisation in higher education, be it in science or the arts, would follow the normal distribution to be expected on ability and inclination and I believe there would be no need to take any special measures to direct the flow in one special direction or another.

There is, however, one aspect of education that calls for special comment and that is the training of technicians. People tend at times to forget that if one is going to apply the findings of one scientist or technologist one needs three or four technicians. The role of the technician is vital and yet we still seem to treat the training of technicians in a very casual way. What is, to my mind, worse is that the recent moves to push our technical institutions in the direction of university status may well cause them to be less effective in producing technicians. We ought to face the fact that only a relatively small group of our school leavers are ever likely to become creative scientists or technologists. A considerably larger number can, however, become competent technicians given the proper training and a clear cut and socially respectable career structure to follow it. That training is, however, not the traditional university type of training. Remember, too, that if we push all these young people through courses designed to produce scientists and technologists many of them after graduation will in the very nature of things have to do the work of technicians—work which requires lower academic qualifications and for which their training has not been designed. We know that this happens to some extent even today—complaints about scientists not being properly used in industry are not uncommon. If men and women trained at university for careers in science and technology find that they are subsequently to be employed as technicians they will become increasingly frustrated; and a frustrated white collar class can be potential political dynamite. The technician problem is one of the most serious aspects of the scientific manpower problem and I would urge that our whole system of technical education be looked at afresh; mere multiplication of universities is not the answer.

I have said that basically the problem of welding science and society is educational. But even if we really tackled our educational system at once and with vigour it would probably take at least a generation to derive major benefit from the changes made. Meanwhile we are faced with a multitude of problems and these we must seek to solve or mitigate as best we can. This is why the place of science in the formulation and execution of Government policy is of such moment today. Equally important is the rôle of Government in the promotion of science and technology. Government clearly must be interested in science if only because it provides the basis for future power. Its attitude towards pure science, however, differs from its attitude to technology. Pure science, which is essentially devoted to advancing the frontiers of human knowledge, is a cultural activity just like music or the arts and Government must act as a patron towards it. It cannot, however, be a wholly disinterested patron because pure scientific research, which is largely centred in universities, has an important training function as well as the function of making discoveries from which will later—often much later—come practical developments which Government can use. The outcome of scientific research is of necessity unpredictable and it cannot therefore be closely controlled or directed; hence the rôle of Government as patron remains. When we look at applied science and technology the situation is different. Here the objectives are economic and usually well defined. Government has a clear interest in promoting it and in many areas may indeed dictate the objectives and directly or indirectly control research and development (and even at times production); this is perhaps most clearly exemplified in the field of defence where Government not only dictates the objectives, but is also the main consumer of the ultimate products. It is also concerned to promote technological progress in those industries whose development aids the achievement of national economic objectives. But Government cannot set its economic or its defence objectives today without technological forecasting—without a real knowledge of the scientific and technological basis for making choices. How can it do this? Here is the central problem of science in Government.

Before considering the machinery which might be devised to ensure that scientific and technological knowledge is brought fully to bear in decision-making by Government let us first briefly review the present involvement of Government in the promotion of science and technology under the three headings I have just mentioned. Government provides most of the money devoted to pure and applied research in the universities. There is frequent complaint from universities that the scale of support is too small. This may well be so, but it is impossible to say how much money this or any other country should devote to this kind of research. It is nevertheless striking that the proportion of the GNP devoted to university-type research does not differ very greatly in most highly developed countries. This may be because the amount spent should be sufficient to ensure that its training function is adequately discharged to supply the country's need for scientific manpower both qualitatively and quantitatively. I believe that its inflation to the point where research gets divorced from training and involves the setting up of permanently staffed research institutes is wrong, and is likely in the long run to hinder rather than to promote science. For a long time scientific research in universities involved few people and was not very expensive; under these circumstances its support presented no serious problems. But today it has grown enormously in scale with increasing demands for trained graduates and it has increased even more in cost. Today, for example, we are probably spending much more on nuclear physics or astronomy alone than we did on the whole of science 15 years ago. Government in this country (as in most others) does not have unlimited money at its disposal and there are many competing claims on what it does have. The fantastic rise in research costs today presents Government—and scientists—with a serious problem which they have been very reluctant to tackle. If adequate support cannot be provided for everything then priorities will have to be established in science even if this means that some areas will have to be neglected or pursued at a very low level of activity. This is quite a different thing from trying to control science; it amounts, however, to setting up a policy for the support of science. Such a policy can be devised, but only in association with, and indeed as part of, economic policy since its operation will determine in large measure the number and type of highly trained scientists that will become available for industrial and other employment. There is no doubt that the number of our ablest young people going into one subject or even one area of a subject is affected by the scale and glamour of the research effort within it. Failure to take economic policy into account in determining those areas of science in which to mount a major effort can lead to frustration, brain drains and in the long run industrial stagnation. Failure to make choices at all is equally disastrous since it leads to a general low level of activity and a consequent lack of progress and glamour which is undoubtedly one factor in the much discussed drift away from science among our young people today.

The second way in which Government is today involved directly with science is in research and development activities carried out in its own establishments. There is an obvious need for such establishments in the defence field where ministries not only set the precise objectives of research and development, but are themselves virtually the sole consumers of the products. Security considerations also require close Government control of work in this field, although actual production of weapons may be the subject of contracts with industry. Defence establishments have clear-cut and frequently changing economic objectives and for this reason they can and do function effectively over long periods with the same kind of staffing as industrial research and development laboratories. When we look outside defence, however, the situation is more confused. There are certain fields of activity in which Government must participate directly in the public interest—for example road and transport research, water pollution, control of standards, health and so on. Research establishments concerned with such matters are found in practically every country. As a rule they are attached to the appropriate executive departments except in this country where for largely historical reasons they are usually controlled by Research Councils or by the Ministry of Technology. There are, however, other civil research establishments under the control of the Science Research Council and the Ministry of Technology whose real function is much less clear. It is my belief that scientific research without the spur of clear-cut (and preferably changing) economic objectives cannot be successful in the long term in permanently staffed institutions unless it is associated with a training function as it is in universities. Permanently staffed institutes pursuing "pure" research may appear to be successful in the first few years of their existence, but a process of decline always set in with an aging staff and even first-class direction does little more than slow down the process. It is for this reason that, for example, the Chemical Research Laboratory of the former Department of Scientific and Industrial Research never really succeeded. It is for the same reason that the Atomic Energy Research Establishment, Harwell, has been a problem in the last few years. Harwell began as a mission-oriented establishment and did quite outstanding work during the first 15 years of its existence. But with the development of our nuclear power programme its mission was, in fact, accomplished and the troubles that it has experienced in the last few years are due simply to this fact; a specialised permanent research staff is lost without an appropriate objective. We have, of course, a highly developed system of Government civil research establishments in the United Kingdom and the process of re-shaping them and re-distributing their activities will no doubt take time. But it is clear to me that our aim should be to achieve that re-distribution as soon as possible.

The third area of Government contact with science and technology in the civil field is industry, where it is concerned to promote technological innovation in order to maintain and improve our economic well-being. This is perhaps the most complex and difficult field of all for there is no single reason for backwardness in industrial innovation and each of the many factors involved varies in importance from time to time and from one case to another. Backwardness and lack of technical awareness on the part of management are often cited these days; there is, of course, a good deal to this argument and lack of communication between research, production, marketing, and top management is all too common. But even with good management questions of commercial risk, availability of capital and so on can often obstruct progress as much as any lack of entrepreneurial spirit. On this aspect I would only say that maximum fiscal incentives should be given, that Government purchasing power should be used to the greatest extent possible in placing development contracts and that the provision of capital at low interest rates could well be considered for industrial developments which fit in with national economic plans. The featherbedding of long-established industries for no real reason except political convenience should be avoided. (It is worthy of note that Japan has used fiscal weapons, including variable interest rates, to adjust its industrial pattern.) The direct participation of Government in industry by contributing part of the equity and fixed assets in a company may well be justified in those cases where a development is envisaged which is too large or long-term to be dealt with by one private firm or a consortium of firms alone. I do not propose to discuss in detail the efforts made by Government in these and similar directions for I do not claim to be a financial expert.

It is now 15 years or so since I first tried to promote the idea of civil development contracts in civil industry, but the rate of progress in implementing the idea has been slow. One of the reasons most frequently given to me for this slowness is the problem of spending public money to produce profits for private firms. (This has, I believe, also been something of a handicap to the National Research Development Corporation in its activities.) I confess I find it hard to accept that this should be a real difficulty. The making of private profit as a result of public spending is surely well enough established to make it admissible nowadays. Let us consider for a moment our biggest industry—agriculture. This industry consists of a vast number of small independent firms or units (individual farmers). It is peculiar that virtually all its research (apart from that on fertilisers, pesticides and machinery) is carried out by Government agencies and Government also provides advisory services. The adoption and practical application of the results of research (i.e. innovation) is encouraged and made easy by the application of Government subsidies, sometimes in the form of guaranteed prices for produce. Public funds thus provide most of the industry's research and development and then encourage its application by removing much of the financial risk. I am not arguing against what Government does for agriculture; I merely wish to say that, to me, the argument that one must avoid the making of profit by private firms as a result of the application of public funds sounds a bit hollow. In any case, with our present economic system, the making of profit is essential if industry and the nation are to survive, let alone prosper.

One activity of Government in the industrial field which is of long standing and which has undoubtedly been of considerable value to certain industries is the promotion of industrial Research Associations jointly financed by

Government and the individual firms in the industry concerned. Particularly in industries where individual firms are small and where there is a number of technical problems of quite general importance to them such Associations have proved very useful (although it is remarkable how important to success the personality of the Director can be). My only criticism of the movement is that I would have hoped that the Research Associations might have been more successful in stimulating research within member firms—for in the last analysis there is no substitute for research within industrial firms themselves.

In my view the difficulties so far encountered in finding satisfactory ways in which Government can stimulate innovation, particularly in established industries, bring us back to the main theme of my lecture—the problem of developing a proper rapport between society and rapidly advancing science. For often the major obstacles to innovation are neither financial nor technical, but social. Within an individual firm or group of similar industrial firms in one area a rather rigid social structure based on a heirarchy of skills develops and this, in due course, spreads outwards and becomes part of the local community structure. Technological innovation on any substantial scale will almost certainly disturb this structure; as a result it will be consciously or unconsciously resisted both by management and by workers. This is not a phenomenon confined to Britain—examples can be found in all industrial countries. This resistance to change and the means whereby it can be overcome are problems which call for the most urgent study as do the related problems of industrial retraining and mobility of labour. Failure to solve them could bring all efforts at stimulating industrial innovation to naught. It is for this reason that we must hope for a rapid development of the present rather rudimentary social studies into something more akin to a science; without a much better understanding of man as an individual and a component of a society we may search in vain for lasting solutions to problems such as those I have mentioned.

My discussion of the points of direct contact between Government on the one hand and science and technology on the other has been rather sketchy, but will, I hope, have indicated the complexity of the present situation and the evident need for a very substantial awareness of science and its potential in the formulation of economic, social and indeed international policy. How are we to ensure that this really happens?

The answer to this question has been sought in a variety of ways in different countries—and not surprisingly in view of the variety of political constitutions and systems which they exhibit. The United Kingdom was probably the first country to make a major move in this direction immediately after the Second World War. Faced with an impoverished country with an industrial economy distorted to meet the needs of total war the need to harness scientific knowledge and research to the formulation of Government policy was recognised when in 1947 the Advisory Council on Scientific Policy (ACSP) was set up under the chairmanship of Sir Henry Tizard. This Council was set at Cabinet level directly attached to the Lord President of the Council who was to be responsible for the formulation and execution of scientific policy. I shall not bore you with a recital of the way in which the scheme developed. I myself succeeded Sir Henry Tizard as Chairman of ACSP in 1952, and the Council in due course became the advisory body of the later created Ministry for Science. Until its demise in 1964 the Council did much good work, but it was restricted in its influence mainly by the rather ill-defined rôle of the Minister for Science who, although nominally spokesman for science and scientific policy in the Cabinet, had no effective control over the major executive departments directly concerned with technology. It was this difficulty which led to the setting up of the Committee on the Organisation of Civil Science (the Trend Committee) in 1962. This Committee (of which I was a member) reported in 1963 and proposed a new organisation in which the Minister for Science would control not only the various Research Councils and the Atomic Energy Authority, but would also have under his wing an Industrial Research and Development Authority (IRDA) which would include the National Research Development Corporation and would operate by normal industrial methods to co-operate with industry and promote industrial innovation by all appropriate methods. The Minister was to be advised by a Council on Scientific Policy akin to the old ACSP broadly based and with a remit covering all aspects of scientific and technical policy. Implementation of these proposals—which I still believe were entirely sound—clearly had to be deferred until after the general election of 1964. The new Labour Government, anxious for change, made, in my opinion, the mistake of accepting the Trend Committee's recommendations in part only. They put scientific research under the Secretary of State for Education and Science and instead of having an IRDA they set up a Ministry of Technology. A Council for Scientific Policy was set up to advise the Secretary of State for Education and Science on matters relating to scientific research and a separate Advisory Council on Technology to advise the Ministry of Technology on policy. I believe this was a false move, partly because I do not think that science and technology should be separated, and even more because with two independent advisory councils there is a danger of producing two policies when it is essential to have only one. This has, I think, now been realised by Government and the recent setting up of the Advisory Committee on Science and Technology as an overall Committee attached to the Prime Minister with a remit much like that of the old ACSP, but extended to include defence, is evidence of this. How effective this will be remains to be seen.

No one would claim that we have reached a solution of the problem of science and society, but we are, I believe, making progress in our efforts to allow scientific considerations to play their full part in arriving at political decisions. We may still have a long way to go, but the increasing realisation by politicians that these are vitally important matters gives me ground for optimism that we may find a solution. For find it we must—and soon, for time is not on our side.

J. Oil Col. Chem. Assoc. 1968, 51, 782-791

Transactions and Communications

The electron-beam curing of coatings*

By A. R. H. Tawn

Cray Valley Products Ltd., St. Mary Cray, Kent, England

Summary

An attempt is made to describe and bring into perspective the changes promoted in matter by radiation in general and high energy electrons in particular. Polymerisation and graft-polymerisation are discussed in relation to their potential importance in the electron beam curing of coatings. Recent developments are outlined with a view to assessing the potential of the process and envisaging some features of the appropriate formulating principles.

Le durcissement des revêtements par faisceaux électroniques

Résumé

L'auteur essaie de décrire et de caractériser les changements de matière provoqués par radiation en général et surtout par électrons à haute énergie. On discute les phénomènes de polymérisation et de copolymérisation greffée au point de vue de leur importance eventuelle dans le domaine du durcissement de revêtements par faisceaux électroniques. On trace les grandes lignes des développements récents afin d'apprécier les possibilités du procédé et de proposer quelques aspects des principes de formulation convenable.

Vernetzung von Überzugsmitteln durch Elektronenbestrahlung

Zusammenfassung

Ein Versuch wird unternommen, die Veränderungen zu beschreiben, welche ganz allgemein durch Radiation und im besonderen durch Elektronen von hoher Energie in Stoffen hervorgerufen werden, und diese in Perspektive zu bringen. Polymerisation und Pfropf polymerisation werden entsprechend ihrer bei der Elektronenbestrahlung von Überzugsmitteln möglichen Bedeutung besprochen. Neue Entwicklungen werden mit Bezugnahme auf die Bewertung der durch das Verfahren gebotenen Möglichkeiten skizziert, und der Blick wird auf einige Merkmale für einsetzbare Rezepturprinzipien gerichtet.

Сушка покрытий электронными лучами

Резюме

Делается попытка описать и уточнить изменения вызываемые в веществе излучением и в частности излучением злектронов высокой энергии. Обсуждаются полимеризация и прививочная полимеризация в связи с их возможным значением в электронно-лучевой сушке покрытий. Описываются новые усовершенствования в этой области, с целью оценки преимуществ этого процесса и анализа некоторых характеристик соответственных формулирующих принципов.

---

*Official OCCA paper presented to 5th SLF Congress, Gothenberg, Sweden, 18 September 1967. Reproduced by kind permission of the Editor from Farg och Lack 1968, No. 4

Introduction

The effects of high-energy radiation on matter, first observed by Coolidge some 40 years ago, have been extensively studied since the Second World War, when radioactive sources and powerful accelerators became relatively commonplace. Numerous studies of polymerisation induced by such radiation have been reported, but it was not until 1966 that the feasibility of utilising electron beams to cure coatings on a commercial scale was announced. It had been described[1] as "promising" in 1964 and it is now apparent from the patent literature that active developments to this end were being undertaken in the 1950s.

The idea of electron-beam curing conjures up visions of chemical reactions of a kind quite different from those encountered in conventional air-drying and stoving processes. Whilst there are differences, such visions are essentially false or exaggerated, and one object of this paper is to bring into perspective the nature of the changes which are in fact promoted by such radiation, since their understanding is a prerequisite of both intelligent anticipation of development and intelligent formulation of paints to be dried by these means. A further object is to review the state of the art in so far as it has been revealed to date, so as to indicate fruitful areas of future study.

Definitions and units

Dose (of radiation). The energy absorbed per unit mass of irradiated material. The unit is the rad. A dose of 1 rad corresponds to the absorption of 100 ergs per gram, equivalent to 6.25×10^{13} electron volts per gram.

$$\begin{aligned} 1\ \text{M.rad} &= 10^6\ \text{rads.} \\ &\ 10^8\ \text{erg g}^{-1} \\ &\ 10\ \text{watt sec g}^{-1} \\ &\ 4.5\ \text{Kw sec lb}^{-1} \end{aligned}$$

Dose rate measured in rad sec^{-1}, M rad min^{-1} etc.

Electron volt. A unit of energy equal to the kinetic energy acquired by an electron when accelerated across a potential difference of 1 volt.

$$\begin{aligned} 1\text{eV} &= 1.6 \times 10^{-12}\ \text{erg.} \\ 1\text{MeV} &= 10^6\ \text{eV.} \end{aligned}$$

Energy yield. Analogous to the quantum yield of photochemistry. Energy yield is usually expressed in terms of G-value, sometimes also called the radiation chemical yield. The G-value is the number of individual chemical events (number of molecules reacting or number of changes of a specified type) brought about by the absorption of 100eV of energy.

Nature of ionising radiation

The first ionisation potentials of gases are in the range 9-15eV. The photon of ultra violet light of wavelength 1236 Å has an energy of 10eV. Electromagnetic radiations of much higher frequency, the x- and γ-rays, are thus well able to induce ionisation. Soft x-rays of quantum energy 10-100keV are highly absorbed by thin layers of light elements such as those of which organic matter is composed. Hard x-rays and γ-rays, which may have quantum energies as high as 100MeV, can pass through thick layers of heavy metals. Particulate radiation, such as protons, deuterons, electrons, β-rays and α-particles, as produced by radioactive sources or accelerated in relatively simple equipment, is also of sufficiently high energy to induce ionisation on impact with a molecule. Thus, among β-emitters, H^3 produces electrons of 18keV, Co^{60} of 306keV and Y^{90} of 2.18MeV. Artificial accelerators can produce electrons of energies at least 20MeV. Radiation composed of streams of charged particles has a much lower penetration than electromagnetic radiation of similar quantum energy. Hence for an electron beam to be effective in producing ionisation throughout the thickness of a paint film it must have a high enough energy at source to penetrate the air gap (if there is one) between source and target, and still possess sufficient energy to penetrate the film. Energies at source in the order of 100 keV are needed to do this. On the other hand, much higher energies (say above 500keV) will lead to wasteful, and possibly damaging, penetration of electrons into the substrate. There is thus a rather narrow band of energies appropriate to electrons to be used for curing paint films.

Action of radiation on matter

X- and γ-radiation can interact with matter in three ways, all of which involve energy transfer between the incident photons and the electrons of the target atoms or molecules. (a) In photo electric absorption the energy of the photon is transferred entirely to the electron which, if the photon energy is much greater than the orbital binding energy of the electron, will be expelled from its parent orbit, maybe with sufficient energy to liberate other electrons in its path. Photons of lower energy simply induce excitation of the electron to an orbital above the ground state. Photo electric absorption is important in the light elements comprising organic matter, only at quantum energies below 0.2MeV. (b) Energies in the range 0.2-2MeV promote the Compton effect preferentially in such light elements. Collision of photon with electron causes the latter to recoil and a photon of lower energy is emitted. The energy absorbed per unit volume in this process is proportional to the number of electrons per unit volume of irradiated matter. (c) Energy quanta greater than 1MeV are utilised to some extent in the production of electron pairs. The three mechanisms a, b and c all lead to the formation of fast-moving electrons which are responsible for practically all the changes produced in the irradiated material. Hence, it is not surprising that irradiation with electron beams of appropriate energies produces very similar results.

Charged particles encountering the target material lose most of their energy by electrostatic interaction with its electrons. These are again excited or expelled as a result. Whilst the effect of electromagnetic radiation decreases exponentially with depth of penetration, ionisation by charged particles can be at a maximum some distance below the surface, where the particles have slowed to their most effective velocity. The effectiveness of a parallel beam of electrons can also reach a maximum at some particular depth due to scattering which increases the amount of energy entering a lamina perpendicular to the beam.

Primary and secondary processes

From the foregoing it will be appreciated that the primary incidents following absorption of radiation are dependent on the energy of the incident radiation rather than on its nature. It will be convenient now to refer only to that type of radiation with which we are most concerned i.e. high energy electrons. The primary processes which occur on electron absorption are three in number.

(i) Ionisation. This occurs when the interaction energy is greater than the binding energy of the orbital electron with which interaction occurs and that electron is expelled.

$AB \rightarrow AB^+ + e$
Target
molecule

This is commonly followed by dissociation of the ionised molecule, which may occur so rapidly as to be, to all intents and purposes, a simultaneous reaction thus:

$AB^+ \rightarrow A^+ + B$ (B may be a free radical and A^+ a radical-ion)
or $AB \rightarrow A^+ + B + e$.

If the incident particle has a high enough energy the expelled electron may ionise further molecules; otherwise it will be attracted back by the electrostatic field of A^+. The ionisation potentials to be overcome in extracting an electron from the molecule are roughly half the energy dissipated in the primary reaction. Hence only about half the energy of the incident particle is utilised in ionisation.

(ii) Excitation. This accounts for most of the energy not utilised in ionisation. It also occurs when the interaction energy is insufficient to overcome the binding energy of the orbital electron. Excitation consists in a displacement of an orbital electron from its ground state to a state of higher energy. The energy required is less than for complete removal and is such that, when both phenomena occur, the number of excited molecules is about 1.3 times the number ionised. Excitation is usually represented:

$AB \rightarrow AB^\star$

If the incident electron possesses insufficient energy to excite the lowest singlet state of the molecule it may still excite other low-energy states such as the triplet state with two unpaired electrons. This behaves as a biradical and may undergo rearrangement despite the lack of sufficient energy for ionisation.

(iii) Electron capture. Electrons of still lower energies can be captured by target molecules thus

$AB + e \rightarrow AB^-$

This can also happen to electrons ejected by the ionisation process. Oxygen with its two unpaired electrons is a particularly effective trap for such electrons

$O_2 + e \rightarrow O_2^-$

If one component structure of a molecule has a higher electron affinity than its binding energy to the rest of the molecule, dissociative electron capture is possible:

$AB + e \rightarrow A^\cdot + B^{\cdot -}$

Both products are active so high G-values are to be expected. Some typical electron affinities, after Pritchard and Skinner[2] are, in eV, H 0.75, C 1.7, O 2.2, F 3.6, Cl 3.8, CH_3 1.22, CN 3.61, NH_2 1.21. Dissociative electron capture is thus relatively probable when halogen and nitrile groups are present.

These primary events are followed by secondary reactions in which the ions or excited molecules participate. Ions are always produced in complementary pairs and combination of positive with negative ions is always a possibility. This may be the re-absorption of an electron by a cation, $AB^+ + e \rightarrow AB^\star$, in which case the molecule produced is in such a highly excited state that further reaction is almost inevitable. Alternatively cations can react with other anions to produce pairs of molecules somewhat less excited than those resulting from reabsorption of electrons. Ions may also react with neutral molecules in hydrogen transfer reactions of the type $RH^+ + RH \rightarrow RH_2^+ + R^\cdot$ and condensations such as $A^+ + CD \rightarrow AC^+ + D$.

Excited molecules may dissociate to yield free radicals, $AB^\star \rightarrow A^\cdot + B^\cdot$, or neutral molecules, $AB^\star \rightarrow C + D$ (more or less excited). Reaction with other molecules is also possible. The dissociation into free radicals is the most imimportant reaction of excited molecules. The radicals so formed are themselves in excited states and may be capable of reactions not undergone by low-energy "thermal" radicals.

Radiation-induced polymerisation

The relative importance of ions and radicals in initiating reactions in these systems is still not known. Radicals are probably more important than ions in liquid media where ions have very short life times, and, until recently, it was the fashion to interpret all radiation chemical processes in terms of free radicals. Today the balance of evidence suggests that radical mechanisms are indeed more commonly encountered than ionic mechanisms and that these usually follow a similar kinetic pattern to the reactions initiated by thermal radicals. There are, however, several well documented cases of chain reactions initiated by an ionic mechanism.

Free radicals generated by secondary reactions from ions or excited molecules lead to polymerisation of unsaturated monomers by the usual sequence of initiation, propagation and termination. The evidence for the radical mechanism rests on the behaviour of known inhibitors, the similarity of reactivity ratios in copolymerisation and the identity of activation energies and kinetics with those observed when conventional radical sources are used. An important departure can arise when very high dose rates lead to the generation of free radicals at a rate greater than the rate at which they can be scavenged by monomer. This leads to a modified kinetic scheme[3] in which the rate of conversion is not proportional to rate of initiation and reaches a limiting value. Termination then tends to occur by reaction of the growing chain with a primary radical rather than with another growing chain. Polymers of reduced molecular weight are thus produced. In the extreme case the kinetic chain can become so short that telomerisation rather than polymerisation is the predominant phenomenon.

Other ways in which radiation-induced free radical polymerisation can differ from the thermal process are

(i) Radiolysis of the polymer can occur as it is formed, leading to polymeric radicals. At high conversions most chains are in fact initiated by polymeric radicals. Abnormally high molecular weights, high degrees of branching and even gelation are thus commonly encountered. Although similar effects can result from chain transfer in thermal processes, the ability of radiation to attack any linkage in the molecule means that they are more severe when polymerisation is radiation-induced.

(ii) No solvent can be considered inert. The solvent behaving most like an inert solvent will be one having a similar G-value to the monomer with respect to radical generation and which will yield radicals of the same sort as the monomer. Such solvents are rarely found and in consequence the kinetics are complicated by transfer reactions much more than in conventional polymerisation.

(iii) When solid polymers in the glassy state are produced, trapped radicals can occur. These become active when the polymer is subsequently dissolved or heated above its glass transition temperature.

(iv) The gel or Trommsdorf effect is usually much more pronounced in the radiation induced polymerisation. It is observed[4], for example, at only 2 per cent conversion when methyl methacrylate is polymerised at 15°C and a dose rate of $0.023 \mathrm{rad.sec}^{-1}$.

Styrene and methyl methacrylate have probably received more attention than all other monomers put together. In addition to the pronounced gel effect in methyl methacrylate polymerisation Seitzer & Tobolsky[4] observed marked chain branching. The G-value with respect to radical generation G (R) was found to be independent of dose rate below $1\text{-}2 \mathrm{rad.sec}^{-1}$. At higher dose rates G (R) fell below this level of 11.5. The same authors[4, 5] have studied the polymerisation of styrene, finding little difference between γ-radiation, 500keV x-rays, β-particles and mixed nuclear reactor radiation in the general pattern of behaviour. G(R) values were constant at ca 0.7 for dose rates up to $2\text{-}3 \mathrm{rad.sec}^{-1}$, falling off as dose rates were increased. The pronounced effect of temperature. at a given dose rate, on both molecular weight and rate of conversion was a feature of these authors' findings. It results from an initiation rate constant which is independent of temperature whilst the rate constants for propagation and termination have a temperature dependence similar to that in conventional radical polymerisation.

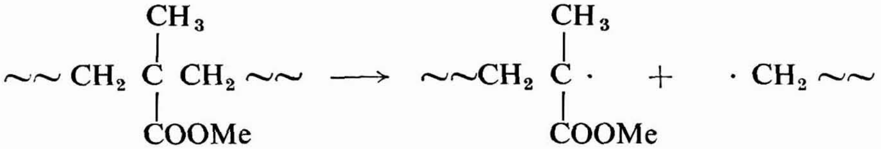
Graft polymerisation

The readiness with which free radicals are produced on "dead" polymer molecules when irradiated has led to extensive studies of this approach to the formation of graft polymers. Irradiation of polymers alone leads to cross-linking or degradation reactions but in presence of a monomer, usually a solvent for the polymer, polymerisation of the monomer is initiated by the radicals on the existing polymer molecules. An alternative approach is to irradiate the polymer alone in the glassy state to produce trapped radicals which become active when the polymer is later dissolved in the appropriate monomer. The subject has been reviewed by Ceresa[6] and Chapiro[7]. By these means it is possible to graft on to polymeric structures which are relatively resistant to attack by thermal radicals.

Much of this work has been done with γ-irradiation, though several workers have compared electron irradiation with other forms and obtained broadly similar results[8, 9, 10]. Through the usual primary events of ionisation and excitation, radicals, may be formed on polymer molecules either by random loss of side groups (including H-atoms)

$$\sim\sim CH_2CH_2CH_2 \sim\sim \longrightarrow \sim\sim CH_2\,\underset{\bullet}{C}H_2CH_2 \sim\sim$$

or by chain fracture



$$\sim\sim CH_2\,\underset{COOMe}{\overset{CH_3}{C}}\,CH_2 \sim\sim \longrightarrow \sim\sim CH_2\,\underset{COOMe}{\overset{CH_3}{C}}\cdot \quad + \quad \cdot\,CH_2 \sim\sim$$

In presence of oxygen, peroxides and hydroperoxides are formed and grafting occurs to a lesser extent if air is present.

Numerous patents for such grafting reactions have been taken out. Grafting on to rubber and cellulose has been extensively studied by several workers. A number of patents[11, 12] claim the use of electron irradiation to initiate grafting of diverse vinyl monomers on to polyethylene, polypropylene, polystyrene and other substrates. It is significant that Odian *et al.* observed that presence of non-solvents for the polymer increases grafting rate, presumably via a Trommsdorf effect[13, 14].

Electron-cured coatings

It may, perhaps, be inferred from the foregoing that the idea of curing coatings by electron irradiation is not a novel one, and that current interest is due more to the development of suitable equipment than to any other factor.

Some of the patents on graft polymerisation refer specifically to surface treatment, often of cellulosic materials such as paper and fabrics as well as of synthetic films[15, 16]. The coating of heat sensitive transistors and other electronic devices with unsaturated polyester-monomer mixtures cured by means of an electron beam from a resonant cavity generator[17] was claimed in 1959 by the General Electric Company[18]. This patent also mentions the pre-irradiation technique. In 1960 T.I. (Group Services) Ltd. described the coating of impervious substrates, such as aluminium, by similar materials cured by means of 250keV electrons[19]. It is interesting to note that Charlesby and Wycherly[22] had reported in some detail on the electron irradiation of unsaturated polyesters in styrene in 1957, noting that the cross-linked product was similar to that obtained by conventional free-radical curing. The use of high energy electrons to improve the lightfastness of printed fabrics by polymerising a resin *in situ* was described by GEC in 1963[20]. Preactivation of resin coatings by electron irradiation was claimed by Slatkin in 1964[21].

Considerable investigations have been undertaken of the irradiation of drying oils through these mostly employed γ-rays or the glow discharge rather than electron beams. Much of this work is more than 20 years old and relates to both bleaching and polymerisation [23-29].

More recent developments

The patent of T. I. (Group Services) Ltd.[19] reveals some highly significant features of the electron-beam curing of coatings, which have been the subject of much subsequent discussion and commercially directed publicity by other writers. In particular, attention is drawn to the high cost, in both capital and operating, of electrons in the energy range 500keV-4MeV. It is noted that such particles have a range of 0.1-0.7in in an organic material of unit density and that, if used to cure coatings of conventional thickness, penetration into the substrate results in wasteful dissipation of energy which may, moreover, cause damage either directly or by the generation of heat. Electrons of energies below about 300keV are claimed to be cheaper to produce and to be free from this technical disadvantage. The power requirements to deliver 0.1M.rad to 1,000sq ft of coating are said to be 2KWH for 2MeV electrons but only 0.025KWH for 100keV electrons. The latter, projected through the window of the accelerating device, have an effective penetration range of 0.001in.

The present explosion of interest results from a series of announcements in the trade journals during 1966. The Ford Motor Co. announced[30] that it had licensed the Boise Cascade Corp. to cure paint on timber by their electron beam process. Boise in turn stated that they would build a pilot plant but gave no commercial target at that time. The start-up of this plant was reported a year later[31] when it was revealed that the accelerator had been built by Texas Nuclear Corporation. Ford were planning pilot coating of steering columns with an eye to the eventual finishing of car bodies. They claim to be the only organisation currently offering the complete system of equipment and the paint to go with it.

Also in 1966, Trageser of High Voltage Engineering Corp. reported[32] that their 300keV equipment was available for lease or purchase as a packaged unit complete with scanned beams and conveyor line. Given a coating that would cure at a dose of 2M.rad, the apparatus was said to be capable of processing plywood and hardboard sheets 4ft wide at the rate of 150 linear ft/min for a cost of 0.1-0.3 cents per sq ft. Advantages claimed were savings in factory space compared with conventional drying equipment of the same throughput, absence of problems relating to solvent recovery and pot-life, low power consumption (ca 10 per cent of that of the equivalent oven), freedom from substrate damage and low labour costs. The point was made that improved adhesion would result from some graft copolymerisation on the surface of the substrate. Polyesters and acrylics were said to be the coating materials most sensitive to cure.

A few weeks later,[33, 34] the development of a 300keV accelerator by Radiation Dynamics Inc. was announced and discussed. A rather wider range of curable coatings was claimed, embracing pvc plastisols, polyester plastisols and epoxy acrylics in addition to polyesters and acrylics. Excellent adhesion was claimed on a wide variety of substrates such as paper, steel, aluminium, wood and concrete. Emphasis was again laid on economics and freedom from solvent loss.

Texas Nuclear are now offering a 300keV accelerator independent of the Ford design; General Electric's X-ray department make two models, and Applied Radiation Inc. are active in development. Considerable interest has been shown by the United Kingdom Atomic Energy Authority who have licensed Nuclear Chemical Plant Ltd. in irradiation equipment. Reviews of commercial progress continue to appear at frequent intervals. A recent one[35] compares the equipment and aims of the main American contenders for the 300keV market, pointing out that high energy units were in use for wire coating as long ago as 1957.

Little has been published on the formulation of paints or polymeric systems for use with the equipment now available though all the equipment manufacturers offer some sort of service in conjunction with paint, polymer or chemical interests. Unless one is conveniently placed in relation to suitable equipment there is little alternative to investing in one's own accelerator if serious development work is to be undertaken. A useful study has been reported by Hoffman & Smith[36] who irradiated mixtures of styrene, ethyl acrylate and methyl methacrylate with two unsaturated polyesters using a 500keV accelerator, and evaluated extent of cure as a function of composition, dose and dose rate. Very extensive investigations of unsaturated systems have been undertaken[37] in the direction of ascertaining structural features conducive to rapid cure. Among the most rapid curing systems are wholly aliphatic unsaturated polyesters dissolved in glycol dimethacrylate. Acrylic acid, methacrylic acid and the acrylates are readily polymerised but monomethacrylates, vinyl ethers, olefines, acetylenes and unsaturated oils appear to respond sluggishly, at least to doses and dose rates currently considered economical. Halogen atoms can confer reactivity owing to the ease with which dissociative electron capture occurs in their presence, and other groups of high electron affinity, such as nitriles, would clearly repay study. In general, cure does not seem to be promoted by the addition of free radical sources such as AZBN and peroxides. On the other hand there are well authenticated cases of reactions promoted by absorption of the reactant on solid surfaces. An example is the photosensitising action of zinc oxide on the polymerisation of styrene[38]. This would seem to be a fruitful area of investigation for those whose interests lie in the paint industry.

[*Received 25 September 1967*

References

1. Clark, K. R., *Forest Products Journal* 1964, **14,** (2), 51.
2. Pritchard, H., & Skinner, H., *Chem. Rev.* 1953, **52,** 529; 1955, **55,** 780.
3. Chapiro, A., Magat, M., Sebban, J., & Wahl., P., *International Symp. Macromol. Chem.* Milan-Turin 1954.
4. Seitzer, W. H., & Tobolsky, A. V., *J. Amer. Chem. Soc.* 1955, **77,** 2687.
5. Seitzer, W. H., Goekerman, R. H., & Tobolsky, A. V., *J. Amer. Chem. Soc.* 1953, **75,** 755.
6. Ceresa, R. J., *Block & Graft Copolymers*. London 1962.
7. Chapiro, A., *Macromolecular Chemistry* 2. London 1966 (Proc. IUPAC Symposium, Prague 1965).
8. Chapiro, A., *J. Polymer Sci.* 1958, **29,** 321; 1959, **34,** 439.
9. Griffin, J. D., & Rubens, L. C., 130th Meeting Amer. Chem. Soc. Atlantic City, 1956.
10. Rapson, W. H., Huang, R., Immergut, B., & Immergut, E. H., 138th Meeting Amer. Chem. Soc. New York, 1960.
11. Dow Chemical Company. B. P. 825,680.
12. Union Carbide Corp. B. P. 823,462.
13. Odian, G. G., Rossi, A., & Trachtenberg, H., *J. Polymer Sci.* 1960, **42,** 575.

14. Odian, G. G., Rossi, A., & Klein, K., 138th Meeting Amer. Chem. Soc. New York, 1960.
15. Degering, E. F., U.S.P. 3,236,584.
16. DuPont. B. P. 839,483.
17. General Electric Co. U.S.P. 2,144,518.
18. General Electric Co. U.S.P. 2,900,277.
19. T. I. (Group Services) Ltd., B. P. 949,191.
20. General Electric Co. U.S.P. 3,097,960.
21. Slatkin, A. D., U.S.P. 3,133,828.
22. Charlesby, A., and Wycherley, V., Internat. *J. Appl. Radiation & Isotopes.* 1957, **2,** 26.
23. Lavigne, J. B., *J. Amer. Chem. Soc.* 1958, **35,** 117.
24. Mead, J. F., *Science* 1952, **115,** 470.
25. Slover, H. T., & Dugan, L. R., *J. Amer. Oil Chem. Soc.* 1957, **34,** 333.
26. Bawn, C. E. H., Pennington, A. A., & Tipper, C. F. H., *Discuss. Faraday Soc.* 1951, **10,** 282.
27. Boelhouwer, C., *et al. J. Amer. Oil Chem. Soc.* 1960, **37,** 373.
28. Gotoda, M., *J. Electrochem. Soc. Japan.* 1956, **24,** 177.
29. Chipault *et al. Ind. Eng. Chem.* 1957, **49,** 1713.
30. *Chem. & Eng. News,* 14 Feb. 1966; *Chem. Week.* 1966, **98** (8), 86.
31. *Chem. & Eng. News,* 20 Feb. 1967.
32. Trageser, D. A., *Paint & Varnish Production,* 1966, **56,** (4), 41.
33. *Chem. & Eng. News* 1966, **44** (24), 29.
34. Morganstern, K. H., *Industr. Finishing* 1966, **42,** (9), 42.
35. *Chem. & Eng. News.* 20 Feb. 1967.
36. Hoffman, A. S., & Smith, D. E., *Modern Plastics,* June 1966, 111.
37. High Voltage Engineering Corp. Private communication.
38. Yamamoto, M., & Oster, G., *J. Polymer Sci.* in Press; Oster, G., *J. Polymer Sci.* 1966, **C12,** 63.

Oil Col. Chem. Assoc. 1968, 51, 792-815

Prefabrication primers for structural steelwork: Part II*

By D. A. Bayliss† and D. C. Wall‡

†Scientific Services Department, S.E. Region, Central Electricity Generating Board, Cockfosters, Herts

‡Smith & Walton Ltd., Haltwhistle, Northumberland

Summary

This report on the second part of the work on prefabrication or holding primers carried out for the Central Electricity Generating Board describes:

1. The behaviour of subsequently applied paint systems which have now been exposed in a severe environment for up to three-and-a-half years, particularly the disruptive effect of a semi-corroded holding primer.
2. Observations on the phenolic-resin-modified single-pack etch primer, particularly regarding its good durability and the importance of film thickness and coverage of rough surfaces, and the effect of change of pigmentation and different solvents.
3. A closer look at zinc-containing primers and certain modifying pigments.
4. A preliminary examination of a wide variety of follow-on primers.

Couches primaires pour utiliser avant la fabrication des charpentes en acier

Résumé

Un compte rendu de la deuxième partie du projet effectué par le Central Electricity Generating Board, (Régie Autonome de la Production d'Electricité), sur des couches primaires destinées à l'application aux éléments en acier avant de les utiliser pour la fabrication de charpentes. Les auteurs décrivent:

1. Le comportement des systèmes de peinture appliqués plus tard, après leur exposition dans un milieu sévère pendant 3½ ans, et en particulier, l'effet disruptif d'une couche primaire demi-corrodée.
2. Observations sur l'etch-primer à seul emballage modifié à résine formophénolique, surtout à l'égard de sa durabilité et l'importance de l'épaisseur de feuil et du degré de revêtement des surfaces rugueuses, et l'effet du changement de pigment et de différents solvants.
3. Une consideration plus détaillée des primaires contenant du zinc et de certains pigments modifiants.
4. Un examen préliminaire d'une gamme etendue des apprêts pour être appliqués après la fabrication des charpentes en acier.

Shop-Primer für Eisenkonstruktionen: Teil II

Zusammenfassung

In diesem Bericht wird über den zweiten Teil der für den Central Electricity Generating Board mit Shop- oder "holding" Primern (d.h. eine gewisse Wetturbeständig-keit besitfend) ausgeführten Arbeiten folgendes berichtet:

1. Das Verhalten von anschliessend aufgebrachten Anstrichsystemen, welche bisher bis zu 3½ Jahren in schwieriger Umgebung exponiert wurden, insbesondere die zerstörende Wirkung eines halb-korrodierten "holding" Primers.

---

*Presented to the Newcastle Section on 4 January 1968.

2. Beobachtungen an mit Phenolharz modifiziertem Einkomponenten-Waschprimer, besonders hinsichtlich seiner guten Dauerhaftigkeit und der Wichtigkeit der Filmdicke und Bedeckung rauher Oberflächen, sowie des Einflusses von Änderungen in der Pigmentierung und von verschiedenen Lösungsmitteln.
3. Eine intensivere Betrachtung von zinkhaltigen Primern und gewissen modifizierenden Pigmenten.
4. Eine vorbereitende Prüfung zahlreicher, verschiedenster Primer für den nachfolgenden Anstrich.

Грунтовки заводского изготовления для строительных стальных изделий — Часть II

Резюме

Доклад второй части работы посвященной заводским связывающим грунтовкам, выполненной для Центрального Правления по Снабжению Электричеством, описывающий:

1. Поведение в последствии примененных красочных систем, которые были уже выдержаны в суровых условиях в течение 3½ лет, и в частности разрушающее влияние полу-разъеденной сцепляющей грунтовки.
2. Характеристики фенольно-смольной модифицированной однопородной травильной грунтовки в частности по отношению к ее стойкости, и значение толщины пленки и покрытия шероховатых поверхностей, и влияние изменения пигментации и различных растворителей.
3. Более подробное изучение грунтовок содержащих цинк и некоторых модифицирующих пигментов.
4. Предварительное изучение больщого числа грунтовок предназначенных для последующего применения.

Introduction

The first part of this programme of work on prefabrication primers has been reported[1].

The programme, which started three and a half years ago, was designed to obtain more information about the protection of structural steel surfaces which had been blast cleaned prior to erection and general painting and, in particular:

1. which holding primer (or prefabrication primer) was most suitable for such application,
2. what degree of blast cleaning was required,
3. how much surface preparation of the weathered holding primer was necessary before the follow-on painting,
4. assuming that the follow-on paints would be conventional undercoat and gloss systems, which was the most satisfactory conventional primer to use.

The experimental work was carried out on as practical a level as possible and the primers and systems were exposed on RSJ sections 4ft long and 6in wide with 3in deep flanges.

The main exposure site is at Brighton "A" Power Station which is considered to be one of the most aggressive sites in the country. The girder sections were laid horizontally on the centre parapet of a cable bridge.

Exposure tests of the same type started on a roof site at Battersea have now been discarded since they gave the same order of results as at Brighton at a slower rate.

Table 1

Composition of holding primers on exposure

Reference	Binder	Pigment	Metallic zinc content on dry film weight
CEGB 1 ..	Epoxy/polyamide	Zinc dust	87.0%
CEGB 2 ..	Proprietary primer		
CEGB 3 ..	Proprietary primer		
CEGB 4 ..	Epoxy/isocyanate	Zinc dust	92.5%
CEGB 5 ..	High polymer epoxy	,, ,,	91.7%
CEGB 6 ..	Epoxy/polyamide	Zinc dust/colloidal zinc oxide	74.1%
CEGB 7 ..	Single pack reinforced etch primer	Zinc chromate	
CEGB 10 ..	Epoxy/polyamide	Zinc flake	66.5%
CEGB 11 ..	Proprietary primer		
CEGB 12 ..	Proprietary primer		
CEGB 15 ..	Epoxy/polyamide	Zinc dust/colloidal zinc oxide	60.2%
CEGB 16 ..	Epoxy/polyamide	Zinc dust/colloidal zinc oxide	46.5%
CEGB 17 ..	Epoxy/EDA adduct	Leafing aluminium powder	35.65% aluminium
CEGB 18 ..	Epoxy ester resin	Leafing aluminium powder	36.2% aluminium

After six months' exposure, the zinc rich, reduced zinc above 74 per cent zinc, the proprietary primers and the etch primers were all in good condition. However, the aluminium primers and the reduced zinc primers below 74 per cent zinc content were already showing a 50 per cent rusting even at Battersea. After 12 months' exposure, only the primers containing a minimum of 91.5 per cent zinc on the dry film weight were in reasonably good condition, that is, showing less than 10 per cent rust formation. When the zinc content on the dry film was allowed to fall only slightly below the theoretically required figure of 92 per cent, as with CEGB 1, there was a marked deterioration in performance. After 15 months' exposure at Brighton all the primers were failing, and even the full zinc rich primers 2 and 4, which gave the best all-round performance, had an average of over 40 per cent rusting.

Discussion of results in November 1965

From the results of this work it is obvious that there are a number of primers which will hold blast cleaned steel in a rust-free condition on even the most aggressive site for a period of six months. However, longer periods of exposure resulted in some breakdown with all the primers examined, particularly at film thicknesses below 10^{-3}in and on horizontal surfaces which represent the type of exposure likely to be encountered when steel structures are stored. The durability of zinc-based primers depends largely on the zinc content, but even the primers with a minimum of 91.5 per cent zinc on the dry film weight had approximately 40 per cent rusting after 15 months' exposure.

As a result of this work the etch primer CEGB 7 was favoured because:

1. it is a one-pack material,
2. films follow the contours of blast cleaned profile better than zinc primers,
3. it has least effect on welding, i.e. toxicity and weld porosity,
4. presents no problems in re-coating,
5. unlike epoxy films, etch primer coatings do not become hard with age,
6. if rusted, it can be easily prepared by wire brushing.

It is now intended to examine these comments in the light of the additional experience gained over the last two years, as follows:

1. further observations on etch primers,
2. further observations on zinc primer and certain modifying pigments,
3. the behaviour of subsequently applied paint systems after a maximum of three and a half years' exposure,
4. a preliminary examination of follow-on primers.

Etch primers

Film thickness

All the work indicates that the durability of the holding primer is proportional to film thickness and, when evaluating these materials, it is important to take this into consideration. Since the ability of a holding primer to cover the peaks of a rough surface is a vital consideration, it is necessary to determine the desirable film thickness of this cover. For this purpose burnished steel test panels were used and the coatings applied in a series of thin steps.

The panels were exposed horizontally because, since the surface remains wet for long periods, this not only represents the worst possible conditions but also those most likely to be met with the storage of structural steel.
In this way the following results are obtained:

0.25×10^{-3}in thickness will rust in approximately 11 weeks.

0.5×10^{-3}in in six months.

1×10^{-3}in in $>$ nine months.

If these same thicknesses are applied as two coats, the durability is increased quite significantly. It would not normally be considered good practice to overcoat an etch primer with a further coat of etch primer, but it has been found to be perfectly satisfactory. Under normal drying conditions an etch primer film can be overcoated in approximately ten minutes to give 50 to 60 per cent greater film thickness. This is one method of bringing etch primer film thickness up to the normal level obtained with zinc rich epoxy primers applied by airless spray.

In practice, variations in performance have been observed between batches of CEGB 7 and this is believed to be due to inconsistencies in application viscosity. It is essential that viscosity should be most carefully controlled both in manufacture and in application to ensure that a satisfactory dry film thickness is obtained.

Coverage of rough surfaces

It appears therefore that the coverage over the peaks of a rough surface should be at least 0.5×10^{-3}in to give reasonable durability. An indication of the peak coverage can be obtained by the difference between magnetic film thickness gauge measurements before and after coating, the gauge having been originally calibrated on a plane surface[2].

Recently the CEGB Paint Testing Laboratory carried out a survey of the roughness of blast cleaning obtained from fourteen structural steel fabricators. Sample panels of steel to BS. 15 were submitted for blast cleaning, the steel being covered by millscale to a degree approximately half-way between rust grades A and B of the Swedish Standard. The fabricators were asked to clean the sample plates to a "white metal" finish and also to supply details of their cleaning plant along with samples and details of both new and used abrasive.

Figs. 1 and 2 show the roughest and smoothest finish obtained.

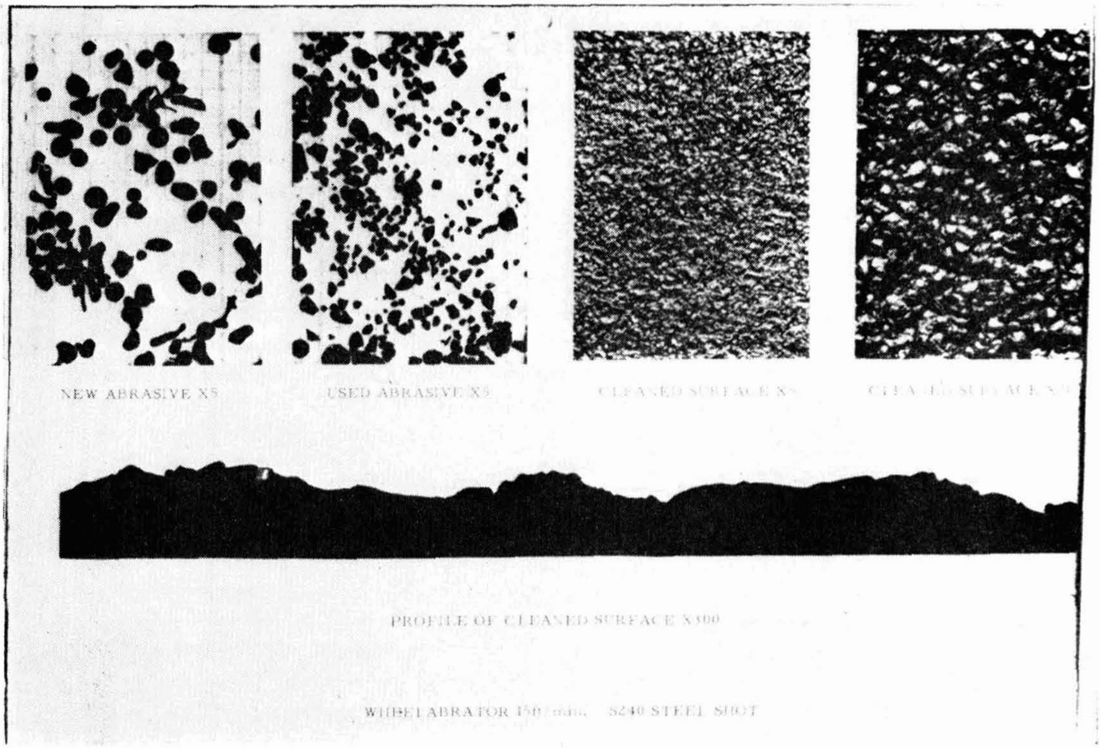
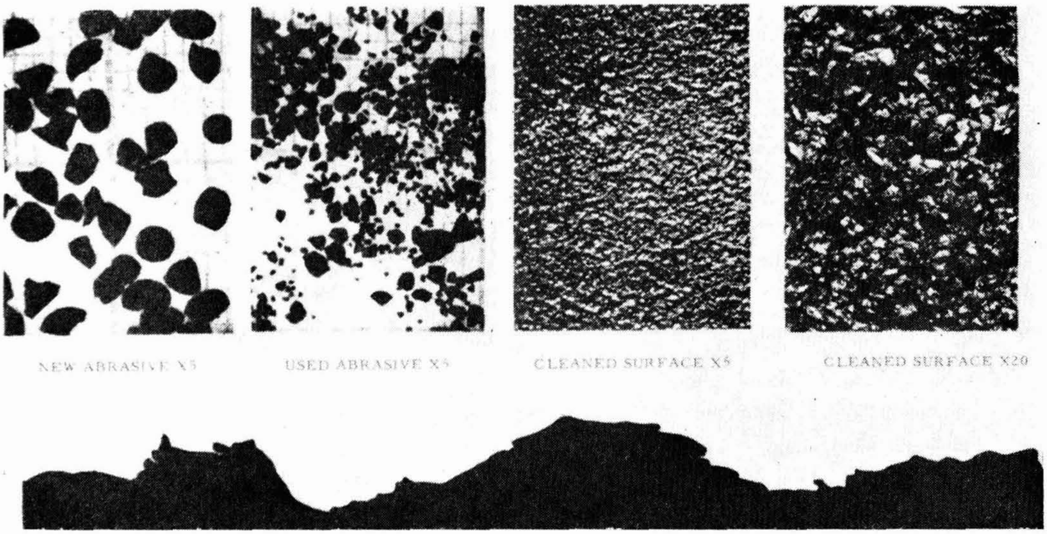


Fig. 1. Shot blast profile



NEW ABRASIVE X5 USED ABRASIVE X5 CLEANED SURFACE X5 CLEANED SURFACE X20

Profile of cleaned surface × 300 manual 47s chilled angular grit

Fig. 2. Grit blast profile

An experiment was devised to determine to what extent the painting of these panels would be affected by the coarseness of the surfaces. Sections from the panels were cut and weighed and magnetic gauge readings taken on each surface. The panels were masked to give a set area and given a single coat of holding primer by one pass of a spray gun at a constant distance. Magnetic gauge readings were taken after each coat until the difference in readings between the coated and uncoated surface was 0.5×10^{-3}in. It was found that it required 2.7 times more paint on the coarsest surface than on the smoothest to achieve the same coverage over the tops of the metal peaks. The insistence on at least 0.5×10^{-3}in coverage of holding primer above the highest peaks of the blast cleaned metal appears to be the most practical method of protecting the surface until it can be finished by the full paint system. The fact that the roughest surfaces will require more paint to achieve this standard of protection may encourage firms to provide a smoother blast cleaned surface when the final objective is painting rather than metal spraying.

Modifications to CEGB 7

Paints were prepared replacing:

1. asbestine by red oxide of iron,
2. zinc chromate by zinc phosphate,
3. zinc chromate by zinc phosphate and asbestine by red oxide of iron,
4. asbestine by micaceous iron oxide.

In view of the previous experience with the acceleration of breakdown in thin films, 0.25×10^{-3}in coatings were exposed. None of the modifications showed any improvement in performance. In general, corrosion resistance was worse.

Table 2
Modifications to CEGB 7

Modification	Result
1. Replacing asbestine by red oxide	Whole of panel badly rusted
2. Replacing zinc chromate by zinc phosphate	Whole of panel badly rusted
3. Replacing zinc chromate by zinc phosphate asbestine by red oxide	Fairly bad surface rusting
4. Replacing asbestine by micaceous iron oxide	Best of experimental paints although still quite badly rusted
5. Standard CEGB 7	Some slight surface rusting

Use as a pre-operational coating

The purpose of a pre-operational coating is to preserve the internal surfaces of plant in a clean, rust-free state before commissioning, thereby reducing the amount of iron oxide carried into the boiler from the feed system in the early stages of operation. CEGB 7 was chosen as a suitable non-removable pre-operational coating because it has good protection in thin films and therefore, in the event of failure, it could only contribute small amounts of solids into the feed system. In fact it has been found that the immersed water resistance of this coating is extremely good and the breakdown is gradual.

When CEGB 7 was used in open workshops, complaints were soon received from operators about the acrid nature of the solvent vapours. Whilst it is recognised that primary alcohols are important for the chemical reactions taking place in two-pack etch primers, there was at this time no indication that butanol was specifically required nor was there any evidence to suggest that alcohols play a part in the stability of *one-pack* etch primers.

In view of these accepted theories, it was decided to remove butanol from CEGB 7 to produce a low odour version on a solvent blend of 64 OP methylated spirit, ethylene glycol monoethyl ether and diacetone alcohol. Within a few weeks of manufacture, the liquid paint appeared to undergo certain reactions in the can not dissimilar to those of the conventional two-pack etch primer type. The freshly prepared paint gave a continuous film, but as the instability developed the freshly cast films became less continuous, more granular and finally dried as a completely discontinuous film.

A wide range of solvent variations were tried with similar results, and it became increasingly obvious that the presence of *n*-butanol was contributing to the stability of the one-pack etch primer and, since this raised most odour objection, a more fundamental approach was required. Any change from the original formulation caused deterioration in performance in some respects. It seemed that the phosphoric acid needed to be held in a relatively non-reactive reservoir. It could be considered that if the acid were being used in the reactions in the can during storage, the changes in the liquid should bring about a stable equilibrium and that further acid should only be released as required. *n*-Butanol has this effect, probably due to the formation of butyl phosphoric acid. Applying this theory, alternative "acid acceptors" were included in the primer, and it was found that, by the inclusion of a suitable epoxide-ring-containing compound, a stable paint could be formulated without the use of either low boiling ketones or *n*-butanol.

Zinc containing primers

Zinc rich types—no reducing pigment

In the original series of primers, CEGB 1, with 87.0 per cent zinc, compared poorly with a zinc rich primer CEGB 4 containing 92.5 per cent zinc. The effect of different media on the performance of zinc rich primers at two different pigment levels 92.5 per cent and 87.5 per cent zinc on the dry film weight has now been compared. CEGB 2 proprietary primer of high performance level was used as a control. These primers were tested as single coat films on $\frac{1}{4}$in steel plate which had been blast cleaned. The exposure was on a normal rack at 45° facing south and so was subject to less stringent conditions than the RSJ sections used in the original trials.

Table 3

Zinc containing primers *Blast cleaned panels* *Brighton exposure site at 45° facing South*

Medium type	PVC %	92.5% Zn % rusting after exposure periods of			PVC %	87.5% Zn % rusting after exposure periods of		
		6 mths.	18 mths.	2 yrs.		6 mths.	18 mths.	2 yrs.
High polymer epoxy resin	71	20	100	100	56	100	100	100
Chlorinated rubber (plasticized) ..	67.5	0	10	15	54	5	10	30
Polystyrene (plasticized)	65.0	5	5	50 from rust spotting	54	5	10	80 from rust spotting
Epoxy/polyamide (two pack) ..	70	0	5	5	56	20	50	85 from rust spotting
Epoxy/isocyanate (two pack) ..	70	0	0	5	56	0	5	5 from rust spotting
CEGB 2		0	0	10				

With 92.5 per cent zinc content, the two-pack epoxy types, including CEGB 2, were superior to the single-pack types. Chlorinated rubber based paint gave a surprisingly good result and warrants a more detailed evaluation. Polystyrene was good for about eighteen months and then showed rapid failure at two years. With 87.5 per cent zinc content, there was a general reduction in performance at the lower zinc content except in the case of the epoxy isocyanate binder. The differences in performance were not due to variations in pigment volume concentration since calculations show that these are fairly consistent for each type at the different levels, except that the polystyrene at 65.0 per cent might be considered slightly low.

All these tests were carried out on blast cleaned steel panels with a sharp, rough, profile. The tests were repeated on burnished steel panels, and in every instance a worse result was obtained, showing that, in general, satisfactory coverage of peaks on the blast cleaned panels must have been achieved and the loss of adhesion on the burnished panels was the most critical factor.

Fig. 3 shows the range of zinc primers on polystyrene after eighteen months exposure. It shows the superiority of the 92.5 per cent zinc BL (shot blasted) over the 87.5 per cent BL, also the corrosion and loss of adhesion on the BN (burnished surface).

Fig. 4 shows the range of zinc primers on epoxy/isocyanate after eighteen months' exposure. In all cases a better performance is obtained than with the polystyrene, but there is the beginning of loss of adhesion of the 87.5 per cent zinc primer on the burnished panel.

Reducing pigments

Having established the significance of overall zinc pigment content, it was then decided to examine more closely the effect of the addition of so-called reducing pigments.

In the original trials, two primers had given similar performance in terms of corrosion resistance:

CEGB 6	Overall pigmentation	92.7%
	Zinc content	74.1%
	ZnO	17.8%
CEGB 1	Overall pigmentation	87%
	Zinc content	87%

indicating that overall pigmentation was an important consideration in reduced zinc rich primers and that there is a critical pigment volume concentration for any particular system at which optimum performance is achieved. Accelerated weathering tests do not produce significant results in respect of zinc primers, so, to obtain information on exposure characteristics as quickly as possible, it was decided to prepare paints at relatively low PVC's in order to obtain fairly quick breakdown on exterior exposure.

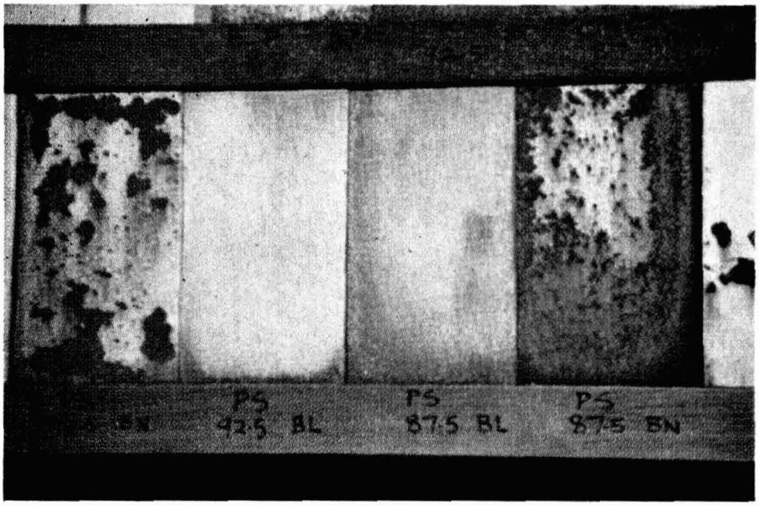
The results with primers 6A, 6D and 6B in Table 4 show that, within a range of PVC 50 to 60 per cent, there was a relatively quick breakdown, but the exact PVC within the range is not critical. The results obtained after nine months' exposure at 45° facing south with primers using different extending pigments is acceptable as indication of performance of the systems at higher pigmentation.

Zinc oxide was used as the reducing pigment in the original trials since it was reported that this was a satisfactory material for such purpose. Experience has shown that the inclusion of micaceous iron oxide in pigment in any media invariably improves its performance in terms of durability, so this was included as an extending pigment, at the same time maintaining the zinc oxide at a relatively constant level, and the overall PVC at about 53 per cent. The results on primers 6D1, D2 and D3 are extremely interesting in that increasing amounts of micaceous iron oxide gave surprisingly good performance, particularly at low zinc contents.

Table 4

Experimental prefabrication primers *Exposure Brighton 45° facing South* *Binder epoxy/polyamide*

Reference	PVC %	Percentage by weight of pigment on dry film weight			Rusting per cent	
		Overall	Zinc	Reducing pigment	3 mths. exposure	9 mths. exposure
6A	60	89.5	71.9	17.2 ZnO	none	40
6D	55.5	88.0	70.5	16.9 ZnO	none	50
6B	50.1	85.5	68.5	16.4 ZnO	2	80
6D 1	55.8	88.0	64.5	17.4 ZnO 5.3 MiO	100	100
D 2	56	87.5	55.0	17.7 ZnO 13.6 MiO	2	90
D 3	56	87.0	45.5	18.2 ZnO 22.5 MiO	5	95
6DA	57	88.0	75.5	10.4 Zn phosphate	10	100
CEGB 6	69	92.7	74.1	17.8 ZnO		



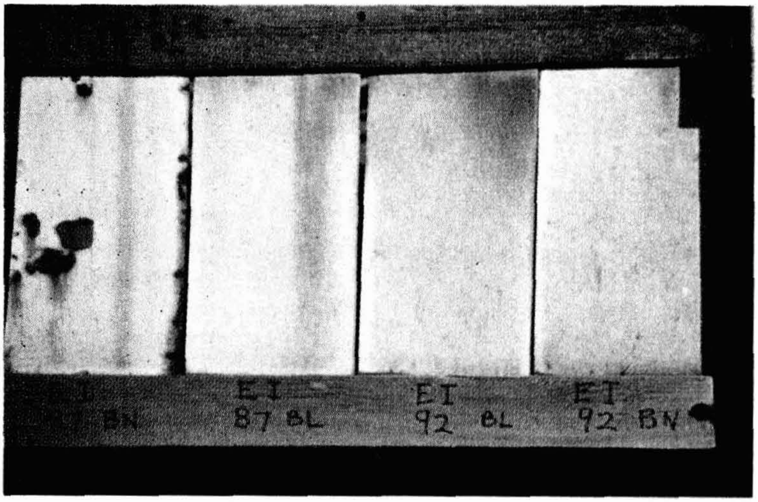


Fig. 3 (top). Primers based on polystyrene, 18 months' exposure

Fig. 4 (bottom). Primers based on epoxy/isocyanate, 18 months' exposure

Finally, in this series of experiments, zinc phosphate was used as a reducing pigment (primer 6DA), producing a disappointing result, the paint being somewhat inferior to a similar primer containing slightly less zinc metal and ZnO as the reducing pigment.

As a result of this work, micaceous iron oxide pigment was included in a primer with an overall higher PVC (approximately 70 per cent throughout). CEGB 4 was chosen as the basic paint since it was felt that the epoxy resin/isocyanate cure system was the best that had been examined.

Table 5

Experimental pre-treatment primers *Exposure Brighton 45° facing South*

Binder epoxy/isocyanate

Reference	Percentage by weight of pigment on dry film weight			Rusting per cent	
	Overall	Zinc	Reducing pigment	3 months exposure	9 months exposure
4A	93	83.5	9.3 micaceous	0	0
B	93	69.5	23.3 ,,	0	very slight at one edge
C	93	56.5	36.0 ,,	0	slight at edges
CEGB 4 . .	92.5	92.5			
6DA . .	88.0	75.5	10.4 Zn phosphate	10	100

From Table 5 it can be seen that after nine months' exposure the results are exceptionally promising. Even at a zinc content of only 56.5 per cent there is only slight rusting at the edges of the panel where, presumably, the film is thinnest. The possibilities here are either

(a) improved performance over a true zinc rich paint, at a relatively low micaceous iron oxide content, say 10 per cent.

or

(b) outstanding performance of a reduced zinc rich primer with considerable cost saving, and the likelihood of less overcoating problems.

Overpainting

It is important to know which primer should be used in the final paint system to ensure adequate adhesion and provide maximum performance from the finishing system. In the initial exposure programme each pretreated girder section was marked off into 1ft lengths and treated as follows:

1st painting —first 1ft length, overpainted with appropriate primer two days after surface treatment. A "standard" white undercoat and gloss paint (both alkyd based) were then applied after a further seven days.

2nd painting—painted as above at exposure site two months after surface treatment.

3rd painting—painted as above at exposure site six months after surface treatment.

4th painting—painted as above at exposure site 12 months after surface treatment.

A conventional decorative undercoat and gloss paint were used because this is normally the most practical finish for power station and similar structures. In all instances except the first, the prefabrication primer treated steel was exposed to site conditions during the period between surface treatment and the subsequent application of the final paint system. It was intended originally to examine three primers, red lead Type B, zinc chromate and calcium plumbate Type A, over all the prefabrication primers but this was not practicable because of the vast number of girder sections involved. As a compromise the following "standard" primers were applied:

on zinc rich and reduced zinc prefabrication primers—calcium plumbate
on etch primers —red lead Type B
on aluminium prefabrication primers —zinc chromate

It is now possible to report on the performance of these systems after a maximum of three-and-a-half years' exposure.

Exposure results—adhesion

On the first painting (no exposure of the holding primer before painting) wherever calcium plumbate primer has been used, there is cracking and flaking of the whole system away from the prefabrication primer this effect being particularly severe on the higher zinc content primers, and on the top horizontal face (See Table 6). Cracking and flaking has not occurred on the outside vertical surfaces or on the underneath surfaces.

Table 6

Adhesion (finishing paints to holding primer). First painting

No exposure before overpaint

Holding primer	Zinc content %	Follow-on primer	Section horizontal exposed surfaces			
			A	B	C	D
CEGB 2 ..	approx. 92	calcium plumbate	cracking and flaking	as A	extensive flaking	as C
CEGB 4 ..	„ 92.5	calcium plumbate	cracking and flaking	extensive flaking	as B	very extensive flaking
CEGB 1 ..	„ 87	calcium plumbate	extensive cracking	as A	some cracking	as C
CEGB 6 ..	„ 74	zinc chromate	no cracking or flaking	as A	as A	as A
		calcium plumbate			extensive flaking	as C
CEGB 11 ..	approx. 65	calcium plumbate	cracking and flaking	satis-factory	slight cracking	satisfactory
CEGB 7 ..	etch primer	red lead	satisfactory		satisfactory	

Two of the CEGB 6 sections (approximately 74 per cent zinc content) were primed with calcium plumbate and there is cracking and flaking on the first painting. Two others, however, were primed with zinc chromate and they show signs of corrosion blistering but no loss of adhesion. Red lead over the etch primers shows no sign of cracking or flaking.

From Table 7 it can be seen that the adhesion failure is directly related to zinc content and not to overall pigmentation since CEGB 1 at 87 per cent Zn is worse than CEGB 6 at 74 per cent Zn even though the overall PVC is 56 as against 67 per cent.

Table 7

Adhesion—finishing paints to pre-treatment

Holding primer	Zinc content per cent	PVC	Follow-on primer	Exposure time before overpaint	Average performance on horizontal exposed surfaces
CEGB 4	92.5	70	calcium plumbate	none	extensive cracking and flaking
				2 months	some cracking and flaking
				6 months	(one section only) some cracking and flaking
				12 months	(one section only) very slight cracking
CEGB 1	87	56	calcium plumbate	none	extensive cracking
				2 months	slight cracking
				6 months	satisfactory
				12 months	satisfactory
CEGB 6	74	69	calcium plumbate	none	some cracking and flaking
				2 months	some cracking
				6 months	satisfactory
				12 months	satisfactory

Exposure results—corrosion

The exposure at Brighton is particularly severe and, as can be seen from Fig. 5, in three years a three-coat conventional paint system has almost completely deteriorated. The top girder in Fig. 5 (the sections have been temporarily stacked in that position for the purpose of the photograph) was hand wire brushed and the first foot at the left hand end primed with red lead BS2523 Type B at the same time as the other specimens were blast cleaned. The remaining foot sections were hand wire brushed and painted at the same two, six and 12 month intervals as the blast cleaned specimens. The middle girder was prepared by power driven wire brush and primed with calcium plumbate BS3698 Type A. The bottom girder was hand wire brushed and primed with calcium plumbate. It can be seen that the hand wire brushing has given a marginally better performance than the power wire brushing and that the calcium plumbate has given a slightly better performance than the red lead. In contrast, with blast cleaning and protection with good or bad holding primers, there is a considerable uplift in performance. This is particularly so on the vertical sides of the girders which more closely represent the practical exposure of painted erected steelwork than do the horizontal painted surfaces.

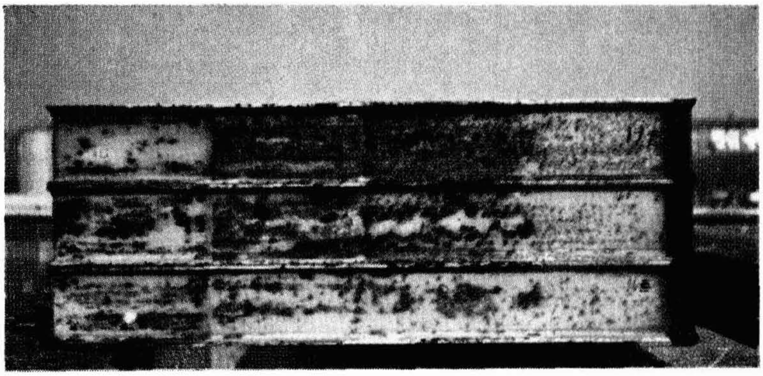


Fig. 5. Sections prepared by wire brushing, exposed three years

The outer sides and underneath of the sections primed with the zinc rich holding primers (CEGB 2 and 4) are in extremely good condition and there is no sign of cracking and flaking. CEGB 1 (87 per cent zinc), CEGB 6 (74 per cent zinc) and CEGB 7 (etch primer) are generally in good condition but there is scattered pin point rust staining on some of the underneath surfaces.

The condition of the top exposed surface, particularly the horizontal face of the girder, is summarised in Tables 8, 9, 10 and 11. The condition of the first painted section, i.e. where the holding primer was overcoated immediately, has been excluded since the situation is confused on the zinc primers by the loss of adhesion of the calcium plumbate primer.

The reference letters refer to the method and standard of the original blast cleaning. A and B were grit blasted. C and D were shot blasted. A and C were cleaned to a first quality standard and B and D to a second quality.

Table 8

CEGB 1 (Epoxy/polyamide 87% zinc content on dry film weight)
followed by BS.3698 Type A calcium plumbate, u/c and gloss finishing coats

Ref. No.	Exposure before overpaint	Condition of holding primer when overpainted	Exposure of finish system	Condition of painted section November 1967 Horizontally exposed face only
1A	2 months	No rusting—primer appears 100% intact	3 years 4 months	4 pin-point rust spots.
1B	,,	,, ,, ,,	,,	1 corrosion blister under $\frac{1}{8}$in dia.
1C	,,	,, ,, ,,	,,	3 rust spots under $\frac{1}{8}$in dia. 1 rust spot $\frac{1}{4}$in dia.
1D	,,	,, ,, ,,	,,	20 rust spots under $\frac{1}{8}$in dia.
1A	6 months	One band of rust = 10% of area.	3 years	4 pin-point rust stains.
1B	,,	No rusting—primer appears 100% intact	,,	12 pin-point rust stains.
1C	,,	,, ,, ,,	,,	1 corrosion blister $\frac{1}{8}$in dia. 3 pin-point rust stains.
1D	,,	,, ,, ,,	,,	1 rust spot approximately $\frac{1}{2}$in dia. 9 pin-point rust stains.
1A	12 months	Rusting from sides, about 30% of primer left intact in centre.	2 years	5 pin-point rust stains.
1B	,,	Overall rusting, less than 10% of primer left.	,,	5 pin-point rust stains.
1C	,,	Approximately 30% rusting.	,,	14 corrosion blisters under $\frac{1}{8}$in dia.
1D	,,	Approximately 20% rusting.	,,	12 corrosion blisters under $\frac{1}{8}$in dia. Small group of corrosion blisters approximately $\frac{3}{8}$in dia. adjacent to unpainted end of section.

Table 9

GEGB 4 (Epoxy/isocyanate 92.5% zinc content on dry film weight)
followed by BS.3698 Type A calcium plumbate, u/c and gloss finishing coats

Ref. No.	Exposure before overpaint	Condition of holding primer when overpainted	Exposure of finish system	Condition of painted section November 1967 Horizontally exposed face only
4A	2 months	No rusting—primer appears 100% intact	3 years 4 months	No rusting
4B	”	” ” ”	”	”
4C	”	” ” ”	”	”
4D	”	” ” ”	”	”
4A	6 months	No rusting—primer appears 100% intact	3 years	No rusting
4B	”	” ” ”	”	”
4C	”	” ” ”	”	”
4D	”	” ” ”	”	”
4A	12 months	No rusting—primer appears 100% intact	2 years	No rusting
4B	”	” ” ”	”	”
4C	”	” ” ”	”	”
4D	”	” ” ”	”	”

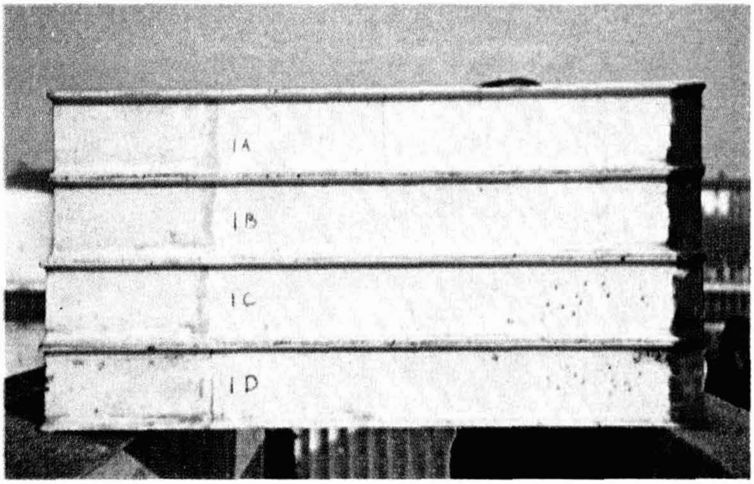
Table 10

CEGB 6 (Epoxy/polyamide reduced zinc. 74% zinc content on dry film weight) followed by BS.3698 Type A calcium plumbate, u/c and gloss finishing coats

Ref. No.	Exposure before overpaint	Condition of holding primer when overpainted	Exposure of finish system	Condition of painted section November 1967 Horizontally exposed face only
6A	2 months	No rusting—primer appears 100% intact	3 years 4 months	6 small areas (approximately 1in dia.) of rust staining.
6B	,,	,, ,, ,,	,,	Areas of rust staining covering approximately 100% of area.
6C	,,	,, ,, ,,	,,	18 pin-point rust stains.
6D	,,	,, ,, ,,	,,	No rusting.
6A	6 months	No rusting—primer appears 100% intact	3 years	No rusting.
6B	,,	Light rusting. Appears to be about 80% of the primer remaining.	,,	16 pin-point rust stains.
6C	,,	No rusting—primer appears 100% intact	,,	10 pin-point rust stains.
6D	,,	,, ,, ,,	,,	1 area rust staining approximately 2in × 2in.
6A	12 months	Good condition—small area of rust staining close to webs.	2 years	8 pin-point rust stains.
6B	,,	Light rusting spreading 2 to 3in from each side. Primer in centre with patchy appearance.	,,	4 corrosion blisters approximately $\frac{1}{2}$in dia. 3 corrosion blisters approximately $\frac{3}{8}$in dia. 66 corrosion blisters under $\frac{1}{8}$in dia. Corrosion mainly in centre area of section.
6C	,,	An overall rust staining mainly from corroded sides but primer appears to be at least 75% intact.	,,	1 corrosion blister approximately $\frac{3}{4}$in dia. 2 corrosion blisters $\frac{3}{8}$in dia. 7 corrosion blisters $\frac{1}{4}$in dia. 20 corrosion blisters under $\frac{1}{8}$in dia.
6D	,,	Good condition except for a band of rusting approximately 2in wide, close to side 3.	,,	No rusting.

The results are very good compared with the weathered and wire brushed sections. Figs. 6, 7, 8 and 9, show CEGB 1, 4, 6 and 7 respectively. The breakdown at the opposite end to the unpainted end on primers 4 and 6 is due to loss of adhesion. However, on certain of the painted sections, notably 7C and 6B last painting, and to a lesser extent 7A and 6C, there are the beginnings of complete breakdown of the paint systems. On the others there are isolated corrosion blisters. It is difficult to relate this breakdown with the apparent state of the primer when overpainted.

In several instances, the holding primer appeared to be in sound condition when overpainted and yet isolated corrosion blistering has occurred. In other instances there are banded areas of definite corrosion and these are not reflected in the finishing systems. The worst result occurs when about 50 to 60 per cent of the surface is rusting.



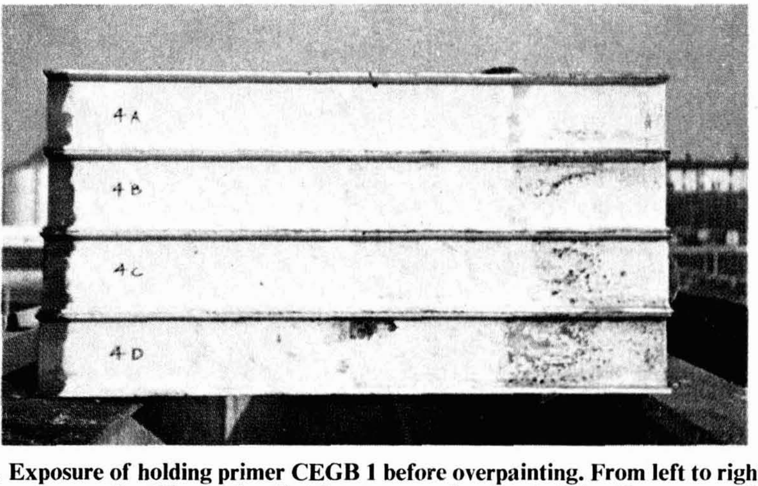
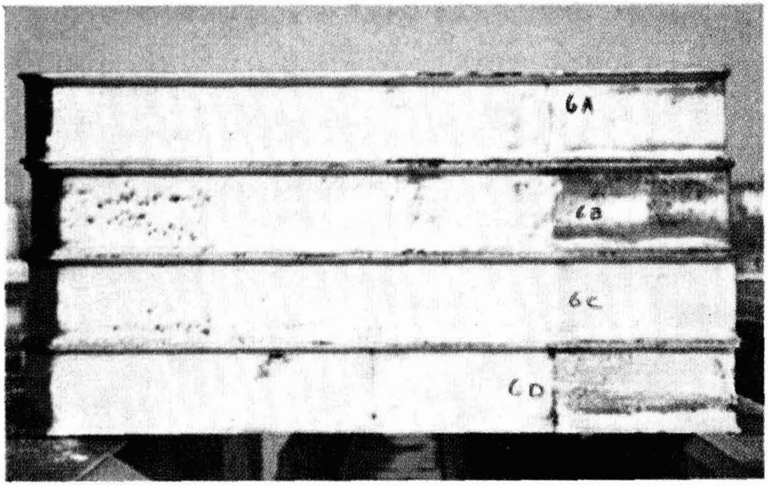


Fig. 6 (top). Exposure of holding primer CEGB 1 before overpainting. From left to right: one day, two months, six months, 12 months. Total exposure of painted girder three years six months

Fig. 7 (bottom). Exposure of holding primer CEGB 4 before overpainting. From left to right: 12 months, six months, two months, one day. Total exposure of girder three years six months



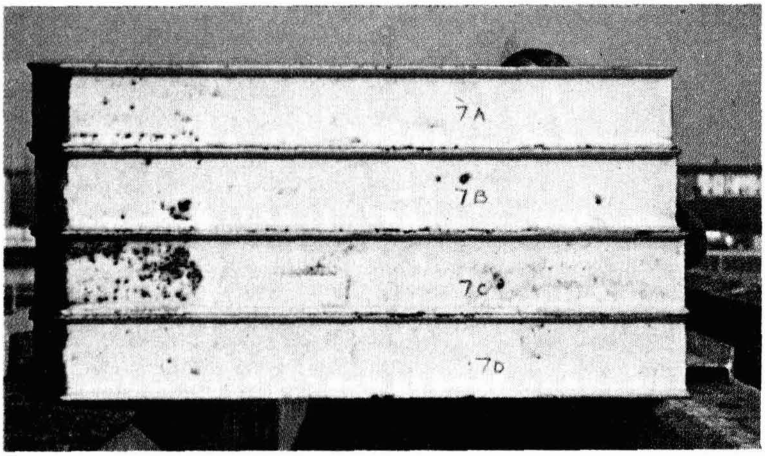


Fig. 8 (top). Exposure of holding primer CEGB 6 before overpainting. From left to right: 12 months, six months, two months, one day. Total exposure of girder three years six months

Fig. 9 (bottom). Exposure of holding primer CEGB 7 before overpainting. From left to right: 12 months, six months, two months, one day. Total exposure of girder three years six months

Follow-on primer

The selection of a suitable follow-on primer is important, and further exposure work is in progress with a number of holding primers. These were exposed for one month and then overcoated with a wide range of follow-on primers and finished in undercoat and gloss. To date the painted sections have only been exposed for nine months and visible effects have been slight, but to some degree it is possible to place the follow-on primers in order of merit, also taking into consideration the results obtained on the girder trials.

Table 12 shows the results so far on the zinc rich primer CEGB 4. The blistering of the calcium plumbate primers is significant in terms of the known adhesion failure in the original trials. It may be that some of the red lead con-

Table 11

CEGB 7 (One pack etch primer)

Followed by BS.2523 Type B red lead, u/c and gloss finishing coats

Ref. No.	Exposure before overpaint	Condition of holding primer when overpainted	Exposure of finish system	Condition of painted section November 1967 Horizontally exposed face only
7A	2 months	No rusting—primer appears 100% intact	3 years 4 months	17 pin-point rust stains.
7B	,,	,, ,, ,,	,,	Pin-point rust staining over area approx. 6in × $1\frac{1}{2}$in. 1 corrosion blister 1in dia., 1 corrosion blister $\frac{1}{4}$in dia.
7C	,,	,, ,, ,,	,,	Approx. 30 rust spots under $\frac{1}{8}$in dia. 1 corrosion blister approx. 1in dia. situated in centre at right hand end.
7D	,,	,, ,, ,,	,,	4 rust spots under $\frac{1}{8}$in dia.
7A	6 months	No rusting—primer appears 100% intact	3 years	6 rust stains approx. $\frac{1}{4}$in dia. small patch of rust staining close to web.
7B	,,	Good except for two rust bands close to webs.	,,	4 rust spots under $\frac{1}{8}$in dia.
7C	,,	Very good.	,,	7 rust spots under $\frac{1}{8}$in dia. Slight rusting over the embossed name of steel supplier.
7D	,,	,,	,,	6 rust spots under $\frac{1}{8}$in dia.
7A	12 months	Primer appears in good condition.	2 years	A line of 11 corrosion blisters approx. $\frac{3}{8}$in dia. approx. $\frac{3}{4}$in from side 2. 3 corrosion blisters $\frac{3}{8}$in dia., 6 corrosion blisters under $\frac{1}{8}$in dia.
7B	,,	Primer appears to be intact except for two bands of light rusting close to edges.	,,	1 corrosion blister approx. $1\frac{1}{2}$in dia. 1 corrosion blister approx. $\frac{1}{2}$in dia., 2 approx. $\frac{3}{8}$in dia., 3 under $\frac{1}{8}$in dia.
7C	,,	Overall light rusting, appears to be about 40% of primer remaining.	,,	Corrosion blistering over 25 % of surface.
7D	,,	Primer appears in good condition.	,,	3 rust spots approx. $\frac{3}{8}$in dia., 2 under $\frac{1}{8}$in dia.

taining primers will be satisfactory for adhesion. However, it is known from the girder trials that zinc chromate is satisfactory, although in view of its poorer corrosion resistance it would probably be desirable to apply two coats.

Table 12
CEGB 4 (Epoxy/isocyanate 92.5% zinc content on dry film weight)
9 months' exposure of painted section

Follow on primer	Assessment painted section	
	"Adhesion"	"Corrosion"
red lead type B	satisfactory	none
zinc chromate	"	"
quick drying red lead ..	"	"
red lead/zinc phosphate ..	"	"
red lead/graphite	"	"
red lead/red oxide	slight flaking at edges	rust creep from edges
calcium plumbate type A ..	overall pin-point blistering	" "
calcium plumbate type B ..	shallow blistering	5 rust spots

Table 13 shows the results so far on the extended zinc primer CEGB 6. The adhesion problems associated with a reduced zinc rich primer are not so severe as those of a true zinc rich paint, but obviously calcium plumbate is suspect. Zinc chromate would be satisfactory for adhesion but, because in this case there is less contribution to overall corrosion resistance from the holding primer, it would seem important to use a red lead primer which will, in all probability, be satisfactory for adhesion and have better anti-corrosive properties. For a severe environment two coats are suggested.

Table 13
CEGB 6 (Epoxy/polyamide reduced zinc 74% metal)
9 months' exposure of painted section

Follow on Primer	Assessment painted section	
	"Adhesion"	"Corrosion"
red lead type B	satisfactory	none
red lead/red oxide	"	"
red lead/zinc phosphate ..	"	3 rust spots
red lead/graphite	severe flaking at edges	none
quick drying red lead ..	satisfactory	rust at edges
calcium plumbate type A ..	shallow blistering	none
calcium plumbate type B ..	" "	"
zinc chromate	satisfactory	slight rust creep from edges

Table 14 shows the results so far on the etch primer CEGB 7. Adhesion does not appear to present any problems whichever follow-on primer is used. However, again due to the slightly lower anti-corrosive properties of the etch primers as compared with the zinc rich, the best possible anti-corrosive follow-on primer should be used. Again for a severe environment two coats are recommended.

Table 14
CEGB 7 (Etch primer)
9 months' exposure of painted sections

Follow on primer	Assessment painted sections	
	"Adhesion"	"Corrosion"
red lead type B	satisfactory	none
calcium plumbate type B ..	,,	,,
red lead/zinc phosphate ..	,,	slight rust creep from edges
red lead/red oxide	,,	slight rust creep from edges—one rust spot
zinc chromate	,,	rust creep from edges
quick drying red lead ..	,,	8 rust spots
red lead/graphite	,,	rust creep from edges—10 rust spots

Conclusions

It has been established that CEGB 7 is outstanding as an etch primer type and modifications with pigments other than zinc chromate have little to offer in terms of improved performance. Application viscosity is important. The performance can be considerably improved by double coating. The work on the so-called pre-operational coatings has shown the importance of very careful formulation of one pack etch primers due to the complexity of the reactions in the can.

It is important to ensure that a minimum coating thickness of 0.5×10^{-3}in is obtained with CEGB 7 particularly over peaks of blast cleaned surfaces. In this respect the variations in surface roughness obtained in practice are shown and emphasise the need for more careful control of blast cleaning processes.

The further work on zinc rich primers has indicated the possibilities of obtaining improved performance by modification with micaceous iron oxide pigment and shown the value of certain binder media such as epoxy/isocyanate. The overcoating of new holding primers containing zinc has caused cracking and flaking of the paint system when calcium plumbate is used but not with zinc chromate. The cracking is particularly severe with the higher zinc content primers under stringent weathering conditions.

The overcoating of weathered holding primers has been satisfactory except where the primer is partially broken down and then severe localised corrosion blistering can cause rapid disruption of the finishing system. The result is worse than if the holding primer had completely deteriorated. The situation, therefore, is very similar to that experienced with a millscaled surface, partial breakdown of the primer is the most dangerous circumstance. Although it must be emphasised that, like a semi-millscaled surface, better barrier protection in the finishing system, as for example using micaceous iron oxide as an extra undercoat, would probably go a long way to minimising the effect. It is unfortunate that there is a tendency to pare down the finishing systems applied to blast cleaned and treated steelwork to try and offset the higher initial expense of the cleaning process.

Acknowledgments

The authors wish to thank the Director of the South Eastern Region CEGB and the Directors of the Wall Paper Manufacturers Limited respectively for their permission to publish this paper.

[*Received 26 April 1968*

References

1. Bayliss, D. A., and Wall, D. C., *JOCCA*, 1966, **49**, 9.
2. Truelove, R. K., *JOCCA*, 1966, **49**, 57.

J. Oil Col.Chem. Assoc. 1968, 51, 816-823

The laboratory preparation and properties of alkyd resin films

By E. M. Kinsella and J. E. O. Mayne

Department of Metallurgy, University of Cambridge

Summary

The distribution of naphthenate driers in films formed from a pentaerythritol alkyd and a tung oil phenolic varnish has been examined by means of an X-ray scanning microanalyser. The driers were not readily dispersed and it is suggested that this was due to micelle formation.

Two factors affected the properties of films cast under laboratory conditions: (a) Ventilation which removed low molecular weight degradation products with consequent strengthening of the films, (b) Maturing the varnish, which appeared to bring about a modification of the structure of the films.

La préparation en laboratoire et les caractéristiques des feuils de résines alkydes

Résumé

On a déterminé la répartition des siccatifs naphténiques dans des feuils à partir d'une alkyde pentaérythritique et d'un vernis à huile de tung/résine formophénolique, au moyens d'un microanalyseur à balayage des rayons-X. On a trouvé que les siccatifs n'étaient pas facilement dispersés, à cause, on suggère, de la formation de micelles.

Les deux facteurs suivants ont une influence sur les propriétés des feuils coulés sous les conditions de laboratoire:

(a) L'aérage qui enlevait les produits de dégradation à faible poids moléculaire, et aussi par conséquent rendait des feuils plus solides.

(b) Le mûrissage du vernis qui semblait de provoquer une modification de la structure des feuils.

Herstellung im Laboratorium und Eigenschaften von Alkydharzfilmen

Zusammenfassung

Die Verteilung von Naphthenat-Trockenstoffen in aus einem Pentaerythritol-Alkydharz und einem Holzöl-Phenolharzlack gebildeten Film wurde mittels eines Röntgen-Abtast-Mikroanalysators untersucht. Die Trockenstoffe waren nicht gut verteilt. Als Ursache wird Micellenbildung vorgeschlagen.

Die Eigenschaften von im Laboratorium aufgegossenen Filmen wurden von zwei Faktoren beeinflusst:

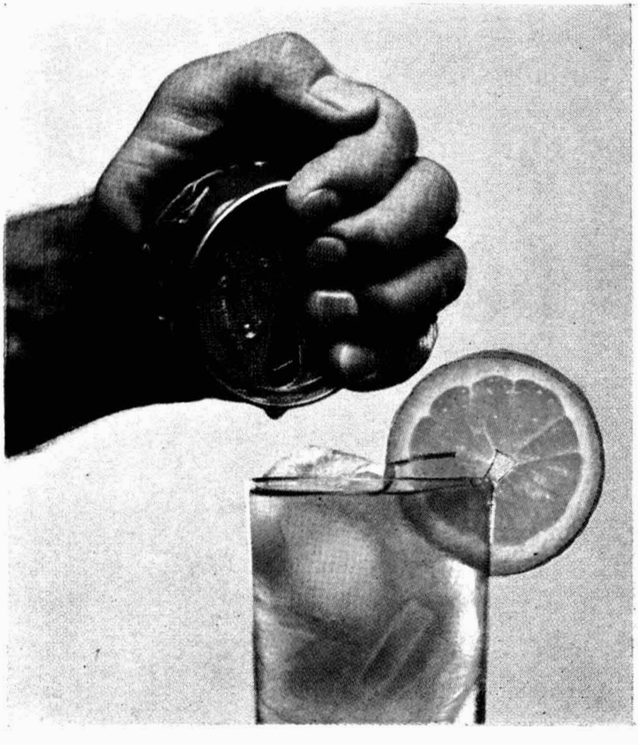
(a) Ventilation, welche die niedrig-molekularen Abbauprodukte mit konsequenter Filmverstärkung entfernte,

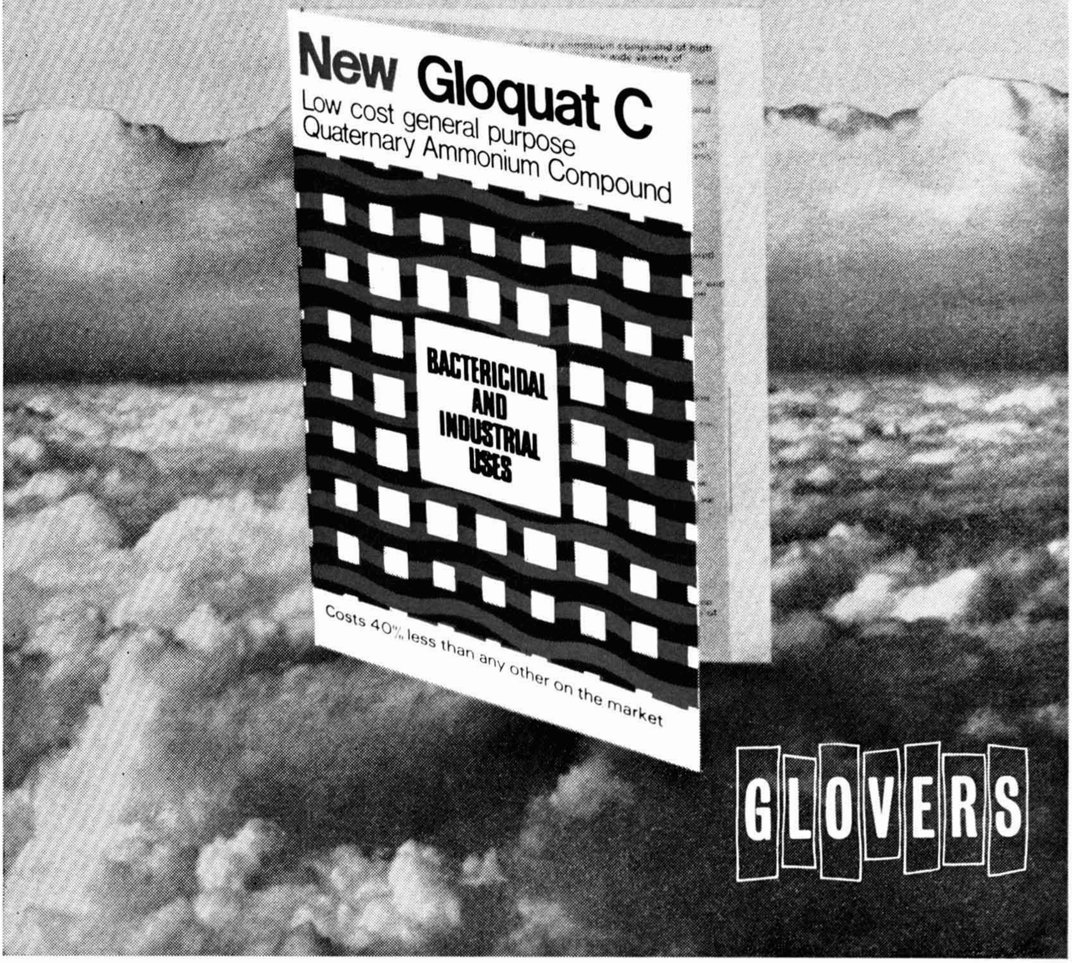
(b) Reifung des Lackes, die scheinbar eine Modifizierung der Filmstruktur hervorrief.

Лабораторное изготовление и свойства алкидно-смольных пленок

Резюме

Анализируется, при помощи рентгеновского обзорного микроанализатора, распределение нафтенатных сушителей в пленках образованных из пентаэритритного алкида и фенольного лака на основе тунгового масла. Сушители не легко диспергировались и предполагается что это обусловлено образованием мицелл




New Gloquat C
Low cost general purpose Quaternary Ammonium Compound
BACTERICIDAL AND INDUSTRIAL USES
Costs 40% less than any other on the market
GLOVERS

Два фактора оказывали влияние на качества пленок отлитых в лабораторных условиях: (а) вентиляция, которая устраняла продукты деградации низкого молекулярного веса, в результате чего пленки упрочнялись и (б) старение лака, которое повидимому вызывало изменение в структуре пленок.

In the course of work carried out in these laboratories on the mechanism of the protective action of polymer films, it became necessary to prepare detached films under standard conditions, in order that their electrochemical properties should be as reproducible as possible. The method by which films were prepared initially has been described[1]. A more detailed examination has now been made of several factors which influence the properties of dried varnish films. This paper is concerned mainly with the process of film formation in the case of a long oil pentaerythritol alkyd varnish, but some of the observations have been extended to a tung oil phenolformaldehyde varnish.

Materials

The tung oil phenolformaldehyde varnish and the long oil pentaerythritol alkyd varnish were kindly supplied by the Paint Research Station.

Lead, cobalt and manganese naphthenates, dispersed in white spirit, were used with the tung oil phenolformaldehyde varnish but only lead and cobalt naphthenates were added to the alkyd varnish.

In order to prepare films, the resin solutions, with or without the addition of driers, were cast on clean glass plates, 8in x 4in, by means of spreader bars. The casting was done in a glove box fitted with an extractor fan, which changed the air in the box about once an hour. The films were allowed to dry in the glove box for 48 hours, with or without the fan running; no attempt was made to control the humidity in the box and the temperature did not vary by more than a few degrees. The films were then transferred to an oven maintained at 65°C for a further 48 hours and then cooled and soaked in water in order to permit their removal from the glass.

The concentration and distribution of driers in films were investigated using a Cambridge X-ray scanning microanalyser. A circle of film, 0.75in diameter, was cut and fitted into a brass holder. Carbon was evaporated on to the surface of the film in order to make it conducting and a layer of colloidal graphite was painted round the edge to ensure good electrical contact. A 15 kilovolt beam gave a penetration of about 500 Å into the film. The electron scanning beam is 1μ in diameter and may be traversed electronically to scan an area of $400\mu^2$; in these experiments areas of $100\mu^2$ were examined. In addition, the specimens may be rotated mechanically and traversed orthogonally. Nine measurements were made on each specimen in a cruciform pattern.

Due to the unevenness of the film surface, it was not possible to obtain reproducible results by scanning at the correct Bragg angle for each particular metal. Accordingly, at each position on the cruciform pattern, the Geiger counter was moved a few minutes either side of the Bragg angle and the intensity of the emitted radiation plotted against the angle of incidence. The maximum value was taken to be the correct one. This procedure was repeated for each of the drier metals. Background radiation from the film was always negligible. Readings were corrected to weight percent using known standards.

Tensile tests were carried out using an Instron Tensometer. A strain rate of 0.1cm/min^{-1} was used with a chart speed of 1.0cm/min^{-1}.

The concentration of carboxyl groups in the films was estimated by infra red spectroscopy using a Perkin-Elmer "Infracord" spectrometer. Details are given in the Appendix.

Results

The liquid varnish

It was observed that, when the normal amount of driers was added to the pentaerythritol alkyd varnish, it became green after about one hour. This colour gradually disappeared on storage for a month, at room temperature, in a sealed bottle. No changes in the infra-red spectrum of the resin during this period of maturing were observed. It is proposed to call the freshly mixed resin and driers "green resin" and the material stored for one month "mature resin."

The colour changes in the resin solution were probably associated with changes in the valency state of cobalt due to dissolved oxygen. It was found that blowing oxygen into the amber resin rapidly turned it green again; furthermore, these colour changes were not observed with the tung oil phenol formaldehyde varnish. This behaviour of the varnish based on tung oil may have been due to the conjugated dienes in the tung oil, which formed stable peroxides with the dissolved oxygen.

The distribution of driers

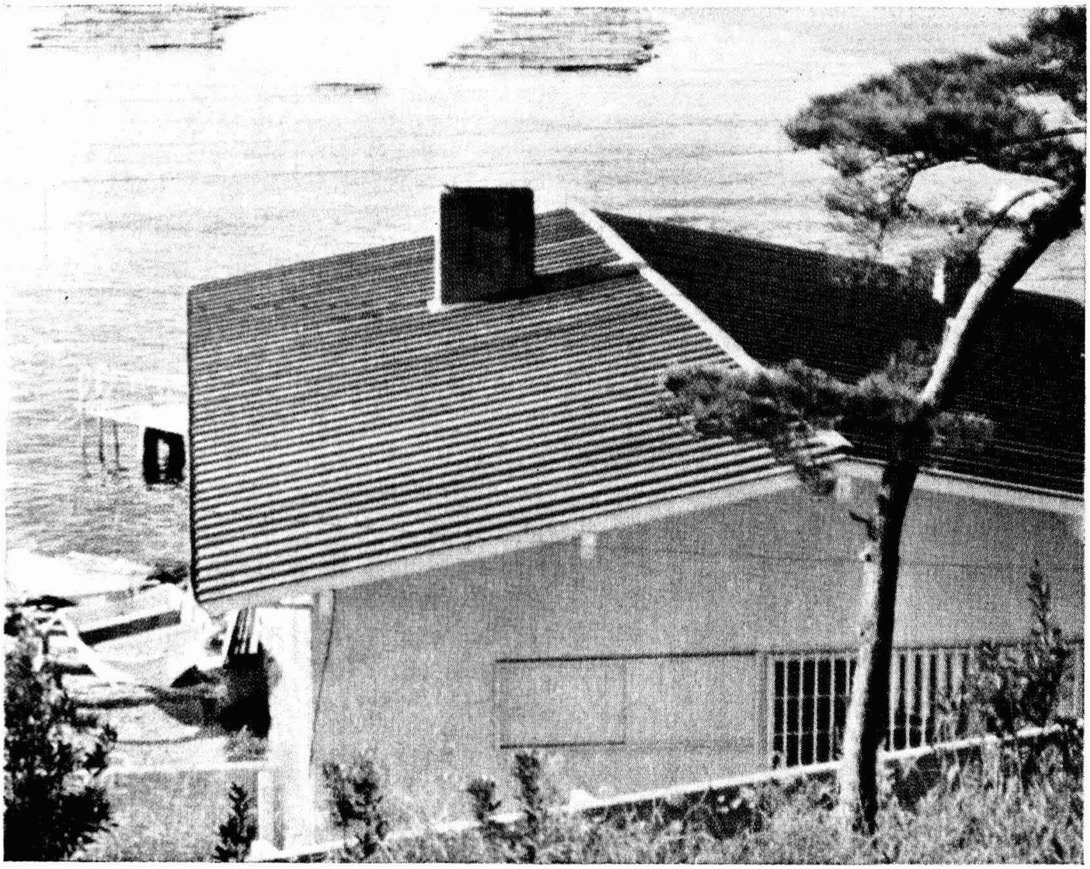
Since litharge is frequently used as a catalyst in the manufacture of alkyd resins, drier-free films of the alkyd resin were examined in the X-ray scanning micro-analyser. No lead was detected.

Films containing the normal amount of driers were cast from the pentaerythritol alkyd and the tung oil phenolformaldehyde varnishes, which were stirred continuously after the addition of the driers for half an hour. The distribution of lead, cobalt and manganese was then determined and is shown in Table 1.

Table 1

The distribution of driers in varnish films

Spot	Pentaerythritol alkyd				Tung oil phenolformaldehyde					
	% Lead		% Cobalt		% Lead		% Cobalt		% Manganese	
1	0.00	0.30	0.00	0.05	0.25	0.40	0.04	0.04	0.02	0.00
2	0.00	0.30	0.00	0.06	0.00	0.25	0.02	0.03	0.00	0.04
3	0.00	0.00	0.00	0.00	0.25	0.40	0.00	0.03	0.00	0.00
4	0.00	0.20	0.00	0.05	0.00	0.25	0.02	0.00	0.00	0.04
5	0.00	0.30	0.00	0.05	0.00	0.20	0.04	0.00	0.00	0.00
6	0.30	0.00	0.04	0.00	0.00	0.40	0.02	0.04	0.00	0.02
7	0.30	0.30	0.05	0.06	0.00	0.00	0.03	0.04	0.04	0.00
8	0.00	0.30	0.00	0.05	0.00	0.25	0.00	0.00	0.02	0.00
9	0.00	0.30	0.00	0.05	0.00	0.25	0.00	0.00	0.04	0.02




TiO₂
PIGMENT

Each determination was carried out on duplicate specimens of film; furthermore, the distribution was examined on both sides of the film and no difference could be detected. It can be seen that the distribution of the metal was not uniform so that two further determinations were made. The first was made after the alkyd varnish had been mixed intermittently for four days, and then another determination after this varnish had been stored for several months.

The results obtained are shown in Table 2. The standard deviation of the determinations obtained after only half an hour is significantly higher than those obtained after longer periods, showing that dispersion of the driers in the medium was obtained only after some days. In order to see if this were associated with micelle formation, two further experiments were carried out. In the first the drier was heated with the alkyd resin for a few minutes at 100°C; in the second, the alkyd resin was mixed with an alcoholic solution of cobalt nitrate for half an hour and from Table 2 it can be seen that in both cases good dispersion of the metal was achieved.

Table 2

Alteration with time of the distribution of driers in alkyd varnish films as shown by determinations, in duplicate, at 9 sites

Treatment of varnish	Lead		Cobalt	
	Mean metal content %	Standard deviation	Mean metal content %	Standard deviation
Rolled for ½hr	0.14	0.146	0.026	0.026
Rolled intermittently 4 days	0.53	0.082	0.083	0.018
Stored several months ..	0.52	0.085	0.081	0.014
Heated	0.048	0.069	0.026	0.009
Cobalt nitrate			0.060	0.008

The mechanical properties of films

An alkyd varnish, free from driers, formed coherent films on exposing to air and subsequent curing. These films were of low modulus and ultimate tensile strength, Fig. 1. and contained no free COOH groups detectable by infra-red analysis: the limit of detection is probably about 0.2 per cent. The infra-red spectrum was typical of alkyd films[2]. Presumably, in the case of films free from driers, comparatively little oxidation of the unsaturated acids occurred during the drying process. It was found that ventilation during drying had no effect on the mechanical properties of the films.

In the presence of driers, films prepared from both the green and the mature resin were appreciably different in their load/extension curves and were affected by ventilation, Fig. 1. Moreover, no free COOH groups could be detected by infra-red analysis in the ventilated films; whereas, films prepared from both the green and mature resins without ventilation contained about 2.5 per cent COOH groups.

The behaviour of films cast from the tung oil phenolformaldehyde varnish was also examined; the results obtained are shown in Fig. 2. Again, no free COOH groups could be detected in the ventilated films, but the films cast without ventilation were found to contain 1.8 per cent COOH.

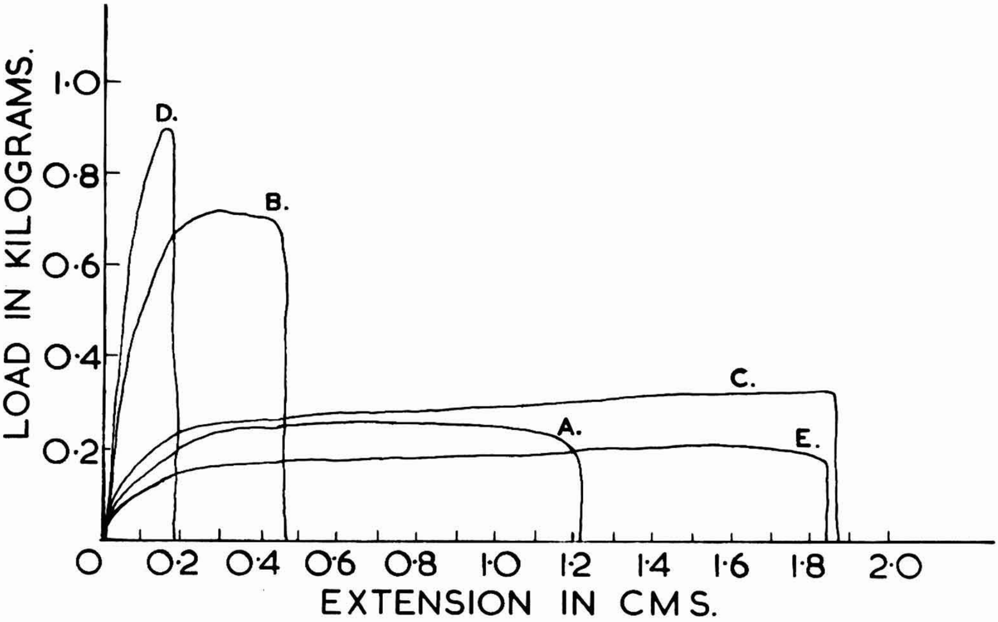


Fig. 1. Tensile behaviour of pentaerythritol alkyd varnish films

A. Cast from green varnish
B. Cast from green varnish, ventilated
C. Cast from mature varnish
D. Cast from mature varnish, ventilated
E. Cast from varnish free from driers

Discussion

An X-ray scanning microanalyser has indicated that, in both a pentaerythritol alkyd and a tung oil phenolformaldehyde varnish, metallic naphthenates are not readily dispersed and work with the alkyd varnish has suggested that this may be due to micelle formation, since improved dispersion was obtained when the mixture was heated and when a metallic salt, which would not readily form micelles, was used.

In the absence of driers, the varnishes examined appeared to dry by solvent evaporation, but in their presence there appeared to be two independent factors affecting the mechanical properties of the cast films. Ventilation probably acted merely by removing low molecular weight degradation products, which acted as a solvent, or plasticiser, and the film was consequently strengthened. Maturing, on the other hand, appeared to act by modification of the structure of the resin.

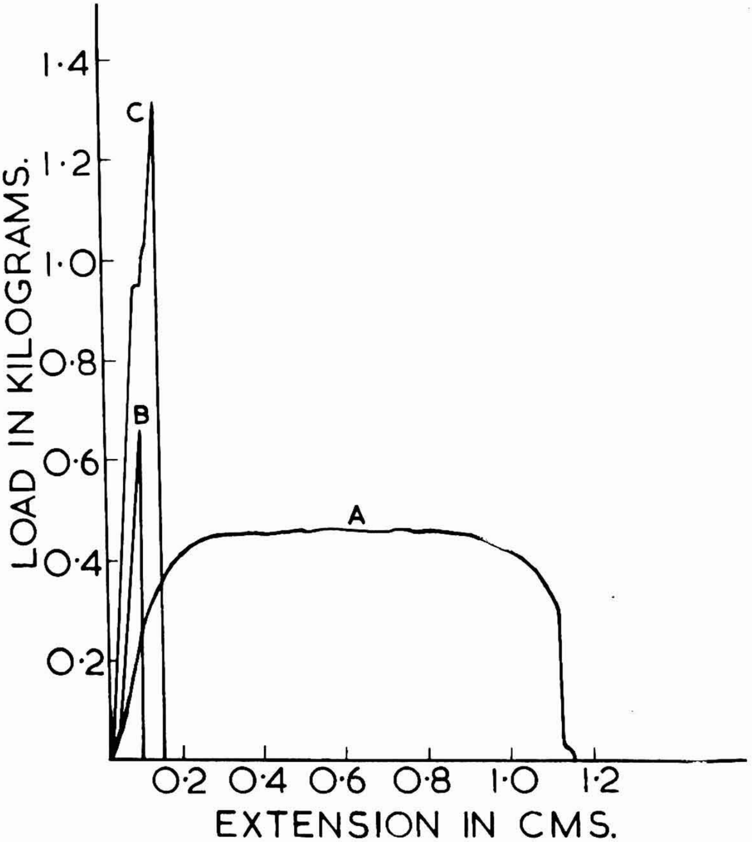


Fig. 2. Tensile behaviour of tung oil phenolformaldehyde varnish films

A. Cast from varnish free from driers
B. Cast from varnish, driers freshly added, ventilated
C. Cast from sample B, which had been stored one month, ventilated

The necessity of maturing varnishes before testing is well recognised, but less attention has been paid in the past to the importance of good ventilation during the preparation of paint films under laboratory conditions.

Acknowledgment

The authors wish to thank Dr U. R. Evans for advice, and the Ministry of Technology for encouragement and support.

[*Received 13 December 1967*

Appendix

The estimation of carboxyl groups from infra-red spectra

It is possible to estimate the amount of free acid, as formic, in a varnish film using infra-red spectroscopy.

The spectrum of an alkyd film, prepared as described before, is shown in Fig. 3, in which the carbonyl groups of acids and esters, at 1,740cm^{-1}, are not resolved. The sharp doublet at 1,600cm^{-1} is an overtone of the *o*-disubstituted benzene rings in the phthalate residue, whose fundamental lies at 700—750cm^{-1}.

This alkyd spectrum is typical[2], and does not depend on the presence of driers, ventilation, or maturing of the resin.

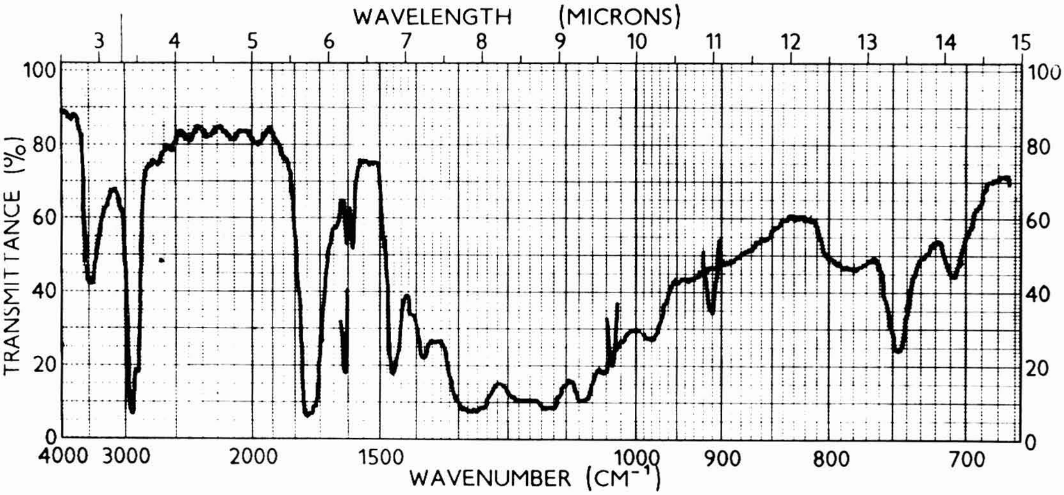
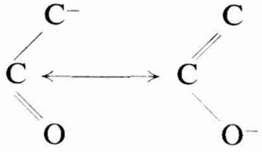


Fig. 3. Infra-red spectrum of an alkyd film in the hydrogen form

When a film containing free acid is equilibrated with a sodium or potassium solution of rM 7* or higher, for five minutes at 65°C, the infra-red spectrum changes, as in Fig. 4. A new band is superimposed on the doublet at 1,600cm^{-1} due to carboxylate groups having the structure.



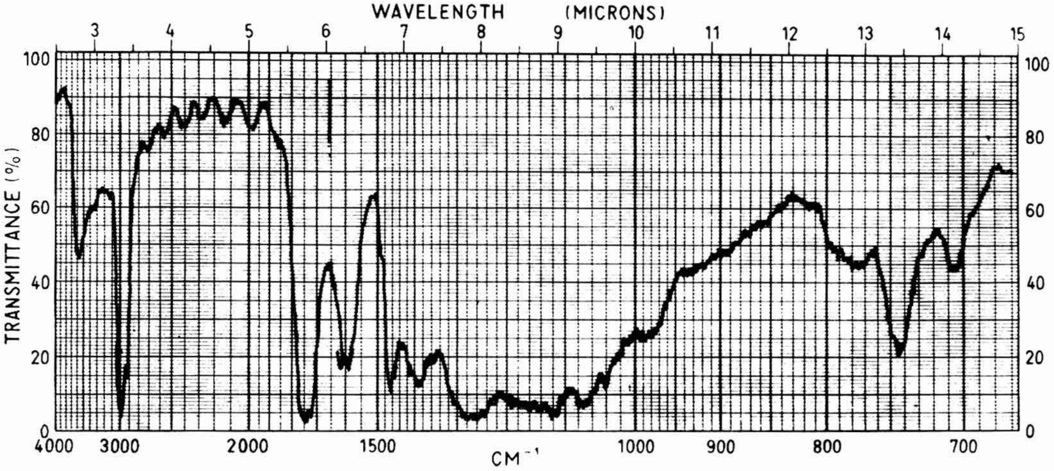


Fig. 4. Infra-red spectrum of an alkyd film in the sodium form

---

*The term rM is defined as $\log \frac{\text{activity of metal ions}}{\text{activity of hydrogen ions}}$

The concentration of carboxyl groups in the film may be estimated by comparing the anion peak height, allowing for the original doublet, to that of a similar peak in the spectrum of sodium acetate. A suitable disc may be made by dissolving one part sodium acetate and one hundred parts potassium bromide (by weight) in water. An appropriate amount of the solution may then be "flash evaporated" on an aluminium block at about 120°C, giving a very fine powder consisting of 1 per cent sodium acetate homogenously dispersed in potassium bromide. This powder may then be compressed under vacuum in the normal way to give a standard disc, whose infra-red spectrum may be recorded by transmission. The carboxylate peak height is then measured, and the thicknesses of both film and disc. Then:

$$\frac{\text{concentration in film}}{\text{concentration in disc}} = \frac{\text{peak height in film}}{\text{peak height in disc}} \times \frac{\text{thickness of disc}}{\text{thickness of film}}$$

The concentration of carboxylate groups in the film is then the only unknown, and may be calculated.

References

1. Cherry, B. W., and Mayne, J. E. O., Proc. 1st Int. Congress on Sci. of Met. Corrosion, London, Butterworths, 1962, p. 539.
2. Chatfield, H. W., The Science of Surface Coatings, London, Ernest Benn Ltd., 1962, p. 560.

Next month's issue

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

"Physical testing of printing ink," *by C. C. Mill.*

"Durability of paint," *by T. R. Bullett.*

"Suitable tests to ensure the economic use of titanium dioxide in emulsion paints," *by F. Wagener.*

"The formulation of fungus resistant paints : Zinc oxide in latex paints," *by E. Hoffmann, C. J. Lancucki, G. F. Moss and A. Saracz.*

J. Oil Col. Chem. Assoc. 1968, 51, 824-826

Short Communication

The rapid vacuum stripping of solvents from paints

By D. R. Bush and M. Thompson*

London Transport Research Laboratory, 566 Chiswick High Road, London W4

Introduction

The analysis of the solvents of paints, adhesives etc. usually requires complete separation of the solvent from non-volatile matter. Methods based on steam-distillation are sometimes adequate for the separation of solvents which consist only of hydrocarbon fractions, but are unsuitable if the solvent contains compounds which are appreciably water-soluble, or if some constituents of the solvent fall outside a limited boiling range. The removal of the solvent under reduced pressure in an enclosed system is a more generally suitable technique but published methods are time consuming and require specially constructed glassware which is not readily recoverable[1]. Methods of paint sample preparation, including vacuum stripping, have been recently reviewed.[2]

The apparatus described in this paper provides a method for the rapid and complete separation of volatile matter from a wide variety of products. It can easily be constructed from standard glassware. It can be used an indefinite number of times, and is easily cleaned. It also has the advantage that the non-volatile residue is not subjected to high temperatures.

Apparatus

The lower, evacuable, part of the apparatus, which receives the sample, is made from standard glassware. The flask is a 250ml heavy-walled conical flask with a 24/29 socket. The condenser can easily be made by the modification of a Drechsel bottle head. A vacuum stopcock is sealed on to the side arm. A small glass thimble is fused to, and closes the bottom end of, the delivery tube. The thimble should be just small enough to pass through the socket, i.e. about 18mm in diameter, and about 30mm in length. The bottom of the thimble should come to rest about 10mm above the bottom of the flask.

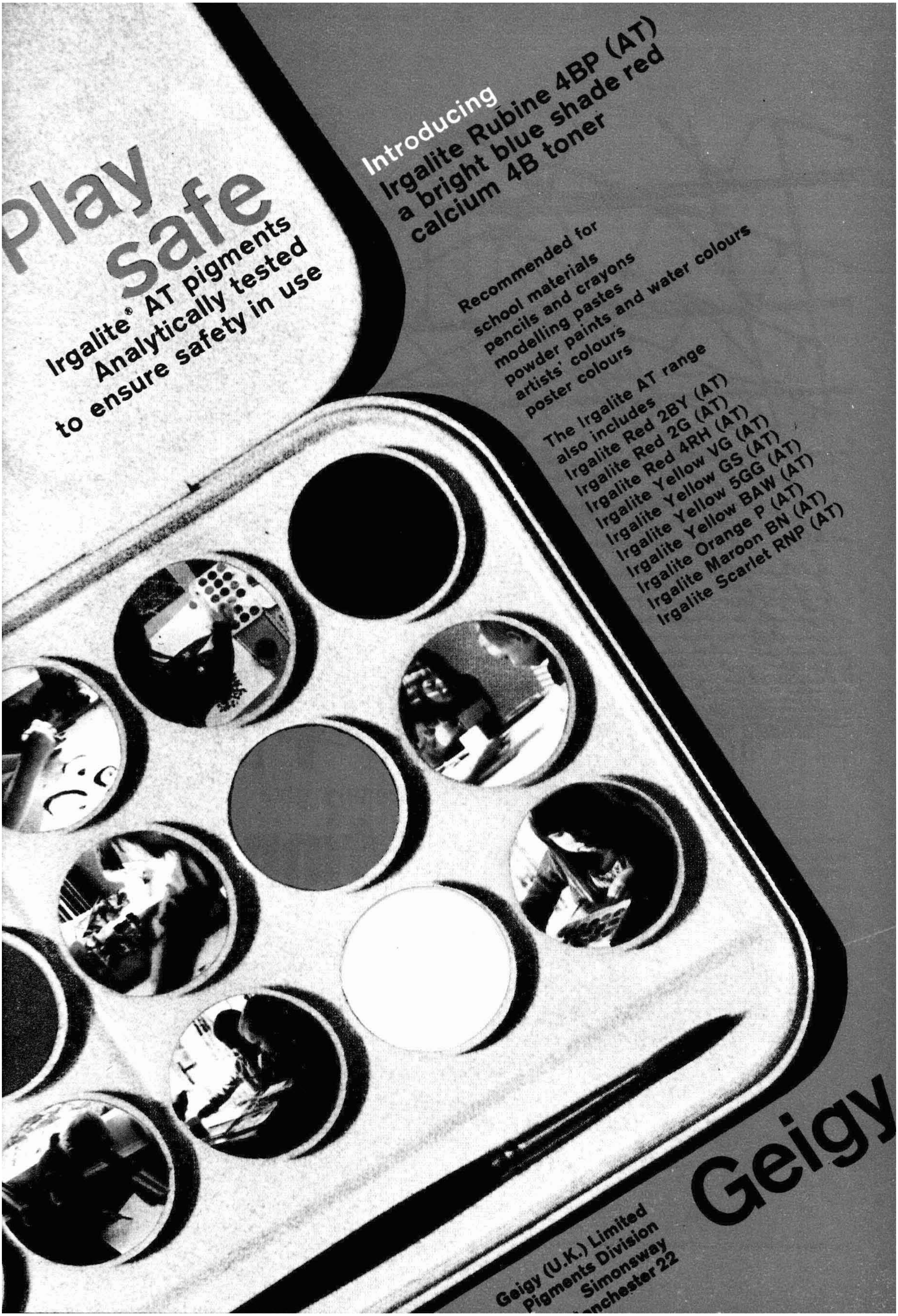
Precaution

Owing to the danger of implosion it is advisable to enclose the conical flask in metal gauze.

The upper part of the apparatus was devised to provide a continuous stream of cooling liquid for the condenser. It can be constructed from normally available polyethylene ware. Other materials might be suitable, and the dimensions are not critical.

---

*Present address: Metropolitan Police Laboratory, 2 Richbell Place, Holborn WC1.



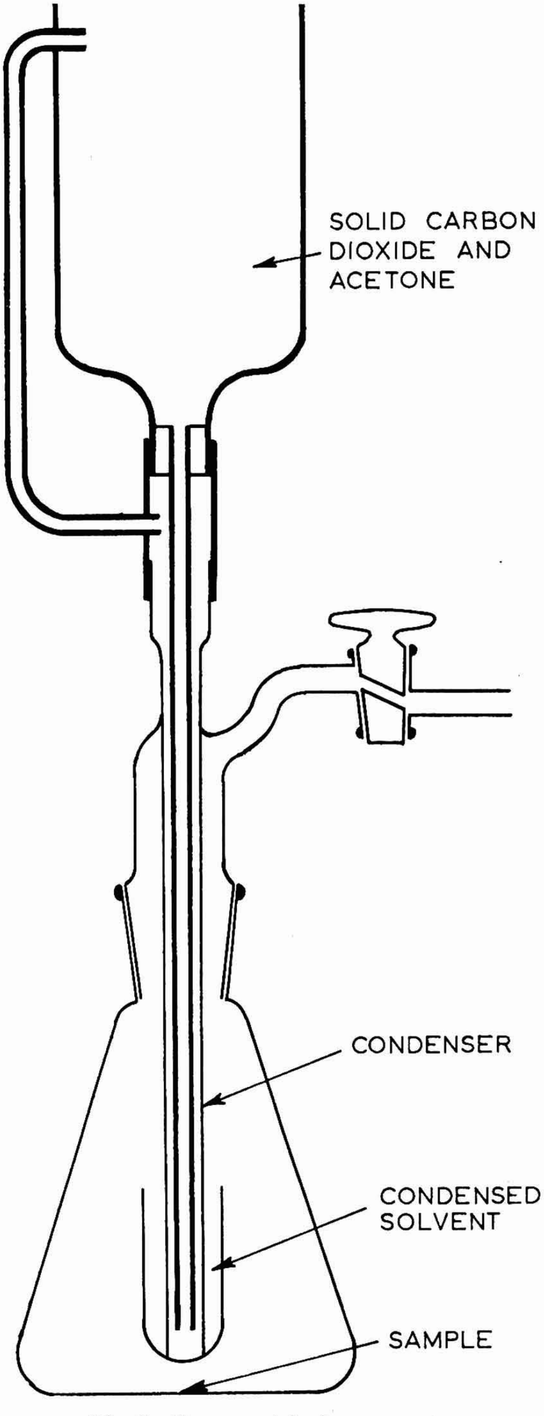


Fig. 1. Vacuum stripping apparatus
(Thick lines indicate parts made in polyethylene)

Operation

The paint, or other sample, is introduced on to the bottom of the conical flask, where it forms a thin layer. The condenser is placed in position and the bottom part of the flask is reduced to a low temperature in acetone/solid carbon dioxide mixture. The pressure inside the flask is reduced to about 0.1mm Hg. The flask is removed from the freezing mixture, and the coolant circulator is placed in position and half filled with acetone, to which solid carbon dioxide is then added. A rapid circulation of cooling liquid is set up. As the temperature of the sample rises to ambient, solvent begins to distil and collect in the thimble. A small amount of solvent condenses on the outside of the thimble, but drops back into the sample and redistils. Eventually all of the solvent is collected inside the thimble. Most paint samples require little external heating to complete the distillation, but it is usual to speed the final stages by placing the flask on the steam bath. The thimble and condenser should be removed and allowed to regain room temperature in an enclosed vessel, e.g. a 6in × 1in test tube with a 24/29 socket, to prevent condensation of atmospheric moisture in the separated solvent. Paint residues can be removed from the bottom of the flask by the prompt addition of dichloromethane, with boiling under reflux if necessary.

We have used the apparatus mainly for the treatment of paints, from which the solvent is usually completely removed in about an hour, but a wide range of other applications is possible.

Acknowledgment

We thank London Transport for permission to publish this note.

[*Received 24 June 1968*

References

1. Haslam, J., Jeffs, A. R., and Willis, H. A., *JOCCA*, 1962 **45,** 325.
2. Hundert, M. B., and Farnotsky, A., *J. Paint Tech.*, 1968, **40,** 33.

Correspondence

SIR,—During this time of celebration dare I remind you that everything in the oil and colour garden is not rosy?

A prime example is news ink. As manufactured today this is certainly not to be reckoned among the seven wonders of the world. This material appears to be simply a dispersion of carbon black in mineral oil. As such it may well rank in the forefront of progress in our present glorious technological age but I regret to say, Sir, it is not satisfactory.

Obviously the material will never dry and hence, having served the printers, it continues to blacken everything with which it comes in contact and especially the hands of all those foolish enough to read newspapers.

Yours very truly,
W. H. Stevens.

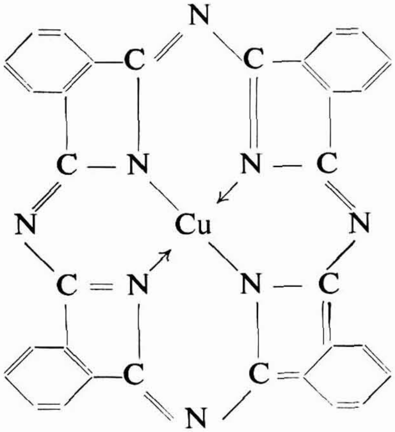
Park House,
Hawthorne Road,
Bromley, Kent.

Phthalocyanine pigments

By J. D. Stewart

Geigy (UK) Ltd., Paisley, Renfrewshire

Phthalocyanine pigments cover a range of shade from reddish blue to yellowish green and show outstanding strength, brightness, and stability to light and chemicals. The copper compound is by far the most widely used phthalocyanine, having a brilliant deep blue shade and being quite readily synthesised. It is used for colouring a wide variety of products—paints, printing inks, rubber, plastic goods and synthetic fibres.



Copper polychlorophthalocyanine is a brilliant bluish green pigment prepared by chlorination of copper phthalocyanine, and quite recently a range of polychlorobromo phthalocyanines has given brighter and yellower shades. The higher the bromine content the yellower is the shade.

Historical

In 1928 at the factory of Scottish Dyes Ltd., Grangemouth (now part of ICI) the formation of a blue impurity was noticed in a batch of phthalimide which had been prepared from phthalic anhydride and ammonia in a glass-lined iron kettle. The impurity had been formed when a portion of glass had flaked off, leaving the surface of iron exposed. The blue impurity was iron phthalocyanine. Phthalocyanine had almost certainly been prepared by Braun and Tcherliac at the South Metropolitan Gas Company in London (1907) and by de Diesbach and von der Weid at Fribourg University (1927), but these workers did not investigate the compounds.

Preparation

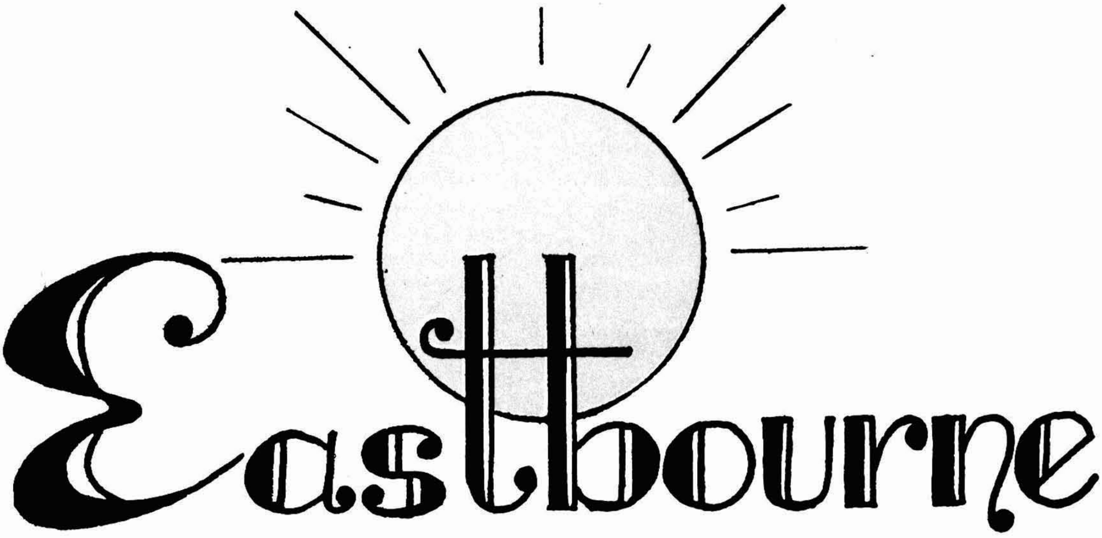
Copper phthalocyanine is prepared commercially by two methods. The more widely used is the reaction of phthalic anhydride with cupric chloride and urea

OIL & COLOUR CHEMISTS' ASSOCIATION

BIENNIAL CONFERENCE

FILM FORMATION AND CURING

GRAND HOTEL



Eastbourne

17—21 June 1969

in an organic solvent in the presence of a catalyst. In the other process phthalonitrile is reacted with cupric chloride either in a solvent or as a dry mixture. By modifying the phthalonitrile process one can obtain either a chlorine-free copper phthalocyanine (i.e. the compound obtained also from the phthalic anhydride process) or a slightly chlorinated copper phthalocyanine. This slight chlorination (about 1 atom of chlorine per phthalocyanine molecule) renders the phthalocyanine resistant to crystallisation in aromatic solvents. This resistance is important in some applications, and will be mentioned again later.

Polymorphism

Phthalocyanines can exist in several different crystal forms and to date six forms have been identified α, β, γ, ς, R and X. However, copper phthalocyanine has at present only two forms of commercial importance—α and β. The two forms differ quite markedly in their X-ray diffraction patterns and infra red spectra. The α form is redder in shade than the β, to which it converts under the action of organic solvents or even at temperatures of about 250°C. Crude unchlorinated copper phthalocyanine as obtained from a reaction vessel is always in the β form but the slightly chlorinated compound (from the phthalonitrile process) exists only in the α form—hence its resistance to crystallisation.

It is important to note that the β form can also yield a useful pigment, quite distinct from the dull shade of the β form crude blue.

Conversion to pigmentary form

Crude unchlorinated copper phthalocyanine has very little colouring power as it exists in large crystals of the β form. Therefore it is necessary to convert the material into the α form or into smaller crystals of the β form. The two chief methods are (1) acid pasting, (2) salt grinding.

In the acid pasting process the phthalocyanine is dissolved in concentrated sulphuric acid with gentle heating and the solution drowned in a large volume of water. The phthalocyanine is thus precipitated in the form of finely divided particles. Acid pasting yields the α form, although by modification of the process many products of differing tinctorial properties may be obtained. The temperature of the drowning water, the rate of drowning, the rate of agitation and the addition of surface active agents can all have an effect.

In the salt milling process crude copper phthalocyanine is mixed with an inorganic salt such as sodium chloride or sodium sulphate and the mixture is ground in a ball or vibratory mill. The inorganic salt can then be removed by slurrying the discharged mixture in hot water and the pigment isolated by filtration and washing. Whereas acid pasting yields the α form, salt grinding can be used to give either the α or the β form. The latter is obtained when the grinding process is carried out in the presence of a small amount of solvent, or when the pigment is subjected to a solvent treatment after salt milling. The pigmentary properties of a salt ground standard are very much dependent upon the time of grinding and the weight of mill charge. Thus, if it is desired to produce a pigment of very high α content the grinding time should be long and the charge small. Naturally economics play an important part and a compromise must be reached. A very long grinding time for a very small charge would render the pigment much too expensive.

Acid pasting and salt grinding are used to convert to pigmentary form both unchlorinated and the slightly chlorinated copper phthalocyanine blue. With the latter compound, however, it is not possible to produce a β form pigment.

Phthalocyanine green

The polyhalogenated derivatives of copper phthalocyanine, giving a fairly wide range of green shades, are becoming increasingly important.

At one time mixtures of phthalocyanine blue and yellow azo pigments were used to produce mixed pigments of bright green shade, but the difference in fastness properties between the two components often gave trouble. For example, the yellow azo component could fade much more quickly than the blue phthalocyanine with a resultant change of shade on the pigmented surface.

Polychlorophthalocyanine usually contains about 14 atoms of chlorine, and it is practically impossible to substitute every available hydrogen atom—16 in all. It is a bright bluish green pigment of outstanding fastness.

In 1959 the first chlorobromo phthalocyanine appeared commercially. This pigment contained about 8 chlorine and 4 bromine atoms and had a considerably yellower shade than the polychloro compound.

Since 1959 interest in the yellow shade green has gradually increased and there is now available a yellow green pigment containing 10 bromine and 2 chlorine atoms. It will be seen that the more bromine atoms present, the yellower is the shade. Attempts have been made to attach an iodine atom to the phthalocyanine molecule to shift the shade still further to the yellow side, but to date these have proved unsuccessful.

Phthalocyanine green is obtained only in one crystal form and therefore finishing techniques are less complex than for phthalocyanine blue. Acid pasting can be used, although solution is rather difficult and some oleum or chlorosulphonic acid must be added to the sulphuric acid. Refluxing with a solvent in the presence of a surface active agent is a favourite method.

Commercial applications

Paint

Phthalocyanine blue and phthalocyanine green are used extensively in paint. The unchlorinated blue is, however, unsuitable in the α form because of its poor resistance to crystallisation under the influence of aromatic solvents. The slightly chlorinated form has quite satisfactory resistance, as has also the pigmentary β form.

Recently a great deal of work has been carried out to improve the resistance of phthalocyanine blue to flocculation, flotation and flooding in paint. When any of these three phenomena occurs there is a breakdown in the homogeneity of the paint with resultant weakness, streakiness or peculiar "ring" effects. Phthalocyanine blue is now available treated in such a way that these defects are all but eliminated.

Phthalocyanine green is much less susceptible to these paint troubles.

Ink

The α form unchlorinated blue is used in ink vehicles which do not contain aromatic solvents. The resultant inks are extensively used for soap-wrappers, labels, cartons, etc. For liquid inks the slightly chlorinated and β type pigments must be used to provide solvent resistance. There is now a definite trend towards the production of pigments which will disperse easily and rapidly in modern low shear dispersion equipment, and new grades are continually making their appearance to meet this demand.

The use of phthalocyanine green in ink applications is less than in paint but is rising at an appreciable rate.

Plastics

The ever-increasing demand for coloured plastic materials has naturally increased the sales of phthalocyanines for the plastics and synthetic rubber industries. The problem of colour dispersion is of prime importance as not much work is done on the pigment, and poor colour dispersion is evident in the form of dark specks and streaks. Salt milled pigments are usually superior in texture and dispersibility to acid pasted pigments and thus give better results where high shear is not used.

So firmly is the copper bound to the phthalocyanine nucleus that copper phthalocyanine may be used for the colouring of rubber with no deleterious effect, although it is well known that ionic copper acts as an accelerator for the ageing of rubber.

Scottish Section

The Student Group had a full programme for the session 1967-68, meeting every month to hear speakers on a wide range of subjects. The session finished in June with a visit to the Ardeer works of ICI Limited, Nobel Division, a report of which is given below.

The programme for 1968-69 is also full, with monthly lectures from September 1968 to March 1969.

Over the past two years the Student Group has been carrying out a major project on paint, and this is now reaching its final stages. A range of paints representing types available since about 1900 has been prepared. A paper on this work is being written, containing details both of preparation and of standard testing. It is felt that the paper will be of wide and general interest, and it is intended to submit it for publication in the *Journal* in the early part of next year.

Works Visit

A party of Scottish Members, comprising both Student and Senior Members, visited the Ardeer Explosives Factory of Messrs ICI Ltd. on Wednesday 19 June 1968.

After an introductory talk on explosives in general, the party witnessed the firing of burning and detonating types of explosives. The various effects were demonstrated by the penetration of steel plates. For use in a coal mine, the difference between a *non-permitted* explosive and a *permitted* explosive was effectively demonstrated in a gallery testing unit where the non-permitted explosive ignited a methane/air mixture with what, in a mine, would have been a calamitous effect. The permitted explosive failed to ignite the methane/air mixture.

The party was then shown explosives being tested by various other means including the firing of a ballistic mortar. A demonstration on the use of delay detonators completed this part of the programme. The party was then divided into three groups—one group visiting the Nitrocellulose Applications Section research department, the second group to the Nitrocellulose Manufacturing Plant and the third group to the Biazzi Nitroglycerine Plant and Misk Gelatines Unit.

After high tea served in "Africa House"—the latter being the original Africa Pavilion built for the Empire Exhibition in Glasgow in 1938, the party journeyed home to nurse its earaches in the quiet, comparatively serene, city of Glasgow.

The Section's grateful thanks are expressed to Messrs ICI Ltd. for the tremendous amount of trouble they took to make the visit so interesting and informative. In particular, appreciation and thanks are expressed to Mr D. Hardie, who looked after the party so well.

E.M.B.

South African Section

The Student activities of the South African Section have been closely allied to the course in Paint Technology which has recently been instituted at Technical Colleges in South Africa. The Section was instrumental both in arousing interest in the need for such a course, and in laying down the syllabus for a qualification which is fully Government approved and recognised.

The first group of students has just completed the final examinations, and a high pass rate is confidently expected.

Only a limited number of students are taking the course at present, and for this reason little has been done in the way of evening lectures etc. However a start is to be made at a meeting this year, when six students will present short papers, on a wide variety of subjects, to section members. It is felt that this will serve the purposes of encouraging the students to read widely and giving them confidence in their own ability, advertising the course and encouraging new students to enrol, and rewarding the Section for its hard work.

West Riding Section

Works Visit

The first works visit to be organised by the newly formed Student Branch of the West Riding Section was to the British Railways Loco Workshops and Carriage and Wagon Workshops at Derby. Seven student members, together with Mr E. Smith, Student Liaison Officer on the West Riding Committee, and two other Committee members were welcomed to the works with a brief talk by Mr Read, the Works Training Officer. The morning was spent touring the Siddalls Road Loco Workshops and the afternoon was spent at the Carriage and Wagon Workshops on London Road. At the latter works especial interest was shown in the Paint Shop where Mr Camwall kindly explained the various techniques currently in use and the future developments envisaged. He apologised for being unable to arrange a demonstration but explained that a new dual-purpose stoving oven soon to be installed would enable the department to extend its facilities to include such techniques as the application of powder coatings by electrostatic spray to small items such as steel chair-frames, and other high-bake finishes.

Most of the students commented on the quality of the application techniques and the appearance of the finished wagons and carriages, especially in view of the stringent quality control in paint manufacture insisted upon by the British Rail Standards department. This was particularly evident in the finish of the Freight-Liner wagons but it was explained that for the time being this department was in a state of transition and when new construction techniques, involving less riveting, are eventually adopted, application difficulties will be overcome and a better finish will result.

A group of Student Members at British Rail Workshops, Derby, with Mr J. Mckean, Publications Secretary (extreme left), and Mr J. Groom, Committee Member, West Riding Section (fourth from left).

The visit was voted most interesting and worthwhile and the next one is assured of a good attendance.

J.N.McK.

Forthcoming Events

Saturday 14 September

Scottish Section—Student Group. "Emulsion for Paints and Other Coating Applications," by a speaker from Vinyl Products Ltd., to take place at the Lorne Hotel, Sauchiehall Street, Glasgow, at 10 a.m.

Wednesday 18 September

Manchester Section—Student Lecture. "Titanium Dioxide—Properties Manufacture and Uses," by Mr J. K. Rankin of British Titan Products Ltd., at the Manchester Lit. & Phil. Society, at 4.30 p.m.

Saturday 5 October

Scottish Section—Eastern Branch Student Lecture. "Fluid Handling in the Paint Industry," by Mr D. Muirhead (Wm Sim & Sons Paints Ltd.), at 10.30 a.m., followed by lunch and a skittles match at the Hillburn Roadhouse.

Saturday 12 October

Scottish Section—Student Group. "Dispersible Pigments," by Mr A. Gray of Geigy (UK) Ltd., to take place at the Lorne Hotel, Sauchiehall Street, Glasgow at 10 a.m.

Information Received

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

Blythe Colours Limited has recently announced the setting up of a company in Spain under the name **Colores Blythe SA.**

The new company, which will be centred in Valencia, is to market a complete range of products for the pottery, glass, enamelled iron and pigment-using industries.

The **Fishburn Printing Ink Co. Ltd.** has recently made available a colour guide to all the basic ink requirements of the commercial letterpress and litho printer. The *Readipac Colour Guide* contains 20 *Readipac* colours, eight *Color Finder* colours, four letterpress and two offset blacks, plus transparent and opaque whites. Any combination of letterpress and litho inks featured in the range can be grouped together to gain bulk quantity discounts.

A new *Technical Bulletin* on *Beckurane M118* has recently been issued by **Beck Koller & Co. Ltd.** A solventless moisture-curing polyurethane, *Beckurane M118* is recommended for uses in sealants and putties for marine and civil engineering uses, and heavy coating, foam encapsulating and potting applications. Excellent flexibility and good adhesion to most surfaces are claimed in formulations.

Two new additions have recently been made to the *Selectaset* system of offset process inks produced by **Coates Brothers Inks Limited.** The two new colours, a bright magenta and a warm cyan, bring the range to eight colours, which are available in three series, *CLT5* for normal use, *Nuogloss* for gloss process printing and *CLT/V* for work to be laminated or varnished.

Stella-Meta Filters Ltd. has recently announced the development of a filter, the *Stella-Meta Industrial Tube Filter type 123*, for use as a polishing filter for liquids, corrosive or otherwise, which contain a low percentage of solids. The filter can be used for intermittent or continuous operation with or without a precoat.

The recommended working pressure is 70 psig, and the filter is of mild and stainless steel construction, with flat filter paper liners rolled into cylinders inside perforated filter tubes.

A new improved version of *Flowline Surfacer 22*, a high build primer/surfacer for use in car refinishing systems, has recently been announced by **Pinchin Johnson & Associates Limited.** The new formulation is claimed to give improved hold up, while retaining the ease of flatting of the original version.

A new symbol, colour scheme and typographic style has been designed for all printed matter and display material produced by **PIRA,** The Research Association for the Paper and Board, Printing and Packaging Industries.

The head office of **Bush Beach & Segner Bayley Limited** is to move from Marlow House, Lloyd's Avenue, London EC3, to 175 Tottenham Court Road, London W1. The move has been caused by the need for larger offices.

It has recently been announced that **W. G. Pye & Co. Ltd.** and **Unicam Instruments Ltd.**, two members of the Pye of Cambridge Group, have merged to form **Pye Unicam Ltd.** The new company will market the present *W. G. Pye* range of chromatographic, electrochemical and physical instruments and the *Unicam* range of spectrophotometers, as well as a complementary range of instruments manufactured by *Philips.*

Plastanol Limited has recently issued a booklet giving full details of its range of surface coating resins, including new additions to the *Acrysol*, *Hythane* and *Hytex* ranges.

The **Construction Industry Research and Information Association** (CIRIA) has recently published a pocket-sized booklet containing a set of conversion factors to assist in the construction industry's change to metric measurement in January next year. Printed on thin board, the booklets are useful for anyone who deals in metric and British units. Copies are available from Harvey Pictorial Services, 4 Alfred Square, Deal, Kent, at 2s 6d each, £6 for 50, £9 per 100 and £65 per 1,000.

Proceedings of the Annual General Meeting

The Sixth Annual General Meeting of the Incorporated Association was held on 28 June 1968 at 7.00 p.m. at the Royal Hotel, College Green, Bristol 1, with the President (Mr F. Sowerbutts) in the Chair.

The notice convening the meeting was read.

Apologies

Apologies for absence were received from Mr I. C. R. Bews, Mr L. Brandts Buys, Mr E. A. Brown, Mr A. S. Fraser, Mr P. J. Gay, Mr I. S. Moll, Mr C. H. Morris. Mr E. Oostens, Mr A. R. Penfold, Mr S. A. Ray, Mr A. T. S. Rudram, Mr L. Tasker and Mr V. C. Thompson.

Minutes

The President asked the meeting to take as read the Minutes of the Fifth Annual General Meeting held on 23 June 1967, as printed and circulated in JOCCA, pp. 789-796, August 1967. There being no comments the adoption of the Minutes was put to the meeting and carried unanimously. The President then signed the Minutes.

Report of the Auditors to the Members

The Report of the Auditors to the Members was read.

Annual Report of the Council for 1967

In the absence of both the Honorary Secretary and the Honorary Treasurer, the President called on the Director & Secretary to introduce the Annual Report of the Council and the Statement of Accounts for 1967.

Since copies of the Annual Report and Statement of Accounts had been despatched to members in advance of the meeting, it was assumed that these documents had been read, but Mr Hamblin drew attention to three items contained in the Annual Report of the Council which concerned the Association's interests overseas. He referred to the conference organised by the Federation of Scandinavian Paint and Varnish Technologists which the President and Mrs Sowerbutts had attended in September and which was the first occasion when a President in office had represented the Association on such an occasion. At this conference the official OCCA paper had been presented by Mr A. R. H. Tawn (Honorary Editor).

During the year under review the South African Section had held its first national convention which had proved very successful.

With regard to the five Sections of the Association in Australia, Mr Hamblin pointed out that, as indicated in the Annual Report, these now formed the new organisation set up with effect from 1 January 1968, namely the Oil and Colour Chemists' Association Australia and this was, therefore, the last occasion on which reference to the Association's activities in Australia would be contained in the Annual Report of the Council.

In conclusion, Mr Hamblin referred to the first paragraph of the Annual Report which mentioned the Fiftieth Anniversary Celebrations of the Association to be held in May 1968. As members would already know, these had been successfully concluded and the congratulatory messages received on that occasion had been bound into book form and were available at this Annual General Meeting for members to see. This book would be available for Sections to borrow on suitable occasions; application should be made to the Director & Secretary.

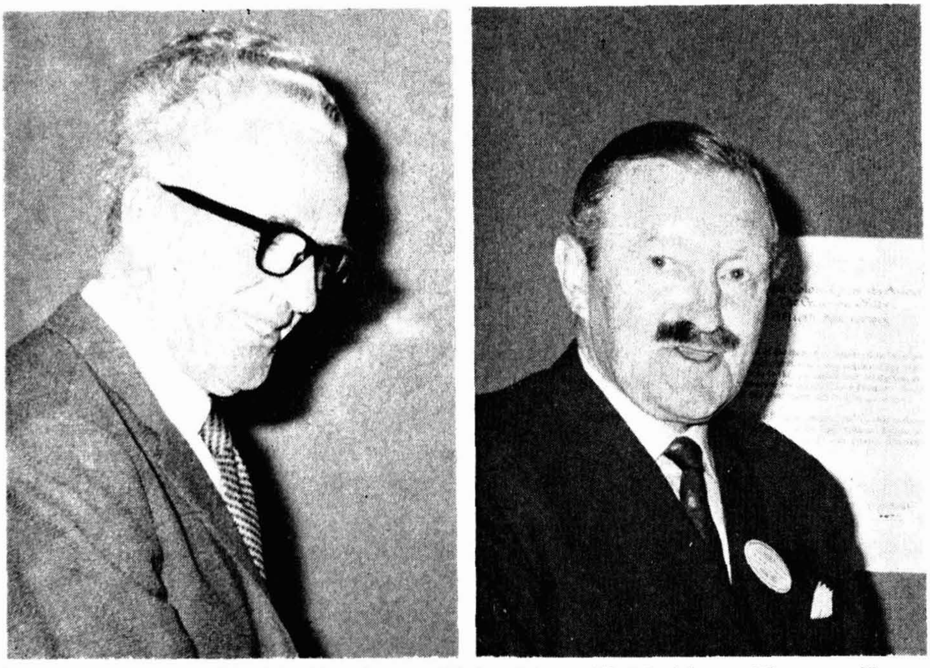
Mr H. A. Newnham referred to the Statement of Accounts and was glad to see that in spite of forebodings at the beginning of 1967 the year had ended with only a small deficit, and had it not been for the £2,900 transferred to the Australian Sections presumably a small profit would have been achieved.

He also commented on the increases in Section expenditure and administrative salaries; the President and the Director & Secretary replied.

There being no further comments, the President proposed, from the Chair, the adoption of the Annual Report of the Council and Statement of Accounts for 1967. These were formally adopted by the meeting.

Appointment of President Designate of the Association

The President reported that, in accordance with the procedure recommended by the Council, recommendations for the office of President Designate were requested from members of the Council and Past Presidents, and as a result of these recommendations and subsequent voting, Mr A. S. Fraser, Honorary Treasurer of the Association, had been appointed President Designate. Unfortunately it was not possible for Mr Fraser to be present at this meeting, but the President read a letter he had received in which Mr Fraser stated how deeply conscious he was of the honour bestowed upon him in being nominated as President Designate. If, when the time came for him to become President, he could discharge his duties half as well as his predecessors, he would be content with a job well done.



Left : Mr A. S. Fraser, President Designate. Right : Mr A. W. Blenkinsop, Honorary Treasurer

Election of Vice-Presidents of the Association

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

(*a*) Vice-Presidents who have not been President:

- (*i*) Dr D. Atherton
- (*ii*) Mr L. J. Brooke
- (*iii*) Mr K. M. Engelbert
- (*iv*) Mr H. Meyer
- (*v*) Mr S. G. Tinsley

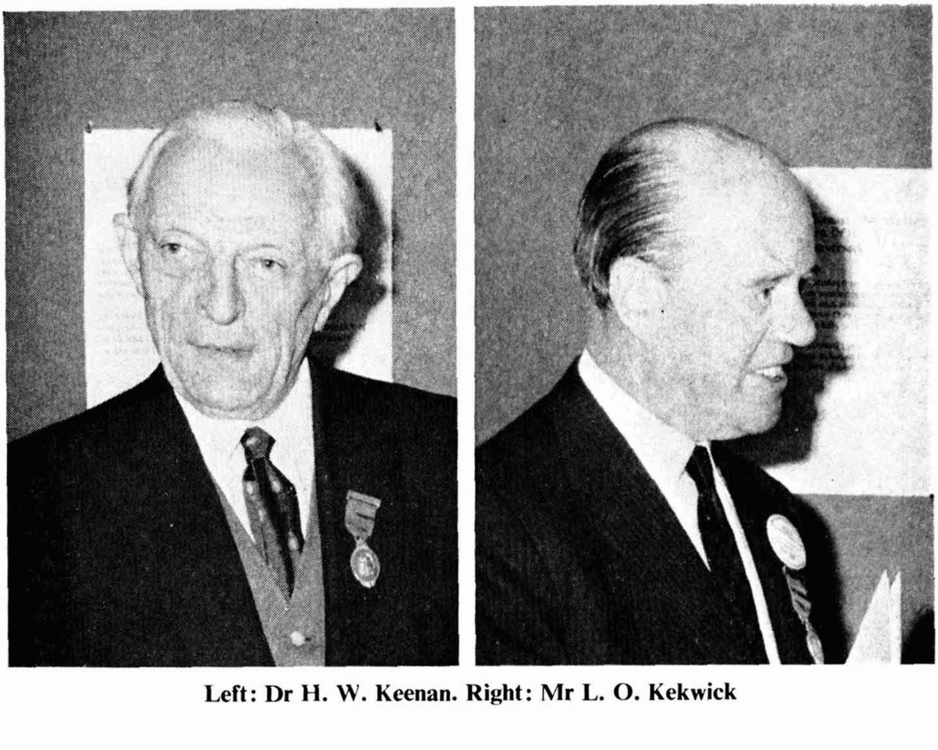
(*b*) Vice-Presidents who have been President:

- (*i*) Mr P. J. Gay
- (*ii*) Dr H. A. Hampton

Election of Honorary Officers of the Association

The President drew attention to the fact that since the Agenda for the Annual General Meeting had been despatched a meeting of Council had been held at which it was unanimously agreed to nominate Mr A. W. Blenkinsop as Association Honorary Treasurer in succession to Mr A. S. Fraser, who had now been appointed President Designate. This information was included with the Annual Accounts later circulated to members. The President, therefore, put the names forward, and it was unanimously agreed to elect the Honorary Officers as follows:

Honorary Secretary	Mr I. C. R. Bews
Honorary Treasurer	Mr A. W. Blenkinsop
Honorary Editor	Mr A. R. H. Tawn
Honorary Research and Development Officer ..	Mr A. T. S. Rudram



Left: Dr H. W. Keenan. Right: Mr L. O. Kekwick

Appointment of Honorary Members

The President stated that it gave him the greatest pleasure to confer Honorary Membership of the Association on Dr H. W. Keenan and Mr L. O. Kekwick. He felt he could not do better than read the inscription on the scrolls of Honorary Membership which he was delighted to present. The scroll presented to Dr H. W. Keenan read:

HONORARY MEMBERSHIP

was this day conferred upon

HENRY WILFRED KEENAN

Doctor of Philosophy and Fellow of the
Royal Institute of Chemistry

in recognition of his outstanding services as President 1944-47, Vice-President 1955-57 and 1961-63, Chairman of the London Section 1940-42, Chairman of the Technical Education Committee and member of the Liaison Committee, and to express the admiration of members for the way in which he discharged these duties and for his endeavours in fostering the close co-operation between the Association and the Federation of Societies for Paint Technology.

(Sgd.) F. Sowerbutts, President.
I. C. R. Bews, Honorary Secretary.
28 June 1968. *R. H. Hamblin, Director & Secretary.*

Referring to his membership of the Liaison Committee, the President pointed out that Dr Keenan had been the first President of the Association to visit the United States of America and establish what had since developed into a very close liaison between the Association and the Federation of Societies for Paint Technology.

The scroll then presented to Mr L. O. Kekwick read:

HONORARY MEMBERSHIP

was this day conferred upon

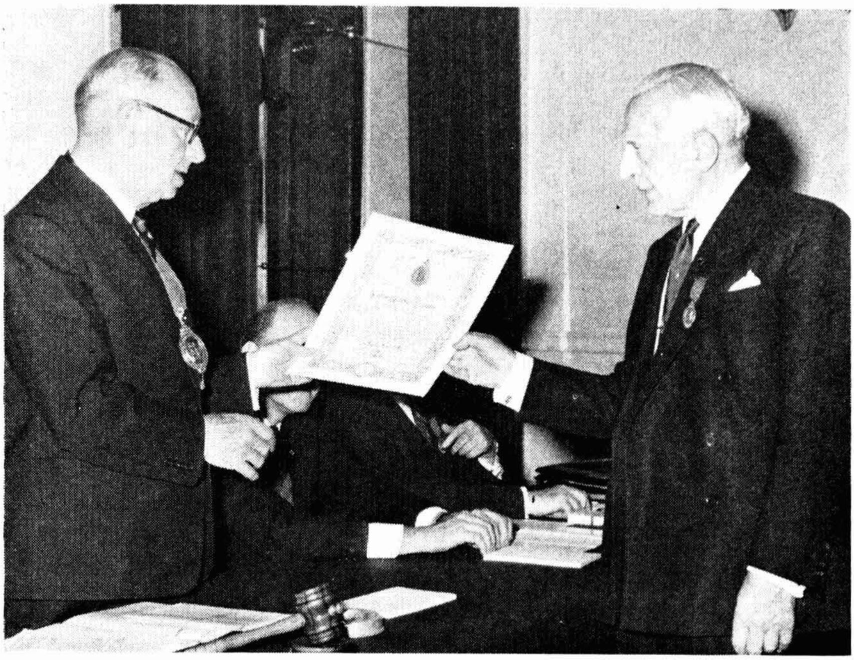
LESLIE OLIVER KEKWICK

Bachelor of Science and Fellow of the
Royal Institute of Chemistry

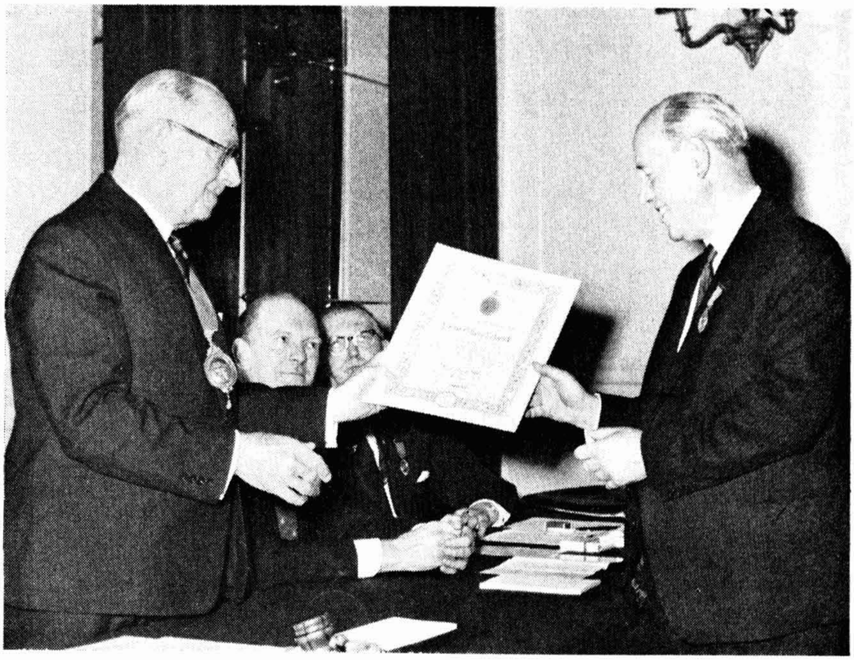
in recognition of his outstanding services as President 1951-53, Vice-President 1957-59 and Chairman of the London Section 1949-51, and to express the admiration of the members for the way in which he discharged these duties and for his constant endeavours in furthering the aims and objects of the Association both in the United Kingdom and overseas.

(Sgd.) F. Sowerbutts, President.
I. C. R. Bews, Honorary Secretary.
28 June 1968. *R. H. Hamblin, Director & Secretary.*

With regard to his endeavours in furthering the aims and objects of the Association overseas, the President pointed out that Mr Kekwick had visited the Sections in Australia, New Zealand and South Africa and this was something which he himself was hoping to do later in the year. In addition, Mr Kekwick had been very largely responsible for the idea of the Association's Technical Exhibition which had grown into an activity of world-wide repute reflecting great credit on the Association.



Dr H. W. Keenan receiving his scroll of Honorary Membership from the President, Mr F. Sowerbutts



Mr L. O. Kekwick receiving his scroll of Honorary Membership from the President, Mr F. Sowerbutts. Also in the picture are Mr A. R. H. Tawn (Hon. Editor) left centre and Dr S. H. Bell (Immediate Past President) right centre

Oil and Colour Chemists' Association

Jubilee Year

Honorary Membership
was this day conferred upon
Henry Wilfred Keenan
Doctor of Philosophy and
Fellow of the Royal Institute of Chemistry

In recognition of his outstanding services as President 1944-1947, Vice-President 1955-1957 and 1961-1963, Chairman of the London Section 1940-1942, Chairman of the Technical Education Committee and member of the Liaison Committee, and to express the admiration of members for the way in which he discharged these duties and for his endeavours in fostering the close co-operation between the Association and the Federation of Societies for Paint Technology.

Frank Sowerbutts.
President
I. C. R. Bews
Honorary Secretary
R. H. Hamblin
Director and Secretary

28th
June
1968

The scroll presented to Dr Keenan

Mr Kekwick stated that both Dr Keenan and himself were very greatly honoured to receive Honorary Membership. It had been a pleasure to give service to the Association and neither of them had aimed for such reward—all they had done was to enjoy themselves. Nevertheless to have Honorary Membership conferred upon them in the Jubilee Year had made them extremely happy.

Oil and Colour Chemists Association

JUBILEE YEAR

Honorary Membership

was this day conferred upon

Leslie Oliver Kekwick

Bachelor of Science and Fellow
of the Royal Institute of Chemistry,

In recognition of his outstanding services as President 1951-1953, Vice-President 1957-1959 and Chairman of the London Section 1949 - 1951, and to express the admiration of the members for the way in which he discharged these duties and for his constant endeavours in furthering the aims and objects of the Association both in the United Kingdom and overseas.

Frank Sowerbutts.
President

I. C. R. Bews
Honorary Secretary

R. H. Hamblin
Director and Secretary

28th
June
1968

The scroll presented to Mr Kekwick

Announcement of Election of Three Elective Members to Council for 1968-70

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

> *We have scrutinised the voting papers for the three elected members of the Council received from members in the United Kingdom and General Overseas Sections, and certify that the votes cast, including*

those notified by letter from the South African Section, show that the following obtained the largest number of votes:

T. A. Banfield *A. E. Claxton* *I. S. Moll*

Fifteen voting papers were rejected as not being in order.

London,
18 June 1968.

Cooper Brothers & Co.,
Chartered Accountants.

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

Chairmen of Sections for the coming session

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

Auckland	Mr G. J. Juster
Bristol	Mr D. S. Newton
Hull	Mr E. A. Brown
Irish	Mr R. Adam
London	Mr R. N. Wheeler
Manchester	Mr W. F. McDonnell
Midlands	Mr D. J. Morris
Newcastle	Mr D. M. James
Scottish	Mr J. Miller
South African	Mr P. A. Draper
Thames Valley	Mr K. R. W. Chitty
Wellington	Mr T. W. Slinn
West Riding	Mr L. H. Silver

The President took the opportunity of saying how pleased he was to see several Chairmen of Sections at this meeting and, in addition to the Chairman of the Bristol Section, he welcomed the Chairmen from the London, Manchester, Scottish and Thames Valley Sections.

Reappointment of Auditors and fixing the remuneration thereof

It was proposed by Mr W. J. McWaters that Cooper Brothers & Co. (Chartered Accountants) be reappointed Auditors of the Association and that their fee be 150 guineas. This was seconded by Mr D. J. Silsby and carried unanimously.

Student Membership

The Director & Secretary reminded members that Junior Membership had been introduced as a category of membership of the Association in 1926 and that the annual subscription rate of 10s 6d had remained unchanged until the current year. Those eligible were members up to the age of 21, although in recent years upon the submission of a study certificate this class of membership could be retained up to the age of 25 years. However, to bring this into line with other societies, and to emphasise the educational aspect, Council now wished to amend the term to Student Membership. Details of the following resolution were set out on the Agenda:

> *That wherever the word "Junior" occurs in the Articles of Association in conjunction with the word "Member" or the word "Members" it shall be deleted and the word "Student" substituted.*

The President proposed the adoption of this resolution from the Chair and it was carried unanimously.

Vote of thanks to retiring Council Members

Dr V. G. Jolly stated that it gave him great pleasure to come from the North to this meeting of the Association to propose the vote of thanks to retiring Council Members. Retirement was something about which he now knew, but it was always a good thing to retain links with friends and colleagues and he was pleased to do this to a certain extent through the pages of the Association's Journal. While in business he had studied in detail the technical content of the Journal and perhaps only briefly read the non-technical part, nowadays he spent more time reading the Notes and News section than the papers published each month, and he was very much aware of the range of topics and the decisions taken by the Council. During the year leading up to the Association's Jubilee celebrations, the Council had obviously had a great deal of work to do, and he therefore proposed a warm vote of thanks for the services rendered to the Association by those who were retiring from Council.

This was carried with acclamation.

The President pointed out that he had been associated with Dr Jolly for many years and had had the privilege of serving under him when Dr Jolly was one of the early Chairmen of the Manchester Section.

Vote of thanks to Honorary Officers of the Association

Mr L. J. Brooke stated that although it was a few years since he had served on Council he well remembered how much work was carried out by the Honorary Officers of the Association. This Annual General Meeting would see two changes among the Honorary Officers; Dr S. H. Bell now retired, having served his year as Immediate Past President. Mr Brooke could not recall having attended a Council meeting without Dr Bell being present since, before becoming President Designate, he had served as a Vice-President. Appropriate tribute had been paid to Dr Bell for his services to the Association at the previous Annual General Meeting, but Mr Brooke made reference to Dr Bell's document on Forward Thinking and was pleased to see that certain of the recommendations contained therein were already being implemented.

The other change among the Honorary Officers was, of course, the elevation of Mr Fraser to President Designate. He had served as the Association's Honorary Treasurer during a particularly difficult period and it was no doubt due to his efforts that the Association's accounts showed a reasonably satisfactory position.

Mr Brooke then asked the meeting to join him in expressing sincere thanks for the time and devotion which the Honorary Officers contributed towards the successful running of the Association. The vote of thanks was carried with acclamation.

Vote of thanks to Chairman of the Meeting

The Director & Secretary called upon Dr S. H. Bell (President 1965-67) to move a vote of thanks to the President as Chairman of the meeting.

Dr Bell stated that he regarded it as a great honour to propose a vote of thanks to his friend Frank Sowerbutts for the manner in which he had conducted this meeting. In doing so, however, it was difficult to avoid thinking of Mr Sowerbutts as President of the Association and although he would receive the thanks of the Association in due course on completion of his term of office, Dr Bell asked the meeting, when showing their appreciation to Mr Sowerbutts, to bear in mind all he had done for the Association during his first year as President. Dr Bell then called on the members to show their appreciation by a warm vote of thanks, which was carried with acclamation.

The President then declared the proceedings closed.

Auckland

The Section Committee has now been received:

Auckland *Chairman:* G. J. Juster, 269 Kohimarama Road, Kohimarama, Auckland, New Zealand.

Secretary: D. W. Sell, 4 Claude Road, Manurewa, Auckland, New Zealand.

Treasurer: O. E. Rutledge, Polychem (NZ) Ltd., PO Box 2704, Auckland 1, New Zealand.

Committee:

R. C. Baynes, 93A Valley Road, Mount Eden, Auckland, New Zealand.

R. S. Blucks, MSc, c/o Mobil Oil (NZ) Ltd., PO Box 1709, Auckland, New Zealand.

G. J. Hutchings, PhC, c/o Esso Standard (NZ) Ltd., Box 3301, Auckland, New Zealand.

P. B. Hunt, BSc, PO Box 15104, New Lynn, Auckland, New Zealand.

P. F. Sharp, BSc, c/o Lusteroid Pty. (NZ) Ltd., PO Box 22-122, Otahuhu, Auckland, New Zealand.

T. Whitfield, 387 Hillsborough Road, Hillsborough, Auckland, New Zealand.

Thames Valley

Choice of colours on automobiles

On 14 March a lecture was given to the Thames Valley Section at the Royal White Hart Hotel, Beaconsfield. Mr Piere Yates, of the Ford Motor Co. Research & Engineering Centre at Basildon, gave a paper entitled "Choice of colours on automobiles."

Mr Yates opened his talk by discussing the reasons for the frequent changes in body colours made by the manufacturers. First he considered the basis for the colour change and how the consequent upheaval in the body finishing shop could be justified.

The reasons were:—

1. Failure of a colour on low popularity grounds.
2. The need to introduce a new colour or colours in conjunction with a new model or face lift of an old model.
3. Inter-company communality, i.e. Ford America, Ford Britain and Ford Germany.

These were discussed in turn:

1. When sales of a colour fell below the economic production level, which was considered to be around 4 per cent of total production, the background might be that it had been running successfully for years and sales had suddenly fallen off, or that it was a relatively new colour that had enjoyed a short period of popularity on its introduction but had fallen below the economic level sooner than anticipated. Whatever the case, such emergencies were covered with fully developed back-up colours. These might be improved versions of the deleted colour or a completely new colour, the most

important factor in its selection being to maintain a good relationship with existing trim colours, in order to avoid the enormous expense of obsolescence and consequently new interior trim and associated parts.

2. To introduce a new model in last year's colours, however, advanced it might be, inevitably lost much of the model's impact. So by launching a new colour and the new model exclusively for 2-3 months, the two became synonymous, for a short period at least. This helped to identify the new model in the eyes of the public, and it also helped by restricting the usage to one model line with the result that the production people were able to eliminate any initial teething problems.

The same exercise could be applied with equal success to a face lift model, except that, relatively speaking, maximum impact was achieved for the minimum outlay.

3. The third reason necessitating a change was purely an internal one, motivated by the desire to rationalise all Ford MoCo products and materials wherever these were manufactured. The advantages were enormous considering that Ford Britain and Ford Germany exported vehicles all over the world. These were often covered by the same dealer network and, until recently, each had carried their own separate interior and exterior colour range (some colours being quite similar). A range of colours common to all Ford MoCo's locations would obviously alleviate many service problems abroad, though it would have some limitations where national differences existed in the acceptance of colour. It would also help the smaller K.D. plants who assembled relatively small numbers of vehicles originating from all Ford locations by drastically reducing manufacturing complexity. Ultimately it was envisaged that the selection and development of these common colours would be conducted from one point, say Ford of Britain, who would initiate parallel development with all supply sources.

Having established the need for new colours, Mr Yates went on to discuss the process of selection. Development of a new body colour took 18-20 months. The company timing plan allowed for 23 months, if strictly adhered to, and therefore requirements must have been anticipated 2 years in advance, at which time the company was committed to a given colour range, which might also be related to a new model.

At this early date, an endeavour was made to establish what the public would want. The first source of material was to review those colours generated internally by staff. These colours might be inspired by a fashion colour that looked like coming into vogue in the future, or perhaps the colour had been related to a particular vehicle, which might only be in prototype stage. A vehicle with sporting connotations, for example, would foster brighter more daring colours, whilst on larger MK4 prestige type models more subtle shades would be favoured.

Many colours came from suppliers, who gave an excellent service in this respect, often allowing the company's personnel to work in their laboratories aided by their paint technologists. A source of inspiration that could not easily be overlooked were the successful colours used by competitors.

Contrary to general belief a trim colour was sometimes developed first, and one or more body colours were created to key in, though from choice the body colours were planned first. It was easier to adjust trim colours during their development, which could be completed in less than 12 months.

Having collected together colour panels from all these sources, the materials development manager was called in. He evaluated the colours from the development and manufacturing feasibility stand point, and the level of confidence on the styling department's selection was indicated. This process reduced the contenders very quickly. At this point there might be up to 50 colours remaining, which would include some metallic shades. These would be suitably displayed in combination with preliminary trim colours. The proposals would then be reviewed within the department, and after a great deal of discussion the aim would be to finish up with around 25 colours. Having narrowed the field somewhat, the next stage was to present the proposal to the Director of Design for his approval. During this time the trim colours would also have progressed, enabling a more accurate picture of the body to trim colour relationship to be presented. Of the 25 colours shown 14 would form the final recommended proposals, and the remainder would be shown as alternatives to those colours among the 14 likely to prove controversial. The display would be reviewed by the Director of Design, and then amended in line with any recommendation he might have given. The next step in achieving final production approval was taken by a product committee, by which time 14 similar production vehicles would have been painted and trimmed in the agreed colours. A product committee considered the sales, marketing and manufacturing aspects of the final proposals. All 14 colours were not always approved, but whatever the results the way was clear for final development of production trim and painting materials before massive production began.

The questions reflected the wide interest in the subject and came from Messrs. Simpson, Chitty, Holt, Gunn, Helmsley, Inshaw, Long, Allan, Staples, Snow and Dr. Ellinger. Mr Inshaw offered a vote of thanks and remarked on the great responsibility held by the colour stylists.

R.E.G.

Aircraft paints and painting

At the monthly meeting held on 22 February at the Royal White Hart Hotel, Beaconsfield, Mr C. E. Hoey of the Ministry of Technology delivered a paper entitled "Aircraft paints and painting." A summary of what he said follows:

Reasons for painting

The primary reason for painting the structure is to protect it from deteriorating influences such as the weather or from corrosive emissions from the aircraft. Further reasons for painting are, for example, the needs for camouflage or identification markings. Additionally, high reflectance coatings may be required to reduce heat input from external sources, either from the sun or from the flash of an atomic explosion, and there may also be a need for a coating having high emittance. Aircraft designers are mostly reconciled to the necessity for protecting the structure adequately in spite of the weight premium involved.

The aircraft environment

Many aircraft operate long range and encounter a wide range of climatic conditions. Intense sunlight can give rise to a temperature of 70°C on a dark coating. High altitude operation gives severe exposure to the various radiations contained in sunlight, without attenuation by fog and haze. Skin temperatures can change rapidly during flight so that the coating is severely stressed. The speed of the aircraft also exposes the coating to considerable erosion when flying through rain. Additionally the whole structure is vibrating and any cracking tendencies are accentuated. The aircraft surface may reach a temperature of 120 to 130°C on current designs due to kinetic heating. Flight cycles are such that they give rise to cyclic condensation and some keel areas may be awash with water, frequently containing dissolved salts. And, finally, the fluids carried by the aircraft may also exert a profound deteriorating influence. Among the more aggressive materials which cause most trouble are Skydrol 500, Lockheed 22, ester lubricants, Avpin fuel and various de-icing fluids.

The nature of the structure to be painted

The aircraft is a complex assembly of different metals consisting mainly of aluminium alloys but with many ferrous and magnesium fittings. The many cut edges and dissimilar contacts are most susceptible to corrosion. Painting such a structure is a difficult task and it may be impossible if it is not done sufficiently early. Furthermore, during the long period of construction the coatings will have to withstand a variety of mechanical operations. When the exterior is finally painted even the best hangar heating may be indifferent.

Principles of protection

The aim is to coat the structure with a continuous layer of protective paint, to insulate dissimilar contacts, to fill crevices, and to coat cut edges, but first of all it is necessary to prepare the surfaces by means of pretreatment. The nature of the pretreatment has a most important bearing on the adhesion of the coatings and on the choice of primer. If the surface has not been pretreated an etch primer must be used. Following this the paint scheme proper must be considered. For aeronautical purposes paint schemes usually consist of two or three coats, apart from some interior areas where only one coat may suffice.

The primer coat effectively bonds the total system to metal and usually contains the corrosion inhibitor. The finish coat confers resistance to the varying climatic conditions and to the aircraft fluids mentioned earlier. Filler coats may also be needed in the system. Each of these elements of the system is now discussed in turn.

Primers

Alkyd air drying and stoving primers are of diminishing importance and so need not be discussed. Etch primers based on polyvinyl butyral resins are sensitive to moisture deposition during the drying period, and give poor results if the relative humidity is below 30 per cent. They should be considered as pretreatment primers rather than as fully protective primers.

Today, the most important group is the epoxy resin based primers which are usually cross-linked with amine terminated polyamides. The resulting cross-linked structures have good resistance to water and organic fluids and good corrosion protection is usually conferred by strontium chromate. Although they are two-pack materials they give adequate pot life. They should not be applied direct to untreated structures.

An indication of the performance of the various primers relative to each other (on anodised surfaces) may be noted from the table.

Primer	Adhesion lb/in^2	Over-coating	Fluid resistance	Scratch	Inhibi-tion	Bend	Pre-treatment
Epoxy	4,000	4 hrs.	V. Good	2,500	Good	$\frac{1}{4}$	Necessary
PVB/Etch	2,500	1 hr.	Good	1,500	Slight	$\frac{1}{4}$	Not ,,
PVB/Phenol etch	3,000 (Erratic)	1 hr.	Good	1,500	Slight	$\frac{1}{4}$	Not ,,
Synthetic	1,500	4 hrs.	Fair	1,200	Good	$\frac{1}{4}$	Necessary

Since it is impossible to achieve complete impermeability to the various corrosive influences at work on the structure it is necessary to provide for a degree of corrosion inhibitive character in the primer itself. Mention has already been made of the use of chromates where a considerable amount of work has been done relating the availability of the chromate to the prevention of corrosion. If chromated pigmented films are placed in water, chromate ions are released at rates which differ according to the period of immersion. A plot of the release of the ions into the solution versus time is referred to as a leaching curve and it is an indication of the probable behaviour of the primer. An "ideal" leaching curve is one which releases chromate fairly rapidly at first (5 mg CrO_4/10cm^2/day) falling to about 1mg after 24 hours followed by a steady release at 0.05mg between ten and 15 days.

Finishing coats

These may consist of alkyd, nitrocellulose, epoxy, acrylic, polyurethane and vinyl copolymers suitably pigmented. It is usual to designate a scheme by the type of finishing coat rather than by the fillers or undercoats and in the descriptions that follow composite systems are referred to.

Today the acrylics, polyurethane and epoxy paints are the finishes of dominant interest. Acrylic systems have fair resistance to the operating fluids used in aircraft but because they have characteristically low solids the consequent high shrinkage leads to surface stress which in turn makes them liable to cracking. More recently a flexible acrylic co-polymer has been evolved with reactive pendant groupings which are cross-linkable with the aid of a catalyst. Unfortunately the excellent properties are marred by the short stable life of the parent polymer. Among the advantages of acrylic systems are rapid drying, stability to heat and light, acceptable drying rate at low temperatures, and easy removal and touch up. Their effective life is around three years.

The second major class is the polyurethanes. They have limited pot life but dry to very hard glossy films with outstanding weathering properties. Of special importance is their high resistance to organic fluids and the ease with which they are decontaminated. A properly applied scheme will last at least five years and because of their stable colour, patch repair is quite acceptable. Certain of the isocyanates used in polyurethanes give rise to toxic hazards and the use of efficient face masks is essential unless a method of application is used which avoids the droplet hazard.

Catalysed epoxy resin systems are similar to polyurethanes in respect of drying rate, solids content, gloss from the gun and resistance to aircraft fluids. Their disadvantages are pronounced chalking and yellowing tendencies during exposure.

Methods and conditions of application

There are broadly three categories of aircraft finishing—initial finishing by the original contractor, a complete repaint in service or back at the contractor, and thirdly under in-service conditions. Since aircraft may be painted under a variety of conditions, in many parts of the world with no chance of providing controlled conditions, it is of the utmost importance to select carefully the type of paint to be used. Optimum conditions for maximum life are laid down for constructors and naturally more permissive limits are allowed for painting during service. Constructors are expected to provide favourable drying conditions e.g. temperatures of 60° to 80°F with relative humidities between 30 per cent and 75 per cent.

Traditionally pneumatic spraying was used for aircraft painting but in recent years much consideration has been given to alternative methods. Both airless and electrostatic spraying are being used to a fair extent but even the remotest possibility of an explosion with the electrostatic method has meant a certain diffidence toward it, especially when a million pounds worth of equipment may be at stake. Considerable success has attended the recent introduction of the pressurised roller when used in conjunction with airless spray. The importance of clean substrates cannot be overemphasised. The Services are now examining detergent steam cleaning from a high pressure lance and the experiments indicate that the method is exceptionally effective.

The future

The speed limit for aluminium aircraft is Mach 2.2. Changes in design below Mach 2.2 will be mainly in respect of greatly increasing size and the protective performance is likely to rest largely on the present pattern. For faster designs, operating surface temperatures will rise sharply, and since the temperature limit available from current polymer technology is about 200°C new developments will be needed. A further 100°C rise is probable from organic polymers such as silicones and polyamides but beyond this inorganic coatings will be needed. Protective considerations will also need to be revised since fabrication will employ titanium and nickel alloys extensively and corrosion protection may not be such an important consideration. Adhesion problems are also expected and already work is under way to pretreat titanium for improved paint adhesion.

Question time reflected the interest shown in Mr Hoey's subject. The questioners were Messrs K. W. Green, J. D. Sutherland, J. Lewis, W. Arnott, R. E. Gunn and a warm vote of thanks was given by Mr J. Lewin.

R.E.G.

AGM Bristol, 1968

In non-conference years Council has on occasion arranged for the AGM to take place in one of the centres of section activity, and this year it was held for the first time at Bristol, with the Bristol Section as hosts.

Before the meeting, members and their guests assembled at the Royal Hotel for a coach tour of the nearby countryside. At 2.00 p.m. the coach left the Hotel and set out across the Severn Bridge towards Chepstow. From there the route lead through Lydney, and the Forest of Dean, stopping at Speech House Hotel in the Forest for tea. Mr R. P. L. Britton, a Founder Member, and Mrs Britton, who live at Ross-on-Wye, were waiting at Speech House to welcome the party, and joined them for tea.

Speech House stands alone in 20,000 acres of unspoilt forest. The greater part of the house was erected in 1676, and the house was built as near as possible to the centre of the forest for the hearing of disputes over mining and forestry laws and customs. To this day both the court of foresters, or "Verderers' Court" and the assembly of the Free Miners of the Forest of Dean are held in the Court Room of Speech House, which is used as the dining room when no court is in session. Members showed interest in the many old pieces of furniture to be seen.

After tea the coach proceeded through the forest to the Wye Valley, passing Tintern Abbey on the way back to the Severn Bridge and the Royal Hotel. A spell of good weather had shown the beautiful countryside at its best, and it was generally agreed that it had been a most worthwhile trip.

At 6.00 p.m. the company assembled in the Ballroom of the Hotel, where a film, made by the BBC, of the building of the Severn Bridge, and its opening by the Queen, was shown. Perhaps of particular interest was the fact that the smaller part of the bridge, which crosses the River Wye, while being less spectacular than the main span, is probably the more technically interesting.

The building of the Severn Bridge, in particular the use of prepainted units, had been featured on the Technical Education Stand at the Associations 19th Technical Exhibition in 1967, and the film was thus of great interest to members.

Following the showing of the film, the Ballroom was rearranged for the Annual General Meeting, the proceedings of which are reported elsewhere in this issue.

After the AGM dinner was served, grace being given by the President.

In the opening speech following the dinner Mr D. S. Newton, Chairman of the Bristol Section, welcomed members to Bristol. This was the fourth occasion in the history of the Association that the AGM had been held out of London in a non-conference year, and he was honoured that it should occur during his term of office. He hoped that the members, and their ladies, had enjoyed their stay.

Next Dr H. W. Keenan thanked the Association for the honour which had been bestowed on him when he had been invested with Honorary Membership at the Annual General Meeting. He had had much pleasure from his work in the Association. In particular he mentioned the Association's insignia, about the conception of which there was some mystery. In fact the idea had arisen at a Council Meeting, when a suggestion was made that the Association be called the Da Vinci Society, and thus cover a much broader field. During the discussion Dr Keenan had roughly drawn the head of Leonardo in an oval frame. The late Dr L. A. Jordan had seen this, and feeling that it would be an appropriate symbol for the Association had produced a suitable motto, arranged for the whole design to be drawn by an artist, and registered it as a *bona-fide* work of art.

The other new Honorary Member, Mr L. O. Kekwick, then thanked the Association for honouring him in this way. It was not with any thought of reward that he had done what he had done, and he was sure Dr Keenan felt the same. They had merely been enjoying themselves. There had always been good fellowship in OCCA, and this was a reward in itself.

Mr Kekwick recalled his visit to the South African, Australian and New Zealand Sections during his term of office as President. He was pleased to see the progress made overseas.

The President, Mr F. Sowerbutts, thanked the Bristol Section for their hospitality, which he was sure was warmly appreciated by all present. In particular he thanked Mrs Newton, who had supplied the lovely sprays of roses for all the ladies from her own garden.

Members dispersed at about 10.30 p.m., it being generally agreed that it had been an enjoyable day's proceedings.

R.W.

---

21 OCCA

On Monday 24 March the Exhibition Luncheon will be held at the Savoy Hotel, London WC2, and full details will be announced at a later date. In conjunction with Grand Metropolitan Hotels Ltd., the Association has again arranged, as a service to visitors to the Exhibition, for accommodation at a 10 per cent reduction. All persons overseas receiving the "Official Guide" will find a form enclosed; others wishing to avail themselves of this service should write to the Association's Offices.

Newcastle Section

Joint winners of the British Titan Cup, (Left) Mr J. G. Bell, (Right) Mr T. E. Meir

Seventh Annual Golf Tournament

The Section held its Seventh Annual tournament for the British Titan Cup at Hexham Golf Course on Saturday 29 June.

The competition was a fourball betterball against bogie and was won jointly by:

Mr J. G. Bell—Smith & Walton Ltd.

Mr T. E. Meir—British Titan Products Ltd.

with an exceptionally good return of "nine up" on bogie.

In jointly winning the trophy this year Mr J. G. Bell has become the first person to win the trophy on three separate occasions.

To round off the day's activities, friendly matches were held during the afternoon.

West Riding Section

Works Visit

The annual Works Visit of the West Riding Section was held on 28 May 1968, and was to the Paint Research Station at Teddington.

About 12 members were expected, and when the Hon. Pub. Officer finally decided to join the party and make it lucky 13, our worthy Chairman, Mr L. H. Silver, volunteered to forego the pleasure of our company on the Minibus and steeled himself to lie abed for another two hours after the coach's scheduled departure from the Wentbridge service station at 6 a.m. He eventually arrived at Teddington a few minutes ahead of the main party, having travelled the "high" way by BKS from Yeadon to Heathrow.

The party was welcomed by Dr G. de W. Anderson, the Director of Research, and then split into two groups, members of the PRA in one group, and non-members in the other, to tour the various departments and hear explanations of the projects, long and short-term, currently under way.

The Luncheon break was enjoyed at a hostelry overlooking Hampton Court Maze and fortified by liquid "Courage" and other stimulants the rest of the visit was over all too soon.

Needless to say, the West Riding Works Visit once again lived up to its reputation of providing some unscheduled incident to fix it in the memory of those taking part. There was the Liverpool trip when only three members turned up, then the Laporte trip when the coach-driver got lost. This year's highlight was provided by Bob Frost who provided permanent air-conditioning in the coach, halfway along the M1, by removing, with his elbow, the window and frame from the back of the Minibus.

Obituary

Arthur Rudkin

T.A.F. writes:

In the 25th Anniversary year of the Hull Section, it is with deep regret that we have to record the passing of one of our founder members.

Arthur Rudkin launched out into a man's life with a vengeance. At the tender age of 15 years he joined the army to take part in the Great War and although he survived this gruelling experience, his health was impaired thereafter as a result of being gassed in the trenches.

His working life was spent in the seed crushing and vegetable oil processing industry in Hull, in which he rose to become Works Manager of John L. Seaton & Co. Ltd., the position from which he retired in a consultative capacity in August 1964. By the passing of Mrs Rudkin shortly after this, they were unfortunately denied the pleasure of sharing the new bungalow they had taken for more leisurely times.

Never seeking the limelight, Arthur Rudkin was a practical man and an acknowledged expert in plant design and operation. His services were greatly valued by his employers and he was held in high esteem by his many friends in OCCA and throughout the trade.

Joining OCCA in 1942, he helped to pioneer the wartime emergency Hull Regional Group of the London Section, leading to the formation of the Hull Section in 1943.

We record our deepest respect to the memory of a keen supporter and loyal committee member.

News of Members

Mr C. W. A. Mundy, a Past President and Member of the London Section, was recently elected to the Sevenoaks Rural District Council, his election agent being Mr H. C. Worsdall, a Past Chairman of the London Section.

Mr K. Smith, an Ordinary Member attached to the London Section, has been appointed Deputy Sales Manager of Armour Hess Chemicals Limited, based on Armour Hess's Leeds Head Office. Mr Smith was previously London Manager, Fatty Acids Sales.

Mr I. D. Sutherland; an Ordinary Member attached to the London Section, has been appointed Midland Area Manager of J. M. Steel & Co. Ltd., and will move to the company's Birmingham sales office.

Mr M. J. Hodges, an Associate Member attached to the London Section, is to take over responsibility for the sale of the raw materials handled by J. M. Steel & Co. Ltd. to the surface coatings industries. He will maintain his responsibilities for epoxy resins and products for the food industry.

It was noted with pleasure that the July issue of the "Perfumery and Essential Oil Record" contained an editorial devoted to the life, work and achievements of Mr A. R. Penfold, an Honorary Member of the Association.

Commemorative Celebrations

It is very much regretted that, in the report in the July issue, amongst the names of those attending the Fiftieth Anniversary Celebrations and presenting messages on behalf of their societies, mention was not included of Dr Bernhard Cyriax, a Member of the General Overseas Section, who presented a message from the Paint & Pigment Section (Fachgruppe Anstrichstoffe und Pigmente) of the German Chemical Society. This message together with all the others received on the occasion of the Fiftieth Anniversary has been bound into a book, which will be displayed at Section functions and was first shown at the Association's Annual General Meeting on 28 June in Bristol.

BISRA Corrosion Committee 40th Anniversary

A Luncheon was given recently to celebrate the 40th Anniversary of the Corrosion Committee of the British Iron and Steel Research Association.

The Luncheon was held at the St. Ermins Hotel, London, on 17 July, and among members of the committee and their guests were four of the original members of the Committee at its inception in 1928.

After the Luncheon Dr E. C. Williams, Chief Scientist at the Ministry of Power, congratulated the committee on its 40 years' work, and proposed the toast "The Corrosion Committee and the next 40 years." Mr P. E. White, chairman of the Committee, replied on behalf of the Committee and went on to welcome the guests.

Professor G. Wesley Austin, a member of the original Corrosion Committee, spoke of the late W. H. Hatfield, who had been largely responsible for its formation, and thanked BISRA for its hospitality.

Color 69

The 1st congress of the International Colour Association, Color 69, is to be held at the Institute of Technology in Stockholm from 9-13 June 1969, arranged by the Swedish Colour Group.

The following sessions have been provisionally arranged:

(1) Colour vision.
(2) Psychology of colour perception.
(3) Colorimetry, including metamerism and colour rendering.
(4) Teaching of colour.
(5) Colour technology, including colorant formulation, production control and colour reproduction.
(6) Uses of colour in art, architecture, interior decoration, design, fashion and marketing.

Colour Group—Northern Section

It is proposed to form a Northern Section of the Colour Group and, to inaugurate this, a meeting will be held at the Manchester University Institute of Science and Technology, Lecture Theatre C2 at 6.30 p.m. on 9 October 1968. A lecture entitled "The perception of colour," will be presented by Professor W. D. Wright, of Imperial College, and this will be followed by a public meeting and election of committee.

Courses in surface coatings technology in the Manchester area

The following courses will be held at the John Dalton College, Chester Street, Manchester, during 1968-69:

The City & Guilds "Paint Technicians Certificate" (subject 357) Parts I and II.
The Higher National Certificate Endorsement subject in "Chemical Technology with special reference to Polymers and Surface Coatings."
The "Associateship of the Society of Dyers and Colourists."

Further details are available from the Registrar, and enrolment commences 16 September 1968.

Register of Members 1968

The following are corrected entries:

BASSETT, PETER NIGEL, BSc, 12 Kirstenbosch, Playfair Road, Durban, South Africa. S.AF/O. 1965.

DURY, IAN CLIFFORD JAMES, LRIC, 23 The Chippings, Stapleton, Bristol 5. B/O. 1967.

GREENALL, BRIAN JOHN, BE(Chem), ANZIC, W. Graham Hitchins Ltd., Box 13, Renwick, New Zealand. WEL/O. 1966.

HARE, PETER DENNIS, BScTech, AMCST, Woodbank, Hopton, Derby, DE4 4DF. MID/O. 1965.

MCKIERNAN, EUGENE, BSc, Vogt Mfg. Corp., 100 Fernwood Avenue, Rochester, New York 14621, USA. I/O. 1962.

NICKLIN, RANDALL JOHN PETRIE, FICorrT, AMIEI, 13 Rosamond Place, Bradway, Sheffield, S17 4LX. L/O. 1968.

POBORCA, STEFAN, Polish Cross of Valour, 25 Chapel Fields Road, Olton, Solihull, Warwicks. MID/A. 1955, O. 1960.

SMITH, KENNETH ROBERT, BSc, ARIC, "Fairfield," Goldcliff, Newport, Mon. B/O. 1965.

WILLIAMS, ADRIAN ARTHUR OWEN, 36 Southover High Street, Lewes, Sussex. L/O. 1935.

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

BROWN, LENARD ROY, Wardkiss Paints (Pty.) Ltd., PO Box 52, Alberton, South Africa. (*South Africa*)

CHADWICK, FREDERICK JOSEPH, BSc, 246 Kings Road, Chorlton, Manchester 21. (*Manchester*)

DUDLEY, MICHAEL, BA, BSc, 89 South Esk Road, Forest Gate, London E7. (*London*)

HILL, COLIN NEVILLE, 5 Park Avenue, Swinton, Lancs. (*Manchester*)

JEFFERY, MATTHEW CYRIL, BSc, Thomas de la Rue International Ltd., Research Division, Lower Cookham Road, Maidenhead, Berks. (*London*)

LAKIN, WILLIAM KENNETH HOUGHTON, BSc, 186 Withington Road, Manchester 16. (*Manchester*)

QUINN, STEPHEN JOSEPH, BSc, 125 Deveron Street, Coatbridge, Lanarkshire. (*Scottish*)

REEVE, FRANK NICHOLSON, Mander-Kidd Ltd., PO Box 99, Troyville, Johannesburg. (*South Africa*)

SHAW, ERNEST VICTOR, 77 Cooley Road, Drimnagh, Dublin. (*Irish*)

TEAR, BRIAN JOHN, GRIC, 6 Landeck Avenue, Grimsby, Lincs. (*Hull*)

VON BENECKE, ABRAHAM AARON HECTOR, c/o Smith & Walton (SA) (Pty.) Ltd., PO Box 46, Jacobs. (*South Africa*)

Associate Member

BRENNAN, IAN HAROLD, Carst & Walker Chemicals (Pty.) Ltd., PO Box 1193, Durban. (*South Africa*)

Student Members

ANDERSON, BASIL MCKIERNAN, 3 Blackheath Park, Clantorf, Dublin 3. (*Irish*)

ATKINSON, KENNETH, 12 Fearnville Place, Roundhay, Leeds 8. (*West Riding*)

BARRY, DAVID AUSTIN, The Walpamur Co. (Ireland) Ltd., Cardiff Lane, Dublin 2. (*Irish*)

COWIE, EDWARD BRUCE, 1383 Gallowgate, Parkhead, Glasgow E1. (*Scottish*)

HAMILTON, JAMES, 36 Winifred St., Robroyston, Glasgow E3. (*Scottish*)

KIRKSWOOD, Thomas, 81 Montrose Gardens, Kilsyth. (*Scottish*)

MCMAHON, MAURICE JAMES, 111 Glenacre Road, Carbrain, Cumbernauld. (*Scottish*)

MULHOLLAND, WILLIAM, 106 Dundyvan Road, Coatbridge, Lanarkshire. (*Scottish*)

VANSPALL, ALFRED RAYMOND, Laporte Synres, Stallingborough, Grimsby, Lincs. (*Hull*)

WATT, GORDON THOMAS, 183 Stonelan Road, Rutherglen, Glasgow. (*Scottish*)

Section programmes for 1968-69 session

Scottish

Eastern Branch

All meetings to be held in The Wee Windaes Restaurant, 142 High Street, Edinburgh, at 7.30 unless otherwise stated.

1968

Wednesday 23 October

"Dispersible Organic Pigments," by Dr R. Plant (Imperial Chemical Industries Ltd.).

Saturday 12 October

Junior Lecture. "Fluid Handling in the Paint Industry," by Mr D. Muirhead (Wm Sim & Sons Paints Ltd.), at 10.30 a.m., followed by lunch and a skittles match at the Hillburn Roadhouse.

Wednesday 20 November

"Colour Computers," by a speaker from the Paint Research Station.

Wednesday 18 December

"Crime Prevention," by Chief Superintendent Brown (Edinburgh City Police).

1969

Wednesday 22 January

"Layout of Machines and Machine types in the Paint and Ink Industries," by Mr D. P. Sullivan (DH Industries Ltd.).

Wednesday 26 February

"Safety in Industry with particular reference to Toxicity," by Mr S. J. Silk (HM Chief Factory Inspector).

Joint Meeting with the Society of Dyers & Colourists at the Carlton Hotel, North Bridge, Edinburgh.

Wednesday 19 March

Annual General Meeting followed by a selection of films from the Shell library.

Wednesday 23 April

"The Use and Development of PVA Emulsions in the field of Paper Coatings, Paint and Adhesives," by Mr R. A. C. Kuenzli (Resinous Chemicals Ltd.).

Amendment

The following amendments to the Bristol Section programme for 1968-69 have been notified:

The lecture originally scheduled for Friday 25 October 1968 will now take place on Friday 8 November 1968.

The speaker for the lecture "Metallic Pigments" on Friday 29 November 1968 will be Mr G. W. Wendon, of the English Metal Powder Co. Ltd.

Forthcoming Events

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

Tuesday 10 September

West Riding Section. "Accelerated Weathering of Paints" by Mr M. Hipwood of Ordinance Inspectorate, Paints Dept., to be held at the Griffin Hotel, Boar Lane, Leeds 1, at 7.30 p.m.

Friday 13 September

Midlands Section. Annual Ladies' Evening, at the Westbourne Suite, Botanical Gardens, Birmingham 15, at 7.00 p.m.

Saturday 14 September

Scottish Section—Student Group. "Emulsions for Paints and Other Coating Applications" by a speaker from Vinyl Products Ltd., to be held at the Lorne Hotel, Sauchiehall Street, Glasgow, at 10.00 a.m.

Wednesday 18 September

London Section. "New Concepts in Polymer Architecture" by Mr A. R. H. Tawn of Cray Valley Products Ltd., at the New Engineering Block, University College, WC1, at 6.30 p.m.

Manchester Section—Student Lecture. "Titanium Dioxide—Properties Manufacture and Uses" by Mr J. K. Rankin of British Titan Products Ltd., to be held at the Manchester Lit. & Phil. Society, at 4.30 p.m.

Friday 20 September

Midlands Section. "Trends and Developments in Automobile Finishing" by Mr N. Jeffery of Lewis Berger (GB) Ltd., to be held at the Chamber of Commerce House, 75 Harborne Road, Birmingham 15, at 6.30 p.m.

Thursday 26 September

Midlands Section—Trent Valley Branch. "Paint Application Methods with special reference to Electrostatic Spraying" by Mr R. C. Lever, Sales Director of Volstatic Ltd. (with demonstration), to be held at the Loughborough University, No. 2 Lecture Theatre, Edward Herbert Building, at 6.30 p.m.

Thames Valley Section. "Pretreatment Prior to Electropainting" by Mr D. James of the Pyrene Co. Ltd., to be held at the Royal White Hart Hotel, Beaconsfield, Bucks, at 7.00 p.m.

Friday 27 September

Bristol Section. "Radiation Curing of Paint Films" by Dr F. L. Dalton of UKAEA, at the Royal Hotel, Bristol, at 7.15 p.m.

Irish Section. "Paint Faults and Remedies" by Mr H. Wells, to be held at the International Hotel, Belfast. It is hoped to have a works visit in Belfast on the same afternoon—details to be announced later.

Manchester Section. Works Visit—Bromborough Power Station.

Thursday 3 October

Newcastle Section. "Gel Permeation Chromatography" by Mrs S. M. Rybicka of PRS, to be held at the Royal Turks Head Hotel, Grey Street, Newcastle upon Tyne 6.30 p.m.

Saturday 5 October

Scottish Section—Eastern Branch Student Lecture. "Fluid Handling in the Paint Industry" by Mr D. Muirhead of Wm Sim & Sons Paints Ltd., at the Wee Windaes Restaurant at 10.30 p.m. followed by lunch and a skittles match at the Hillburn Roadhouse.

Monday 7 October

Hull Section. Joint meeting with the Hull Branch of the National Federation of Master Painters and Decorators at the Bullock Lecture Theatre, Hull College of Technology, at 7.00 p.m.

Tuesday 8 October

West Riding Section. "Printing Inks for Plastics" by Mr J. Hastings-Long of Ultra Printing Inks Ltd., to be held at the Griffin Hotel, Boar Lane, Leeds 1, at 7.30 p.m.

Thursday 10 October

Scottish Section. "Developments in Paint Industry" by Mr J. M. Butler of Lewis Berger (GB) Ltd., to be held at the Whitehall Restaurant, Renfield Street, Glasgow, at 6.00 p.m.

Friday 11 October

Hull Section. Annual Dinner Dance at the Hotel Eden, Willerby.

Manchester Section. "Recent Advances in the Technology of Painting of Ships" by Dr D. Atherton of John S. Craig & Co. Ltd., to be held at the Manchester Literary and Philosophical Society, 36 George Street, Manchester 1, at 6.30 p.m.

Saturday 12 October

Scottish Section—Student Group. "Dispersible Pigments" by Mr A. Gray of Geigy (UK) Ltd., to be held at the Lorne Hotel, Sauchiehall Street, Glasgow, at 10.00 a.m.

Monday 14 October

London Section—Southern Branch. "Thick Coatings" by Mr G. C. R. Russell of Shell Research Ltd., and Mr T. F. Birjenhead of ICI Mond Division, to be held at the Keppel's Head Hotel, The Hard, Portsmouth, at 7.30 p.m.

Thursday 17 October

London Section. "Management by Objectives in Research and Development" by Mr G. S. Sanders of Urwick Orr & Partners Ltd., to be held at the New Engineering Block, University College, London WC1, at 6.30 p.m.

Friday 18 October

Manchester Section. Annual Dinner Dance at the Piccadilly Hotel, Piccadilly Plaza, Manchester 1.

Midlands Section. Joint meeting with Midlands Section, Plastics Institute, "Coatings on Plastics" by Mr E Kubitza of Farbenfabriken Bayer AG to be held at the Chamber of Commerce House, 75 Harborne Road, Birmingham 15, at 6.30 p.m.

Wednesday 23 October

Scottish Section—Eastern Branch. "Dispersible Organic Pigments" by Dr R. Plant of Imperial Chemical Industries to be held in The Wee Windae's Restaurant, 142 High Street, Edinburgh, at 7.30 p.m.

Friday 25 October

Irish Section. "Printing on Plastic Materials" by Mr R. Ruttledge.

Wednesday 30 October

Thames Valley Section. "Forensic Science" by Dr I. G. Holder of the Home Countries Forensic Science Laboratory to be held at the Royal White Hart Hotel, Beaconsfield, Bucks, at 7.00 p.m.

Thursday 31 October

Midlands Section—Trent Valley Branch. Joint Meeting with Nottinghamshire, Derbyshire and Lincolnshire Society of Architects. Two half hour talks. "The Problems which arise when dealing with Architects" by Mr F. C. A. Hovey, and "The Problems which Architects encounter in connection with the Application of Paint" by an Architect, to be held at the British Rail School of Transport, London Road, Derby, at 7.30 p.m.

Oil and Colour Chemists' Association

President : F. SOWERBUTTS, B.SC.TECH.

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

There are Sections of OCCA in Auckland, Bristol, Hull, Ireland, London, Manchester, the Midlands (with a Trent Valley Branch), Newcastle upon Tyne, Scotland (with an Eastern Branch), South Africa (with Branches in the Cape, Transvaal and Natal), Thames Valley, Wellington, and the West Riding, and these are responsible for the conduct of their own local affairs. There is also a General Overseas Section. There is also a close alliance between the Association, the 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).

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

Ordinary Membership is granted to scientifically trained persons, and Associate Membership to others interested in the industries covered. Student 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 five guineas, except for Student Members whose subscription is one guinea. 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 Director & Secretary at the address given below. Application forms and full details of membership may be obtained from the offices of the Association.

PUBLICATIONS

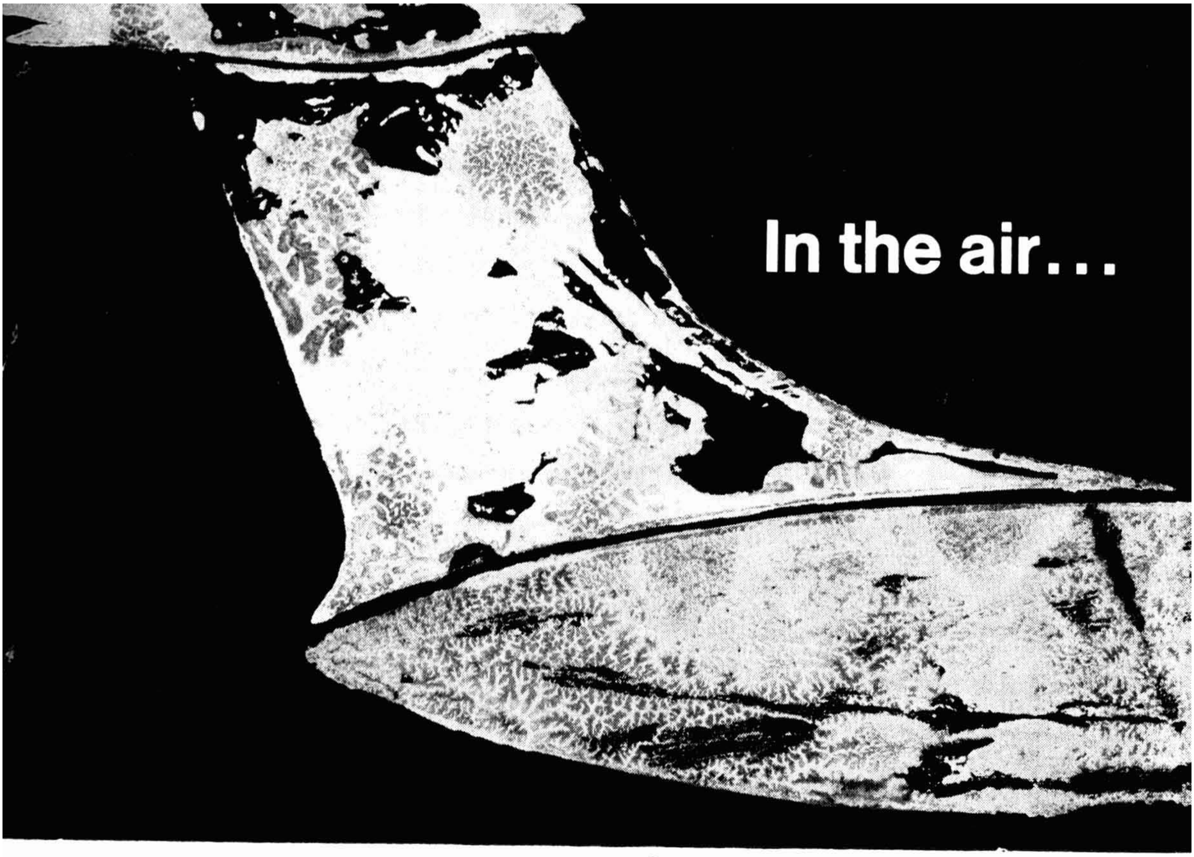
Journal of the Oil and Colour Chemists' Association. Published monthly. Subscription rate to non-members in UK and abroad, £7 10s. p.a. post free ; payable in advance.

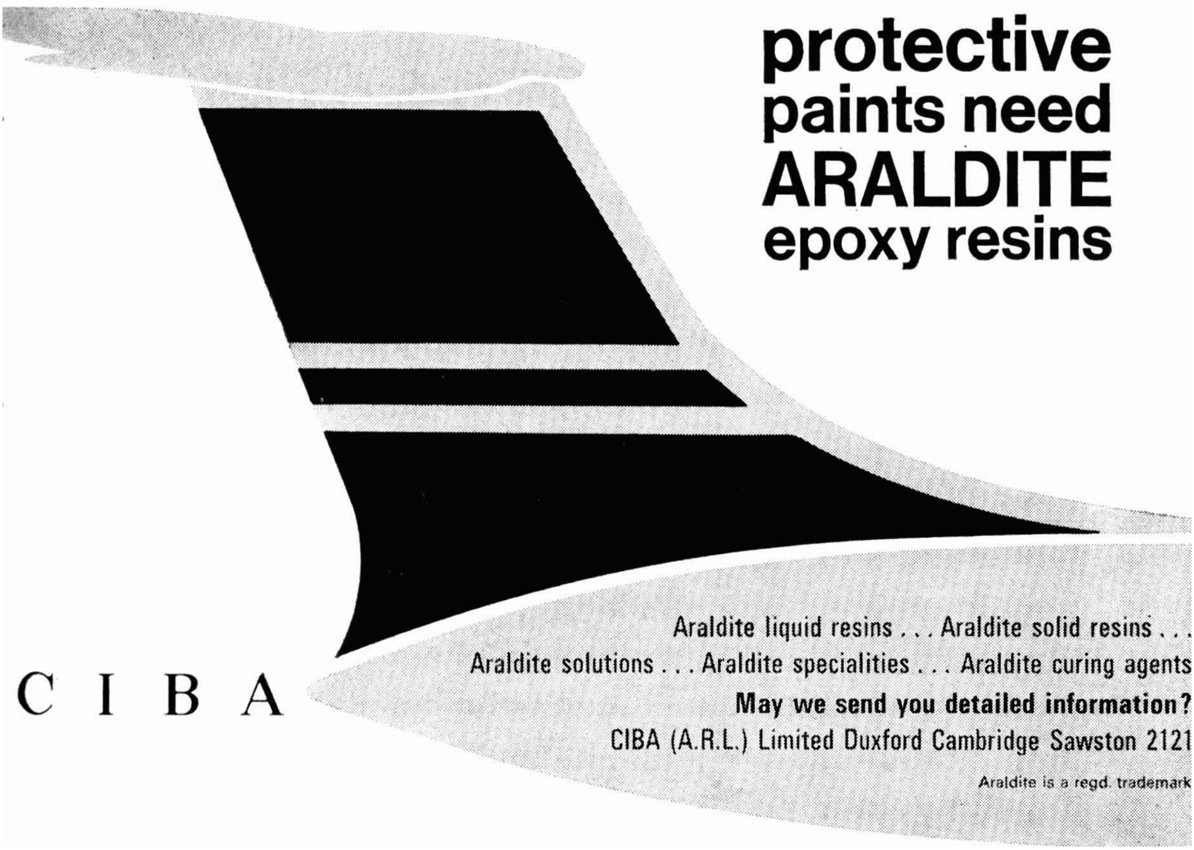
An Introduction to Paint Technology (Second Edition with additional chapter). Pp. 187, illustrated, with index, £1 (including postage).

Paint Technology Manuals

Part 1 : " Non-convertible Coatings " } Second editions will appear
Part 2 : " Solvents, Oils, Resins and Driers" } in November 1968.
Part 3 : " Convertible Coatings," Pp. 318, 35s.
Part 4 : " The Application of Surface Coatings," Pp. 345, 35s.
Part 5 : " The Testing of Paints," Pp. 196, 35s.
Part 6 : " Pigments, Dyestuffs and Lakes," Pp. 340, 35s.

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





CAN YOU AFFORD NOT TO TAKE THE ?

PRS REVIEW

OF CURRENT LITERATURE ON THE PAINT AND ALLIED INDUSTRIES

Lei legge ogni articolo e patente intorno le pitture? La PRS fa questo per voi.

Lisez-vous chaque communication et chaque brêvet sur la peinture? PRS le fait pour vous.

Do you read every paper and patent on paint? The PRS does, and abstracts them in the REVIEW.

Читаете ли Вы каждую статью и каждый патент о красках? PRS (прс) читает их и абстрагирует их в “Обзорном Журнале.”

Lee Vd. todos los articulos y patentes tocante a las pinturas? La PRS lo hace para Vd.

Lesen Sie jede Mitteilung und jedes Patent über Anstrichstoffe? Die PRS liest alles für Sie.

Each year the REVIEW contains approximately 10,000 abstracts carefully selected from over 1,600 publications in 30 languages, including abstracts of more than 3,000 patents from 20 countries.

Subjects covered include paints, lacquers, varnishes, wood preservatives, anticorrosive and antifouling materials, putties, plastisols, floor coverings, printing inks and writing, drawing and marking materials, pigments, drying oils, natural and synthetic resins, solvents and plasticisers.

The REVIEW is backed by the Library of the Paint Research Station which is the largest and most comprehensive in the world for its subjects and itself takes nearly 400 periodicals, also standard specifications, trade literature, university theses and reports from other research organisations.

The annual subscription to the REVIEW (12 monthly issues, January to December, and annual author, subject and patent indexes) is £25 sterling ($60 in Canada and USA).

Please write for a specimen copy to:

THE PAINT RESEARCH STATION
WALDEGRAVE ROAD, TEDDINGTON
MIDDLESEX, ENGLAND

we sell refined linseed oil

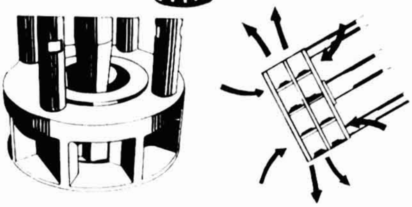
OIL PARTICULARS FROM

Samuel Banner

LIVERPOOL: 34 CASTLE STREET. 051 CEN 0223
LONDON: 10 NEWTON RD. E.15. 01 MAR 4321
GLASGOW: 289 CASTLE STREET. C.4. BEL 0723

Patent No.
1004752

THIS NEW EDWARDS & JONES DUO-FLO MIXER AND DISPERSER GIVES EVEN FASTER MIXING AND COSTS LESS TO MAINTAIN



Single bearing construction—no bottom bearing—means longer working life and lower maintenance costs.

The unique Duo-Flo Mixer Head sucks in liquid from the top *and* from the bottom simultaneously. Gives thorough mixing—extra fast.

The Duo-Flo Mixer will put almost any solid into suspension—thoroughly dispersing solids from the bottom of the container—while at the same time, having a grinding action on the solids. It is especially useful for remixing settled out suspensions or mixing two or more liquids. For use with paints, resins, glazes or clays, it is highly successful on viscous or high density mixtures. Substantial, screw-operated, motor driven stand to lift machine into or out of containers. It can also be slung from a simple overhead suspension such as an electric hoist.

The Unit is made in stainless steel or Phos. Bronze, in a range from 3-50 h.p. using standard squirrel cage motors. It is supplied complete with contactor and overloads fitted on the side of the motor.

For illustrated leaflet giving full details write to:

EDWARDS & JONES LIMITED
LONGTON · STOKE-ON-TRENT
Telephone: Stoke-on-Trent 33077 (4 lines)
Telegrams: "GLOBE Longton"

Frankfurter

ZEITUNG FÜR

S-Ausgabe / Freitag, 21. Juli 1967

Herausgegeben von Nikolas Benckiser, Bruno Dechamp

Wirtschaft und Gewerkschaften wünschen rasche

Aussprache mit Schiller über das Fünf-Milliarden-Programm / Erster Investitionshaushalt unzureichend / Sozialpart

Fk. BONN, 20. Juli. Die Vertreter der Wirtschaft und der Gewerkschaften haben beim jüngsten Gespräch der „konzertierten Aktion“ sowohl dem zweiten Investitionsprogramm der Bundesregierung als auch der Zielprojektion für die mittelfristige Wirtschaftsentwicklung (bis 1971) zugestimmt. Die Teilnehmer des Gesprächs mit Bundeswirtschaftsminister Schiller waren sich, wie das Kommuniqué mitteilt, darin einig, daß der erste Investitionshaushalt des Bundes die konjunkturelle Abschwungsbewegung gebremst hat; er habe jedoch für einen neuen Aufschwung nicht ausgereicht. Man war sich auch einig, daß dieses zweite, mit Krediten finanzierte Investitionsprogramm mit seinem Gesamtvolumen von fünf Milliarden Mark „für alle weitaus billiger als ein Anhalten der konjunkturellen Schwäche“ sei.

Diese Ansicht des Bundeswirtschaftsministers haben vor allem die Vertreter des Bundesverbandes der Deutschen Industrie unterstützt. Alle Anwesenden haben sich deshalb für eine zügige Beratung des Programms im Parlament und für eine rasche Verwirklichung ausgesprochen. Die Zustimmung kam auch von jenen Verbänden, die — wie beispielsweise der Deutsche Industrie- und Handelstag — bei den ersten Erörterungen über den zweiten Konjunkturhaushalt Zurückhaltung geübt hatten.

Der Bundeswirtschaftsminister hat mit seinen Gesprächspartnern außerdem seine Zielvorstellungen für die mittelfristige Wirtschaftsentwicklung bis 1971 erörtert. Sie stellen nach seinen Worten ein politisches Programm der Bundesregierung und nicht nur eine Vorausschätzung dar.

Zu einer ausgedehnten Diskussion kam es über die Zahlenangaben der verschiedenen wirtschaftlichen Zielvorstellungen. Die Vertreter der Wirtschaft kritisierten beispielsweise, daß eine Arbeitslosenquote von 0,8 Prozent anvisiert werde; derart exakt ließen sich solche Ziele nie verwirklichen, hieß es; außerdem stelle sich die Frage, ob bei einer Arbeitslosenquote von 0,8 Prozent noch von einem Gleichgewicht am Arbeitsmarkt gesprochen werden könne.

Die Gesprächsteilnehmer kamen überein, die Konsequenzen aus dem mittelfristigen Wirtschaftsprogramm auf der nächsten Gesprächsrunde im Herbst zu erörtern. Dabei geht es beispielsweise um die Frage, wie die Lohnpolitik, die Einkommensverteilung, die Wettbewerbs- oder Energiepolitik gestaltet werden müssen, um die anvisierten Ziele zu erreichen. Der Wirtschaftsminister geht davon aus, daß bis 1971 das Sozialprodukt jährlich real um durchschnittlich vier Prozent pro Jahr wachsen soll. Zugleich soll der Preisauftrieb auf eine Zuwachsrate von einem Prozent im Jahr 1971 zurückgeführt werden.

Die Sozialpartner wollen außerdem außerhalb der „konzertierten Aktion“ versuchen, über die Frage der Einkommens- und Vermögensverteilung eine Verständigung zu erreichen. Ihre Ergeb-

Hochschulen brauchen bis 1970 noch über fünf Milliarden

Der Wissenschaftsrat drängt zu Reformen / Neue Empfehlungen dem Bundespräsidenten übergeben

B. B. KÖLN, 20. Juli. Abschied von liebgewordenen Traditionen hält der Wissenschaftsrat für unerläßlich, wenn die Hochschulen zu handlungs- und koordinationsfähigen Organisationsformen kommen sollen. In seinen am Donnerstag dem Bundespräsidenten
nen neuen Empfehlungen für
bau der wissenschaftlichen Ho
bis 1970 erklärt der Wissens
daß zwar Anregungen der
schen Rektorenkonferenz in di
tung schon verwirklicht word
daß die bisherigen Reformen
Gewicht der alten Institutionen
punktuelle Ansätze beschränk
ben seien und sich der herkö
Struktur oft nur widersprüch
fügten. Der Wissenschaftsrat
bis 1970 für den Ausbau der
den Hochschulen 5,6 Milliard
zu investieren und 1793 neue
den Lehrkörpern zu schaffen.

Bei der Übergabe der Emp
sprach sich Bundespräsident
Bonn für eine Überprüfung d
ten Bildungswesens aus. „W
vor tiefgreifenden Reformen
Bildungswesens nicht zurück
auch wenn wir Neuland betre
zu gehöre, im Hinblick auf

Der Wissenschaftsrat empfiehlt, den kleinen Senat als das zentrale Entscheidungsgremium der Hochschule zu stärken. In den leitenden Ämtern der Selbstverwaltung sei eine größere Konlen für Bauvorhaben, Stellenpläne, Studentenzahlen und Ausgabenvoranschläge. Der Wissenschaftsrat stellt fest, daß die Lage an den Hochschulen sich dank der Leistungen ihrer Träger in

A newspaper without print?

You have never seen one? You wouldn‘t. What makes the print visible is the carbon black in the ink. The ‘blackness‘ of the pigment is due to its light absorption which, according to quality, varies between 90 and 99,8 %.

Since the days of ‘black magic‘, carbon-black has been used as pigment in printing inks. The products used in the printing industry must be deep black, strong pigments, dispersing readily and not impeding the flow of the ink. DEGUSSA carbon black pigments meet all these requirements. Each product in the range is tailored to the needs of particular applications.

DEGUSSA carbon black pigments are also used in paints, plastics, synthetic fibres, building materials, papers, etc.

Sales concessionaire in the U. K.:
Bush Beach & Segner Bayley Ltd.,
Marlow House, Lloyd‘s Avenue,
London, E. C. 3

DEGUSSA

Allgemeine

DEUTSCHLAND

Jürgen Eick, Karl Korn, Jürgen Tern, Erich Welter

40 Pfennig / Nr. 153 D 2955 A

rgesehen

:rteidigungs- und am Agrarhaushalt?

dürften die Beiträge vom 1. Januar 1968 an von 14 auf 15 Prozent des Arbeitsentgelts erhöht werden. Weitere Beitragserhöhungen um jeweils ein Beitragsprozent sind für 1969 und für 1970
vorgesehen, so daß am Ende
trag von 17 Prozent erreicht w
Beitragserhöhung würde der
versicherung vom 1. Januar a
einnahmen von etwa zwei M
Mark verschaffen, die allerdin
die dann vorgesehene Rente
in vollem Umfang wieder a
würden. Die Rentenversicheru
damit auch im kommenden J
derum mit einem Milliarden-D
schließen müssen, das nur aus d
lage gedeckt werden kann.

Zur Verbesserung der Einnal
das Bundeskabinett allerdings
schlossen, daß künftig alle Ang
ohne Rücksicht auf ihr Einkom
sicherungspflichtig in der Re
sicherung werden. Die Pflichtgr
derzeit 1800 Mark Monatsein
soll also aufgehoben werden. V
Maßnahme werden etwa 300 0
stellte betroffen. Es wird a
wohl davon auszugehen sein,
diese Angestellten, wenn ein
zureichende Alterssicherung
von der Versicherungspflicht
lassen können. Das Arbeitsmir
schätzt die Mehreinnahmen der
versicherung auf rund 600 Milli
dere Fachleute gehen von Meh
men von etwa 300 Millionen M
Um weitere 400 Millionen Marl
Rentenversicherung dadurch
werden, daß es künftig bei de
keine Erstattung der bisher g
Versicherungsbeiträge mehr gel

(Fortsetzung Seite 4, Spalte 6.)

Weniger Arbeitslo

F.A.Z. NÜRNBERG, 5. Juli.
der Arbeitslosen in der Bunde
hat sich im Juni weiter saiso
um rund 57 700 auf 400 800 v
Das entspricht einem Rückgang
Prozent. Die Arbeitslosenquote
Mitteilung der Bundesanstalt
beitsvermittlung und Arbeitsl
sicherung von 2,9 auf 1,9 Pro
rückgegangen. Im Vorjahr be
0,4 Prozent. Auch die Zahl d
arbeiter hat sich verringert. C
tig wurden mit 325 700 offene
17 100 mehr als im Mai angebote
im Wirtschaftsteil.)

Ausnahmezustan im Kongo

KINSHASA, 5. Juli (dpa). K

Zu ſparſam geſtrichen

Kg. Die freilich zunächst nur vorläufigen Entscheidungen der Bundesregierung zum Sozialetat machen deutlich, daß die Bundesregierung ihre gewiß schwere Aufgabe, die Finanzpolitik grundlegend neu zu ordnen, nicht bewältigen wird. Zu sparsam ist der Rotstift

verdienenden Angestellten entstehen eines Tages ebenfalls Rentenansprüche, die honoriert werden müssen, wie auch das Geld, das nun durch den Verzicht auf Beitragserstattungen gespart wird, später in Form von Renten ausgezahlt werden muß. Damit werden die Finanzfragen der Rentenversicherung nicht gelöst. Die dynamische Rentenlast wird

Carbon Black news

On the front page, in the headlines, in stop-press items, down to the last letter of the last line on the last page. DEGUSSA‘s quality Carbon Black. The jet black, strong pigment with good flow and dispersion, making high quality inks for rotary news, offset and gravure printing.

Among experts, the DEGUSSA Carbon Black range and the technical service departments are appreciated when it comes to solving the problem of which type of Carbon Black best answers a particular purpose and how to get the results sought. Still, there is nothing new in this for the expert, except that, for once, he sees it here in print.

Sales concessionaire in the U. K.:
Bush Beach & Segner Bayley Ltd.,
Marlow House, Lloyd‘s Avenue,
London, E. C. 3

DEGUSSA

DEGUSSA black pigments for lacquers and printing inks

	Nigrometer Index	Tinting strength	Oil absorption g/100 g	
Regent Super . . .	58	0,75	840	for top quality, jet black lacquer finishes; car lacquers
FW 2	64	0,78	730	for deep black lacquer finishes
FW 200	64	0,73	540	for thermosetting acrylic finishes
S 170	71	0,98	650	for leather finishes
Special Black 4 . . .	80	0,86	300	for dip and electrophoretic coatings high quality printing and duplicating inks
Special Black 4 A . .	80	0,86	230	for high quality printing inks, carbon paper and tape compounds
Printex V	83	0,95	400	for industrial and decorative paints, gravure and rotary news inks
Printex 140/V . . .	84	0,91	360	for decorative paints, carbon papers, gravure and rotary news inks
Printex 30	90	0,91	400	medium black, rotary news inks
Printex 300	94	0,94	360	for gravure and low cost offset printing inks
Printex A	94	0,73	300	for gravure printing
Printex G	98	0,64	250	for tinting purposes and matt gravure prints
Lamp Black 700 . . .	93	0,66	400	for tinting purposes
Lamp Black 101 . . .	102	0,21	280	tinting pigment, stable in mixture, for lacquer finishes and paints

CLASSIFIED ADVERTISEMENTS

Classified Advertisements are charged at the rate of 9s. per line. Advertisements for Situations Wanted are charged at 2s. 6d. per line. A box number is charged at 1s. 0d. They should be sent to the Director & Secretary, Oil & Colour Chemists' Association, Wax Chandlers' Hall, Gresham Street, London, E.C.2. Telephone: Monarch 1439

SITUATIONS VACANT

TECHNICAL MARKET DEVELOPMENT

LAPORTE INDUSTRIES LIMITED, Organics and Pigments Division invite applications for posts, both in the UK and export market, as Technical Executives in the Market Development Department. These posts will be filled by men with a thorough knowledge of the chemical industry, particularly with experience in the following industries:—

Paint and Printing Ink
Plastics and Vitreous Enamel
Paper and Adhesives

Objectives include evaluation of technological trends in these industries and technical support of sales of titanium dioxide pigment, resins, solvents and other Divisional products.

Based at Stallingborough, Nr. Grimsby, Lincs., the posts are responsible, permanent and carry a good salary with a non-contributory pension scheme. Age range 25-40 years. Generous assistance with relocation expenses.

Applications should be addressed to:—

Divisional Personnel Manager,
LAPORTE INDUSTRIES LIMITED,
Organics & Pigments Division,
P.O. Box 26,
GRIMSBY,
Lincs.

LAPORTE

PAINT TECHNOLOGIST

Atomic Power Constructions Limited have a vacancy on their staff at Dungeness "B" Nuclear Power Station for a Painting Supervisor/Technologist.

Applicants should have had considerable experience in the supervision of painting contracts together with a good technical knowledge of modern painting techniques.

Apply Resident Manager,
Atomic Power Constructions Limited,
Dungeness "B" Nuclear Power Station,
Romney Marsh, Kent.

SITUATION WANTED

QUALIFIED PAINT TECHNOLOGIST, early forties, widely experienced in all aspects of the formulation, manufacture and application of industrial finishes, seeks change. At present Senior Executive with medium sized paint company. No dispute—genuine reason for wishing to move. Box No. 290.

"YOU CAN HAVE ANY COLOUR YOU LIKE

—providing it's black"

SAID HENRY FORD

This also used to be true of coal tar epoxy resin coatings until recently. Unrivalled in the marine field and for protecting structural steelwork, these coatings were subject to one limitation — based upon a blend of epoxy resins and coal tar pitches, they had to be black.

Now UCC have successfully produced a derivative from coal tar — "DIPOL" — which makes coloured finishes readily possible. Two grades are available: "Dipol L" in liquid form, and "Dipol H" in semi solid form.

Send for a copy of our "Dipol" Technical Information Bulletin today.

UCC
CHEMICALS FROM COAL

THE UNITED STEEL COMPANIES LTD

UNITED COKE AND CHEMICALS CO., LTD.

(Sales Department D. 120) P.O. Box 136, Handsworth, Sheffield 13. England.
Telephone Woodhouse 3211 Telegrams Unichem, Sheffield.

AIR DRIVEN LABORATORY MIXERS

Specialists in high efficiency mixing machinery

for hazardous conditions

Capable of infinitely variable speeds up to 10,000 r.p.m.

The machine is capable of emulsifying, homogenising, dispersing and preparing Heavy Pastes. The adjustable deflector prevents admission of air and reduces the vortex to a minimum.

Brochures of this and other types of Mixers and Agitating Gears available from:

Joshua Greaves & Sons Ltd.-Dept JOCCA
Ramsbottom, Bury, Lancashire
Telephone : Ramsbottom 3159
Telegrams : GREAVES Ramsbottom

Printed in England by Metchim & Son Ltd., 8 Storey's Gate, Westminster, London, S.W.1.

Technical Exhibition

Alexandra Palace

London

24-28 March 1969

A full list of exhibitors will be published in the October issue