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JOURNAL OF COATINGS TECHNOLOGY

JCTAX 51(650) 1-92 (1979)

MARCH 1979

Exposure Evaluation

Part II - Bronzing

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MARCH 1979

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Volume 51 Number 650

Features

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JOURNAL OF COATINGS TECHNOLOGY

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Comment

Slide/Tape Programs — Projects With a Dual Purpose

Several years ago the Federation initiated production of slide/tape programs which had been developed by Society Educational and Manufacturing Committees. A total of 12 such programs were collected and offered as Volume I of the Federation Training Series on Test Methods. Last year, Volume II was produced, and currently work is underway on additional presentations, including one by the Birmingham Paint, Varnish and Lacquer Club on "The Setaflash Tester." Meanwhile, a number of slide/tape programs have been prepared by Society Manufacturing Committees and are currently being readied for production. The initial effort, "High Speed Dispersion," produced by the Montreal Society, was made available in 1975 and is the "best seller" in the Federation audio/visual library. It will soon be joined by the Toronto Society's production of "An Introduction to a Resin House Operation."

These programs have been well received and have been purchased by a wide cross-section of coatings producers and supplier firms — with a sizeable number of orders received from overseas companies, particularly those in Third World countries. In addition to filling a need as training tools, these programs offer an excellent medium for Society Committee work, and several Societies have been able to revitalize lagging committee efforts through initiating work on such slide/tape presentations.

If your Society is looking for a project to undertake, consider developing an A/V program. The Federation headquarters office has a list of suggested topics for either Educational or Manufacturing Committee work, and will be pleased to pass them along for consideration. — TAK

EXPOSURE EVALUATION. PART II - BRONZING—R. Johnston-Feller and D. Osmer

Journal of Coatings Technology, 51, No. 650, 37 (Mar. 1979)

"Bronzing" is a subjective, descriptive term applied to the metal-like reflectance that appears at the surface of nonmetallic pigmented materials. Of concern in the coatings industry are both bronzing that appears on freshly made paint films of moderate or high pigment concentration and that which appears after exposure of a paint film to degradation conditions, such as light, moisture, heat, and chemicals. The bronze aspect of exposure evaluation by spectral analysis was not covered in the first paper.

In order to study the phenomenon of bronzing, two methods of spectrophotometric reflectance measurements were used: sphere geometry, from which the specular reflectance can be calculated and correlated with visual evaluations by using color difference equations; and directional-directional geometry (goniospectrophotometry), a direct measurement of the specular reflectance. Spectrophotometric curves of the specular reflectance that describe the color and magnitude of the bronzing are reported. Both types of measured results show good correlation with visual evaluations.

The major purpose of this article is to show that a simple measurement technique, using a conventional integrating-sphere color measuring spectrophotometer, will provide information to demonstrate the presence of bronzing following exposure. The chromaticity coordinates of the measurements made at various angles and the coordinates derived for the specular reflectance calculated from sphere geometry are shown to correlate with one another and with visual evaluations.

PRACTICAL ASPECTS OF CURRENT COLOR-MEASUREMENT INSTRUMENTATION FOR COATINGS TECHNOLOGY—D.C. Rich and F.W. Billmeyer, Jr.

Journal of Coatings Technology, 51, No. 650, 45 (Mar. 1979)

Recent advances in optical and electronics technology have given rise to a new generation of color-measurement instrumentation. The most frequently observed instrument is the microcomputer-controlled spectrophotometer. The new computer-controlled instruments exhibit unparalleled speed and precision. The speed allows one to make multiple measurements of a single sample and the precision requires better or multiple samples to characterize a coating's color accurately. Each of the newer instruments has one or more optical innovations which must be evaluated in the light of the user's particular needs. Some of the possible advantages and disadvantages of the newer instruments are presented here. These discussions are neither recommendations for nor judgements against any specific manufacturer. It is important to note that the new optical technology is not a panacea for poor personnel in the research or quality-assurance laboratory. An instrument is only as good as the individual operating it, and as the samples presented for measurement.

A COMPUTER PROGRAM TO EVALUATE ANTI-FOULING MATERIALS—B.R. Appleman and R.E. Panzer

Journal of Coatings Technology, 51, No. 650, 48 (Mar. 1979)

A computer program has been developed to evaluate the performance of immersed plates coated with various anti-fouling coating formulations and polymeric materials. Numerical ratings of barnacle fouling and total fouling (all species) of several hundred panels are recorded and stored for each month up to 72 months. An update routine allows additional fouling data to be added at one to six-month intervals. Additionally, for each panel are recorded the date and place of immersion, substrate, anti-corrosive coating, anti-fouling coating, toxic materials, manufacturer, color, and specific comments. The basic output of the program is a set of graphs showing the percent fouling resistance of the panels versus the number of months exposed.

A key feature of the program is the parameter search-and-select option. With this option, a search can be made for all the panels having one or more parameters in common; for example, anti-fouling coating, substrate, manufacturer, or binder. At the user's option, the computer will print any of several analyses of the overall or average performance rating of the particular group selected, in addition to individual plots and performance summaries.

MILDEW AND CHALKING OF LINSEED OIL PAINTS FROM TREATED PIGMENTS—R.L. Eissler, J.A. Stolp, and F.L. Baker

Journal of Coatings Technology, 51, No. 650, 56 (Mar. 1979)

Mildew resistance of linseed oil paints from zinc oxide surface-treated with an organic phosphate to improve blister resistance is as good as that of similar paints from the untreated pigment. Paints were compared during 36 months' exposure on a test fence at Peoria, Ill. Mildew resistance of paints from rutile titanium dioxide treated with selected quaternary ammonium compounds was not significantly better than resistance of those from untreated rutile. During the 36-month test, resistance to mildew depended primarily upon the topcoat. A system composed of a zinc oxide pigmented topcoat over a low-mildew-resistant primer worked as well as a system with two coats of the zinc oxide paint. Throughout the test, paints containing zinc oxide remained cleaner and whiter than those without this pigment even though paints from rutile chalked more in tests. The scanning electron microscope (SEM) showed that zinc oxide remained relatively well vehicle coated throughout the test, whereas surfaces of rutile-pigmented paints had an increasing number of bare particles with longer exposure time. Differences were still apparent when silicate extender was substituted for 50% of the primary pigment. Occurrence of mildew colonies appeared to be associated with microscopic cracks in the paint surface.

SOLVENT-PLASTICIZER-RESIN INTERACTIONS BY GAS-LIQUID CHROMATOGRAPHY—P. Alessi, I. Kikic, G. Torriano, and A. Papo

Journal of Coatings Technology, 51, No. 650, 62 (Mar. 1979)

Solubility and monomeric plasticization of high molecular weight epoxy resins were investigated through the evaluation of the solubility parameters for the resins and some plasticizers from GLC data. Epoxy resins used were commercially available products; plasticizers were aromatic and aliphatic phosphates and phthalates; and solvents were compounds of different chemical nature.

Solubility parameters were evaluated from the activity coefficients of the solvents considered in the resins and plasticizers employed as stationary phases, taking into account the entropic contribution (according to the Staverman theory) and the enthalpic contribution (according to the Hildebrand theory) to γ^{∞}. The results were compared with the data obtained from technological tests.

Papers to be Published in Future Issues

"Steric Stabilization of Surface-Coated Titanium Dioxide Pigments by Adsorbed Methyl Methacrylate Copolymers"—G.J. Howard and Choy Chow Ma, of University of Manchester Institute of Science and Technology.

"Interplant Quality Control by Means of Simple Tristimulus Colorimeters"—D.H. Cook, of Standard T Chemical Co., Inc.

"Coating Durability on Organolead-Treated Southern Pine in Exterior Exposure"—H.M. Barnes, of Mississippi State University.

"Re-search for Opportunity"—C.M. Hansen, of Scandinavian Paint and Printing Ink Research Institute.

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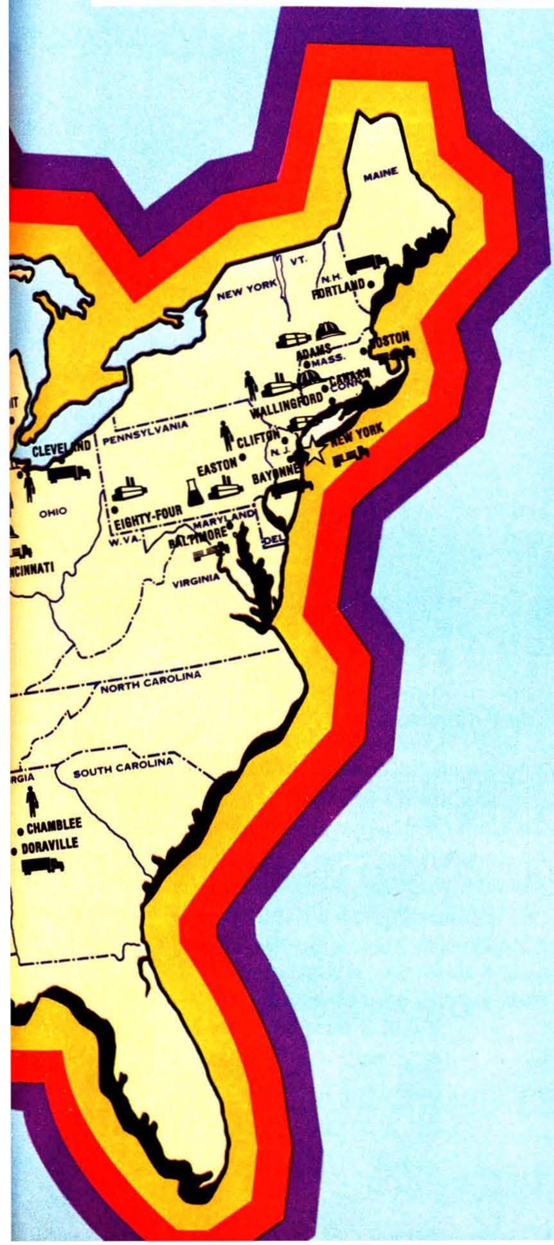

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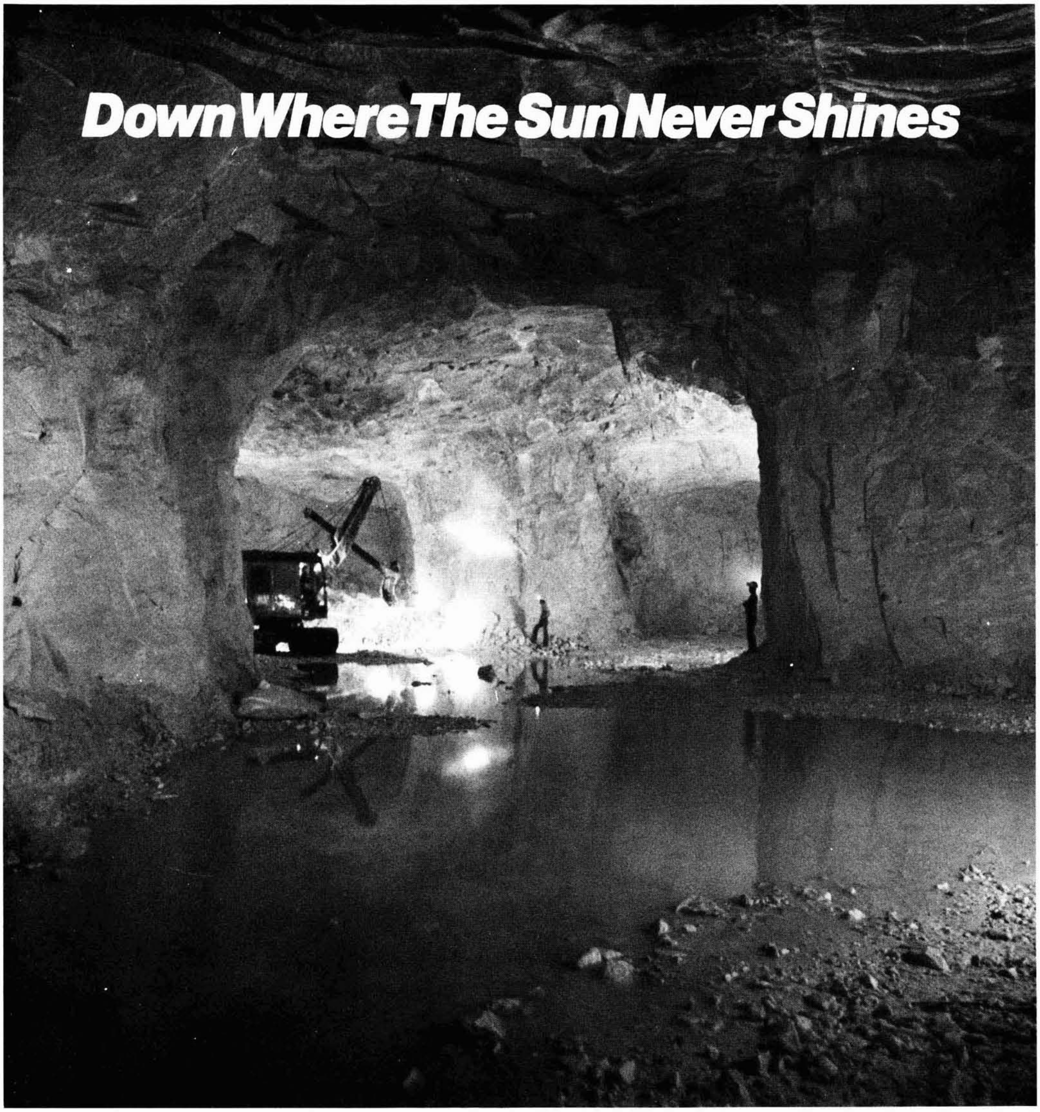
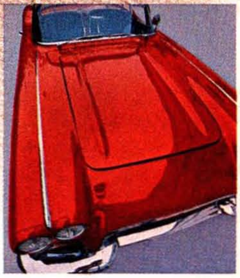

Down Where The Sun Never Shines

NEW EPONEX RESISTS CHALKING!

Coatings based on Shell's new Eponex™ resins provide traditional epoxy benefits plus weatherability to resist chalking and yellowing in the sun.



New Eponex resins provide the chemical and corrosion resistance and the adhesive qualities that you expect from epoxy... plus weatherability that helps to retain gloss and resist chalking. Eponex epoxy-based coatings shine and keep on shining in applications ranging from consumer products to industrial maintenance.

Versatile Eponex resins can be formulated into high bake, low bake or ambient cured coating systems. And because these new resins have extremely low viscosities of approximately 20-25 poise at 25°C, they are suitable for both high solids and solventless systems.

Potential cost savings over urethanes. Best of all, Eponex actually costs less than urethane. In one industrial maintenance cost comparison, an Eponex system with 64% volume solids was matched against a polyester urethane coating with 47.5% solids. On a per gallon basis, the Eponex system was 8% lower in raw material cost than the urethane. *But on an application cost basis (per square foot per mil thickness) Eponex was actually 48% less expensive.*

Eponex resins are now available from Shell in market development quantities. For complete technical data comparing Eponex applications, economics and weatherability to conventional epoxies and acrylics, please write: Shell Chemical Company
Manager, Chemical Communications
One Shell Plaza
Houston, Texas 77002.

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NUMBER 79 MARCH 1979

FEDERATION
newsletter

Federation of Societies for Coatings Technology
YE OLDE PAINT STONE 1737

130 COMPANIES SIGN UP FOR 1979 PAINT SHOW WHICH WILL BE LARGEST IN FEDERATION HISTORY

One hundred and thirty suppliers to the coatings manufacturing industry have contracted for exhibit space in the 1979 Paint Industries' Show which will be held at the St. Louis Convention Center on October 3, 4, and 5.

The total net square feet of paid exhibit space reserved so far is 31,800, compared to 28,600 in Chicago, 1978.

The exhibitors are:

Aceto Chemical Co.
Air Products & Chemicals, Inc.
Alcan Ingot & Powders
Alpine American Corp.
Aluminum Co. of America
C.M. Ambrose Co.
American Felt & Filter Co.
American Hoechst Corp.
American Nepheline Corp.
Applied Color Systems, Inc.
Ashland Chemical Co.
Atlas Electric Devices Co.

B.A.G. Corp.
BASF Wyandotte Corp.
Bennett's (Colorant Div.)
Blackmer Pump Div., Dover Corp.
Brookfield Eng. Labs., Inc.
Brunswick/Technetics Div.
Buckman Laboratories, Inc.
Byk-Mallinckrodt Chem. Prod.

Cabot Corp., Cab-O-Sil Div.
Cargill, Inc.
CDI Dispersions
Celanese Chemical Co.
Celanese Polymer Specialties Co.
Chicago Boiler Co.
Cities Service Co., Col. Chems. Div.
Color Corp. of America
Cosan Chemical Corp.

Custom Chemical Co.
Custom Scientific Instruments, Inc.

Daniel Products Co.
Degussa Corp.
Diamond Shamrock, Proc. Chems. Div.
Diano Corp.
D/L Laboratories
Draiswerke, Inc.
Dresser Minerals Div., Dresser Ind.
DSET Laboratories, Inc.

Eastman Chemical Products, Inc.
Ebonex Corp.
Engelhard Min. & Chem. Corp.
Epworth Mfg. Co., Inc.

Federated Metals Corp., Sub. ASARCO
Fed. of Societies for Coatings Tech.
Filter Specialists, Inc.

Gail Industries
Gardner Laboratory, Inc.
General Electric Co.
Georgia Kaolin Co.
Goodyear Chemicals
W.R. Grace & Co., Davison Chemical Div.
Graco, Inc.

Halox Pigments
Harmon Colors Corp.
Harshaw Chemical Co.
Henkel Corp.
Hercules Incorporated
Hilton-Davis Chemical Co. Div.
Hockmeyer Equipment Corp.
Hooker Chemicals & Plastics Corp.
J.M. Huber Corp.
Hunter Associates Lab., Inc.

IBM Instrument Systems
Impandex, Inc.
International Mins. & Chems. Corp.
Interpace Corp.
Interstab Chemicals, Inc.

Johns-Manville

Kelco, Div. of Merck & Co.
Kenrich Petrochemicals, Inc.

Leneta Co., Inc.
Liquid Controls Corp.

Macbeth Div., Kollmorgen Corp.
Madison Industries, Inc.
Manchem Limited
Mateer-Burt Co.
Meadowbrook Corp.
Merck Chemical Div.
Mini Fibers, Inc.
Modern Paint and Coatings
Montedison USA, Inc.
Morehouse Industries, Inc.
Mozel Chemical Products Co.
Myers Engineering, Inc.

Nat'l Assn. of Corrosion Engineers
Netzsch Brothers, Inc.
Neville Chemical Co.
New Way Pkg. Machinery, Inc.
N L Industries, Inc.

O'Brien Industrial Equipment Co.

Paint Research Institute
Patco Coatings Products
Penn Color, Inc.
Pennsylvania Glass Sand Corp.
Pfaudler Co., Div. Sybron Corp.
Pfizer, MPM Div.
Polyvinly Chemical Industries
PPG Industries, Inc.
Premier Mill Corp.
PVO International, Inc.

Q-Panel Co.
Quackenbush Co.

Reichard-Coulston, Inc.
Reichhold Chemicals, Inc.
Rohm and Haas Co.
Russell Finex, Inc.

Semler Industries, Inc.
Shamrock Chemicals Corp.
Shell Chemical Co.
Silberline Mfg. Co., Inc.
Spartan Color & Chemical
Spencer Kellogg Div.
Sun Chemical Corp.
Synres Chemical Co.

TAMMSCO, Inc.
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R.T. Vanderbilt Co.
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Warren Rupp Co.
Wellco Products/Itasco Div.
Wilden Pump & Engineering Co.

ACTIVITIES OF TECHNICAL, EDUCATIONAL, ENVIRONMENTAL, AND MANUFACTURING COMMITTEES

Technical Advisory (Chairman Colin Penny, of Baltimore Society) will sponsor a meeting of all Society Technical Committee Chairmen on March 30 in Atlanta. Will focus on reports of Society Technical Committee projects underway, as well as discussions of projects which will be recommended by the Federation committee.

Educational (Chairman John A. Gordon, Jr., of the St. Louis Society) will hold a meeting of Steering Committee members in Louisville on March 21 to discuss current and future educational programs......One of the responsibilities of this committee is an annual compilation of coatings courses, symposia, and seminars. The 1979 edition has been completed by the Federation staff and mailed to the Societies. Copies are available from the Federation office.

Environmental Control (Chairman S. Leonard Davidson, of the New York Society) has just released the first edition of its Newsletter. A copy was direct-mailed to all members of the Federation. The committee solicits input on local impending regulatory activity for inclusion in the next Newsletter.

Manufacturing (Chairman Don Fritz, of the Philadelphia Society) held a meeting of Steering Committee members in Toronto on February 21. Society Manufacturing Committee Chairmen will be advised of proceedings of that meeting.

ACTIVITIES OF FEDERATION'S CONSTITUENT SOCIETIES

BALTIMORE--Will sponsor a one-day coatings exhibit on March 16 at the Hilton Inn on Reisterstown Rd., Baltimore. Exhibit will feature 35 booths manned mostly by local reps of suppliers. No admission charge.

CHICAGO--Continuing its scholarship grants to North Dakota State Univ......In addition, Joint Educational Committee of Society and PCA will present grants to Univ. of Southern Mississippi, Elmhurst College, and NDSU......Sponsoring competition for new Society logo. Member who submits best design can win two tickets to Ladies Night......Looks like SYMCO '79 on March 20-21 will be a complete sell-out......Dr. Albert Haster will speak at Management Development Seminar on April 26.

CDIC--Lew Larson, of Painteco and a Past-President, received Ernest R. Mueller Education Award. Mrs. Mueller made presentation.

DALLAS--31 teachers and students from 12 schools attended recent "Education Night." Speaker was Dr. George Bufkin, of Univ. of Southern Mississippi.

DETROIT--Member companies are welcome to borrow - at no cost - the Federation Training Series Test Methods: I and II, which were purchased by the Educational Committee......FOCUS Seminar on "Recent Advances in Automotive Coatings" scheduled for May 3 at Michigan Inn, Detroit.

GOLDEN GATE--San Jose Regional Vocational Center donated laboratory equipment to Society which will make it available to members......The second semester Coatings Courses will be taught by Bill Sawyer and Ted Favata......Donated the "Paint/Coatings Dictionary" and $350 (for more books) to Redwood City Library...... June 18 Manufacturing Committee symposium called "Mixing Time '79."

HOUSTON--Will host Southwestern Paint Convention, April 5-7......Past-President Loren Odell made Honorary Member......Manufacturing Committee presented program at December meeting on "Wash Water Recycling."

LOS ANGELES--Will award a $50 savings bond to the best student in the Paint Formulation Class at Los Angeles Trade Technical School. Trev Whittington is the instructor.

NEW ENGLAND--Moving right along with its technical projects on "Freeze-Thaw Resistance of Latex Paints" and "Flash Rusting."

NEW YORK--The joint meeting - a "Legislative Update" - with the New York PCA on February 8 featured Sen. Harrison A. Williams, Jr., New Jersey, as the principal speaker. Industry experts also participated in program which was keyed to providing an update on the legislative requirements facing producers of paints and coatings......Will co-sponsor a symposium (with Philadelphia Society) on May 30-31, at Hightstown, N.J. Subject to be "Maintaining Quality Coatings Under Pressure."

NORTHWESTERN--Sponsoring Symposium on Coatings Application, March 6......Will hold May 4th meeting at North Dakota State Univ., jointly with its Winnipeg Section. Speakers will be Drs. Zeno Wicks, Loren Hill, and Peter Pappas, of NDSU.

PHILADELPHIA--January meeting was held jointly with local PCA......February meeting was "Bosses Night"......Technical Committee meetings, which feature outside speakers, changed to first Thursday of month and moved to Hofbrau House.

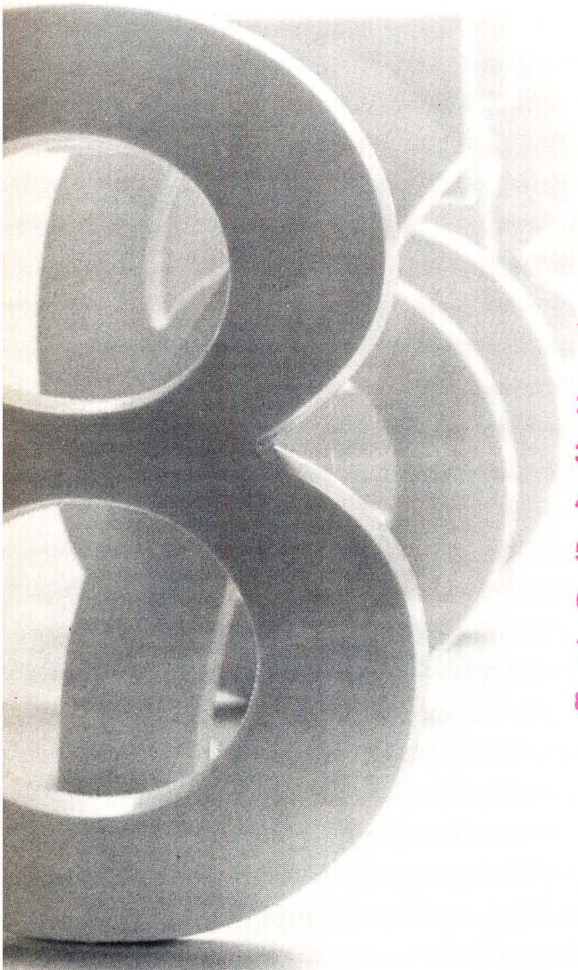
PITTSBURGH--Sponsoring Symposium on "Controlling Corrosion with Organic Coatings" at Duquesne University, May 22.

ROCKY MOUNTAIN--Educational Committee sponsored Seminar on Coatings Technology on February 21.

ST. LOUIS--Gateway Award, for outstanding service to Society, Federation, and the coatings industry presented to Dr. Herman Lanson, a Past-President and former Educational Committee Chairmen......24 high school science teachers attended "Education Night" in January.

TORONTO--Will celebrate 60th Anniversary at Ladies Night on April 28......Will issue membership cards......Joint symposium with Montreal Society on "Paint Technology Economics," September 20-21......Manufacturing Committee will debut A/V program on "Introduction to a Resin Operation" in April.

WESTERN NEW YORK--Will meet with Buffalo PCA on April 9.



Newsman/TV Commentator Howard K. Smith To Be Keynote Speaker at Annual Meeting

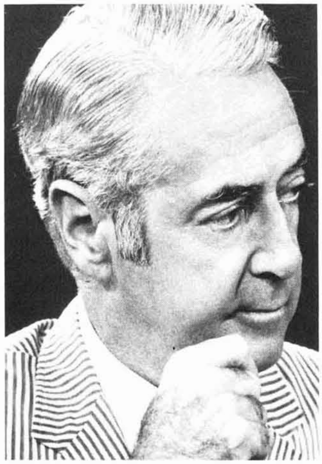
The Federation is pleased to announce that Howard K. Smith, noted newsman and TV commentator, will present the E. W. Fasig Keynote Address at the Federation's 57th Annual Meeting, to be held October 3-5 at the Convention Center, St. Louis, Mo.

Mr. Smith will be featured at the Opening Session on Wednesday morning, October 3.

A member of the ABC News team for the past 17 years, Mr. Smith has reported on most of the important news stories of that period. Previously, he had served for 20 years with CBS, serving much of that time as chief European correspondent, reporting on the major international news stories of the period, including the Allied sweep through Belgium, Holland, and Germany in 1944, the German surrender to the Russians in 1945, and the Nuremberg war crimes trials in 1946.

Born in Ferriday, Louisiana, he is a 1936 graduate of Tulane University where he studied journalism and German. He went to Germany to study briefly at Heidelberg University, then attended Oxford University, where he studied under a Rhodes Scholarship.

In 1939 he joined United Press in Copenhagen and then, on January 1, 1940, was sent to the United Press Bureau in Berlin. Joining CBS News as Berlin Correspondent in 1941, he was forced by the Nazi government to leave, but continued to report on the war in Europe for CBS from Switzerland.



Widely known for his nightly commentary on ABC-TV News, Howard K. Smith is an incisive and provocative speaker on the contemporary scene.

He returned to the U.S. in 1957 to become CBS News Washington Correspondent and, in March 1961, was appointed Chief Correspondent and Manager for the Washington Bureau of CBS News. During that time, he narrated numerous news specials, as well as serving as moderator, commentator, or reporter on most of the major CBS News efforts.

He joined ABC in December 1961, and has provided the widely-quoted commentary on a wide range of subjects for "Evening News" and the American Information Radio Network. Since January 1977 he has been permanent host and narrator of the award-winning "ABC News Closeup" series of documentaries. He has also anchored or co-anchored ABC News television coverage of every national election since 1964.

His accomplishments have earned him numerous professional honors. In 1961 Mr. Smith became the first working journalist to win the Paul White Memorial Award, until then only given to U.S. Presidents and one network president. That same year he won an "Emmy" for writing "CBS Reports: The Population Explosion," in which he also served as narrator. In 1962 he became the only commentator to win the duPont Commentator Award twice. In 1967 he won the Overseas Press Club Award for television interpretation of foreign affairs — his sixth Overseas Press Club Award, four of which were consecutive awards for the best reporting from abroad.

Mr. Smith was chosen to deliver the Fourth of July Oration at Independence Hall in Philadelphia in 1974. And in 1975 he became the only newsman ever to address the House of Representatives, when he was chosen to deliver the Flag Day speech as a Special Congressional Honoree for his contributions to American journalism.

He holds numerous honorary degrees from educational institutions, including Bachelor of Arts, Doctor of Laws, Doctor of Literature, Doctor of Humanities, and Doctor of Humane Letters.

Mr. Smith has authored three books: "Last Train from Berlin," published in 1942; "The State of Europe," published in 1949; and "Washington, D.C.," published in 1968.

Other Program Highlights

The theme of the 1979 Annual Meeting is "Progress Through Innovation," and Program Chairman Morris Coffino, of D. H. Litter Co., Inc., New York, N.Y., and the members of his Committee are developing presentations which address this topic. Prospective speakers are being invited to present original papers that focus on exploration and innovation of new functions and applications for coatings, the challenge of new regulations, and responding to the dictates of new and exciting markets and raw materials.

Featured program sessions tentatively scheduled include the Mattiello Lecture, Society papers, Roon Awards competition papers, Paint Research Institute Seminar, Manufacturing and Educational Seminars, and papers by overseas authors.

Paint Industries' Show

To be held concurrently with the Annual Meeting in the Convention Center, the 1979 Paint Show will be the largest in history. To date, 130 supplier firms have reserved 318 exhibit spaces, some 15% more than the record number at last year's event.

The Paint Show is the only national exhibit of raw materials and equipment used in the manufacture of paints and related coatings, and participating firms will have their top technical personnel on hand to discuss the latest developments.

Earlier Deadline For Society Papers

Societies wishing to submit papers in competition for the A. F. Voss/*American Paint and Coatings Journal* Awards in 1979 must do so earlier than usual because of the advanced date of the Federation Annual Meeting.

Horace S. Philipp, Chairman of the AFV/APCJ Awards Committee, advises that Society papers must be received at the Federation office in Philadelphia no later than July 30 to be eligible for the 1979 competition.

Notification of intent to compete must be sent to the Chairman by May 1. Write Horace S. Philipp, Sherwin-Williams Co., P. O. Box 489, Montreal, Quebec H3C 2T4, Canada.

NPCA Challenges OSHA's Final Lead Standard

The Occupational Safety and Health Administration's Final Standard on Occupational Exposure to Lead has been challenged by the National Paint and Coatings Association in a Petition for Review filed in the Court of Appeals for the Fifth Circuit. NPCA also has filed a Petition for Modification, Withdrawal and Reconsideration, or for Stay Pending Appeal with OSHA to give the agency one final opportunity to provide necessary relief to the paint and coatings industry.

The final standard, effective February 1, 1979, limits occupational exposure to lead to 50 micrograms per cubic meter of air averaged over an 8-hr period. Initial monitoring to measure workers' exposure to airborne lead must have been completed by March 2. Paint and coatings manufacturers must be in overall compliance by one year from the effective date of the standard.

In its petition for administrative relief, the association pointed out that the final standard contains more stringent requirements than those in the proposed standard. Specifically, the proposed standard set the permissible exposure level at 100 micrograms per cubic meter of air, averaged over an 8-hr period. The proposed standard said that initial determination for employee exposure was to be discretionary, based on inspection; the final standard requires actual air monitoring.

Other problems with the final standard include the requirement that employers must file, within six months of the effective date of the standard, a compliance program for discontinuation of the use of respirators as supplemental control. Existing technology does not indicate that it will ever be possible to eliminate the use of respirators in spray painting operations. Also, as there is no lower limit for the presence of trace lead impurities, clerks in retail tinting operations might have to wear protective clothing and be provided separate changing rooms with shower facilities.

NPCA to Conduct Production/Inventory Seminar

A two-part course on "Production Planning and Inventory Management" developed specifically for the Coatings Industry will be held by the National Paint and Coatings Association at Stouffer's Inn On The Square, Cleveland, Ohio, April 20-21 (Part I-Fundamentals) and May 11-12 (Part II-Advanced).

The course will be conducted by Dr. Gene Groff, of Georgia State University, whose book, *Production and Inventory Management Manual,* will be used as the course text. Registrants may purchase the book at the seminar for $30. A course workbook is included in the registration fee of $120.

Further information may be obtained from Georgene Savickas, Director of Meetings and Conventions, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005.

Proposed Amendments to Federation By-Laws

The following proposed amendments to Articles III and V of the Federation By-Laws will be presented for first reading at the Federation Board of Directors meeting on May 18, 1979.

If passed at that time, they will then be presented for adoption at the Board of Directors meeting of October 2, 1979, in St. Louis.

ARTICLE III—ORGANIZATION
Paragraph B, Section (1)

WHEREAS, through an oversight an important duty of the Board of Directors was omitted from this paragraph, and

WHEREAS this duty has been in actual practice for some time, be it

RESOLVED that a new sub-paragraph (f.) be added as follows:

> "To serve as the stockholders (or members) of the Paint Research Institute and attend the annual meeting of the stockholders to elect Trustees of PRI".

The balance of this By-Law remains unchanged except that each succeeding sub-paragraph will advance by one letter.

ARTICLE V—COMMITTEES
Paragraph A, Section (1)

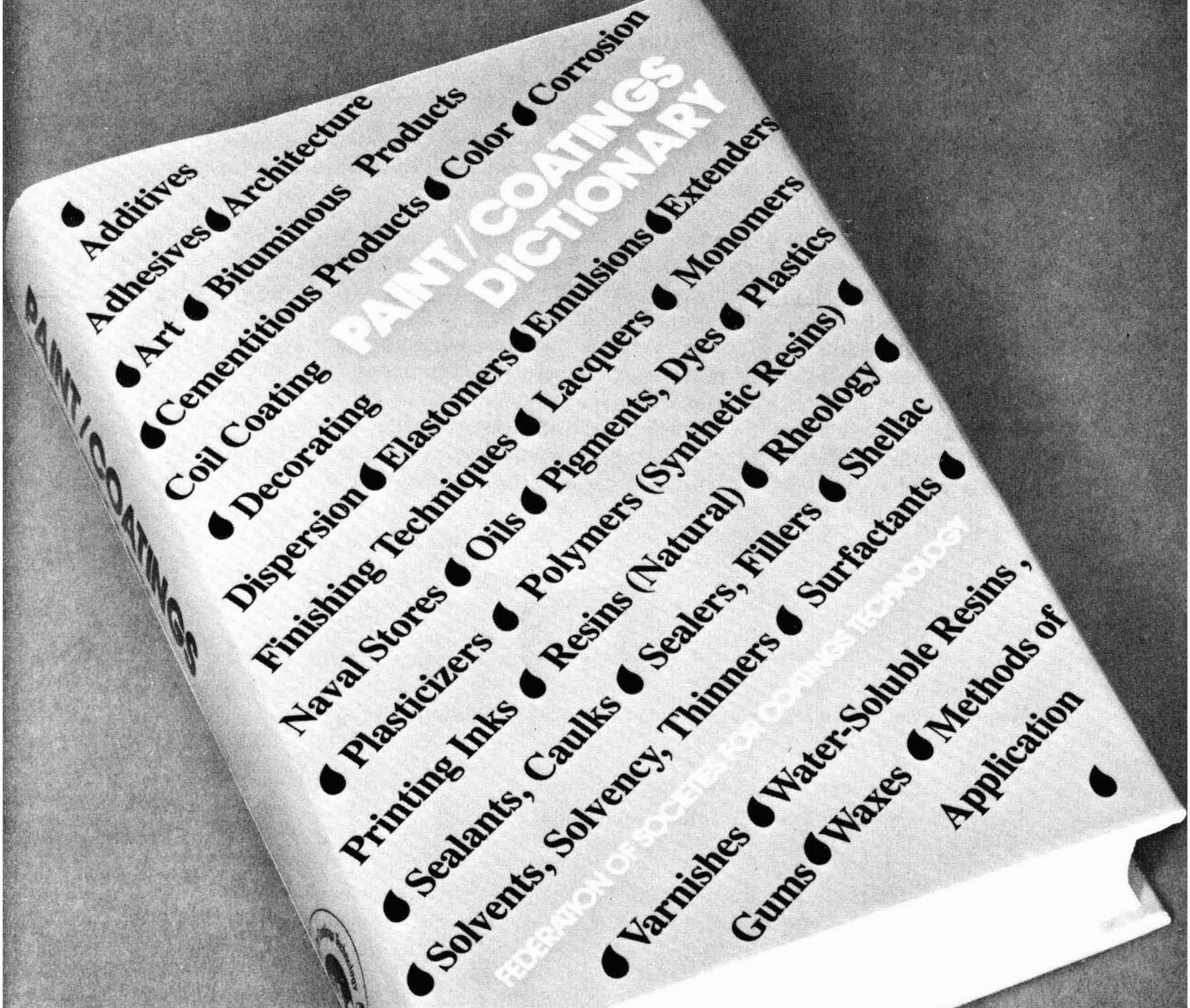
WHEREAS the Society Representatives have requested that the make-up of the Nominating Committee be modified, and

WHEREAS the intent of the By-Laws Committee in their revision was to assure representation on the Nominating Committee from the Constituent Societies, be it

RESOLVED that the wording in Article V, Paragraph A. (1) be amended as follows: (proposed change in *italics*)

> "The President shall appoint a Nominating Committee consisting of the immediate Past-President or the most recent available Past-President as Chairman; one other Past-President; and three members of the Board of Directors who are not officers, *at least two of whom shall be Society Representatives.*"

The balance of this By-Law remains unchanged.



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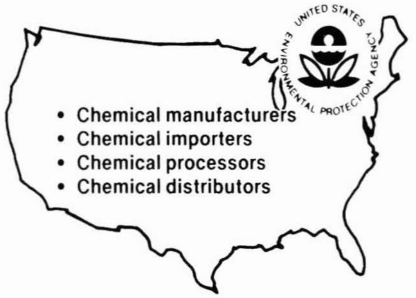

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Exposure Evaluation

Part II - Bronzing

Ruth Johnston-Feller

Consultant*

and

Dennis Osmer

CIBA-GEIGY Corporation†

"Bronzing" is a subjective, descriptive term applied to the metal-like reflectance that appears at the surface of nonmetallic pigmented materials. Of concern in the coatings industry are both bronzing that appears on freshly made paint films of moderate or high pigment concentration and that which appears after exposure of a paint film to degradation conditions, such as light, moisture, heat, and chemicals. The bronze aspect of exposure evaluation by spectral analysis was not covered in the first paper.

In order to study the phenomenon of bronzing, two methods of spectrophotometric reflectance measurements were used: sphere geometry, from which the specular reflectance can be calculated and correlated with visual evaluations by using color difference equations; and directional-directional geometry (goniospectrophotometry), a direct measurement of the specular reflectance. Spectrophotometric curves of the specular reflectance that describe the color and magnitude of the bronzing are reported. Both types of measured results show good correlation with visual evaluations.

The major purpose of this article is to show that a simple measurement technique, using a conventional integrating-sphere color measuring spectrophotometer, will provide information to demonstrate the presence of bronzing following exposure. The chromaticity coordinates of the measurements made at various angles and the coordinates derived for the specular reflectance calculated from sphere geometry are shown to correlate with one another and with visual evaluations.

INTRODUCTION

In the previous paper,[1] a spectrophotometric reflectance measurement and computation scheme was described for characterizing and quantifying the type of change in a pigmented material following exposure to deleterious conditions. The purpose of that paper was to formulate a method of measurement to augment visual evaluations with analytical measurements descriptive of the type of change, and which could also be computed into psychophysical (visual) terms. The method provides means for the determination of the relative contributions of changes in gloss, pigment color, vehicle color, surface chalking, etc. on the total change in appearance. Specifically not covered in that paper was the instrumental measurement of bronzing.

The purpose of this paper is to illustrate a method of measurement and calculation of bronzing that can be correlated with visual evaluations of changes following exposure. The method also provides an analytical measurement of degree of bronzing which can be used for studying the factors which may affect its occurrence. It is not the purpose of this paper to discuss the origins of bronzing or the theoretical aspects concerning its nature.

So far as the authors have been able to determine, no generally accepted definition for bronzing exists and no specific method for its measurement has been proposed. The definition of bronzing included in the *Paint/Coatings Dictionary* of the Federation of Societies for Coatings Technology, is the following:[2] "Bronzing (1) A subjective, descriptive, appearance term applied to the metal-like reflectance which sometimes appears at the surface of nonmetallic colored materials. It is perceived at the specular angle, by observing the image of a white light source, for example, and is characterized by a distinct hue of different dominant wavelength than the hue of the paint film itself. The origin of the selective specular reflectance observed is generally considered to be reflectance from very small particle size pigments partially separated from surrounding vehicle at or near the surface." Excepting the last sentence speculating on the cause of the phenomenon, this definition serves our purpose in this work.

Buc, Kienle, Melsheimer, and Stearns[3] characterized bronzing according to two types or models, one being metallic reflectance such as from polished gold, copper, brass, etc., which they called "interface bronze," and the other being interference reflectance which arises from closely adjacent layers or ridges, which they

Presented at the Symposium on Color Appearance Instrumentation, March 14, 1978, Cleveland, Ohio.

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†Pigments Dept., Ardsley, N.Y. 10502.

Table 1—Pigment Composition of Masstone Samples Prepared To Demonstrate Bronzing

Ink	% Pigment	Generic Classification	C.I. Pigment
Red	40%	azo	red 144
Blue	50%	Beta phthalo	blue 15:3
Green	45%	halogenated copper phthalo	green 7
Black	38%	carbon	black 7

called "interference bronze." On this basis of classification, they suggested the following definition: "Bronze is the appearance of color which originates in selective reflectance at one interface or interference of white light reflected at closely adjacent structures." They showed spectrophotometric curves of the specular reflectance measured at $-60°/60°$ for alkali blue and for bronze orange printing inks on paper.

The definitions and descriptions clearly indicate the type of measurement that must be made to quantify the nature of bronzing; i.e., the bronze color must be observed at the angle of specular reflectance. Thus, many common color-measuring instruments that measure color at 45° incidence, 0° reflectance, i.e., 45°/0° or, the converse, 0°/45°, will not detect the color of a bronzed surface. On the other hand, color-measuring instruments that utilize integrating-sphere geometry with the capability for either including or excluding the reflectance at the specular angle can be utilized for measuring bronze surfaces. With such an instrument, the specular reflectance can be obtained indirectly by calculating the difference between the two measurements, one of the total reflectance, i.e., with the specular reflectance included, and one of the diffuse reflectance, i.e., with the specular reflectance excluded. The measurement of the specular component by difference with an instrument utilizing sphere geometry was described in detail in the first paper.[1] Although Buc, et al.[3] specify that specular reflectance measurements well off the normal are best for measuring bronzing, it will be shown that results of integrating sphere measurements with near normal illumination agree well with visual evaluations of the color and magnitude of bronzing on bronzed paint films.

A second method of measurement that can be used is the direct measurement of the specular reflectance utilizing a goniophotometer that also incorporates a monochromator or abridged monochromator for determining the reflectance at separate wavelengths in the visible spectrum necessary to describe the color. Such instruments are called goniospectrophotometers when the light reflected at specific angles is measured as a function of wavelength, or are called spectrogoniophotometers when the light reflected at specific wavelengths is measured as a function of the angle of illumination and viewing. With the latter arrangement, determination of the color at specific angles requires considerable data processing. A goniospectrophotometer, which records the light reflected at specific angles as a function of wavelengths, was used for this study. When making direct measurements at the specular angle, the amount of energy detected is very high relative to that detected by the indirect method using sphere geometry (which is in the range of about 10%). As a consequence, a 20% neutral-density filter is used in the sample beam of the instrument with variable-angle direct specular-reflectance measurements to bring the measurements made relative to a diffusing white standard on the scale of the instrument.

As will be shown, the agreement between the two methods—sphere geometry and goniospectrophotometry—in characterizing the chromaticity (color) and the relative intensity of the bronzed samples is good. The precision and repeatability that can be obtained using the indirect method is excellent provided that the instrument is in good calibration and is operated as carefully as is required for reliable color measurement.

The major advantage of the sphere geometry using the difference method is that such results are immediately correlateable to visual evaluations in terms of intensity as well as in terms of chromaticity of the specular reflectance. In contrast, the direct measurement is not easily correlateable to visual evaluations: the magnitude (amplitude) of the reflectance changes as a function of the angle of incidence. Gonio instruments permit the angles of incidence and viewing to be changed, whereas, with sphere geometry, they are fixed by the design of the instrument. For analytical studies, the direct measurement, as made on a goniospectrophotometer or on a spectrogoniophotometer with suitable data processing, can provide more detailed information. Both methods have been used in the present study.

Although the instrument used for the measurements to be described here, the Trilac Spectrophotometer and Goniospectrophotometer, is not widely used in the United States, various other instruments can be utilized for some of the measurements. Basically, the problem is the same as that of measuring the color of metals. Christie[4] summarized the types of instruments appropriate for measuring the color and reflectance of metals, pointing out the usefulness of instruments with sphere geometry with specular reflectance included in the

Table 2—Difference in Measured Specular Reflectances, Bronzed - Nonbronzed

Wavelength	Azo Red	Phthalo Blue
400	2.64	-1.83
420	2.57	-1.39
440	2.62	-1.08
460	2.51	-0.77
480	2.18	-0.41
500	1.49	0.09
520	0.68	0.60
540	0.36	1.42
560	-0.24	1.83
580	-0.13	0.65
600	0.17	-1.12
620	0.25	-3.07
640	0.28	-4.13
660	0.18	-3.87
680	0.27	-3.71
700	0.31	-4.54

measurement and of instruments of the goniophotometric type.

The phenomenon of bronzing of colored, nonmetallic materials has been recognized for a long time, particularly in the coatings and printing ink fields. Generally considered as a defect or an undesirable change in the normal appearance, it may appear in freshly made paint or ink films of high pigment concentration or in highly pigmented paints made with pigments of very small particle size. Perhaps the most objectionable occurrence of bronzing is that which is encountered following exposure, resulting in a nonuniform appearance of a pigmented material surface. The phenomenon can be eliminated by covering the bronzed surface with a clear coating of liquid or vehicle.[3] While paint and pigment manufacturers have made great strides in preparing materials that do not bronze easily, the problem still exists and a method for analytically characterizing and quantifying the phenomenon is needed.

BACKGROUND

Nonmetallic objects normally appear colored because of selective absorption and scattering from within the material. The *nonselective* reflectance at the surface, highly directional on high-gloss surfaces, and diffuse on matte surfaces, does not distort or alter the basic hue of the body of the material. Diffusely reflected light from a matte surface is *additively* mixed with the diffuse light reflected from inside the material, lowering the chroma and increasing the lightness, but basically not changing the hue. In contrast, when bronzing occurs, the selective surface reflectance has a distinctly different hue which also is additively mixed with the diffuse reflectance from the interior of the material. This additivity aspect of the bronzing phenomenon was pointed out by Smith[5] in the illustrated pamphlets devoted to the subject.

Bronzing is most visible when there is little or no reflectance from the interior of a material; thus, we are most aware of the phenomenon on dark surfaces. In fact, a good way to demonstrate bronzing is simply to rub a little dry phthalocyanine blue pigment over a piece of polished black glass. The very thin layer of pigment will appear to have a bright purple-red metallic reflectance.

Armstrong and Ross[6] described sub-surface interference bronzing in films pigmented primarily with TiO_2 in an alkyd-type vehicle. Observations of exposed white high-gloss paints of this type will readily reveal the common occurrence of this phenomenon, once one becomes accustomed to looking for it. Any of the colors of the rainbow may be revealed. Such colors also may be observed on freshly-sprayed panels, as pointed out,[6] and have sometimes been found to affect the accuracy of computer color matching on white and near-white gloss paints.

The origins of the phenomenon of bronzing have been studied by a number of workers. Tulsen[7] (1942), studying the effect of particle size and shape on the optical properties of printing inks, concluded that needle-

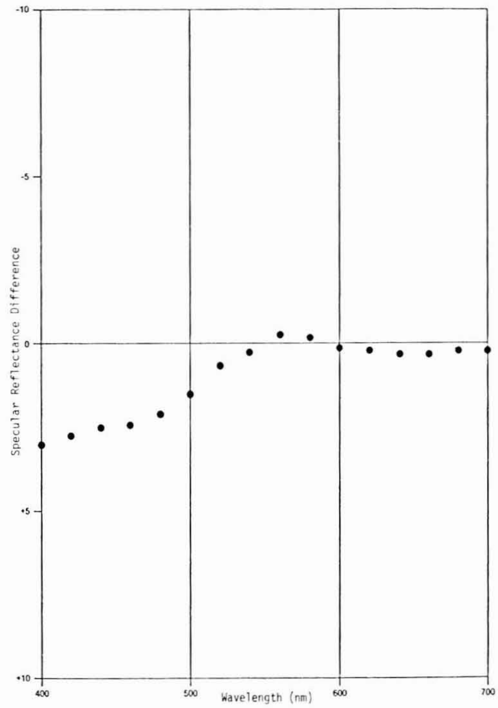

Figure 1—Graph of film surface reflectance differences between the red masstone sample without clear overcoat (bronze) and the same sample with two clear overcoats (bronze eliminated). The ordinate axis has been reversed so that the plotted shape can be easily interpreted in terms of reflected color

shaped pigments are more likely to bronze than spherical particles. Buc, Kienle, Melsheimer, and Stearns,[3] in their classical paper of 1947, published two forms of the Fresnel equation that describe both interface and interference bronze. They calculated theoretical interface-bronze color, comparing this to the measured spectral distribution (color) of bronzing for an alkali blue ink. Cooper,[8] in 1948, pointed out the importance of the refractive index of organic pigments on behavior, including bronzing. His is a very interesting description, "very strong reflection of a fairly narrow band of wavelengths giving rise to a characteristic coloured glove or metallic reflection from the surface."

Twiss, Weeks, and Thomas[9] made an extensive study of the surface characteristics of automotive enamels, pigmented with a wide variety of pigments, using electron microscopy. They pointed out that chalking results from vehicle "shrinkage," but bronzing results when the pigment is released in the form of thin sheets on the weathered surface. They postulated that chalking would occur when the pigment or pigment-agglomerate size was greater than 0.1 microns (0.1 micrometers), that bronzing would occur when the particle size was less than 0.1 microns, and that both would occur when the particle size of the pigments was both below and above 0.1 microns. They reported bronzing with both inorganic and organic pigments. Their microscopic work, using both optical and electron micrography, coupled with gloss measurements, etc., showed that bronzed samples retained a fairly high gloss and could be characterized as smooth surfaces ("blankets of very fine particles").

Braun,[10] in a paper concerning the bronzing of phthalocyanine pigments, attributed the appearance to simultaneous metallic and dielectric reflectance. He further pointed out that bronzing was related to particle size, surface texture, and pigment refractive index.

[The authors did not intend to include an extensive literature survey, but each of the above articles deals with a different aspect of the problem. One of the reviewers also suggested adding papers by Crowl,[11] one by Nye and Mackie,[12] and three by Kawabata.[13] The authors agree that these are very interesting articles on the subject and are happy to add them: those by Kawabata are a series devoted to the TiO_2 phenomenon discussed by Armstrong and Ross.[3] A review of the literature has revealed that, while many people have discussed the origins and causes, few have measured it directly or correlated measurements with visual evaluations.]

EXPERIMENTAL

Preparation of Special Bronze Paint Samples

Four masstone samples were prepared to demonstrate bronzing (an azo red, a phthalocyanine blue, a carbon black, and a phthalocyanine green; see *Table* 1 for formulas). Definite bronzed appearance was achieved by formulating the paints at a very high pigment-to-binder ratio. One-half of each sample was overcoated with a clear vehicle to demonstrate that bronzing can be eliminated when the refractive index at the interface is changed from that of the pigment plus binder to that of the binder alone. The samples were prepared to simulate masstone bronzing, and also the condition following binder erosion during weathering.

The first step in evaluating these samples was to assess them visually:

Masstone Sample	*Visual Description of Bronzing*	
phthalo green	blue	- weak
azo red	yellow	- strong
phthalo blue	purple-red	- very strong
carbon black	yellow	- weak

Both the bronzed and the overcoated portions of the samples were then measured using sphere geometry, with the specular reflectance both included and excluded. The computer program, EXPOS, based on the math outlined in *Reference* 1, was used to assess these measurements. Program EXPOS was used to calculate the specular reflectance by difference and to analyze its color.

Calculated Specular Reflectance Differences

The calculation of the specular reflectance of the samples is performed by subtracting the diffuse reflectance measurement from the total reflectance measurement. Such measurements are made on a color measuring instrument equipped with an integrating sphere designed so that the specular reflectance can be excluded (designated as an SCE measurement) or included (designated as an SCI measurement). The former, SCE, is a measure of the diffuse reflectance and the latter, SCI, the total reflectance. In the case of the Trilac Spectrophotometer used for these measurements, the specular angle was 8° off the normal.

The total reflectance measurement (SCI) is not grossly affected by surface characteristics, because all of the reflected light is included in the measurement, both that reflected from the surface and that reflected from inside the film. Therefore, this SCI measurement remains approximately the same regardless of the relative amounts of specular and nonspecular components.

On the other hand, the diffuse reflectance measurement (SCE) is affected by the changes in the surface reflectance. (Both measurements are affected by the pigment and vehicle color changes.) The narrow cone of light reflected specularly (at the angle equal and opposite to the incident angle) is absorbed by a light trap or is reflected back into the instrument, depending on sphere design and, hence, is excluded from the SCE measurement.

The specular reflectance from the surface of a sample, obtained by subtracting the measured diffuse reflectance from the measured total reflectance [$S = R^{SCI} - R^{SCE}$], must be calculated for every wavelength. (When the specular reflectance is calculated in this manner, it is dependent upon the specific optical geometry of the measuring instrument.)[1] If bronzing is present, the specular component of

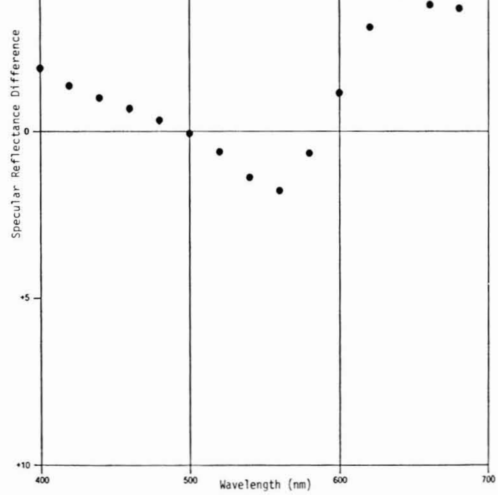

Figure 2—Graph of film surface reflectance differences between the blue masstone sample without clear overcoat (bronze) and the same sample with two clear overcoats (bronze eliminated)

the reflected light, calculated in the above manner, will reveal the difference in the color of the specularly reflected surface light from the color of the illuminant. If there is no bronzing, no differences in chromaticity coordinates will occur - a change in magnitude of the specular reflectance then indicates a change in gloss.

Detection or Calculation of Bronze Program EXPOS

Table 2 gives the *differences* in specular (or the surface reflectances) between bronzed and overcoated samples as calculated by Program EXPOS from sphere geometry measurements for the azo red and phthalo blue masstone samples. It is noted that the change in film surface reflectance is not uniform with respect to wavelength. A graph of the difference in the specular reflectance between the bronzed and nonbronzed samples of the azo red, shown in *Figure* 1, indicates that the surface reflectance of the bronzed sample is yellowish and not neutral as is the case with the overcoated (nonbronzed) red sample. This is in agreement with the visual assessment. In the case of the nonbronzed red, the specular reflectance would be constant across the spectrum, the "difference" being zero on the graph.

The difference in surface reflectance for the phthalo blue masstone sample also is not uniform with respect to wavelength. A graph of the specular reflectance differences between bronzed and nonbronzed samples, shown in *Figure* 2, indicates that the surface or specular reflectance of the bronzed sample of phthalo blue is purple-red, agreeing with the visual assessment.

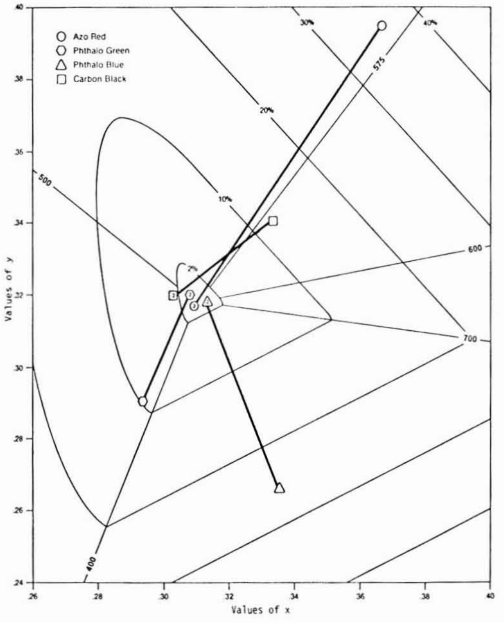

Figure 3—Section of the chromaticity diagram for Illuminant C showing the location of the samples measured by the difference method using sphere geometry. The open, unlabeled points show the location of the bronze color. These are connected to corresponding symbols labeled with a 2 inside to denote that two overcoats of clear vehicle have been applied over the bronzed sample, thus eliminating the bronze effect. The measurements on the overcoated samples are located very near to the neutral or illuminant point indicating a lack of bronzing

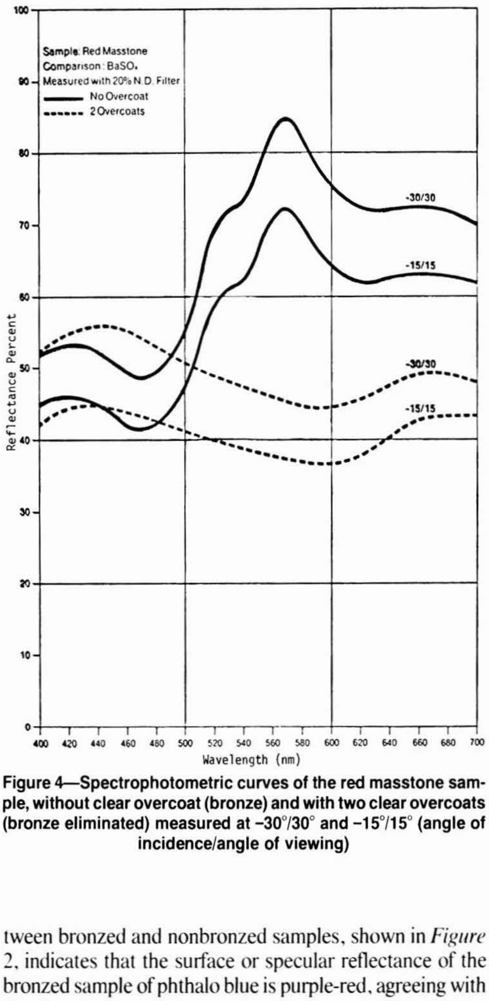

Figure 4—Spectrophotometric curves of the red masstone sample, without clear overcoat (bronze) and with two clear overcoats (bronze eliminated) measured at −30°/30° and −15°/15° (angle of incidence/angle of viewing)

Chromaticity coordinates for the calculated specular reflectances for both the bronzed and overcoated (or unbronzed) samples have been plotted on a chromaticity diagram (*Figure* 3). The chromaticity coordinates were calculated by first integrating the specular reflectance curves in the normal way to determine the tristimulus values of the surface reflected light (Illuminant C, 2° observer).

$$X = \sum_{400}^{700} E_c(\lambda)\bar{x}(\lambda)R(\lambda)\Delta\lambda$$

$$Y = \sum_{400}^{700} E_c(\lambda)\bar{y}(\lambda)R(\lambda)\Delta\lambda$$

$$Z = \sum_{400}^{700} E_c(\lambda)\bar{z}(\lambda)R(\lambda)\Delta\lambda$$

From the tristimulus values, the chromaticity coordinates are then calculated.

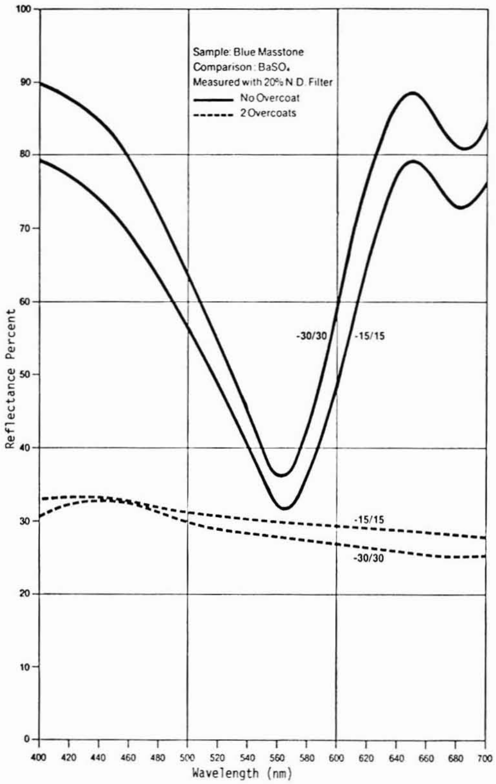

Figure 5—Spectrophotometric curves of the blue masstone sample, without clear overcoat (bronze) and with two clear overcoats (bronze eliminated) measured at −30°/30° and −15°/15°. As evidenced by the spectral curves, the bronze color is purple-red

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

Figure 3 shows that the chromaticity coordinates of the surface-reflected light for the overcoated samples are very nearly the same as for the incident light (Illuminant C). In contrast, the chromaticity coordinates of the bronzed samples indicate definite hues. The hue and saturation agree with the visual assessments: e.g., both the azo red and carbon black samples have yellow surface reflectance. But the red sample was visually judged as strongly yellow, whereas the black was judged to be weak or low in chroma. The differences in chroma are indicated on the chromaticity diagram as the relative distances from the illuminant point. Visual judgments of the bronze color of phthalo green indicated it was blue in hue and of weak intensity. This is borne out on the diagram; the dominant wavelength of the specular reflectance is blue, but the chroma is low. The purple color of the phthalo blue bronze color is in the purple region of the diagram and is of moderately high chroma.

Direct Measurement of Bronze

Goniospectrophotometric measurements of the samples were also made at two different angles. *Figure* 4 shows the results of measurements of the azo red masstone sample, at −30°/30° and −15°/15° [angle of incidence/angle of viewing]. These curves indicate that the specular reflectance is yellow. Note that the curve shape at both geometries is similar. As would be expected with gonio when the incident angle is changed, the magnitude of the reflectances is different.

Figure 5 shows the variable angle measurements of the phthalo blue masstone sample [−30°/30° and −15°/15° respectively]. The curves indicate that the specular reflectance color is purple-red, in agreement with the visual assessment. Moreover, the curve shape is similar to the one shown in *Figure* 2 as determined by difference using sphere geometry. Note especially the shape of the curve at the longer wavelengths.

Chromaticity coordinates, shown graphically in *Figure* 6, based on the variable-angle measurements of all four samples (at the two different specular angles), indicate the hue and saturation of the bronzed samples. The locations on the diagram are in agreement with the

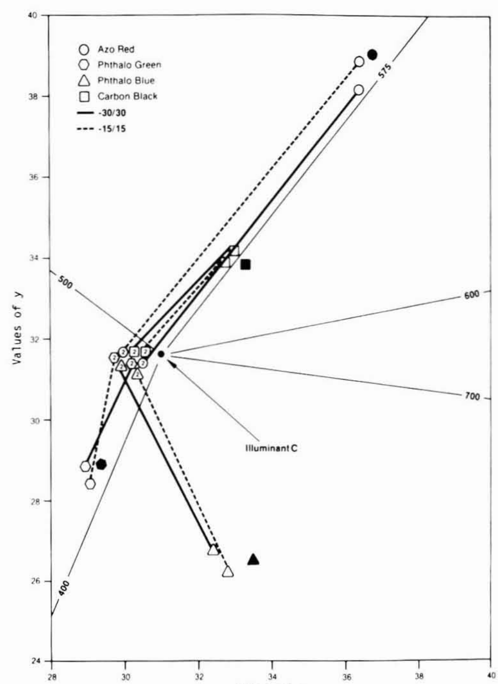

Figure 6—Section of the chromaticity diagram for Illuminant C showing the location of the samples measured by the direct goniophotometric method at two angles of illumination and viewing, −15°/15° and −30°/30°. The open symbols show the location of the bronze color. These are connected to corresponding symbols labeled with a 2 inside to denote that two overcoats of clear vehicle have been applied over the bronzed samples to eliminate the bronze effect. Again the overcoated samples are located very near to the neutral point. For comparison, the blacked points represent the values on the same bronzed samples as measured by the difference method using sphere geometry as plotted in *Figure* 3

Table 3—Visual Ranking Results, by Six Observers, For Degree of Bronzing Of Exposed Perylene-Red Samples

Bronzing	1	2	3	4	5	6
Most	IB	IB	IB	IB	IB	IA
↑	IA	IA	IA	IA	IA	IB
│	IIIB	IIIB	IIIB	IIIB	IIIB	IIIB
↓	IIIA	IIA	IIA	IIA	IIIA	IIIA
Least	IIA	IIB	IIIA	IIIA	IIB	IIB
	IIB	IIIA	IIB	IIB	IIA	IIA

visual assessments and with the indirect (sphere geometry) method of measurement. To emphasize the agreement between the two methods of measurement that were employed here, the chromaticity measured by the sphere method is also plotted on the diagram in corresponding black points. Note that the chroma (purity) of the specularly reflected light determined by either method is about the same. It can be seen that the hue determined by the indirect method (sphere geometry) is shifted slightly, in each case in the direction one would expect for near normal incidence and viewing, i.e., away further from the 30° than from the 15° line.

Measurement of Exposed Paint Panels Pigmented with Perylene Red

Six samples of a perylene pigment (two different batches and three different techniques of dispersion) incorporated into a thermosetting acrylic lacquer were exposed for six months at 5° south in Florida. The exposed samples, as well as the unexposed panels, were measured on the Trilac spectrophotometer using the sphere geometry mode. The data were analyzed using Program EXPOS to assess the various aspects of the changes after exposure. Results indicated that all six samples showed some degree of bronzing and that some of the samples were, in fact, quite severely bronzed. Based on the curve shape of the difference in specular reflectance (calculated by Program EXPOS) the surface reflectance is "greenish" (see *Figure* 7).

These samples were visually assessed by six different observers for degree of bronzing. The ranking results, given in *Table* 3, indicate some agreement among the observers. The color difference in the specular reflectance between the exposed and unexposed samples, calculated using Program EXPOS, are given in *Table* 4. When these calculated color differences for the surface change (specular reflectance) were used to rank the

Table 4—Calculated Color Difference Due to Changes in Specular Reflectance

Sample	ΔE (FMC2 - Ill. C)
IA	10.76
IB	9.83
IIIB	6.26
IIIA	2.04
IIB	1.84
IIA	1.72

Table 5—Degree of Bronzing Of Exposed Perylene-Red Samples

Observer #	Rank Correlation Relative to Average Visual Ranking
1	1.0000
2	0.8286
3	0.9429
4	0.9429
5	0.9429
6	0.8857
EXPOS	0.8857

degree of bronzing, good correlation was found between the calculated values and the average visual ranking of the observers (*Table* 5).

CONCLUSIONS

Techniques for measuring and characterizing the bronzing of nonmetallic pigmented paints have been described. This investigation used an instrument with both sphere geometry and variable directional-directional, or goniogeometry, for the measurement of specular reflectance, coupled with a suitable computer analysis program. Measurements of bronzing were carried out on both high concentration masstone samples (an azo red, a carbon black, a phthalocyanine green,

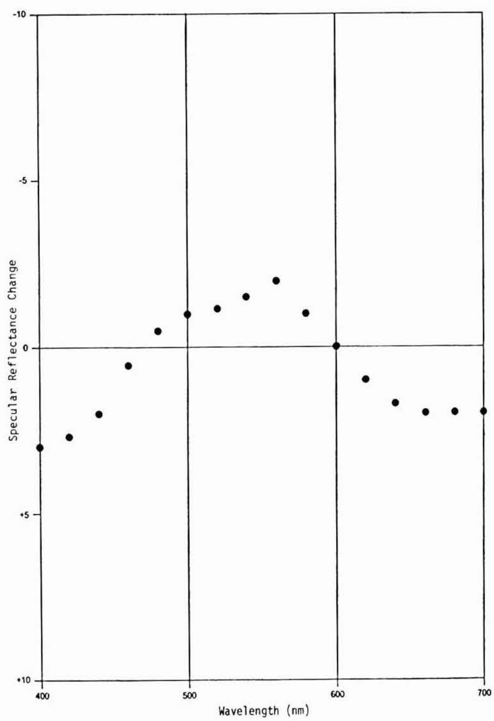

Figure 7—Graph of film surface reflectance change of an exposed perylene red sample. The bronze color is green

and a phthalocyanine blue) and on perylene-red pigmented samples in a thermosetting acrylic vehicle that were exposed for six months in Florida. The analytical information, as illustrated on a chromaticity diagram, demonstrated the excellent agreement between the two methods of measurement and resulted in excellent correlation with visual evaluations as to character and relative magnitude of bronzing.

The authors do not wish to characterize the bronzing measured here as either interface bronzing or interference bronzing.[3] As can be seen from *Figure* 6, there is a slight shift in hue (dominant wavelength) as the angles of incidence and viewing are changed. If one agrees that the definition of interference bronzing is a change in hue with angles of illumination and viewing, such a slight—but consistent—shift is of interest. However, the authors have made no attempt to evaluate the validity or significance of this measured shift in dominant wavelength.

Few quantitative measurements of the bronzing phenomenon exist in the literature. The authors hope that others will test and evaluate the described procedure. For that purpose, the Program EXPOS used, programmed in Fortran IV, is available to anyone wishing to use it. Contact either of the authors for a copy.

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Practical Aspects of Current Color-Measurement Instrumentation For Coatings Technology

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Recent advances in optical and electronics technology have given rise to a new generation of color-measurement instrumentation. The most frequently observed instrument is the microcomputer-controlled spectrophotometer. The new computer-controlled instruments exhibit unparalleled speed and precision. The speed allows one to make multiple measurements of a single sample and the precision requires better or multiple samples to characterize a coating's color accurately. Each of the newer instruments has one or more optical innovations which must be evaluated in the light of the user's particular needs. Some of the possible advantages and disadvantages of the newer instruments are presented here. These discussions are neither recommendations for nor judgements against any specific manufacturer. It is important to note that the new optical technology is not a panacea for poor personnel in the research or quality-assurance laboratory. An instrument is only as good as the individual operating it, and as the samples presented for measurement.

INTRODUCTION

In the last 10 years electronic and optical engineering has experienced a growth of unparalleled dimensions. Much of this growth has been carried over into the color measurement field by many bright and innovative scientists and engineers. The changes introduced by these innovative professionals are due in part to the improved solid-state detectors and halogen-cycle tungsten-filament lamps, and in part to the rise of large-scale integration in the electronics industry. The advances in technology applied in the color-measurement industry have led to a new generation of color-measurement instruments with amazing speed and precision.

This paper describes some of these advances and the new instruments which they have made possible. Instrument performance is discussed mainly in reference to short-term repeatability, the precision of measurement of a single sample many times over a period of a few days or a few weeks. For this analysis, only the highest quality samples were used, such as transmitting filters or reflecting tiles from national standardizing laboratories. In most cases, it has not been possible to test more than one instrument of a given type and manufacturer. In the few instances where more than one instrument was available, excellent short-term reproducibility was demonstrated.

TECHNOLOGICAL ADVANCES

Nearly every major manufacturer of color-measurement instrumentation has at least one entirely new instrument on the market. The one most often seen is a spectrophotometer that is interfaced to and controlled by a microprocessor-based microcomputer. These "computers on a chip" operate at a typical clock rate of one megahertz and can read and store data in less than 10 cycles. The speed at which the new spectrophotometers operate frees the user from dependence on a single isolated measurement of a sample. In the time that one used to spend performing a single spectrophotometric measurement, 5 to 10 measurements can now be made and averaged. The advantages of averaging have been clearly illustrated.[1] Along with its speed, the microcomputer also allows the storage of reference or calibration values.[2] This capability is especially advantageous in the light of recent reports[3] from the National Bureau of Standards.

Results from an international round-robin indicate excellent agreement on the absolute scale of diffuse reflectance. The corrected reflectance values of a widely used white reflectance standard have been published.[4] Utilizing the storage capabilities of the microcomputer, one is now able to standardize each instrument to the same scale of reflectance. This means that instrument-to-instrument, plant-to-plant, city-to-city, and even country-to-country comparisons can be efficiently performed, regardless of the make, model, or geometry of the instrument. It should be emphasized, however, that great care must be taken in choosing a transfer standard to be used to calibrate to the new absolute scale. Vitrolite, Cararra, and some Russian opal glasses do not qualify as good transfer standards because of their translucency or poor surface characteristics. According to the CIE,[5] a good standard should be completely and uniformly opaque, be highly reflecting, and have a flat surface.

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TECHNOLOGICAL DRAWBACKS

As with most things in life good news is usually accompanied by some not-so-good news. In this instance the bad news concerns the samples which one presents to an instrument for measurement. The majority of the new instruments have a demonstrated short-term repeatability of 0.10% reflectance. This increased instrumental precision implies increased sensitivity to poorly prepared samples. Where once a single, casually prepared drawdown was sufficient to characterize a specific coating within the capability of an instrument, the new instruments are easily capable of identifying point-to-point variations across the surface of a specimen. An example is the British Ceramic Research Association (BCRA) Ceramic Colour Standards. With the more sensitive new instruments it is possible to measure point-to-point variations in the tiles repeatably—a problem which the tiles were specifically selected to avoid in 1968. While the variations in the BCRA standards are not large, they do demonstrate the need for greater care in sample selection.

None of the newer instruments, with the exception of the Diano-Hardy II, is being offered to the customer without an interfaced computer. This means that continuous spectral scanning is being replaced by discrete spectral scanning. Because most individuals are interested only in the digitized reflectance values at a few selected wavelengths, discrete scanning does not represent a significant drawback. It can offer a big advantage in speed or in precision through multiple measurements at the selected wavelengths and skipping over the unspecified regions. However, for those who have trained themselves to glean significant amounts of information from the spectral curves, the absence of an analog output may be disturbing. Fortunately, most of the instruments come with a digital-plotter option, the best ones sampling many points within the bandpass of the monochromator to give the appearance of a continuous curve.

CURRENT INSTRUMENTATION

One of the first of the new instruments on the market was the Hunter D54P spectrophotometer. This is a single-beam instrument utilizing diffuse illumination and near-normal viewing with an integrating sphere. The monochromator is a low-speed continuously-rotating interference wedge. This monochromator has a variable bandpass ranging between 10 and 18 nm. This interference filter is far superior to those found in the first filter abridged spectrophotometers. However, like all monochromators, including those using a grating or prism, the interference wedge is not insensitive to its environment. High temperatures and humidities can cause random shifts in the central wavelength of the filter.[6-10] Thus, the position of the specific wavelength may drift from its calibrated position, and one needs to test wavelength accuracy periodically, just as one has always done with the more conventional monochromators. Because this is a single-beam instrument a correction must be applied for changes in sphere efficiency. This correction is performed at the factory on suitably aged spheres, and the user is expected to make periodic checks with a neutral tile to determine the current validity of the correction. One thing for which the correction cannot compensate is a careless or indifferent operator. A few dark threads, or a few chips of a dark coating inside the sphere, is enough to place the grey-tile values out of tolerance. You would not want to place this instrument or any high-quality spectrophotometer near your pigment milling or dispersing areas.

An instrument which is similar to the D54P is the ACS Spectra-Sensor scanning spectrophotometer. This is an electrically more sophisticated version of the Hunter optical unit. It was designed to be incorporated with a color-matching system, but is also available as a stand-alone instrument. The user is given much more control over the instrument and is expected to make periodic recalibrations of the single-beam correction factor with a set of neutral tiles supplied with the system. Short-term errors due to careless operators can still be a problem for this instrument. Both the ACS and the Hunter instruments are capable of performing as well as if not better than their advertisements indicate.

The IBM 7842 Color Analyzer II also utilizes a rotating interference wedge as the monochromator. The instrument is sold as a stand-alone optical instrument and in a computer-color-matching system. The interference wedge is rotating at a much higher speed than in the previous instruments. Thus, the IBM instrument scans the spectrum many times in the process of making a measurement. In the previous examples, multiple readings are accumulated in the computer as the spectral region of interest passes before the detector. The IBM machine, however, averages successive scans of the wedge. The IBM is also the only 0°/45° spectrophotometer on the market. Again, the repeatability of the photometric measurements on good quality samples is well within the advertised limit.

The authors have not personally had an opportunity to sit down with the Zeiss DMC 26 to perform critical diagnostics, but during the AIC Congress, COLOR 77, they did spend a few hours operating the demonstrator, and were quite impressed with its speed and versatility. If sales is any indication of virtue then the DMC 26 must be a good instrument. The DMC 26 has taken all of the good points of the old Zeiss DMC 25, reversible optical geometries, filtered-xenon illumination, adjustable bandwidth, measurement into the near-UV and near-IR wavelength regions, and added to them a grating double monochromator operated by a computer-controlled stepping motor, and state-of-the-art electronics. The instrument can be specified with either a diffuse/normal-normal/diffuse integrating sphere, 45°/0°, or goniophotometric geometries. It can also be fitted with color-matching software.

The Macbeth MS 2000 abridged spectrophotometer probably incorporates the largest number of technological innovations among the new instruments. A xenon flash lamp is used to replace the usual tungsten lamp. The scanning monochromator is replaced by a fixed grating and a spatial array of detectors. The instrument also comes with 45°/0° geometry, and both geometries can be obtained with software for either abridged spectrophotometry or colorimetry. The most unconventional aspect of this family of instruments is the use of a logarithmic photometric scale. This feature may require some time to learn to appreciate. The electrical matching of detector and *A/D* converter has produced an extremely sensitive instrument. The concentration on optical innovation, however, has made this one of the most inflexible instruments on the market. If you want more than 18 spectral points you must approximate the data by interpolation, which for high-chroma pigments can be a risky procedure. There is also an artificial zero point imposed by the electronics. At any spectral point where the value falls below about 0.10, the value is set to approximately 0.08 to 0.10. Thus, cut-off coatings or photometric blacks may not be accurately displayed in spectral regions where the photometric values are less than 0.10. There is also a computer-color-matching system available for the MS 2000 with software supplied by Davidson Colleagues.

The Unicam spectrophotometer, manufactured in England by Pye and marketed in the U.S. by Phillips, is a conventional analytical spectrophotometer converted for color measurements by adding an integrating sphere and a computer interface. The authors have not had the opportunity to test the instrument, whose specifications call only for ±0.5% repeatability of reflectance. It can be used in the near-ultraviolet and near-infrared regions.

While the Hardy-type instruments are not new and the Diano-Hardy II has been on the market for some time, it is included here because Diano has incorporated many of the technological advances into the Hardy II and because it is one of the few continuously-recording spectrophotometers now available. In many respects the Hardy is still the standard for instrumental performance. It is, of course, a precision-made instrument—each instrument is hand assembled, component by component. The reversible optics allows either polychromatic diffuse/normal geometry for fluorescent samples or the more sensitive monochromatic normal/diffuse geometry. The recording ability forces the instrument to run much slower than the microprocessor-controlled instruments.

The newest instrument on the market is the Diano Match Scan spectrophotometer. Optically this is the equivalent of the Hardy II, with similar sphere geometry and reversible optics. There has been the addition of a grating monochromator, and a microprocessor to control the instrument. This is perhaps the most versatile of all of the newer instruments. The entire operation of the instrument is software controlled. The area of view is continuously variable down to 2.0 mm. Diano will supply either the Hardy II or the Match Scan with a color-matching system.

CONCLUSIONS

Today, more than ever, the use of color-measuring instrumentation is a necessity and not a luxury. The speed of the microprocessor allows spectral measurements to be made in a time comparable to that required by colorimeters and at an equivalent price. It appears to the authors that unless there is a drastic decrease in the cost of filter colorimeters, most of them could soon be replaced by the microprocessor-controlled stand-alone spectrophotometer.

At the present time we do not feel that anyone can indicate that, optically, any one of the newer instruments is significantly better than any other. Each has its advantages and disadvantages. But whatever the requirements or cost of an instrument, the value of that investment is no greater than the worth of the personnel operating it. While they may appear simple and toy-like, these new instruments are sensitive optical devices and should be treated accordingly. One must faithfully perform all necessary calibrations and periodic checks of performance. The authors strongly recommend participation in the Collaborative Reference Program of the National Bureau of Standards to maintain the accuracy of results from your instruments and operators.

ACKNOWLEDGMENTS

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A Computer Program To Evaluate Anti-Fouling Materials

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A computer program has been developed to evaluate the performance of immersed plates coated with various anti-fouling coating formulations and polymeric materials. Numerical ratings of barnacle fouling and total fouling (all species) of several hundred panels are recorded and stored for each month up to 72 months. An update routine allows additional fouling data to be added at one to six-month intervals. Additionally, for each panel are recorded the date and place of immersion, substrate, anti-corrosive coating, anti-fouling coating, toxic materials, manufacturer, color, and specific comments. The basic output of the program is a set of graphs showing the percent fouling resistance of the panels versus the number of months exposed.

A key feature of the program is the parameter search-and-select option. With this option, a search can be made for all the panels having one or more parameters in common; for example, anti-fouling coating, substrate, manufacturer, or binder. At the user's option, the computer will print any of several analyses of the overall or average performance rating of the particular group selected, in addition to individual plots and performance summaries.

INTRODUCTION

A principal concern in the U.S. Navy is to achieve maximum Fleet readiness and operation for the dollars expended. These goals can be achieved in numerous ways, among which is the utilization of the latest in coating technology to preserve and protect the ships and prevent fouling of the hulls. The latter, because of excessive drag as the ships move through the water, increases fuel costs and reduces maximum speed. Presently, no anti-fouling coating is available which will protect against fouling for five years in normal Fleet usage. One aspect of this is that fouling occurs mostly when a ship is docked, and Navy ships spend a great deal of their time in port. With changing requirements of the Fleet, new ships and ship construction materials, and more severe stress conditions, the development of new coatings has become a top priority.

In addition, U.S. Navy paint formulators and users have become increasingly concerned about the environmental, health, and safety aspects of anti-fouling coatings. The Environmental Protection Agency (EPA) is in the process of establishing new, extremely rigorous, toxicity criteria for the use of metallic and organic anti-foulants. Additional restrictions, shortages, and changes in manufacturing processes have also affected the use of other materials, notably organic solvents. The need for a more effective, nonpolluting, safe-to-handle anti-fouling coating has brought about increased emphasis in the research and development of new anti-fouling paints. This situation has, in turn, resulted in a vastly increased program of testing and evaluation of the newly developed coatings.

An anti-fouling coating is, in effect, an engineered polymer-pigment-toxic matrix. The toxic must be released at a controlled rate into seawater, i.e., a rate that does not deplete the reservoir of toxic required for a long life coating, but which is adequate to prevent fouling by the various marine flora and fauna. The coating must obviously be physically durable in seawater; the coating is expected to change significantly during the anti-fouling (AF) film's lifetime and test methods must take account of this fact.

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In the formulating of an anti-fouling coating, conventional paint tests, i.e., physical properties of wet and dry films, are useful, although other tests such as leaching rate of the toxic may be required. Sometimes accelerated aging tests are run, such as hot water immersion, cycling through various operations, or rotating cylinders. Almost invariably, the evaluation includes a static immersion test at a natural fouling site, essentially an unaccelerated aging test for determining anti-fouling efficacy. The final step in the evaluation process is the testing of the coating in service on a Navy ship, either as a patch test or as a full ship coating. The service test is critical for acceptance, but at the same time, it is the most limited and is the least controlled.

This paper describes a computerized method for monitoring, evaluating, and updating the performance of coated panels immersed at fouling sites presently used by the Navy at Biscayne Bay, Miami, Fla. and Pearl Harbor, Hawaii.

Table 1—Typical Report from a Fouling Site At Miami (Biscayne Bay), Fla.

	Fouling on Surface					Percent Ratings			
Surfaces	Barn.	E.B.	Tun.	Others	Physical Condition	F.R.	A.F.	A.C.	O.P.
E-103	50+		5%	3 TW		40	100	100	40
B	C.F.								0
E-109	N.F.								100
B	N.F.								100
E-115		5%				90	100	100	90
B		20%				75	100	100	75
E-116		25%		5%Al		50	100	100	50
B	C.F.								0
E-117	C.F.								0
B	10 med.				Incipient	85	100	100	85

Fouling reported as found on the more heavily fouled surface. Solitary forms reported numerically; colonial forms by percent of surface covered.

Legend: Al=algae; An=Anomia; Barn.=Barnacles; Bug=Bugula; E.B.=Encrusting Bryozoans; Hyd.=Hydroids; Oy.=Oyster; Sp.=sponge; T.W.=Tube worm; Tun.=Tunicates; C.F.=completely fouled; B=Back side of panel.

PANEL IMMERSION TEST

The panel immersion test at an appropriate fouling site is essentially an unaccelerated aging test, as well as a biological test. It normally entails periodic evaluation of the condition of the paint film and a description of its fouling. Slide photos of the panels and written reports are often used. Since superior paints can last for five years or more, one of the criticisms of the immersion test is that it is too lengthy; often 12-18 months elapse before a decision is made whether to continue the test, reformulate the paint, or abandon the general formulations under test.[1] Other criticisms are: the immersion is a static test and does not simulate the ship's motion; there is too much variation in exposure conditions and insufficient controls and ratings are too subjective with too many fouling species present and approximations required. Finally, correlation with service performance has not always been good, although it seems to have been on an upgrade in recent years.[2-5]

On the other hand, poor coatings fail quickly, so accelerated aging and other tests can be started within 6 to 10 months of immersion and can be run concurrently.[6] Tidal flow does provide some water motion. Variation can be minimized by using multiple coating controls and samples and the recently suggested ASTM standards for acquiring and reporting the fouling data.[7] Static panel testing has its limitations, but it is still unmatched in its versatility, usefulness of results, comprehensiveness, and its extent of usage.

These remarks hold true particularly when panel immersion data are used in conjunction with other test and evaluation procedures.[8]

The panel testing sequence described below follows a regular pattern in order to allow comparison between coatings immersed over many years. After development and initial testing of the coatings, standard 10 × 12 in. (24.5 × 30.5 cm) panels are coated with the Navy epoxy-polyamide (MIL-P-24441), vinyl (MIL-P-15238/15929), or other anti-corrosive primer system and then with the experimental anti-fouling coating. At least two panels are prepared for each anti-fouling coating. Two 6 × 16 in. (15.2 × 40.6 cm) panels are also included if a boot topping, i.e., splash zone, coating is being tested. Additionally, two panels coated with a control coating are immersed with each batch of experimental coatings. The controls are usually Navy Formula 121/63 (MIL-P-15931) or Mare Island Paint Laboratory Formula 1020A, whose performances have been extensively monitored over many years and whose fouling efficacies are well known.

For new anti-fouling coating formulations, the first 6-12 months after an immersion of the panels is a screening test. Coatings which have begun to foul or deteriorate during this period are eliminated from the testing program. For those coatings exhibiting 100% fouling resistance, the testing is continued and augmented by exposing new panels of identical or slightly different formulations. As the particular coating system continues to excel, additional test panels are periodically exposed, thereby building up the statistical base of data required to overcome the large variability in exposure condition, panel preparation, and coating formulation variables.

Finally, as a means of comparing the service life versus the static immersion test results, another set of panels may be immersed when service tests begin on a ship. The latter tests are often done with batches of experimental paints prepared by different manufacturers in order to follow variations which may occur.

To insure complete fouling history, each of the panels is pulled from the water and evaluated each month. The specific criteria and parameters are described in detail in the following section. In addition, initially and periodically, the test panels are photographed for visual comparison.

From the foregoing brief description of panel immersion testing, it is obvious that large volumes of data are forthcoming from the fouling readings. This is especially true where a series of paints may have been

Table 2—Sample Input Cards for "Panels" Program

A.	**Panel Parameters**		
	5 71 1 1 1 1 2 2 3 3 0	1 17 1 4	3960
	40 5 71 1 1 1 1 5 3 3 3 0	2 3 1 4	3963
B.	**Data on Barnacle and Total Fouling**		
	0 0 0 0	0	Barn. 1 3960
	0 0 0 0	0	Barn. 2 3960
	0 0 022223334440 0	0	Total 1 3960
	0 0 033333444440 0	0	Total 2 3960
	0 0 0 0	0	Barn. 1 3963
	1122333344445777777778888888999000000000	0	Barn. 1 3963
	0 0 01111000000000	0	Total 1 3963
	113355555777777888888888888999900000000	0	Total 2 3963
C.	**Fouling Update**		
B1	969696969696 2 999999999999 T1 606060504030 2	606060505040	3960

developed using a factorially designed experiment, and the immersion test is evaluating the final formulations of AF paints prior to service evaluation. For these reasons, the computer program described below was developed to handle and correlate panel immersion data and allow comparison to be readily made between AF paints under development and those immersed at fouling sites.

FOULING DATA

It is necessary for the formulator to rely on second-party fouling reports; i.e., it is not practical for one to personally inspect hundreds of panels month by month. This requires that the fouling data be consistent month to month, with recording of the biological species present and the amounts or extent of the panel covered by each. Additionally, the physical condition of the paint films, anti-corrosive and anti-fouling, is recorded. A typical report from a fouling site is shown in *Table* 1. Obviously, a large amount of data arrives each month, requiring extensive time to digest it and to follow performance trends. In practice, it is necessary to limit the amount of fouling data that is treated by computer. The most important fouling is the so-called "hard fouling" of barnacles and tubeworms, or other calcareous growths. Algae is also important because it provides a foothold for later successions of organisms. Soft fouling, such as tunicates, bugula, and sponges, is less important, since it would be unable to gain a start on a moving ship, or one that is not docked for any lengthy period. At Miami, barnacles are the single most important fouling organism; at Pearl Harbor, tubeworms are the most significant.[9]

In order to facilitate computer analysis of performance, the monthly fouling report for each panel is condensed into two quantities: the calcareous fouling (percentage of surface covered by barnacles and tubeworms) and the total fouling (overall surface deterioration). The total fouling figure is the sum of the soft (noncalcareous) forms of fouling, the calcareous fouling, and film defects, such as blistering, peeling, or checking; it is also reported as a percentage of the surface. Both sides of each test panel are rated; one thus obtains four data items per panel per month or 48 items per year. In addition, special comments about the performance of the panel may be inserted at any time.

OPERATION OF COMPUTER PROGRAM

The computer program for evaluating panel immersion data, entitled "PANELS", was written in Fortran IV and is operated on the DTNSRDC CDC 6600/6700 system. The source deck is located on disk, with a tape backup; the fouling data is on tape, with a backup of a second tape. Additionally, the entire program is backed up with cards, should some catastrophic occurrence eradicate the disk and tape sources. Access to the computer is via the NOS/BE operational techniques. Most data is handled in batch mode from the Annapolis Computer Center, via leased lines to the computers located at Carderock, Md., the Center's main laboratory. Also available, are intercom terminals from which new data can be transmitted or program modifications be made directly to the disk source.

The basic operation of the program, PANELS, is as follows. A matrix is set up consisting of the month-by-month fouling data of a large number (1000) of test panels. This matrix can be periodically updated as additional months of fouling data become available. A simple output of the matrix yields a graph or table of percent fouling or percent fouling resistance per month for each panel. Each panel is characterized by a set of identifying parameters (substrate, immersion date, paints, etc.) as described below. The coding of these parameters allows the program to select and output groups of panel data according to the specific parameters they have in common; for example, all those having the same anti-fouling coating.

The actual names or formula designations are contained in the source program as literal program statements:

(DATA (ISUB(J), J=1,4)/STEEL, ALUM, RUBBER, FBGLS.)

This statement allows the user to select any of the substrates steel, aluminum, rubber, or fiberglass by coding 1 through 4, respectively, in the appropriate column in the panel parameters card. The number of choices and the number of literal characters for each parameter can be chosen arbitrarily and can be readily changed. For example, each anti-fouling coating is allocated 12 characters. The literal data are used in the output section for describing the panels. The numerical code is used for the search-and-select options discussed below.

When adding test panels with new parameters, e.g., new anti-fouling coatings, one must update the literal DATA statement in the source program; the two steps can be done at one submittal to computer operations.

In execution of the program, the input consists of four types of information. They are (1) panel parameter cards, which describe fully the test panels themselves; (2) fouling data cards, which provide numerical ratings for two types of fouling for each month of exposure; (3) fouling update cards, for subsequent fouling data; and (4) search-and-select option cards. The four types are described below.

```
PNL 3001,DEC 71,STEEL,AC-F-117,F-119.AF- USN F-121/63,
          TOXICS-CUP.OXID.
PCT FR     BARNACLE FOUL.RESIST. 3001,SIDE 1 (MOS)
    1   5   10   15   20   25   30   35   40   45   50   55
100 ----
80        ----------------------------------------------------
60
40
20
 0

PCT FR     TOTAL FOUL.RESIST. 3001,SIDE 1, (MOS)
    1   5   10   15   20   25   30   35   40   45   50   55
100 ----
80       -----------------------------
60                                    -----------------
                                                       -----
40
20
 0
```

Figure 1—Typical output of computer program for evaluating anti-fouling paint performance

Panel Parameters Cards

For each panel to be included in the evaluation program, the following information (parameters) is required:

Identification Number—a unique four-digit number is assigned to each panel.

Date of Exposure and Test Series Number—month and year panel was immersed.

Location of Exposure Site—e.g., Miami, Pearl Harbor.

Substrate—e.g., steel, aluminum, rubber, etc.

Anti-fouling Paint—(a) Generic type of the paint, e.g., vinyl, chlorinated rubber, etc.; (b) Trade name or formula number.

Anti-corrosive Paint System—includes primer and intermediate coats. (a) Generic type; (b) Trade name for formula number.

Manufacturer or Formulator—e.g., DTNSRDC, XYZ Paint Co., etc.

Color—important for camouflage paints.

Toxic Ingredients—zero, one, or two anti-fouling compounds may be listed.

Comments—this entry allows coding of specific comments for individual panels.

All of the above parameters are coded on a single card using a 20I4 format (see *Table* 2, part A). For each parameter the integer field is coded with an integer from 1 to N, where N is the number of possible choices for that parameter, e.g., 1 to 10 for colors, 1 to 100 for anti-fouling paints. Each integer (1 to N) represents a specific anti-fouling paint. The actual names or formula designation are contained in the source program itself as literal program statements. (see previous section).

Fouling Data Cards

The data is abstracted from the fouling reports provided by the testing station. The two types of fouling included in the program are barnacle fouling and total fouling. With the appearance of the first barnacle, the panel rating is dropped to 90%, as this indicates that the fouling resistance is weakening. Each succeeding barnacle to appear reduces the rating by 1%. When the rating reaches 50%, the percentage of the panel area unfouled is used as the reporting base. The total fouling or overall performance is a percent rating which takes into account all the fouling species, e.g., barnacles, algae, bryozoa, tunicates, etc.

For each test panel, four data cards are required, since barnacle fouling and total fouling are recorded for each side of a panel. The format used is (72I1, 1X,I1,A1, 1X,I4) (*Table* 2 part B). The first 72 columns of the card are available for the fouling data. Each column represents a single month of exposure; thus, for each panel a record can be maintained for up to six years. The fouling data are coded as follows for either barnacle or total fouling:

CODE ENTERED -	0	1	2	3	4	5	6
FOULING RESIS. %	100	86-95	76-85	66-75	56-65	46-55	36-45

(Barnacle or total fouling)

CODE ENTERED -	7	8	9
FOULING RESIS. %	26-35	16-25	0-15

Because of the method of rating, scores of 96-99% are not possible.

The remaining entries in the format above are used to specify the side of the panel (1 or 2), the type of fouling (barnacle or total) and the four-digit panel identification number.

Thus, for each test panel included in the program, there are five cards; one card for the panel parameters and four cards for the fouling data. The panel parameters are unchanged throughout the lifetime of the test panel. When a panel is removed (terminated), the total number of months exposed is automatically coded into the panel parameter card. The fouling data cards or card images are continually updated throughout the panel lifetime or until 72 months is reached. The procedure for updating is described below.

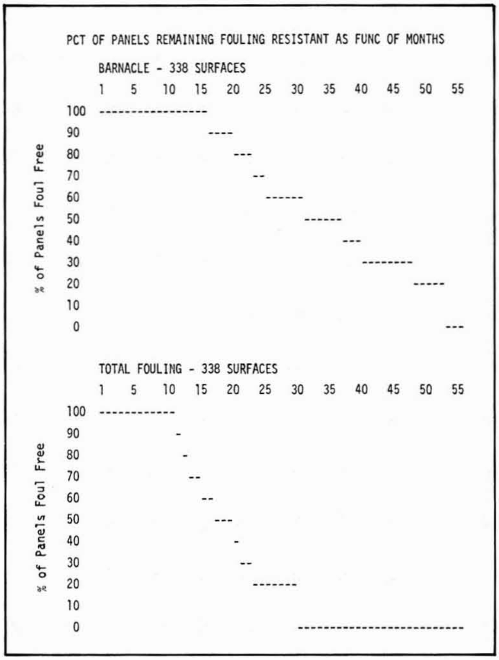

Figure 2—Composite graphs of fouling resistance of standard Navy anti-fouling paint, F-121/63, for 338 surfaces immersed since 1969

The primary input for the program is a set of 5N cards or card images. Following a single control card, these are read in on cards or tape as follows: N parameter cards followed by 4N fouling data cards. In the simplest version, they are simply read in and written out on tape or printer. The output for each panel is a set of four fouling graphs (one per side for both barnacle and total fouling) and a legend providing literal codes of the panels parameters.

Fouling Update

In addition to the basic output described above, the program has features which allow periodic updating of the fouling data and selection of specified groups of panels for analysis.

If the update option is chosen, the program will accept I new panels and J updates of old panels (those already on the system). Each of the new panels requires 5I cards; I parameter card plus 4I fouling data cards. These are coded exactly as original data described above.

For each of the J panels being updated, a single card is used for up to six months of new barnacle and total fouling data. The format of the update card consists of four 6I12 fields (*Table* 2, part C). The fouling rating for the new month(s) is presented as a two-digit number; e.g., 80%, rather than the single digit used on the new fouling data cards. This format was chosen to allow the

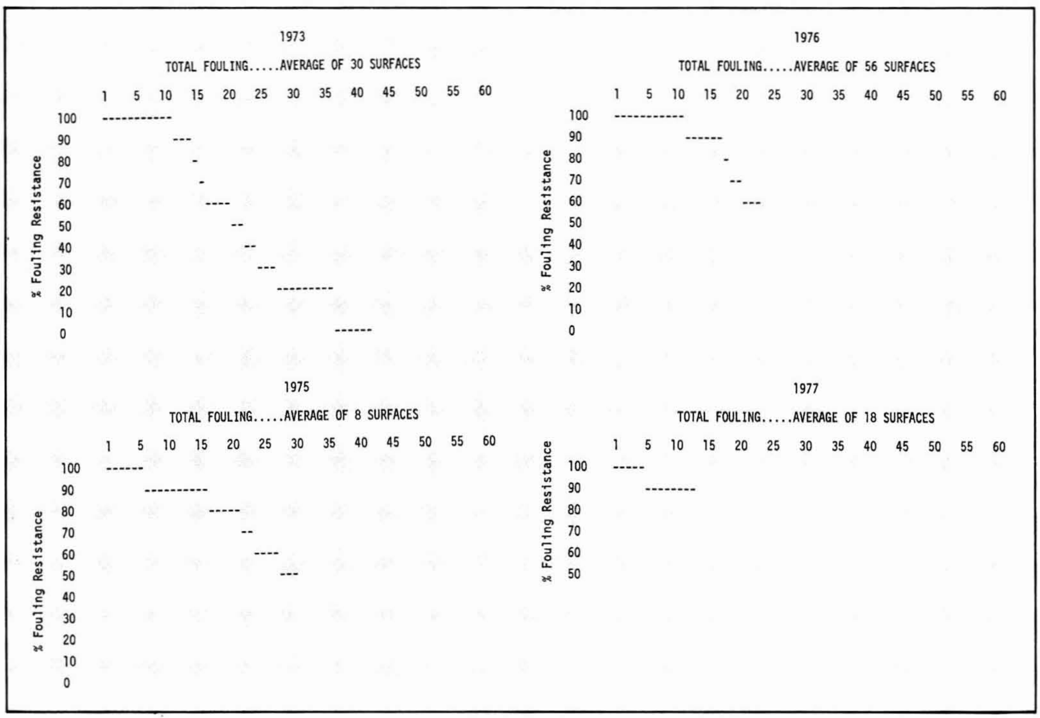

Figure 3—Graphical comparison, year-by-year, of anti-fouling performance of F-121/63

updated ratings to be entered directly on printed computer forms by the personnel at the exposure station.

If a test panel is being terminated, this information must be coded on the update card so that no additional fouling data will be included in the data storage or in the fouling graphs. The only identification required for the updated panel is the four-digit identification number.

When the update option is chosen, the operation is completed before the printing of the fouling graphs.

Search-and-Select Options

In addition to providing fouling plots for each test panel sequentially, the program can sort out panels according to the parameters coded on the parameters card. The control cards for these group selections are placed at the end of the input stream. For each group or series desired, one control card and one comment card are required.

For a single parameter search, the control card specifies the type of parameter to be searched, i.e., F-121/63. For multiple parameter searches, the control card indicates the number of parameters to be searched, the type of parameter, and the specific one of each. Up to five parameters can be searched simultaneously, e.g., one could select all the panels having aluminum substrates, Navy Formula 1020A anti-fouling paint, MIL-P-24441 anti-corrosive paint, and which were exposed in 1972 or 1973. Note that more than one of a given parameter (e.g., two years or two anti-fouling paints) may be chosen from among the five parameters.

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Dr. Panzer has extensive experience in electrochemistry in nonaqueous and fused salt systems. He has recently retired from the Naval Ship R&D Center, Annapolis, Md., where he was associated with the Coatings Branch, Materials Dept. He was engaged in studies of coatings, corrosion, and electrochemical aspects of pollution and anti-fouling coatings. Presently, he is serving as consultant and investigator with private concerns in the Washington, D.C. area.

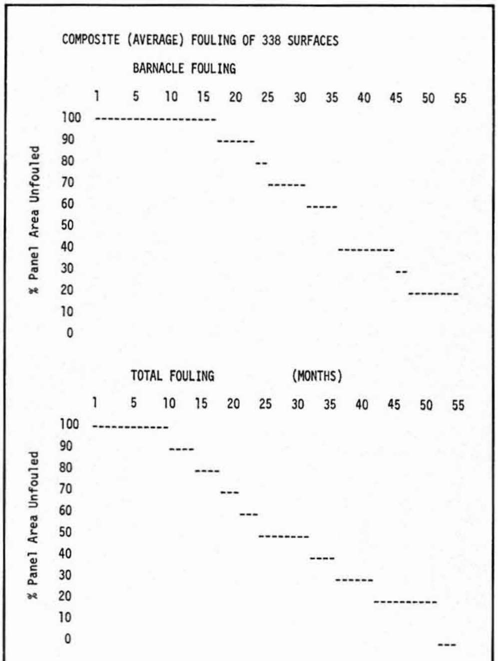

Figure 4—Composite (average) anti-fouling performance of USN F-121/63 cuprous oxide anti-fouling paint

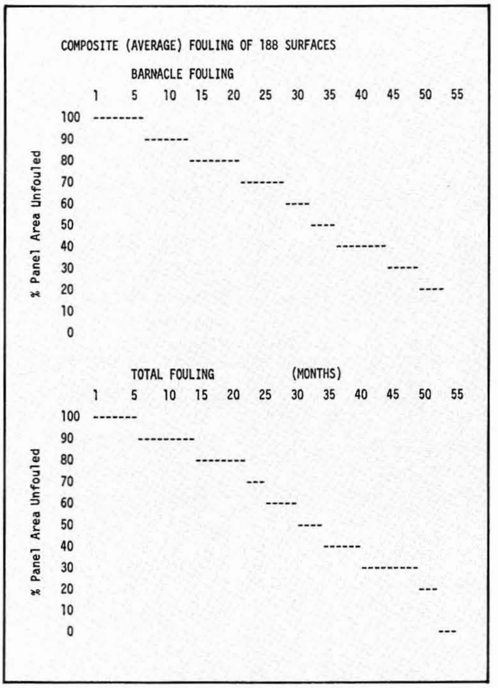

Figure 5—Composite (average) anti-fouling performance of Mare Island Laboratory formula 1020A organotin anti-fouling paint

Table 3—Computer Generated Table Summarizing Fouling Resistance of Experimental Anti-fouling Coating

Panel No.	Months Exposed	Barn. Foul Resist.,%	1st Barn. Fouling	Total Foul Resist.,%	1st Foul	Side
5120	12	100	*** mos	50	5 mos	1
5120	12	100	*** mos	40	5 mos	2
5140	12	100	*** mos	50	5 mos	1
5140	12	70	7 mos	60	7 mos	2
5180	7	100	*** mos	100	**mos	1
5180	7	100	*** mos	100	**mos	2
5184	7	100	*** mos	100	**mos	1
5184	7	100	*** mos	100	**mos	2
5218	5	100	*** mos	100	**mos	1
5218	5	100	*** mos	100	**mos	2
5223	5	100	*** mos	100	**mos	1
5223	5	100	*** mos	100	**mos	2

For each of the series or group searches described above, one can obtain a complete printout of each panel selected plus any of the following additional outputs:

(1) A plot of the percentage of panels which have remained 100% (or other specified rating) fouling resistant versus the number of months.

(2) A composite or average fouling performance of all the test panels in the given series.

(3) A summary table presenting, for each panel, the number of months exposed, the fouling rating at the last reading, and the first month that fouling appeared. Examples of these outputs are given in the next section.

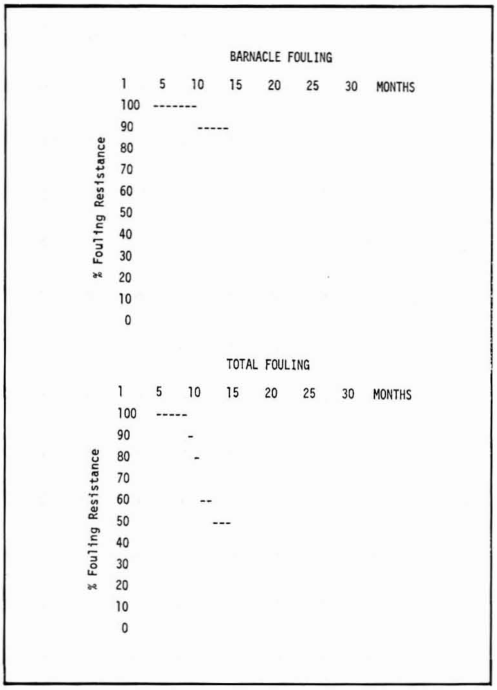

Figure 6—Composite (average) anti-fouling performance of an experimental paint

EXAMPLES OF COMPUTER EVALUATION OF COATING FOULING PERFORMANCE

The program, consisting of approximately 1150 statements, is extremely versatile and is readily modified to provide other outputs as needed. One of the principal uses of the program is to obtain a summary of fouling performance for a given coating, then compare it with that of other coatings immersed during the same period. The output for an AF paint, shown in *Figure* 1, was obtained by designating the parameters for which a search and printout were desired. The first graph is for the barnacle fouling observed on Side 1 of Panel #3001, immersed at Miami, Fla., Dec. 1971, coated with the anti-corrosive system F-117/119 and with anti-fouling system USN F-121/63, which has cuprous oxide as it's principal toxic (in this case, the only toxic). The minimum output for a given panel consists of a set of four graphs like these, including those for barnacle and total fouling for Side 2 of the same panel.

Figure 2 presents a composite graphical output for 338 panel surfaces. All have a common parameter, USN F-121/63, but are from different batches and were immersed at different times since 1969, usually as control panels accompanying experimental coatings. The fouling behavior of F-121/63 has been well characterized; hence, its fouling performance can be compared with that of a new coating as a means of evaluating the relative fouling efficacy of the latter.

Shown in *Figure* 3 is the type of graphical comparison which can be obtained by proper designation of panel parameters. In this case, a comparison for fouling performance of F-121/63 paint was made for various years. The differences may indicate a variation in the paint manufacturer or some other variable in its application, or possibly, differences in the year-to-year fouling profile of the immersion site. In the latter case, it is important to have a monthly fouling profile of the fouling activity at the test site, since growth of most organisms is seasonal.

Figure 4 shows the overall performance of many batches of USN F-121/63; *Figure* 5 shows that for the Mare Island Paint Lab F-1020A. From data such as this, one can decide whether, in the long run, and with many batches of coatings, a new coating can be expected to outperform an old one.

The computer output shown in *Table* 3 and *Figure* 6 summarizes the first year's results for an experimental anti-fouling formulation. For each surface exposed, *Table* 3 indicates the following:

The number of months exposed, the calcareous (barnacle) and total fouling resistances at the latest reading, and the month at which this fouling first appeared. Note that the panels were exposed in three separate tests series, the latter two sets (5180, 5184 and 5218, 5213) being initiated because of the encouraging preliminary results of the first set (5120, 5140).

From *Figure* 6, one observes that this particular coating formulation shows excellent resistance to calcareous fouling, but is somewhat susceptible to noncalcareous forms of fouling, in this case, principally the colonial forms of bryozoa. For this composite plot, the first five months represent an average from all 12 surfaces, month 6 and 7 from 8 surfaces, and months 8 through 12 from 4 surfaces.

SUMMARY

The DTNSRDC computer program, PANELS, for evaluating the anti-fouling behavior of immersed paint panels has proven of immeasurable value in following the trend of fouling behavior of individual coatings. On command, the program will provide information on the overall fouling behavior of a series of panels, of panels coated with specific materials, or of panels with any other selected parameters. In common with many other data processing systems, this one allows handling of the large amounts of data generated and comparison of the data in many ways that would not be accessible. Fouling data and total fouling resistance from the immersion sites can be reduced to two essential items, barnacle and total fouling resistance; the data is then input to the computer and analyzed with moderate effort and expense. The program's update capability, series analysis, and the ease of data presentation in a graphical form offer advantages in the handling of panel immersion fouling data that are not available otherwise.

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Mildew and Chalking Of Linseed Oil Paints From Treated Pigments

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Mildew resistance of linseed oil paints from zinc oxide surface-treated with an organic phosphate to improve blister resistance is as good as that of similar paints from the untreated pigment. Paints were compared during 36 months' exposure on a test fence at Peoria, Ill. Mildew resistance of paints from rutile titanium dioxide treated with selected quaternary ammonium compounds was not significantly better than resistance of those from untreated rutile. During the 36-month test, resistance to mildew depended primarily upon the topcoat. A system composed of a zinc oxide pigmented topcoat over a low-mildew-resistant primer worked as well as a system with two coats of the zinc oxide paint. Throughout the test, paints containing zinc oxide remained cleaner and whiter than those without this pigment even though paints from rutile chalked more in tests. The scanning electron microscope (SEM) showed that zinc oxide remained relatively well vehicle coated throughout the test, whereas surfaces of rutile-pigmented paints had an increasing number of bare particles with longer exposure time. Differences were still apparent when silicate extender was substituted for 50% of the primary pigment. Occurrence of mildew colonies appeared to be associated with microscopic cracks in the paint surface.

INTRODUCTION

Substitution of a surface-treated zinc oxide for the regular pigment reduced water sensitivity and moisture-induced blistering in solvent-based linseed oil paints.[1] There has been some concern, however, that such surface treatment may also reduce the ability of zinc oxide to inhibit mildew growth on the paint surface. With recent decisions concerning mercury compounds in paints, inhibition of mildew growth by other ingredients has become increasingly important. Certain cationic surfactants, like alkyl quaternary ammonium salts, have been used as algaecides, germicides, disinfectants, or fungicides in industrial applications. Some of these materials appear to chemisorb readily on surfaces of titanium dioxide pigments and may be useful for controlling the growth of mildew on paint films.

We initiated a test series to determine mildew resistance of paints with treated and with untreated zinc oxides when exposed along with controls on a test fence. Similar linseed oil paints with treated titanium dioxide pigments were also tested. The evaluation was carried out in Peoria, Ill., for 36 months. In addition to conventional evaluation of panels for general appearance, dirt, color, and chalking on a scale of 0 to 10, mildew colonies were counted so that statistical methods could be employed. Also, the scanning electron microscope (SEM) was used to monitor surface weathering on a microscale throughout the test. Experimental paints were examined, both self-primed and as a topcoat, over a paint made up from untreated rutile which contained no mildewcide. Two coats of the latter paint were used as a control on one section of each panel.

EXPERIMENTAL

Paints were made up in approximately one-pint quantities from linseed oil (No. 10 Grinding Oil, Spencer Kellog Co., Buffalo, N.Y.), driers, and the appropriate pigment. Vehicles were formed by stirring lead naphthenate (0.1%) and cobalt naphthenate (0.7%) into the oil and then adding sufficient pigment to form a 30% pigment volume concentration (PVC) in the final film. In the two-pigment paints, 15% PVC of either titanium dioxide or zinc oxide and 15% PVC of silicate extender were employed. Glass beads, later removed by vacuum filtering, were added to facilitate mixing on a laboratory sandmill.[2] After mixing and filtering, paints were stored under nitrogen in glass jars until needed.

Pigments employed in preparing paints included an American process zinc oxide (AZO® 55, ASHRCO, Inc., New York, N.Y.), a rutile titanium dioxide (Tipure® R-900, Pigments Dept., E. I. duPont de Nemours and Co., Wilmington, Del.), and a silicate ex-

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The mention of firm names or trade products does not imply that they are endorsed or recommended by the U.S. Dept. of Agriculture over other firms or similar products not mentioned.

Table 1—General Appearance[a] of Sections Covered With Two Coats of Test Paint

Coating Pigment[b,c]	Exposure Time (Months) 4	7	12	18	24	30	36
30% ZnOU	9	8	8	8	7	7	5
30% ZnOT	9	8	7	8	8	7	6
15% ZnOU+15% Silicate U	8	5	7	8	8	8	7
30% TiO_2U	6	5	3	3	2	2	3
15% TiO_2U+15% Silicate U	6	5	3	2	2	3	2
30% TiO_2H	5	6	6	3	2	2	2
15% TiO_2H+15% Silicate H	5	6	6	3	2	2	2
30% TiO_2V	7	6	3	3	3	3	4
15% TiO_2V+15% Silicate V	6	5	4	2	2	4	2
30% TiO_2E	7	6	3	3	3	3	2
15% TiO_2E+15% Silicate E	7	7	4	3	2	4	2

(a) General appearance is rated on a scale of 10 (no deterioration) to 0 (extreme deterioration).
(b) Treated pigments were covered with approximately a monolayer of treating material.
(c) Designation U refers to untreated material. T refers to material treated with organic phosphate. H refers to material treated with Hyamine 1622. V refers to material treated with Variquat AiB. E refers to material treated with Ethoquad 18/12.

tender pigment (ASP® 400, Minerals and Chemicals Div. of Engelhard, Minerals and Chemicals Corp., Edison, N.J.). Other pigments and extenders were prepared by surface treating the zinc oxide with an organic phosphate[3] or by surface treating the rutile or silicate with one of three organic quaternary ammonium salts: (a) Hyamine® 1622, Rohm and Haas Co., Philadelphia, Pa., (b) Ethoquad ® 18/12, Armak Chemicals Div., Akzona, Inc., Chicago, Ill., or (c) Variquat® AiB, Ashland Chemical Co., Dublin, Ohio. Methods for pigment treatment by chemisorbing surface-active materials from solution have been given elsewhere.[1,3] A paint containing 30% PVC of the untreated rutile was used as a mildew-susceptible control on each panel.

Paints were tested on selected panels of western red cedar. Test panels were divided into three sections numbered 1, 2, and 3 in random order. Each section numbered 1 was given two coats of a test paint and each section numbered 3 was given two coats of the same control. The number 2 sections had a topcoat of the test paint over a single primer coat of the control. Paints were applied to each panel section with a brush. After about 48 hr drying indoors, topcoats were applied. Topcoats also dried indoors for about 48 hr before panels were placed on the fence. For testing, panels were mounted horizontally on edge and facing north.

At intervals, panels were removed from the fence and brought into the laboratory for evaluation. Each panel was rated on a scale of 10 (no deterioration) to 0 (complete deterioration) for general appearance, dirt, color, chalking, and mildew. After mildew started to appear, the number of mildew colonies on each section was also counted. Chalking was measured by sticking cellulose tape to the painted surface for 5 min at room temperature and then removing the tape and attaching it to dull, black, poster paper. The white pigment removed is clearly visible under the tape against the black background and forms a permanent record.

Initially and before each panel was returned to the fence, small areas of panel surface were removed with a knife and cork borer for SEM examination. After SEM specimens were taken, spots of bare wood (resulting from their removal) were covered with two coats of the control paint.

Specimens for SEM examination were attached to aluminum stubs with conducting paint and coated in a vacuum with a layer of gold-paladium alloy. Each specimen was examined using a Stereoscan Mark II Scanning Electron Microscope, and representative areas were photographed at magnifications of 100 and 2000. Microorganisms found on paint surfaces were also photographed at other magnifications.

RESULTS AND DISCUSSION

Ratings for general appearance, chalking, and mildew colony count are given in *Tables* 1, 2, and 3 for panel sections covered with two coats of test paint. In general, the zinc oxide paints had a better appearance with less chalking than those without this pigment.

Table 2—Dirt[a] on Panel Sections Covered With Two Coats of Test Paint

Coating Pigment[b,c]	Exposure Time (Months) 4	7	12	18	24	30	36
30% ZnOU	9	8	8	8	7	7	5
30% ZnOT	9	8	8	8	8	7	5
15% ZnOU+15% Silicate U	8	6	7	8	8	8	7
30% TiO_2U	7	6	3	2	2	3	3
15% TiO_2U+15% Silicate U	7	6	3	2	2	2	3
30% TiO_2H	7	6	5	3	3	3	3
15% TiO_2H+15% Silicate H	8	7	—	3	3	2	3
30% TiO_2V	7	6	3	3	4	5	4
15% TiO_2V+15% Silicate V	7	6	5	3	2	4	4
30% TiO_2E	7	6	—	3	3	3	3
15% TiO_2E+15% Silicate E	7	7	5	3	3	2	4

(a) Dirt is rated on a scale of 10 (no dirt) to 0 (extremely dirty).
(b, c) See footnotes, *Table* 1.

Table 3—Chalking[a] on Panel Sections Covered With Two Coats of Test Paint

Coating Pigment[b,c]	Exposure Time (Months) 4	7	12	18	24	30	36
30% ZnOU	10	10	10	10	10	10	10
30% ZnOT	10	10	10	10	10	10	10
15% ZnOU+15% Silicate U	10	10	10	10	10	10	9
30% TiO_2U	10	10	10	10	8	7	6
15% TiO_2U+15% Silicate U	10	10	10	10	9	5	4
30% TiO_2H	10	10	10	8	6	5	4
15% TiO_2H+15% Silicate H	10	10	10	10	7	5	4
30% TiO_2V	10	10	9	6	5	5	4
15% TiO_2V+15% Silicate V	10	10	10	9	7	5	4
30% TiO_2E	10	10	10	8	5	5	3
15% TiO_2E+15% Silicate E	10	10	10	9	6	5	4

(a) Chalking is rated on a scale of 10 (no chalking) to 0 (extreme chalking).
(b, c) See footnotes, *Table* 1.

Table 4—Mildew[a] on Panel Sections Covered With Two Coats of Test Paint

Coating Pigment[b,c]	Exposure Time (Months) 18	24	30	36
30% ZnOU	0	0	0.08	0.26
30% ZnOT	0	0	0.12	0.21
15% ZnOU+15% Silicate U	0	0	0	0
30% TiO_2U	0.27	0.50	1.08	1.88
15% TiO_2U+15% Silicate U	0.95	1.29	2.21	10.12
30% TiO_2H	0.02	0.30	0.99	1.56
15% TiO_2H+15% Silicate H	0.08	3.59	7.62	27.18
30% TiO_2V	0.21	0.70	1.20	2.61
15% TiO_2V+15% Silicate V	0.11	0.89	5.76	8.21
30% TiO_2E	0.23	0.53	0.88	1.98
15% TiO_2E+15% Silicate E	0.17	0.65	2.64	3.65

(a) Mildew is rated in colonies per in.^{2} determined from a colony count.
(b, c) See footnotes, *Table* 1.

Ratings for dirt accumulation and general appearance correlated well except after 30 months' exposure when dirt on some titanium dioxide paints started to improve because of chalking. Paints from zinc oxide appeared whiter throughout the test than those from titanium dioxide. Zinc oxide paints had a slight bluish tint while those from titanium dioxide were slightly yellowish or brownish.

Mildew (*Table* 4) was not a great problem in the Peoria area during the period of these tests. No mildew was found on any paint before 18 months' exposure, and none was detected on a zinc oxide paint until 30 months' exposure. For mildew data, a three-way analysis of variance showed no differences between paints from treated and untreated zinc oxide at the 5% significance level. After 18 months' exposure, paint that contained titanium dioxide treated with Hyamine 1622 appeared to have significantly less mildew than other titanium dioxide paints when tested at the 5% level. After 30 months' exposure, however, because of scatter in the data, no significant differences between titanium dioxide paints were shown. Even at the 1% significance level, mildew on zinc oxide paints was less than that on titanium dioxide paints. Mildew increase with time on titanium dioxide paints was also significant at the 1% level. There appeared to be no significant difference between mildew on section 1 of panels and that on section 2, which was a relationship that did not change with time. A two-way analysis of variance

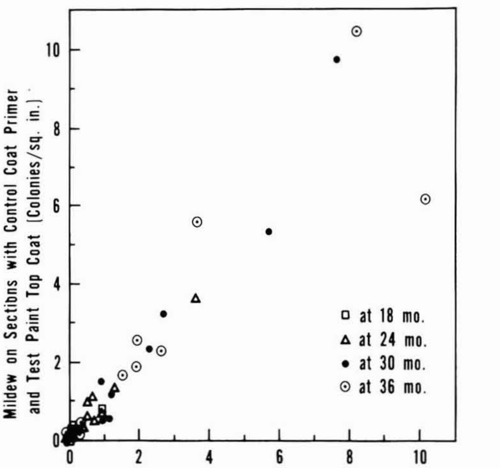

Figure 1—Mildew on panel sections having two coats of test paint (sections 1) compared with mildew on sections of the same panel covered with a topcoat of test paint over a primer coat of the control paint (sections 2)

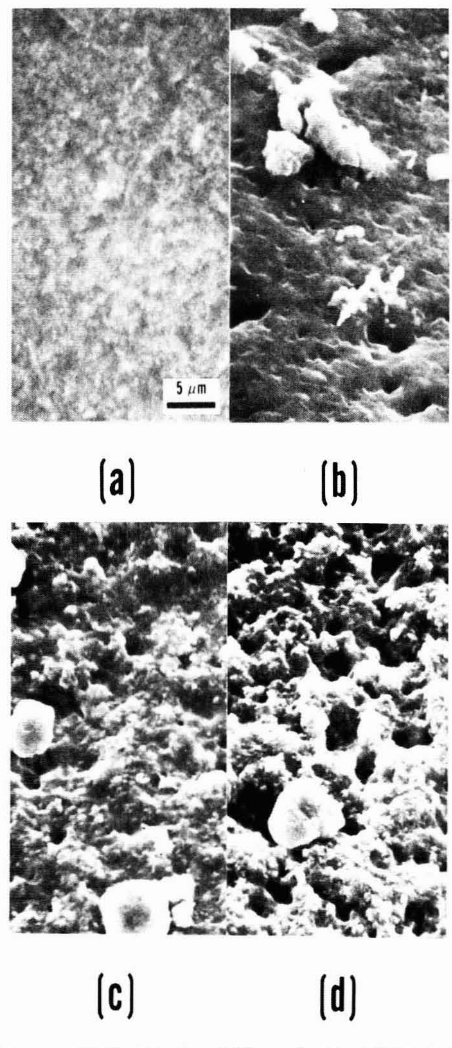

Figure 2—Scanning electron microscope photographs (2000X) of zinc oxide paint. (a) Initial surface; (b) after 7 months' exposure on test fence; (c) after 24 months' exposure; (d) after 36 months' exposure

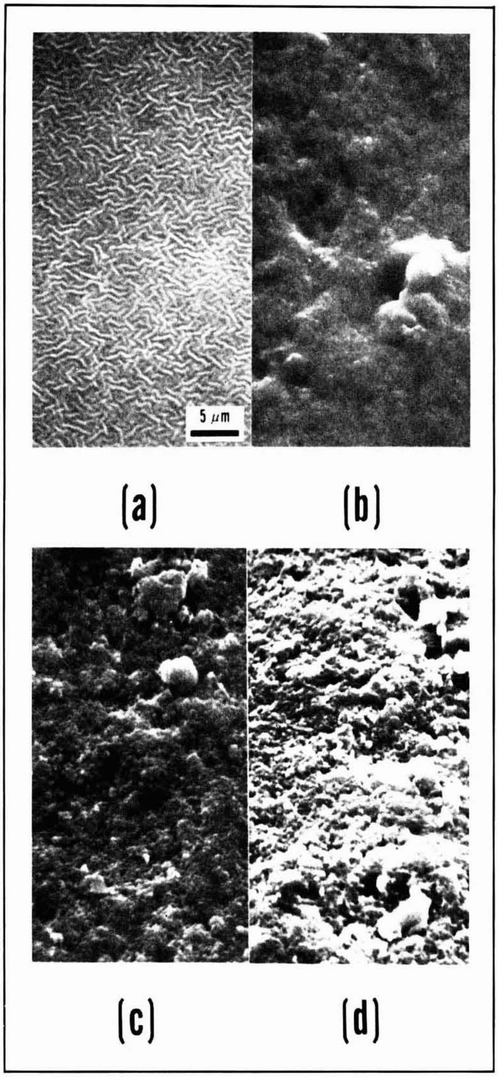

Figure 3—Scanning electron microscope photographs (2000X) of paint from rutile titanium dioxide. (a) Initial surface; (b) after 7 months' exposure on a test fence; (c) after 24 months' exposure; (d) after 36 months' exposure

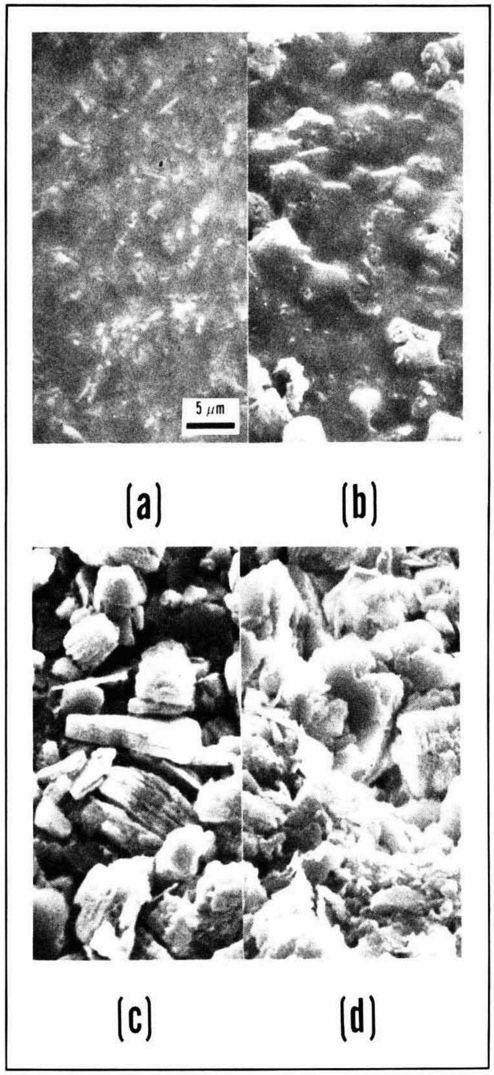

Figure 4—Scanning electron microscope photographs (2000X) of paint from zinc oxide and silicate extender. (a) Initial surface; (b) after 7 months' exposure on a test fence; (c) after 24 months' exposure; (d) after 36 months' exposure

showed no significant differences between the mildew colony counts on the panel number 3 sections.

Figure 1 is a scatter diagram showing mildew density (colonies/in.^{2}) on panel sections covered with self-primed test paint plotted against mildew on sections covered with a test paint topcoat over a control paint primer. Correlation here shows the similarity of the areas compared. This result indicates that, up to at least 36 months' exposure, a low-mildew-resistant primer had minimal effect on resistance of the overall system.

Photographs taken with the SEM of specimens before weathering showed two different characteristic film surface structures that depended on paint pigmentation. After weathering, other differences were observed. *Figures* 2, 3, 4, and 5 each show a series of photographs of specimens taken as weathering progressed. *Figure* 2 is composed of photographs of a paint pigmented with 30% PVC zinc oxide only. At 2000X, before weathering, particles are visible just below the paint surface; whereas after weathering for four months, holes, usually less than one micron across, appear in a surface which seems composed primarily of the vehicle. As the film ages, these holes grow in number and size but pigment particles remain relatively well coated and firmly attached to the film surface. *Figure* 3 is a series of photographs of paints pigmented

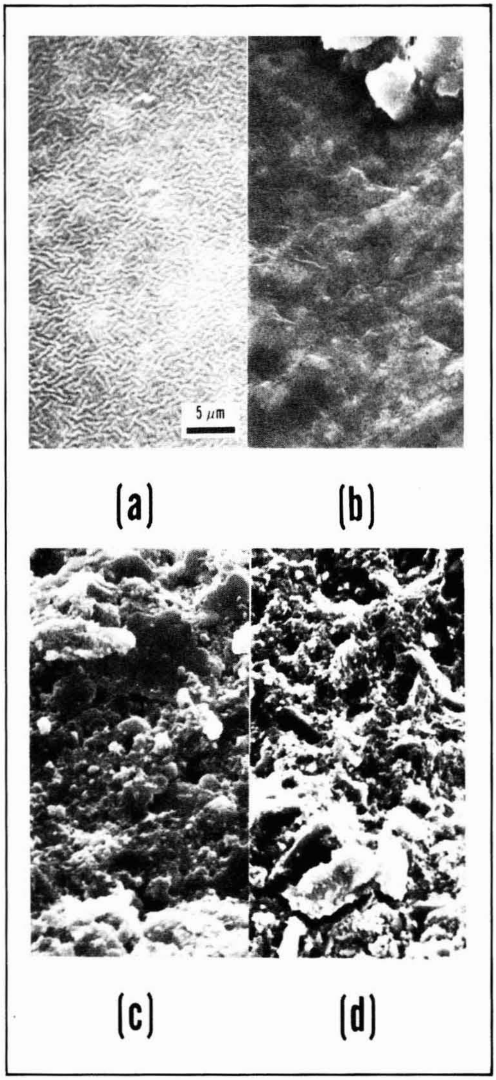

Figure 5—Scanning electron microscope photographs (2000X) of paint from rutile titanium dioxide, and silicate extender. (a) Initial surface; (b) after 7 months' exposure on a test fence; (c) after 24 months' exposure; (d) after 36 months' exposure

with titanium dioxide alone. Before weathering, the paint surface appears composed entirely of vehicle; at 2000X, microwrinkles, characteristic of new linseed oil films,[4] are present. After four months' weathering, pigment particles start to appear in the surface and the microwrinkled film is gone. With increased aging, the surface becomes rougher and an increasing number of bare pigment particles appear. Very fine surface cracks occur in 12-month-old films of paints pigmented with titanium dioxide and these increase in size as the film ages. As weathering progresses, the surface, composed of relatively bare pigment particles, becomes rougher and appears to lose chunks of pigment in vehicle.

Aging of zinc oxide pigmented film is modified when

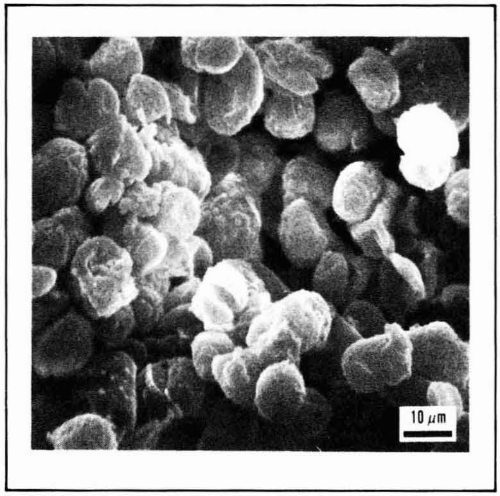

Figure 6—Typical mildew colony (1000X)

a silicate extender forms part of the pigment system (*Figure* 4). Initially, the surface seems rougher than that of a paint from zinc oxide alone, although no bare extender particles appear in the film surface. After four months' exposure, the pigment and extender particles are still buried in the vehicle; but after seven months, extender particles become clearly visible. After 12 months, the surface is composed almost entirely of these particles.

The silicate extender also modifies the appearance of the titanium dioxide pigmented film (*Figure* 5), but here extender particles seem to remain much more embedded in the film surface than with zinc oxide-extender pigmented films. Even after 36 months when the film surface appears to be cracking, breaking, and eroding away in chunks, titanium dioxide particles seem to occupy a much larger fraction of the exposed surface than extender particles. Effects of aging on the surface morphology of all films were observed with the SEM after four months' exposure. Initial chalking, when it occurred, was not evident on macroscale tests until panels were exposed from 12 to 24 months.

An SEM photograph of a typical mildew colony found on our panels is shown in *Figure* 6. Each colony occurred where a very small crack was found in the coating. Although cracks were found where there was no mildew, the reverse was not true. The microorganism was identified as *Pullularia pullulans*. To determine whether hyphae extended through the coating, specimens were broken and examined in cross section (*Figure* 7); however, no hyphae were found extending down through the coating to the substrate.

CONCLUSIONS

Panels covered with paints from zinc oxide remained cleaner and whiter throughout the 36-month test than those from titanium dioxide. Zinc oxide paints had a slight bluish tint while those from titanium dioxide

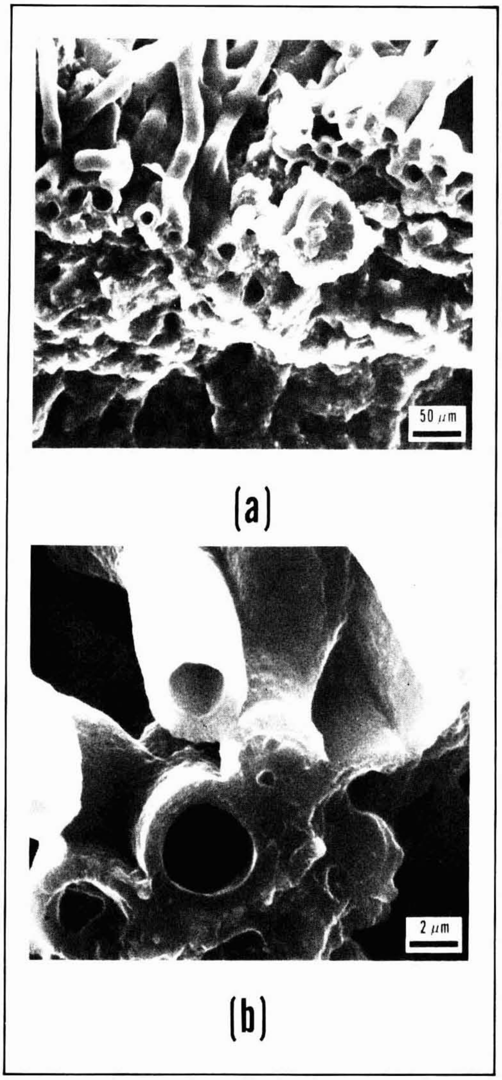

Figure 7—Views of film fractured through mildew colony. (a) 200X; (b) 5000X

tended to have a slight brown or yellow one. Zinc oxide paints, even those coated with phosphate, were much more mildew resistant than the other ones. No difference was observed between paints that contained treated as compared to untreated zinc oxide in mildew resistance, general appearance, dirt resistance, chalking, and whiteness appearance under SEM. Early in the test, one surface-treated titanium dioxide appeared to furnish significantly greater mildew resistance than other TiO_2 treatments and the control, but subsequent observations revealed no improvement. Paints from untreated titanium dioxide did, however, start chalking earlier than paints from any of the untreated ones. Although there were obvious changes in surfaces observed with the SEM as the zinc oxide paints weathered, the tape tests indicated no chalking from these films. Paint from zinc oxide and extender appeared more mildew resistant than any other coating, although the surface was rougher than that of any other zinc oxide paint and appeared to be composed mostly of extender particles.

Our tests revealed no differences, whether topcoats of zinc oxide paints were self-primed or placed over a primer of the titanium dioxide pigmented control. For example, the composition of the primer under a zinc oxide topcoat appeared to have no effect on mildew resistance.

Previous work demonstrated that the surface-treated zinc oxide used in these experiments forms linseed oil paints of lower water sensitivity and blistering tendency than the corresponding untreated pigment.[1,5] This decreased susceptibility is enhanced when the paint is used as a topcoat over a linseed oil paint not containing zinc oxide. Our tests now show that the ability of the zinc oxide to contribute mildew resistance to a paint is unimpaired by this surface treatment and that a linseed oil primer without zinc oxide does not detract from the resistance of the overall system to mildew. We believe that these results indicate the possibility of formulating blister-resistant exterior linseed oil paints that retain mildew resistance without employment of mercury compounds or other toxic fungicides.

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Solvent-Plasticizer-Resin Interactions By Gas-Liquid Chromatography

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Solubility and monomeric plasticization of high molecular weight epoxy resins were investigated through the evaluation of the solubility parameters for the resins and some plasticizers from GLC data. Epoxy resins used were commercially available products; plasticizers were aromatic and aliphatic phosphates and phthalates; and solvents were compounds of different chemical nature.

Solubility parameters were evaluated from the activity coefficients of the solvents considered in the resins and plasticizers employed as stationary phases, taking into account the entropic contribution (according to the Staverman theory) and the enthalpic contribution (according to the Hildebrand theory) to γ^{∞}. The results were compared with the data obtained from technological tests.

INTRODUCTION

The interactions among the components of a paint have a great influence on the successive phases of manufacture, e.g., dissolution of the polymers employed as binders, mill base preparation, grinding of the pigments, and mill base let down. In these operations, different materials are brought into contact, i.e., polymers and solvents in the preparation of both grinding and let down vehicles; pigments, extenders, and vehicle in the preparation of the mill base; and mill base let down vehicles in the final phase. For example, the rheological properties of polymer solutions, which depend on the configuration assumed by the polymeric chain in the medium, are affected by the interactions between polymer and medium. Similarly, the properties of paint storage and application, film formation and performance, etc., depend on the interactions among the materials present in the paint and film. Hence, a deep insight into the interactions among the various components of a paint is an urgent requirement for the paint technician.

To study the interactions and, more generally, the physico-chemical aspects of the previously mentioned processes and the properties of the dry film, different approaches, such as rheological studies, absorption phenomena investigations, etc., can be adopted. Of these, gas-liquid chromatography (GLC) has proven to be very suitable.

In the present work, GLC has been used to evaluate both the solubility of some high molecular weight epoxy resins in a wide range of solvents and their interactions with a number of monomeric plasticizers.

The investigations have been carried out on the basis of the solubility parameter theory, which proved to be successful in explaining and solving problems of solubility and compatibility of polymers.

THEORY

Gibbs excess free energy, g^E, which is assumed, in the theory of solutions, as a measure of nonideality of a given mixture, is related to enthalpy, h^E, and to entropy, s^E, by the well-known equation:

$$g^E = h^E - T\,s^E \qquad (1)$$

Similarly, activity coefficients can be expressed as the sum of two terms:

$$\ln \gamma_i = \ln \gamma_i\,(\text{combinatorial}) + \ln \gamma_i\,(\text{residual}) \qquad (2)$$

The combinatorial or entropic contribution is due to the differences in size and shape of the molecules; the residual or enthalpic contribution is due to energetic interactions.

As proposed in previous papers,[1,2] it is suggested

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Table 1—Solubility Parameters and Molar Volumes at 125°C, and Structural Parameters, r and q, of the Solutes

Solute	δ_d	δ_h	δ_p	δ	V	r	q
Benzene	7.91	1.23	0.44	8.02	101.93	3.1878	2.400
Toluene	7.63	1.76	0.88	7.88	119.42	3.9228	2.968
Ethylbenzene	7.60	1.41	0.44	7.74	137.47	4.5970	3.508
Ethanol	6.76	8.47	3.50	11.39	66.93	2.1055	1.972
n-Butanol	6.63	6.62	2.12	9.61	107.25	3.4540	3.053
Ethyl acetate	6.41	2.15	3.96	7.84	112.23	3.4786	3.116
n-Butyl acetate	6.73	2.63	1.76	7.44	151.13	4.8274	4.196
Methyl ethyl ketone	6.80	2.19	3.85	8.12	103.30	3.2479	2.876
Tetrahydrofurane	6.78	2.89	2.68	7.84	94.30	2.9415	2.720
Chloroform	7.73	2.68	1.07	8.25	94.07	2.8700	2.410

here that the combinatorial term be expressed according to the Staverman theory[3] and the residual term according to the Hildebrand theory,[4] in which the solubility parameter is considered to be (according to Hansen[5]) a vector made up of three components representing dispersion, hydrogen bonding, and polar contributions, respectively.

For binary mixtures at infinite dilution, this approach leads to the following equation for activity coefficients:

$$\ln \gamma_i^{\infty} = \ln \frac{r_i}{r_r} + \frac{z}{2} q_i \ln \frac{q_i r_r}{q_r r_i} + l_i - \frac{r_i}{r_r} l_r + \frac{V_i}{RT}\left[(\delta_{d.i} - \delta_{d.r})^2 + (\delta_{h.i} - \delta_{h.r})^2 + (\delta_{p.i} - \delta_{p.r})^2\right] \quad (3)$$

where $l_i = \frac{z}{2}(r_i - q_i) - (r_i - 1)$

If i and j are two different solutes dissolved separately in the same solvent, the following expression is obtained for $\ln \gamma_i^{\infty} / \gamma_j^{\infty}$:

$$\ln\gamma_i^{\infty}/\gamma_j^{\infty} = \ln \frac{r_i}{r_j} + \frac{z}{2} q_i \ln \frac{q_i}{r_i} - \frac{z}{2} q_j \ln \frac{q_j}{r_j} - \frac{z}{2}(q_i - q_j)\ln \frac{q_r}{r_r} + l_i - l_j - (r_i - r_j)\frac{l_r}{r_r} + \frac{V_i}{RT}(\delta^2_{d.i} + \delta^2_{h.i} + \delta^2_{p.i}) - \frac{V_j}{RT}(\delta^2_{d.j} + \delta^2_{h.j} + \delta^2_{p.j}) + \frac{V_i - V_j}{RT}(\delta^2_{d.r} + \delta^2_{h.r} + \delta^2_{p.r}) - \frac{2}{RT}(V_i\delta_{d.i} - V_j\delta_{d.j})\delta_{d.r} - \frac{2}{RT}(V_i\delta_{h.i} - V_j\delta_{h.j})\delta_{h.r} - \frac{2}{RT}(V_i\delta_{p.i} - V_j\delta_{p.j})\delta_{p.r} \quad (4)$$

This equation is of general applicability, yet in the case of polymer solutions the term $1/r_r$ can be neglected.

CHROMATOGRAPHIC TESTS

Experimental

MATERIALS AND APPARATUS: All the resins and solutes employed were commercially available materials. The resins were Araldit® 488 (CIBA), D.E.R.® 684 (Dow Chemical) and Bakelite® PKHH (Union Carbide Co.). Since they were only available dissolved in methyl ethyl ketone, they had to be dried to a constant weight in a vacuum oven. The solutes were reagent grade products (Fluka and BDH) and were employed as received. The GLC apparatus used was a thermal conductivity chromatograph Fractovap Mod. B (Carlo Erba).

COLUMN PREPARATION: The columns were prepared by dissolving a weighed amount of the dried polymer in tetrahydrofurane and stirring it into a weighed amount of support. The support was Chromosorb® W (60/80 mesh) (Carlo Erba), acid washed, and silanized. The support-polymer-tetrahydrofurane mixture was dried to a constant weight at 50°C. To check the percentage of the polymer in the support, the former was extracted from a sample of the polymer-support mixture with tetrahydrofurane. The quantitative coverage ratio of stationary phase to solid support was 1:3 by weight. The coated support was packed into a copper column one meter in length and 4 mm in interior diameter.

OPERATING CONDITIONS: The flow rate of the carrier gas (pure hydrogen) was 20-30 cc/min and was measured with a soap-film flowmeter. The column temperature was measured with an electronic thermometer (Avo Comark) and controlled to within ±0.1°C. The temperature range investigated was 80-160°C. The quantities of the solute injected were usually 0.2μl.

DATA REDUCTION: Retention times were evaluated according to a method proposed previously,[6-7] in which the influence of carrier gas flow rate and sample size were taken into account.

Specific retention volumes were evaluated according to previously published material.[8]

Activity coefficients at infinite dilution were calculated by means of the relationship:[9]

$$\ln \gamma_i^{\infty} = \ln \frac{273\,R}{V^{o}_{g.i}\, p^{o}_i\, M_s} - \frac{B_{ii} p^{o}_i}{RT} \quad (5)$$

Since the molecular weight of the polymers used as stationary phases was unknown, the ratios of the activity coefficients of two different solutes, i and j, dissolved separately in the polymer, were calculated by means of the formula:

$$\ln \gamma_i^{\infty}/\gamma_j^{\infty} = \ln \frac{V^{o}_{g.j}\, p^{o}_j}{V^{o}_{g.i}\, p^{o}_i} - \frac{1}{RT}(B_{ii} p^{o}_i - B_{jj} p^{o}_j) \quad (6)$$

Benzene was selected as the reference solute j.

Table 2—Natural Logarithms of Activity Coefficients of Resins, Infinite Dilution at 125°C

(Benzene is assumed as reference solute)

	$\ln \gamma_i^\infty / \gamma_B^\infty$		
Solute	Araldit 488	D.E.R. 684	Bakelite PKHH
Toluene	0.47	0.54	0.23
Ethylbenzene	0.49	0.58	0.51
Ethanol	–0.03	–0.13	–0.03
n-Butanol	0.11	0.22	0.17
Ethyl acetate	0.00	0.01	–0.05
n-Butyl acetate	0.10	0.18	0.05
Methyl ethyl ketone	–0.23	–0.15	–0.19
Tetrahydrofurane	–0.52	–0.44	–0.17
Chloroform	–0.38	–0.35	–0.32

Table 3—Solubility Parameters and Fractional Cohesive Energy Densities of the Resins at 125°C

Resin	δ_d	δ_h	δ_p	δ	f^2_d	f^2_h	f^2_p
Araldit 488	6.40	4.09	2.70	8.06	63	26	11
D.E.R. 684	5.09	3.95	2.43	6.89	55	33	12
Bakelite PKHH	5.52	3.90	2.01	7.05	61	31	8

Table 4—Natural Logarithms of Activity Coefficient Of Plasticizers, Infinite Dilution at 125°C

(Benzene is assumed as reference solute)

	$\ln \gamma_i^\infty / \gamma_B^\infty$						
Solute	BBP	DEP	DIDP	TCP	TOP	TPP	TXP
Toluene	0.16	0.12	0.09	0.16	0.16	0.21	0.18
Ethylbenzene	0.21	0.27	0.17	0.36	0.21	0.32	0.26
Ethanol	0.38	0.16	0.79	0.36	–0.01	0.21	0.37
n-Butanol	0.37	0.04	0.87	0.39	–0.08	0.33	0.41
Ethyl acetate	0.20	0.14	0.37	0.25	0.44	0.15	0.32
n-Butyl acetate	—	—	—	0.45	0.49	0.40	0.50
Methyl ethyl ketone	0.16	0.05	0.31	—	—	—	—
Chloroform	–0.24	–0.37	–0.31	—	—	—	—

Table 5—Solubility Parameters and Fractional Cohesive Energy Densities of the Plasticizers at 125°C

Plasticizer	δ_d	δ_h	δ_p	δ	f^2_d	f^2_h	f^2_p
BBP	7.93	3.87	2.11	9.07	76	18	6
DEP	8.00	4.08	2.15	9.23	75	20	5
DIDP	8.04	3.57	2.07	9.04	79	16	5
TCP	8.32	3.90	2.24	9.46	77	17	6
TOP	7.61	4.26	1.65	8.88	74	23	3
TPP	8.35	3.94	2.36	9.53	77	17	6
TXP	8.09	3.91	2.07	9.22	77	18	5

Results and Discussion

Table 1 reports the three-dimensional solubility parameters, the molar volumes, and the structural parameters, r and q, of the solutes. To calculate the three solubility parameter components of the solutes at 125°C, the global solubility parameter was first evaluated from vapor pressure data. Its three components were then obtained from their partition ratios at 25°C, assuming the ratio to be independent of temperature. A temperature of 125°C was selected since, at this temperature, the resins studied were liquid. The parameters, r and q, for the pure solutes were calculated from van der Waals group volumes and surface areas (given by Bondi[10]), respectively.

Table 2 shows $\ln \gamma_i^\infty/\gamma_B^\infty$ values obtained at 125°C for the three resins examined. The reliability of the experimental data was checked by plotting the $\ln V^0_g$ values against 1/T—a perfectly linear correlation was found above the softening point of the resins.

Table 3 reports that solubility parameters, their components, and the fractional cohesive energy densities of the three resins. The solubility parameter components of the resins were determined at 125°C by means of a nonlinear regression of $\ln \gamma_i^\infty/\gamma_B^\infty$ data using equation (4).

The $\ln \gamma_i^\infty/\gamma_B^\infty$ values and solubility parameters at 125°C, obtained with the method proposed, display some differences among the resins. Whereas δ_h values are similar for all the resins, global δ values vary, the highest and the lowest values being displayed by Araldit 488 and PKHH, respectively. It follows that Araldit 488 has the lowest hydrogen bonding percent contribution in the global δ.

In *Tables* 4 and 5, the $\ln \gamma_i^\infty/\gamma_B^\infty$ values at 125°C, the solubility parameters, their three components, and the fractional cohesive energy densities are reported for a series of plasticizers. They are phthalates (butylbenzyl, BBP; diethyl, DEP; diisodecyl, DIDP) and phosphates (tricresyl, TCP; trioctyl, TOP; triphenyl, TPP; trixilenyl, TXP). The solubility parameter components were calculated with equation (4) by means of a fitting procedure. γ^∞ data were taken from previous material.[7,11-13]

It is pointed out that the agreement between the experimental and calculated activity coefficients is in the range of 10%.

Solubility parameters for plasticizers were also evaluated at 25°C with the aim of comparing them with the data given by Hansen. A good agreement was found for the global δ and δ_d values. Whereas, in contrast with data available in the literature, our δ_h values are higher than δ_p values. This may be due to the facts that our approach also takes into account entropic contributions and that different evaluating techniques were employed.

Aromatic phosphates have the highest global δ values. Global δ values decrease from TPP to TXP, that is, with increasing weight of the phenolic component. For these plasticizers, insignificant differences are observed for δ_h. Lower global δ values are given by phthalates. They decrease from DEP to DIDP, that is,

Table 6—Parts of Solvent which Determined Permanent Haziness at 25° C

Cellosolve acetate	<1000
Ethanol	50
Ethyl acetate	60
Methylcellosolve	>1000
Methyl ethyl ketone	350
n-Butanol	60
2-Nitropropane	40
Tetrahydrofurane	>1000
Toluene	50
Toluene-methyl ethyl ketone-cellosolve acetate (2 : 2 : 1)	<1000
Toluene-methyl ethyl ketone-cellosolve acetate (4.5 : 4.5 : 1)	<1000
Toluene-n-butanol (1:1)	≫1000
Toluene-n-butanol-cellosolve acetate (2 : 2 : 1)	≫1000
Toluene-n-butanol-cellosolve acetate (4.5 : 4.5 : 1)	≫1000

with increasing length of the aliphatic chain. The lowest global δ value is given by TOP, aliphatic phosphate, which has, on the other hand, the highest δ_h value.

TECHNOLOGICAL TESTS

Solubility Tests

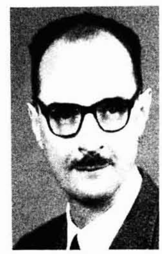
PROCEDURE: Solubility tests were carried out with a spectrum of solvents of adequately differentiated solubility parameters.

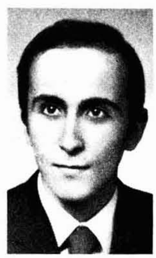
Tests were made at 25°C in glass tubes by adding the diluting material dropwise to a 40% solution of epoxy resin in methyl ethyl ketone. The tubes were shaken until a permanent haziness was observed. Dilution tolerance of the epoxy resin solution for single solvents and solvent mixtures was checked by addition of sol-

PAOLO ALESSI graduated in Chemistry from the University of Trieste in 1964. Since 1966, he has been a research chemist at the University of Trieste and, in 1969, he became a lecturer in Analytical Chemistry. Since 1971, he has been assistant professor at the Faculty of Engineering of the Trieste University. His research activity is at present concerned with fluid phases equilibria and liquid-liquid chromatography.

IRENEO KIKIC graduated in Chemical Engineering from the University of Trieste in 1966. Since then he has been a research chemical engineer and, since 1969, he has been a lecturer in Unit Operations and Physical-Chemistry at the University of Trieste, Faculty of Engineering. His research activity is at present concerned with rheology of non-Newtonian fluids and fluid phases equilibria.

GIOVANNI TORRIANO graduated in Chemistry from the University of Bologna in 1947. He joined, in 1948, Colorifici Zonca, of Trieste, with which he was until 1968. Since 1961 he has been a lecturer in Paint and Plastics Technology at the University of Trieste, Faculty of Engineering, and since 1969 he has been a regular consultant of Veneziani Zonca Vernici Spa, Trieste, the Italian member of Transocean Marine Paint Association.





ADRIANO PAPO graduated in Chemical Engineering from the University of Trieste in 1973. He has been a research chemical engineer and, since 1977, a lecturer in Applied Chemistry at the Udine branch of the Faculty of Engineering of the University of Trieste. His research activity is at present concerned with anti-corrosive coatings, paint rheology, and fluid phases equilibria.

Table 7—Solubility Parameters and Fractional Cohesive Energy Densities of the Solvents at 25°C

Solvent	δ_d	δ_h	δ_p	δ	f^2_d	f^2_h	f^2_p
Cellosolve acetate	7.78	2.50	5.40	9.60	63	7	30
Ethanol	7.73	9.70	4.00	12.92	35	55	10
Ethyl acetate	7.44	2.50	4.60	9.10	67	8	25
Methylcellosolve	7.90	7.90	4.50	12.06	43	43	14
Methyl ethyl ketone	7.77	2.50	4.40	9.27	70	7	23
n-Butanol	7.81	7.80	2.50	11.30	48	47	5
2-Nitropropane	8.15	2.00	5.50	10.02	66	4	30
Tetrahydrofurane	8.22	3.50	3.25	9.08	74	14	12
Toluene	8.67	2.00	1.00	8.91	94	5	1
Toluene-methyl ethyl ketone-cell.acetate (2 : 2 : 1)	8.17	2.31	3.74	9.27	78	6	16
Toluene-methyl ethyl ketone-cell.acetate (4.5 : 4.5 : 1)	8.20	2.29	3.48	9.20	80	6	14
Toluene-n-butanol (1:1)	8.25	5.69	1.91	10.20	65	31	4
Toluene-n-butanol-cell.acetate (2 : 2 : 1)	8.18	5.21	3.35	9.27	64	26	11
Toluene-n-butanol-cell.acetate (4.5 : 4.5 : 1)	8.22	5.46	2.49	10.17	65	29	6

Table 8—Shock Resistance Tests Data (kg·cm)

Plasticizer	% Content (w/w) of Plasticizer on Resin				
	25	35	40	45	55
Araldit 488:					
BBP	< 1	10	36	—	—
DIDP	< 1	< 1	< 1	< 1	< 1
DPCP	< 1	< 1	< 1	10	36
DPIDP	< 1	30	36	—	—
TBP	< 1	< 1	15	36	—
TOP	36	—	—	—	—
TXP	< 1	< 1	< 1	< 1	10
D.E.R. 684:					
BBP	< 1	30	36	—	—
DIDP	< 1	< 1	< 1	< 1	< 1
DMP	36	—	—	—	—
DPCP	< 1	< 1	20	36	—
DPIDP	< 1	30	36	—	—
TBP	< 1	< 1	36	—	—
TOP	36	—	—	—	—
TXP	< 1	< 1	< 1	< 1	10
Bakelite PKHH:					
BBP	20	30	36	—	—
DIDP	< 1	< 1	< 1	< 1	1
DMP	36	—	—	—	—
DPCP	36	—	—	—	—
DPIDP	20	30	36	—	—
TBP	36	—	—	—	—
TOP	36	—	—	—	—
TXP	< 1	< 1	< 1	< 1	10

vent until a concentration of 2% was reached in the most favorable cases.

RESULTS AND DISCUSSION: Dilution tolerance is shown in *Table* 6. On the basis of the solubility tests and the solubility parameters of the solvents employed (see *Table* 7), it can be seen that at 25°C the global solubility parameter of the resins should fall within the range of δ=9.27-10.20 and the fractional cohesive energy densities within the ranges:

f^2_d= 64-65; f^2_h= 26-31; f^2_p= 4-11.

Plasticization

A contribution to the understanding of the behavior of the epoxy resins can be obtained by evaluating the toughness of epoxy films plasticized with a series of plasticizers at different resin-plasticizer ratios.

APPARATUS AND PROCEDURE: Shock resistance tests were carried out using a Variable Impact Tester, Charles Braive No. 1610.

Plasticizers employed were phthalates (dimethyl, DMP; butylbenzyl, BBP; diisodecyl, DIDP) and phosphates (diphenylcresyl, DPCP; diphenylisodecyl, DPIDP; tributyl, TBP; trioctyl, TOP; trixilenyl, TXP).

Plasticizer-resin films were formulated with plasticizer ratios which were gradually increased until they passed a 36 Kg cm shock test.

RESULTS AND DISCUSSION: Results are given in *Table* 8.

In general, shock resistance was good for PKHH, which requires smaller amounts of plasticizer to display results similar to that of the other two resins. D.E.R. 684 and Araldit 488 were found to be less satisfactory and both exhibited similar behavior.

Since the repeating structural unit is the same for all the resins, it is suggested that these results are connected with the average molecular weight, chain length distribution and, to some extent, to chain branching and terminals of the resins.

As regards the action of the various plasticizers, it can be noted:

(a) Among the three phthalates, the best results were given by DMP and still good results by BBP, despite larger quantities being required. DIDP does not display plasticizing action in the ratio range tested (20-55% by weight of plasticizer on the resin). There is a marked influence of the nature of the esterifying alcohol; long aliphatic chains prove to be ineffective. These results are given by all three resins tested with only minor differences being observed.

(b) When plasticized with phosphates, D.E.R. 684 and Araldit 488 behaved similarly. The best results were obtained with TOP, followed by TBP and DPIDP, less good by TCP, and the poorest by TXP. There is an influence of the length of aliphatic chain for straight aliphatic phosphates, of the presence of an aliphatic part in mixed aliphatic-aromatic phosphates, and of the ability of stabilizing polarization of P=O covalent bond among straight aromatic phosphates. These effects are not clearly observable for PKHH.

The behavior of the resin-plasticizer system gives an insight into the compatibility of the various plasticizers with the resin. This follows from the assumption that the plasticizing efficiency (other determining conditions being equal) is related to the interactions developed between resin and plasticizer, which control solvation, configuration of resin molecules in the film and, finally, the mechanical properties of the system.

SUMMARY

GLC proved to be suitable for the study of the solubility and plasticizing efficiency of polymeric materials, since it provides data concerning correlations between polymer and solvents and plasticizers and solvents. Accordingly, it enables the evaluation of the correlations between polymer and plasticizer.

As far as solubility is concerned, solubility parameters of resins obtained from GLC data are in complete accordance with the results of the technological solubility tests. In fact, the best solvents proved to be the mixtures toluene/butanol and toluene/butanol/cellosolve acetate, whose fractional cohesive energy densities are almost the same as those evaluated for the resins. Good solubility was also found for tetrahydrofurane and methylcellosolve. In extending the range of solubility, it is suggested that the most significant parameter considered for solubility evaluation is f^2_h.

As far as the plasticization efficiency is concerned, it is suggested that the significant parameter is still f^2_h. Accordingly, the following order of increasing compatibility with the resins is obtained:

DIDP < TPP = TCP < BBP = TXP < DEP < TOP

From an examination of the results of the technological shock resistance tests reported in *Table* 8, the same order of plasticizing efficiency can be seen.

This investigation enables solubility and plasticizing efficiency to be predicted for any solvent and plasticizer with regard to high molecular weight epoxy resins, provided solvents and plasticizers are adequately characterized.

From the above, it follows that GLC provides a rapid method for the characterization of polymeric binders, which enables their solubility and compatibility with plasticizers to be generally forecast.

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APPENDIX

NOMENCLATURE

B	=second virial coefficient (cc/mol)
f^2	=fractional cohesive energy density ($f^2_d = 100\delta^2_d/\delta^2$; $f^2_h = 100\ \delta^2_h/\delta^2$; $f^2_p = 100\ \delta^2_p/\delta^2$)
g	=Gibbs free energy
h	=enthalpy
l	=see equation (3)
M_s	=molecular weight of stationary phase
p^o	=vapor pressure (atm)
q	=pure component area parameter
r	=pure component volume parameter
R	=gas constant
s	=entropy
T	=temperature (K)
V	=molar volume (cc/mol)
V^o_g	=specific retention volume
z	=lattice coordination number (here set equal to 10)

Greek letters

γ	=activity coefficient
δ	=solubility parameter ($cal^{1/2}$ / $cc^{1/2}$)

Superscripts

∞	=infinite dilution
E	=excess

Subscripts

B	=benzene
d	=dispersional component of solubility parameter
h	=hydrogen bonding component of solubility parameter
i,j,r	=component i, component j, component r
p	=polar component of solubility parameter

Birmingham — Jan. 11

Alan Hipwood, of the Materials Quality Assurance Directorate of the Ministry of Defence, discussed "INTERNATIONAL TEST METHODS FOR PAINT AND RELATED PRODUCTS."

Mr. Hipwood explained the structure of the International Organization for Standardization (ISO). He said it is comprised of the national standards bodies of 73 countries (e.g., British Standards Institution) with members participating through 493 technical subcommittees.

The work to be done and the terms of reference are determined by the ISO Council in Geneva, he said. However, any member country or outside organization can make suggestions for work. An International Standard may be used by a country, or it may be incorporated into the country's existing standards.

Test methods for comparison with the standard are becoming increasingly important, he said. The paint industry should be prepared to sell their products on the basis of performance data vs. standard test methods, he added.

Q. Will international standardization favor the large firm over the smaller paint manufacturer?

A. If a small company wishes to compete in a wide range of paints, it must be equipped to carry out all relevant tests. However, small firms usually specialize in particular areas and fewer tests are required.

Q. How important is the cost of test equipment when preparing a standard?

A. It must be one of the items taken into consideration.

B.F. GILLIAM, *Publicity Officer*

Chicago — Jan. 8

Robert R. Englehart, of Amoco Chemical Corp., spoke on "HIGH SOLIDS RESINS AND COATINGS."

William Machemer, of Troy Chemical Corp., spoke on "MICROBIOL PROBLEMS IN PLANTS."

R.M. HILLE, *Secretary*

C-D-I-C — Jan. 8

Paul McCurdy, of Reichhold Chemicals, Inc., spoke on "CONVERSION ENAMELS — ENERGY SAVERS."

Increased energy costs, said Mr. McCurdy, have necessitated the lowering of oven temperatures from 300°F to about 175 - 200°F. In some cases, lower temperatures are used without much crosslinking which becomes, in effect, just forced air dry.

Evaluations were carried out through tests of glass and steel panels at a 15 min. bake at temperatures from 175 to 200°F. Formula used for screening catalysts was 70 parts short oil alkyd, 30 parts urea formaldehyde, and 25 parts xylene.

All phosphorics tested responded, but many were eliminated for other reasons. Sulfonic types were tested at 0.5, 1, 2, and 3% or the urea content.

Excess heat above 300°F decreases hardness because of amino-self-condensation of the urea, he said, which causes the alkyd to act as an external plasticizer. As catalyst increases, hardness increases but gloss decreases, he explained. The intersection of these curves defines allowable formulations.

During the business meeting, Lewis P. Larson received the Ernest P. Mueller Memorial Education Award.

W.J. FROST, *Secretary*

Golden Gate — Jan. 15

During the business meeting, Lowell Cummings, Chairman of the Education Committee thanked the San Jose Regional Vocational Center for donating many pieces of laboratory equipment to the Society. Also, in lieu of a study grant award, the Society has donated $350 to the Redwood City Library towards the purchase of paint and coatings technology books.

Noshir Chinoy, of Air Products and Chemicals, Inc., spoke on "SURFYNOL NONIONIC SURFACTANTS."

Mr. Chinoy discussed his company's development of water-based coatings surfactants based on acetylene chemistry.

Q. How stable are the acetylenic glycols?

A. Very stable, except when used with very high acid or very high alkaline systems.

Q. What is the boiling range?

A. Close to that of ethylene glycol.

Q. When should it be added?

A. It can be added partially in the grind with the balance added in the let down.

SHARON VADNAIS, *Secretary*

Houston — Dec. 13

James Heckt, of Benjamin Moore & Co.; Emil Michael, of Monarch Paint Co.; and James Pennington, of Cook Paint & Varnish Co., spoke on "WASH WATER RECYCLING."

Mr. Heckt said that his company generates up to 100 gallons of wash water daily which is stored in a moveable 250 gal. tank. This water is worked into the grind portion of subsequent batches, he said.

Mr. Michael related that his company also used the 250 gallon tank and the solids are flocculated out by use of Cosan Flok® 18. The sludge is taken out and stored in drums which are then hauled away.

Mr. Pennington explained that his company utilized a system much like Monarch's.

Loren B. Odell was elected to Honorary Membership in the Society. Mr. Odell, who recently retired from Napko Corp., was President of both the Dallas and Houston Societies.

SAM LOE, JR., *Secretary*

Houston — Jan. 10

Howard S. Ritter, of PPG Industries, Inc., discussed "COLLOID CHEMISTRY OF LATEX PAINTS."

Mr. Ritter presented a "typical latex paint formulation" and discussed the part colloid chemistry plays in the various parts of the formulation. He explained that the mill pastes are several different kinds of colloids, that the latexes, themselves, are colloids comprised of monomer droplets combined with water containing soaps, and that very involved colloid chains are utilized in the making of latexes.

SAM LOE, JR., *Secretary*

Los Angeles — Jan. 10

A moment of silence was observed in memory of Allan B. Gold, of Mobile Chemical Co., who died recently.

Noshir Chinoy, of Air Products and Chemicals, Inc., presented "SURFYNOL NONIONIC SURFACTANTS."

Mr. Chinoy discussed the problems that a paint formulator encounters while developing high quality water-based coatings and the different solutions required than those used in other coating types. He gave some specific and prac-

tical recommendations regarding how many paint formulators are solving water-based paint problems with specialty acetylenic glycol-based surfactants. He further discussed problems and solutions including the General Motors test for engine block paints, improved color development, reduction in water sensitivity, and foam related surface defects.

J.P. VAN ZELM, *Secretary*

Louisville — Jan. 17

Paul McCurdy, of Reichhold Chemicals, Inc., spoke on "CONVERSION ENAMELS — ENERGY SAVERS."

Mr. McCurdy explained that low temperature conversion, or catalyzed, finishes have been in use for many years, but have been restricted primarily to clear finishes. The addition of pigmentation creates many problems, he said; in addition to viscosity stability, retention of gloss and of cure response become important concerns. He then examined system limitations and the formulation parameters pertinent to package enamels.

JOHN K. MENEFEE, *Secretary*

Montreal — Jan. 10

A panel of three speakers featured an "UPDATE ON WATER-BORNE FINISHES."

M. Belanger, of Union Carbide Canada Ltd., discussed the increasing prominence of latex stains for exterior wood surfaces. He pointed out that the unique quality of latex coatings having a high molecular weight enables the coating to have superior weather resistance properties.

Al Marchetti, of Nacan Products Ltd., described the problems of formulating gloss and semi-gloss paints. He discussed the following areas of formulation: dispersion, emulsification, viscosity control by various thickening agents, coalescent solvents, defoamers, and pH control.

Raye Fraser, of Canadian National Railways Research Centre, presented an exposure study, of structural steel used in railway cars and bridges. The study contained some unusual latex and solvent base combinations, e.g., latex primer-alkyd top; alkyd primer-latex top; etc.

C.A. MCWADE, *Secretary*

New York — Jan. 9

Marvin Schnall, of Troy Chemical Corp., discussed "NEW DEVELOPMENTS IN ADDITIVES FOR COATINGS."

Mr. Schnall said that recent regulations and environmental considerations have induced the coatings industry to develop new types of coatings, such as water-thinned industrials, powder coatings, UV cured finishes, etc. He then discussed some of the specific additive requirements to optimize application and appearance properties.

New developments in driers, he said, include the replacement of calcium, zirconium, and orthophenanthroline, the development of lead-free feeder drier, new driers for aqueous coatings, and high concentration synthetic acid types.

The trend in biocides, he indicated, has been to move away from mercurials to non-mercurial products. Mr. Schnall pointed out that possible problems could develop from this shift, including viscosity losses due to enzymes, increased costs, and possible adverse effects on coating properties.

Water-thinned industrials have a greater need for defoamers and anti-crawling agents than solvent types, he said. And new products have been developed for both problems. These include anti-mar and anti-settling agents.

Powder coating additives include products to prevent sagging, caking of powders, and cratering or orange peeling, he said, while additives for UV coatings include photoinitiators, anti-mar agents, pigment wetting agents, and products to improve adhesion to aluminum.

Mr. Schnall also presented some new developments in latex paint additives, which included grades of cellulosic thickeners that have improved resistance to enzyme attack, and alkali soluble polymers designed to improve the leveling of latex enamels.

Q. Are any additives available to reduce the sensitivity of latexes to water?

A. Some of the alkali soluble polymers used in latex enamels improve the wet adhesion of latexes.

MARVIN J. SCHNALL, *Secretary*

Northwestern — Jan. 9

Roland Duncan, of Kelco Div., Merck & Co., presented a talk on "ZANFLO — A UNIQUELY NEW CELLULASE STABLE THICKENER."

Mr. Duncan's presentation outlined the basic manufacturing procedures and the thickening characteristics of Zanflo®. He compared this new material to other cellulosic thickeners and pointed out the superior stability, gloss retention, and dispersion characteristics of Zanflo in latex paints.

ROGER M. ANDERSON, *Secretary*

Pittsburgh — Jan. 15

At this annual joint meeting of the Pittsburgh Society and the Pittsburgh Paint and Coatings Association, Ronald Eritano, of Mobay Chemical, discussed "BRIDGE COATINGS IN THE PITTSBURGH AREA."

While showing several slides of local bridges, Mr. Eritano pointed out that because of the local conditions the Pittsburgh area was an excellent testing ground for various coating systems. He then discussed a polyurethane system which consisted of a moisture cured primer, an intermediate coating, and an aliphatic urethane topcoat. The urethane system gave such advantages as lower ambient temperature application and two to three hour ability to top-coat.

RAY UHLIG, *Secretary*

St. Louis — Jan. 16

Dr. Herman J. Lanson, of Poly Chem Resins, Inc., was presented the Gateway Award by the St. Louis Society in recognition of his outstanding service to the Society, the Federation, and the local and national coatings industry.

The attendance of local high school teachers highlighted the "EDUCATION NIGHT" program.

Howard Jerome and Thomas Fitzgerald, Jr., both of Vane Calvert Paint Co., conducted demonstrations in latex paint and polyester. Duplicates of the kits were presented to the teachers for use in their chemistry classes.

John Gordon, Jr., of University of Missouri — Rolla, discussed the opportunities and rewards available in the Coatings Industry. He also noted that scholarships are available for interested students.

It was announced that the Society will again co-sponsor the local Science Fair.

FLOYD THOMAS, JR., *Secretary*

Future Society Meetings

Birmingham

(Apr. 5) — "WASTE DISPOSAL" — H.G. Pullen, of Redland Purle Ltd.

(May 3) — "CATHODIC ELECTRODEPOSITION—CURRENT STATUS" — E. Millington, of International Paints.

Chicago

(Apr. 2) — "ACCELERATED WEATHERING" — George Grossman, of Q-Panel Co.; and "YOU CAN'T AFFORD TO BE WITHOUT SAFETY" — Gilbert Cain, of Hercules Incorporated.

C-D-I-C

(May 14) — "A NEW, IMPROVED THICKENER SYSTEM" — R.J. Duncan, of Kelco Div., Merck & Co., Inc.

Cleveland

(Apr. 12) — Meeting to be held at Ohio Edison Nuclear Power Plant, Perry, Ohio.

(May 17) — "ART OPENS WAY FOR SCIENCE" — Dr. Jon B. Eklund, of Smithsonian Institution.

Golden Gate

(Apr. 16) — "ACCELERATED WEATHERING AND FADING" — R. Metzinger, of Atlas Electric Devices Co.

(May 14) — "USE OF ORGANO TITANATES IN COATINGS" — Salvatore J. Monte, of Kenrich Petrochemicals, Inc.

Los Angeles

(Apr. 11) — "ACCELERATED WEATHERING AND FADING" — R. Metzinger, of Atlas Electric Devices Co.

(May 9) — "USE OF ORGANO TITANATES IN COATINGS" — Salvatore J. Monte, of Kenrich Petrochemicals, Inc.

Montreal

(Apr. 11) — "FSCT SLIDE PRESENTATION" — Federation Officers.

(May 2) — WORKSHOP NIGHT: *Color Matching, Metrification, Quality Control,* and *Technical Service.*

New York

(Apr. 10) — "CLASSES OF WATER DISPERSIBLE BAKING FINISHES" — Nicholas Roman, of Rohm and Haas Co.

(May 8) — PAVAC AWARD NIGHT.

Elections

BALTIMORE

Active

Hansen, Donna Lynn — Dutch Boy Paint, Inc., Baltimore, Md.

BIRMINGHAM

Active

Beard, Colin N. — MacPherson Powders Ltd., Bloxwich, England.
Cope, William J. — R. Cruickshank (Cellulose) Ltd., W. Bromwich, England.
Holliday, Martin L. — Blundell Permoglaze, Birmingham, England.
Matthews, Neil J. — R. Cruickshank (Cellulose) Ltd., W. Bromwich.
Mobbs, Allen C. — Intercoat Paints Ltd., Walsall, England.
Wallington, David A. A. — MacPherson Powders Ltd., Bloxwich.

C-D-I-C

Active

Hollifield, Bill M. — Perry & Derrick Co., Norwood, Ohio.
Roberts, Timothy R. — Armco, Inc., Middletown, Ohio.
Sellers, David R. — PPG Industries, Delaware, Ohio.

Associate

Hite, Leonard — Eastman Chem. Prod., West Chester, Ohio.
Ibsen, William — Lawlor Distributors, Cleveland, Ohio.
Martin, Ronald — Cordova Chemical Co., Columbus, Ohio.
Pieper, Bruce W. — C. L. Zimmerman Co., Cincinnati, Ohio.

GOLDEN GATE

Active

Brill, Bernard M. — Apoc, San Ramon, Calif.
Donlin, Timothy J. — Reichhold Chemicals, Inc., So. San Francisco, Calif.
Sayre, Larry G. — Fuller O'Brien Corp., So. San Francisco.
Silva, Ronald E. — Fuller O'Brien Corp., So. San Francisco.

Associate

Bustillos, Richardo M. — Union Carbide Corp., San Francisco, Calif.
Lipscomb, Shirley — Liscomb Chemical Co., Emeryville, Calif.
Pompeo, B. P. — American Cyanamid Co., Los Angeles, Calif.
Rosiak, Daniel C. — Drew Chemical Corp., Novato, Calif.
Wendt, W. A. — Scholle Corp., Compton, Calif.

HOUSTON

Active

Boucher, James L. — AMF Tuboscope, Houston, Tex.
Curado, A. L. — Champion Paint Mfg., Houston.
Demko, Stephen S. — AMF Head, Jacksonville, Tex.
Eilert, Michael R. — Cook Paint & Varnish Co., Houston.
Montgomery, Donald R. — Napko Corp., Houston.
Viswanath, Bala P. — Plastic Applicators, Houston.

Associate

Bollinger, J. E. — Union Chemicals Div., Houston, Tex.
Rice, Clayton D. — Harmon Colors Corp., Lilburn, Ga.
Tygett, David — Glidden Pigments, Carrollton, Tex.

LOS ANGELES

Active

Dankert, Jr., William R. — CIBA-GEIGY, Fountain Valley, Calif.

NEW ENGLAND

Active

Abelon, Leon H. — Metaflake, Inc., Watertown, Mass.
Wheeler, James — Waterlac Industries, Inc., Danvers, Mass.
Withington, David W. — Tra-Con, Inc., Medford, Mass.

Associate

Dash, Robert S. — N.E. Resins Pigments, Braintree, Mass.
Henshaw, Richard — Independent Packaging, Inc., Boston, Mass.
Rowland, Ronald M. — Omya, Inc., Proctor, Vt.

NEW YORK

Active

Marshall, James B. — Uniroyal Chemical Co., Naugatuck, Conn.

Associate

Kato, Akira — Kansai Paint Co., Ltd., New York, N.Y.

NORTHWESTERN

Active

Charogoff, Ed — Consolidated Ink, W. St. Paul, Minn.
Covington, R. C. — Frost Paint Co., Minneapolis, Minn.
Hymes, Richard H. — Applied Texture, Inc., Minneapolis.
Kokes, James E. — Ceramic Industrial Ctgs., Minneapolis.
Murphy Jr., George R. — Applied Texture, Inc., Minneapolis.
Nellessen, Alfred H. — 3 M Co., St. Paul, Minn.
Swanson, Mark E. — Valspar Corp., Minneapolis.
Winters Jr., Billy — Cargill, Inc., Minneapolis.

Associate

DeLoach, Eric D. — Eastman Chemical, Burnsville, Minn.
Schoendorfer, George — Diamond Shamrock, Waukesha, Wis.
Smith, James M. — Eastman Chemical, Burnsville, Minn.

Educator and Student

Chan, Fanny — N. Dakota State University, Fargo, N.D.

PACIFIC NORTHWEST

Active

Suzuki, Kazuo — Reichhold Ltd., Port Moody, B.C., Canada.

Associate

Chowynyk, John A. — DuPont of Canada Ltd., Vancouver, B.C., Canada.

PHILADELPHIA

Active

Alexander, James R. — Stonhard, Inc., Maple Shade, N.J.
Delich, Jr., Stephen M. — Congoleum Corp., Trenton, N.J.
Gerber, Donald R. — Stonhard, Inc., Maple Shade.
Mercurio, Andrew — Rohm and Haas Co., Spring House, Pa.
Skorupsky, Frank T. — Stonhard, Inc., Maple Shade.

PIEDMONT

Active

Adams, Thomas M. — Reliance Universal, High Point, N. C.
Grindup, Wayne L. — Carolina Solvents, Inc., Hickory, N. C.
Huber, Michael D. — Reliance Universal, High Point.
Rich, Donald C. — Reliance Universal, High Point.

Associate

HARRIS, GARY E. — Chas. S. Tanner, Elon College, N. C.
KEEL, TERRY J. — Inmont Corp., Charlotte, N. C.

PITTSBURGH

Active

ANDERSON, RONALD W. — Mobile Chemical Co., Pittsburgh, Pa.
KORENKIEWICZ, STEPHEN M. — PPG Industries, Springdale, Pa.
MCWHORTER, WILLIAM J. — Hercules, Inc., Washington, Pa.
MILLIKIN, BETTY L. — Hercules, Inc., Washington.
WILKINSON, ROBERT F. — PPG Industries, Springdale.

SOUTHERN

Active

BEST, WILLIAM A. — Artex Hobby Products, Inc., Lexington, N.C.
BROWN, ROGER D. — Artex Hobby Products, Inc., Lexington.
DOUGLAS, STANFORD B. — Artex Hobby Products, Inc., Lexington.
GALLOWAY, LARRY D. — PPG Industries, Inc., East Point, Ga.
GRIFFIN, JOHN L. — Tampa Paint & Varnish, Tampa, Fla.
KELLY, DON A. — Midland Div. — Dexter Corp., Birmingham, Ala.
KLEINMAN, MARTIN — Assoc. Paint Plastic, Miami, Fla.
LECKIE, BETTY — Piedmont Paint Mfg. Co., Greenville, S.C.
LOVE, ROBERT — Sun Coatings, Largo, Fla.
MCCRANEY, THOMAS E. — Mobile Paint Co., Theodore, Ala.
ORUC, ALI — PPG Industries, East Point.
PEACE, BILLY W. — AVX Ceramics, Myrtle Beach, S.C.
SIMSER, JR., JOHN L. — PPG Industries, East Point.
SMITH, PRESTON D. — Glidden C & R Division SCM, Atlanta, Ga.
TIDWELL, D. — Mar Chemical Corp., Fort Lauderdale, Fla.

Associate

HAGEN, FLOYD — Exxon Chemical Co., Atlanta, Ga.
LYNN, GARY R. — Charter International Oil Co., Atlanta.
MICK, ALAN R. — American Hoechst Corp., Atlanta.
NEMETH, D. RICHARD — Atlanta Solvents & Chemical Co., Tampa, Fla.
PROBECK, ROBERT V. — J. B. International Marketing Corp., Dunedin, Fla.
REES, ROBERT H. — Johns Manville Products, Atlanta.
SINGLETON, H. J. — Smith Container Corp., Atlanta.
TAYLOR, LYTTON — Koppers Co., Charlotte, N.C.
TOVEY, JAMES — Durr Marketing Assoc., Pittsburgh, Pa.
UNGER, RICHARD E. — Thompson-Hayward Chem. Co., Tampa, Fla.
WELSH, MARGARET B. — Charter International Oil Co., Atlanta.

Educator and Student

HENTON, LESLIE E. — Georgia Inst. of Tech., Atlanta, Ga.
O'BRIEN, ROBERT M. — University of Southern Miss., Hattiesburg, Miss.
RAY, CHARLES J. — Georgia Inst. of Tech., Atlanta.

Technical Articles in Other Publications

Compiled by the Technical Information Systems Committee—H. Skowronska, Chairman

Deutsche Farben-Zeitschrift (Defazet)
(in German)

Published by Elvira Moeller GmbH, Karl-Benz-Strasse 11, Postfach 11 68, 7024 Filderstadt 1, Germany

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(in German)

Published by Curt R. Vincentz Verlag, 3 Hannover, Postfach 6247, Schiffgraben 43, Germany.

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Mach, M. and Kolar, O.—"Viscoelastic Behaviour of Epoxy Coatings. A Contribution to the Method of Evaluation:" 853-857.
Luthardt, H.J.—"Aging of Alkyd/HMMM Systems in Aqueous Medium;" 858-860.
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Funke, W.—"Assessment of the Corrosion Protection Characteristics of Paint Films and Other Organic Coatings. (4). Comparison of Salt Fog Tests and Practical Behaviour of Waterstream and Oxygen Penetration as well as Adhesion at Elevated Humidity;" 865-869.
Brushwell, W.—"Technical Advances in Powder Coatings" (Literature Review); 870-871.

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Kaluza, U.—"Solubility of Dyes—An Unequivocal Magnitude?;" 935-942.
Keifer, S.—"Colorimetric Assessment of Degree of Flocculation of Inorganic Pigments;" 942-946.
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Kossmann, H.H.—"New Diurethane Thickeners. Effects on the Rheology and Applications Properties of Emulsion Paints and Textured Finishes;" 955-961.
Brushwell, W.—"Technical Developments with Epoxy Resins;" 962-964 (Literature review).
Vial, F. and Gegusch, W.—"Present Standing of Activities of the Committee of Pigments and Extenders at DIN Deutsches Institute für Normung e.V.;" 964-970.
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Double Liaison - Chimie des Peintures
(in French)

Published by Les Presses Continentales Rue de Cherch-Midi, F-75006, Paris, France

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Frerotte, J. and Parez, J.—"Residual Waters of Paint and Varnish Factories;" 39.
Schoñfelder, M.—"Polyurethane System for Plastic Painting;" 53.

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Published by Oil and Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex, HAO 2SF England

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Ghanem, N.A., Naser, A.M., Ismail, M.F., and Ghafar, M.A.—"Synthesis of Modified Phthaloxyanine Compounds Suitable as Pigments;" 369-371.
Naser, A.M., Naoum, M.M., Salman, A.A., and Taha, A.—"Recent Aspects of Some Coloured Urea/Dibasic Acid Fusion Adducts;" 372-374.
Zahoor, M.A., Chandra, A., and Vasishtha, A.K.—"Cellulose-Based Resins for Surface Coatings;" 375-382.
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Carr, W.—"Theory and Practice of Pigment Dispersion;" 397-410.
Callaghan, B.G.—"Corrosion and Protection of Metals in the Building and Construction Industries;" 411-418.
Vetere, V., Rozados, E., and Carbonari, R.—"Measurement of Conductivity, Capacity, Electrical Resistance and Permeabillity of Paint Films in an Aqueous Solution;" 419-426.
Guruswamy, S.—"Electrical Resistance of Electrodeposited Rubber Per Unit Coulomb;" 427-430.

Plaste und Kautschuk mit Fachteil Anstrichstoffe
(in German)

Published by VEB Deutscher Verlag für Grundstoffindustrie, 27 Karl-Heine Strasse, 7031 Leipzig, E. Germany DDR.

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Kestelman, V.N., Naumov, Y.G., Negmatov, S.N., and Blohm, G.—"Studies of the Applicability of Polymeric Materials and Coatings in the Construction of Apparatus for Producing Vitamins;" 545-547.
Reinhard, G., Hahn, K., and Gorzolla, B.—"Impedance Measurements of the Systems Metal - Polymer Coating - Electrolytic Solution. IV: Characterization of the Degree of Reticulation on Baking Varnishes on Steel Surfaces;" 548-550.

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Horn, V., Benndorf, G., and Rädler, K.-P.—"Analysis of Structural Groups of Urea-Formaldehyde Glues;" 570-575.
Daehre, K.-H. and Schulz, H.—"Influence of Free Phthalic Acid on the Stability and Curing Behaviour of Short-Oil Alkyd Resin/Melamine Formaldehyde Resin Combinations;" 606-609.

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Schubert, S.—"Alkyd Resin - Silicone Resin Varnishes;" 666.

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Published by Dansk Bladforlag K/S, Holbersgade 20, 1057 Copenhagen, Denmark

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Kjönsberg, G.—"Research to be Wished;" 262-278.
Eikers, E.—"Total or Partial Ban on Epoxy in Denmark?;" 279-282.

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Hansen, W.—"Treatment of Waste Material from the Coatings and Printing Ink Industry;" 293-311.

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Published by Groot Haesebroekseweg 1, Postbus 71, Wassenar, Netherlands

Vol. 51 No. 10 — October 1978

Locuty, P.—"Toxicological Problems seen Through the Glasses of a Manufacturer of Coatings and Printing Inks;" 267-270.

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Published by Elsevier Sequoia S.A., Lausanne, Switzerland

Vol. 6 No. 2 — 1978

Herbst, W. and Hunger, K. - "Azo Pigments" (in German); 105-202.

Vol. 5 No. 3 — 1977

Furuno, N. and Ohyabu, Y.—"Methods for Measuring Throwing Power in Electrodeposition Coating;" 201-218.

PRI Symposium, to be Held May 1 & 2 at Battelle, Will Feature Discussions on Compliance Monitoring

The Paint Research Institute will hold a symposium devoted to "Analytical Methods to Monitor Product Compliance with Regulations" on May 1 and 2 at Battelle Columbus Laboratories, Columbus, Ohio.

Sessions on Trace Metals, Volatile Organic Components, Flammability, and Trace Organics will reflect the historical division of the elements into earth, air, fire, and water, respectively. Each session will be co-chaired by a scientist representing the industry viewpoint and one serving the regulatory agencies.

The opening day of the symposium, Thursday, May 1, will feature sessions on Flammability of Liquids and Trace Organic Materials.

The following papers will be presented at the Flammability session: "Flammability of Liquids—Theory"— Wilbur Affers, of U.S. Naval Research Laboratory; "Methods for Determining Flammability" — Robert Coffee, of Eastman Kodak Co.; "Present and Future Regulations on Flammable Liquids" — Thomas H. Seyman, of U.S. Department of Labor (OSHA); and "Standardization and Standardization Needs" — Harry A. Wray, of Harry A. Wray Associates.

The following will be presented on Trace Organic Materials: "Epichlorohydrin" — Herbert Siegel, of Shell Development Co.; "Priority Pollutants" — Richard Montgomery, of Carnegie-Mellon University; "Benzene" — James P. Kelly, of DeSoto, Inc.; and "Acrylonitrile" — Glenn Cunningham, of PPG Industries, Inc.

The banquet speaker, Thursday evening, will be Werner Zimmt, of E. I. du Pont de Nemours & Co., Inc., who will discuss "Solvent Regulations: How We Arrived Where We Didn't Want to Be."

The second day will be devoted to presentations on Trace Metals and Volatile Organic Components.

The following papers will be presented at the Trace Metals session: "Applications of Toxicology to Safety Assessment of Metals in Man" — Paul B. Hammond, of University of Cincinnati; "Industry Perspectives of Metals in Paints" — John C. Weaver, Consultant; "Childhood Lead Exposure from Various Sources" — James W. Sayre, of Timely Health Associates; "Certification of Reference Standards for Metal Elements Relating to Toxicity" — Robert Alvarez, of National Bureau of Standards. Papers will also be presented by Harold Swafford, of Glidden Coatings & Resins Div., SCM Corp., and Warren Porter, of Consumer Products Safety Commission.

At the session on Volatile Organic Components (VOC), Richard W. Scott, of Sherwin-Williams Co., will discuss "What Does VOC Mean to Various Sectors?" This will be followed by presentations on behalf of: Regulatory Agencies (EPA) — Gary McAlister, of Environmental Protection Agency; Coatings Manufacturers — Raymond Connor, of National Paint and Coatings Association; Consensus Methodology (ASTM) — Hiro Fujimoto, of Inmont Corp.; and Industry — Eugene Praschan, of General Motors Corp.

For additional information and to register, contact William Mirick, Battelle Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201 (614) 424-5510.

Spray Painting Subject of Workshop Series

Binks Manufacturing Co., Franklin Park, Ill., has scheduled nine courses on current spray painting methods. Three programs are offered.

Program 1 is a two-day course covering sprayable materials, finish problems, spray gun operation, compressed air atomization, selection of air and fluid nozzles, hose and accessories, compressed air supply, fluid supply, operator techniques, gun maintenance and hands-on instruction in conventional spray methods. This program is recommended for those who refinish automobile, furniture, etc.

Program 2 is a three-day course which includes Program 1, plus the principles of airless spray painting, the selection, use, and maintenance of airless spray equipment. This program is recommended for those who refinish automobiles, furniture, etc.

Program 3 is a five-day course which includes Programs 1 and 2. Emphasis in the last two days is on more involved industrial applications. It also covers electrocoating techniques.

At the end of each workshop, participants are awarded a Certificate of Graduation, which is recognized by the Chicago State University, Dept. of Industrial Education, for accreditation of three semester hours of college credit.

Workshops were held Feb. 5-9 in Franklin Park, Ill., Mar. 5-9 in Moonachie, N.J., and Mar. 19-23 in Dallas, Tex. Future workshops are scheduled for Apr. 2-6, June 4-8, Sept. 10-14, and Nov. 5-9 in Franklin Park, Ill., and for May 7-11 in Los Angeles, Calif., and June 4-8 in Atlanta, Ga.

Fee for the two-day course is $25; for the three-day course, $35; and for the five-day course, $50.

For additional information, contact Jack Adams, Director of Training, Binks Manufacturing Co., 9203 W. Belmont Ave., Franklin Park, Ill. 60131.

Southwestern Paint Convention Slated for Houston, April 5-7

The 37th Annual Southwestern Paint Convention will be held April 5-7 at the Shamrock Hilton Hotel, Houston, Texas.

General Chairman Klebert Jacobson, of Cron Chemical Co., has announced a full program of activities, beginning on Thursday, April 5 with the bowling, golf, and tennis tournaments, followed by the suppliers' reception.

Technical papers will be presented on Friday and Saturday, April 6 and 7.

The annual dinner/dance will be held Friday evening, and the awards luncheon on Saturday.

Advance registration fee is $50; on-site, the fee is $55. Registration fee for the spouses' program is $40 in advance, $45 on-site. Full registration includes tickets to the dinner/dance and the awards luncheon.

Registration fee for the technical program only is $17.50.

For complete information and to register, contact Klebert Jacobson, Cron Chemical Co., P.O. Box 14042, Houston, Texas 77021 (713) 644-7561.

ISCC 48th Annual Meeting to be Held in New York

The 48th Annual Meeting of the Inter-Society Color Council will be held at the Roosevelt Hotel in New York City, April 23-24, 1979.

Open meetings of the ISCC Project Committees (formerly Problems Subcommittees) will be held on April 23. As in the past, members and guests of the Council are urged to attend. Meetings of the Project Committees will be held in four 1½ hour periods to reduce as much as possible the conflicts resulting from simultaneous sessions.

On Monday evening there will be a special motion picture and slide presentation "Computer-Controlled Film and Video—Adapting New Technology for Art," prepared by Lillian Schwartz, Resident Visitor, Bell Telephone Laboratories and a member of the Advisory Committee of the Mason and Gross School of Performing Arts at Rutgers University. The application of computer technology as a medium for art will be explored in terms of a number of films that were created with computer techniques. Each film was chosen to illustrate different features of the medium.

The program on April 24 will begin with a symposium on "Color in Motion Pictures and Television," sponsored by the Society of Motion Picture and Television Engineers and chaired by Richard Bauer, of Eastman Kodak Co.

Scheduled for presentation at the symposium are:

"Color Reproduction in Motion Pictures and Television"—Leroy E. DeMarsh.

"Was the Dress that Color?"—Earl W. Kage.

"Television: Does Color Make the Jokes Funnier?"—E. Carlton Winckler.

"Excess Color Temperature Shifts in Motion Picture Screen Images, or Why is it Green on the Silver Screen?"—Glenn M. Berggren.

"The Wheres and Whyfores of Film Color Variability"—Frederick C. Franzwa.

The Annual Meeting luncheon on Tuesday will feature the presentation of the ISCC Godlove Award for 1979 to Dr. Gunter Wyszecki, of the National Research Council of Canada, who will speak on "Color as Seen by a Scientist." The luncheon will be followed by the Annual Business Meeting.

A special symposium on "Selecting Colors for Automobiles," will be held Tuesday afternoon. Speakers will be the Directors of Design for American Motors, Chrysler, Ford, and General Motors. Their presentations will be followed by a question-and-answer session.

For further information, please contact the ISCC Secretary, Dr. Fred W. Billmeyer, Jr., Rensselaer Polytechnic Institute, Dept. of Chemistry, Troy, N.Y. 12181.

ACS to Meet in Hawaii for Spring Conference, April 2-6

The American Chemical Society's Division of Organic Coatings and Plastics Chemistry will hold its Spring Meeting in Honolulu, Hawaii at the Hyatt Regency-Waikiki Hotel, April 2-6, 1979.

Included among the symposiums are the following:

(April 2-5)—International Conference on Adhesion and Adsorption of Polymers.

(April 2-4)—Symposium on Modification of Polymers.

(April 4-6)—Symposium on Polymer Alloys, Blends, Grafts and Interpenetrating Networks.

(April 2-3)—Symposium on Polymers for Optical Fiber Systems.

(April 3-6)—Symposium on Resins for Aerospace.

(April 4)—Workshop on Current Trends in Surface Coatings.

(April 3)—Symposium on Plastic Mortars, Sealants and Caulking Compounds.

(April 2-3, 6)—New Concepts in Coatings and Plastics.

(April 2)—Borden Award Symposium—Highly Ordered Solid Polymers.

The complete list of papers to be presented at the symposium, registration information, and housing requests may be obtained from the American Chemical Society, 1155 16th St., N.W., Washington, D.C. 20036.

Color Technology Course To be Held at Lehigh, May 21-25

An intensive five-day course and symposium, "Colorant Formulation: Theory and Practice," will be conducted at Lehigh University, Bethlehem, Pa., May 21-25, 1979.

The course will cover colorant formulation in detail, beginning with the basics and proceeding through the latest advances. Instruction and practice will be provided in the use of the computer for colorant formulation by Kubelka-Munk single and two-constant theories, and the application of Mie and radiative transfer theory. No previous knowledge of color theory is required.

A one-day symposium, on May 24, will cover general color theory, and may be attended by anyone interested in color.

Fee for the course plus symposium is $495, which covers notebooks, lunches, and a banquet. The one-day symposium fee is $100.

Advance registration is required. For additional information or registration forms, contact the course director, Eugene Allen, Color Science Laboratory, Bldg. #7, Lehigh University, Bethlehem, Pa. 18015.

FSCT Educational Committee Offers Coatings Courses Guide

A 19-page "Guide to Coatings Courses, Symposia, and Seminars," compiled by the Federation Educational Committee, is now available.

Based on information supplied by the Constituent Societies, the Guide lists a variety of coatings educational offerings by geographic region and Society. The Committee plans to update the listing annually to reflect current programs, curricula, etc.

To obtain free copies of the Guide, write to Educational Committee (Coatings Courses), % Federation of Societies for Coatings Technology, 1315 Walnut St., Suite 832, Philadelphia, Pa. 19107.

U.S. Procurement Policies Subject of WPTG Symposium

The 19th annual symposium of the Washington Paint Technical Group, to be held at the Marriott Twin Bridges Hotel in Washington, D.C., April 9 and 10, will feature as its theme, "Federal Government Procurement Policies Designed to Purchase Commercial, Off-the-Shelf Products."

The Keynote Address, "New Directions for the Procurement of Commercial, Off-the-Shelf Products," will be delivered by Daniel S. Wilson, of the Office of Federal Procurement Policy, Office of Management and Budget.

The program also includes the following presentations:

"GSA Actions to Implement a Policy for the Procurement of Off-the-Shelf Products" — Aaron Sarfaty, of Federal Supply Service.

"DOD Actions to Implement a Policy for the Procurement of Off-the-Shelf Products" — John E. Burke, of Department of Defense.

"How HUD Presently Purchases Paint Products" — Clarence Meadows, of Department of Housing and Urban Development.

"How the States Presently Purchase Paint Products" — Sid Levinson, of D/L Laboratories, Moderator.

William V. Mosley, of State of Virginia.
Edward T. Mooney, of State of Florida.

"Industry Interest and Reaction to the Federal Government Procurement of Off-the-Shelf Paint Products" — Larry Thomas, of National Paint and Coatings Association.

"The Manufacturers' Viewpoint" — William W. Allanach, Moderator.

Lou Rich, Jr., of Glidden Div., of SCM Corp.
J.E. Spector, of Everseal Manufacturing Co.
John C. Weaver, of Sherwin-Williams Co.
Joseph Byers, of M.A. Bruder Co.
M.O. Beatty, of C.M. Athey Paint Co.

"Description of the Activities of ASTM Subcommittee D1.41 on 'Government Procurement Criteria for Off-the-Shelf Paint Products' " — Royal A. Brown, of NPCA.

Concluding the program will be meetings of ASTM D-1 subcommittees.

There will be a reception and banquet on the evening of April 9 at the Marriott Twin Bridges Hotel.

Registration fees are $75 for industry personnel (additional registration from same company, $50) and $45 for government personnel. Additional fee for spouses attending the banquet is $20.

For additional information, or to register, write Washington Paint Technical Group, Box 12025, Washington, D.C. 20005.

Series of Coatings Courses Scheduled by IAT for 1979

A series of four-day courses and two-day mini courses have been scheduled by the Institute of Applied Technology, a non-profit research and training organization. Designed to promote quality assurance in high performance protective coatings, the courses will feature both classroom training and hands-on field demonstrations.

The courses are scheduled as follows:

Four-day courses: "Marine Coatings Procedures," Apr. 23-27 at Pascagola, Miss., and Oct. 15-18 at Philadelphia, Pa.; "Painting and Coating for Industry," June 11-15 at Houston, Tex., and Sept. 24-28 at Honolulu, Hawaii; and "Nuclear Quality-Assured Coating Work," May 14-18 at Jackson, Mich., and Dec. 3-7 at Miami, Fla.

Mini courses: "Designing for Protective Coatings," Mar. 20-21 at Denver, Colo., and Oct. 30-31 at Boston, Mass.; "Coating Inspection: Instruments and Practices," May 22-23 at Washington, D.C., and Sept. 11-12 at St. Louis, Mo.; "The Specification Document: Key to Quality Coating Work," Nov. 6-7 at Dallas, Tex.; and "Estimating, Planning, and Scheduling Painting," Nov. 20-21 at Chicago, Ill.

Additional information is available from Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006.

Gordon Research Conferences Scheduled for July and August

A Gordon Research Conference on "Microbiological Degradation" will be held July 23-27 at the Brewster Academy, Wolfeboro, N.H.

The following presentations are scheduled:

(July 23) "Recent Developments in Quantitating Microbial Activity in the Environment" — Richard T. Wright; "Measurement Techniques for Characterizing Microbial Community Composition and Activity" — Randolph L. Ferguson; "Aquatic Microcosm Systems for Toxic Organic Compound Exposure Studies" — P. Hap Pritchard.

(July 24) "Microbial Communities: Biodegradation and Pollution" — Alan T. Bull; Evolution of Microbial Degradative Pathways" — D.W. Ribbons; "Role of Antibiotics in Producer Organisms" — L.C. Vining.

(July 25) "Microbial Metabolism of Lignocellulose" — J.G. Zeikus; "Enzymatic Conversion and Utilization of Cellulosic Biomass" — Douglas E. Eveleigh; "Microbial Mechanisms for Degradation of Polyethylene Glycol Compounds" — Fusako Kawai; "Polyethylene Glycols and Biodegradation of Nonionic Surfactants" — G.K. Watson.

(July 26) "Microbial Transformations of Metals" — Anne O. Summers; "Methylation of Metals: Some Biological and Environmental Implications" — John S. Thayer; "Poster Presentation Summary" — Joseph J. Cooney; "Role of Methanogens in Nature" — R.S. Wolfe.

(July 27) "Recent Developments: Eucaryotic Mutagenicity Assaya" — David Brusick; "Summary of the Conference" — David Hughes.

Another conference on "Chemistry and Physics of Coatings and Films" will be held August 6-10 at the Proctor Academy, Andover, N.H.

Presentations slated are as follows:

"Micellization of Cater Base Polymers" — D.Z. Bacher and P.E. Pierce; "Preparation and Properties of Nonuniform Emulsion Polymers" — D. Bassett; "Time Lapse Infrared Spectroscopic Investigation of Alkyd and Linseed Oil Cure Mechanisms" — J.H. Hartshorn; "Mechanism of Paint Adhesion Loss Under Corrosion" — J. Holubka; "Electrical Properties of Thin Polymer Films" — M. Kryszewski; "Selective Crosslinking of Polymer Networks Via Dual Reactive Groups" — T.K. Kwei and H.N. Zyazirani; "Sagging Balance: A New Instrument to Characterize the Rheology of Resins During Curing" — W. Overdiep; "UV and Thermal Curing by Cationic Polymerization" — S.P. Pappas; "Effect of History on Sorption and Transport in Glassy Polymers" — D. Paul; "Diffusion Controlled Formation of Porous Film Structures in Ternary Polymer Systems" — S. Prager; "Photocuring of Surface Coatings: Excited States and Exciplex Formation" — B. Ranby; "Photoxidation and Degradation of Polymers and Coatings" — C. Rogers; "Flow Phenomena in Coating Application Processes" — L.E. Scriven; "Coatings from ABA Block Copolymers" — J.A. Simms.

The registration fee of $185 for each conference includes meals and lodging.

Complete details are available from Dr. Alexander M. Cruickshank, Director, Pastore Chemical Laboratory, University of Rhode Island, Kingston, R.I. 02881.

People

The Herman Shuger Award of the Baltimore Society for Coatings Technology and the Baltimore Coatings Association was presented to **Ed Countryman,** of the Baltimore Paint & Chemical Co., Div. of Dutch Boy. The award is made for outstanding contributions to the coatings industry.

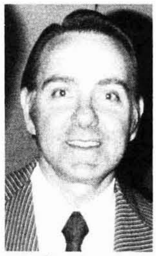
The O'Brien Corp. has named **Adrian S. Adkins** Corporate Technical Director. Mr. Adkins is a member of the Golden Gate Society for Coatings Technology. The company also named **Thomas H. Cahir** General Manager of Eastern Div. operations. Mr. Cahir is a member of the Baltimore Society for Coatings Technology.

Dieter H. Ambros, President of BASF Wyandotte Corp. since 1971 and its Chief Executive Officer since 1975, will head the Fiber Intermediates Div. of BASF AG in Ludwigshafen, Germany, as of August 1, 1979. **Edwin L. Stenzel,** President of Dow Badische Co. since 1976, will assume the Presidency of BASF Wyandotte Corp., effective May 1, 1979. **Hans-Harald Kopper,** a department director at BASF AG in charge of fertilizer production, will join Dow Badische Co. to succeed Mr. Stenzel as President on April 1, 1979.

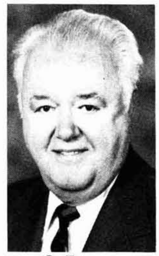
Hugh Morrow III has been promoted to Manager of Technical Information for Climax Molybdenum Co., a division of AMAX Inc. He will continue to serve as Editor of *Molybdenum Mosaic*, the company's quarterly technical journal.

Hugh Purcell, Vice-President, Applications and Technical Services, at Morehouse Industries, Inc., is the first recipient of the Gold Impeller Award, which will be given annually by the company "to an individual in recognition and appreciation of outstanding service to the chemical processing industry for innovative designs and applications in the field of dispersion technology." Mr. Purcell will serve as Chairman of the newly formed awards committee. He is a member of the Los Angeles Society for Coatings Technology.

Battelle Columbus Laboratories has named **Herbert N. Johnston** Manager of the Industrial Marketing Office. Mr. Johnston is a member of the C-D-I-C Society.


E. Countryman


T.H. Cahir


G. Forman


M. Coffino

Jerry E. Waters has been named Market Manager, Coatings, for the Harshaw Chemical Company's Color Dept. He succeeds **George Forman** who has been appointed to the new position of Manager, Marketing Services. Mr. Forman is a member of the Cleveland Society for Coatings Technology.

McCloskey Varnish Co., Eastern Div., has appointed **James L. Nupp** to the position of Field Sales Manager.

Drew Chemical Corp., Water and Waste Treatment Div., has announced the promotion of **Nicholas J. Brindak** to the position of Vice-President, Consulting and Technical Services, and the promotion of **Spencer Curtis** to the position of Vice-President, Marketing.

Howard Buckalew has been promoted to Assistant Test Engineer in the Technical Service Laboratory at Thiokol Corp., Chemical Div., Trenton, N.J. In a series of promotions at the division's manufacturing facilities at Moss Point, Miss., **E.B. Corley** was named Manager of Plant Engineering, **J.M. Walley** was appointed Manager of Maintenance and Construction, **J. Leo French** was promoted to Maintenance Supervisor, **J. Glenn Marshall** was named Technical Area Supervisor—Monomer Area, **Frank A. Spires** was appointed Engineer of Energy and Utilities, and **Robert Bennett** was promoted to Associate Chemist in Process Engineering.

The following executive appointments have been announced by Benjamin Moore & Co., Central Div., Melrose Park, Ill.: **J. Stewart May** was appointed Assistant Divisional Vice-President; **Robert G. Parks** was appointed Divisional Sales Manager, succeeding Mr. May; and **Billy J. Sutton** was appointed Assistant Divisional Sales Manager, succeeding Mr. Parks.

Morris Coffino has been promoted to the position of Technical Vice-President of the D.H. Litter Co., Inc. Mr. Coffino is a member and a Past-President (1972-73) of the New York Society for Coatings Technology. He is Chairman of the Program Committee for the 1979 Federation Annual Meeting to be held in St. Louis, Mo.

Other company promotions include **Fred Holtzman** to Executive Vice-President, **Thomas P. Scanlon** to Vice-President, **Marvin C. Harrow** to Manager Resin Sales, and **Harry Zam** to Director of Marketing.

Paul D. Dague was elected President and Chief Executive Officer of Jones-Blair Co. He succeeds **Howard M. Jones,** who retired after 27 years with the company. Mr. Jones will continue as a member of the board of directors. **R.A. Nayes** was elected Executive Vice-President. He served previously as Vice-President and Manager of the Chemical Coatings Div.

Cyprus Industrial Minerals Co. has named the following divisional officers: **George D. Lessner,** Vice-President, Operations; **Gordon J. Gill,** Vice-President, Technical Services; and **Louis D. Murino,** Vice-President, Marketing. Mr. Murino is a member of the Los Angeles Society.

Fred F. Boehle, of Boehle Chemicals, Inc., Southfield, Mich., and a member of the Detroit Society for Coatings Technology, has been elected President of the Chemical and Allied Industries Association of Michigan. The other officers are Vice-President — **Roderick W. Kallgren,** of Dow Chemical Co.; Treasurer — **William Crawford,** of Brockway Glass Co.; and Secretary — **Paul E. Dochety,** of Eastman Chemical Products, Inc.

Martin E. Schleicher, Vice-President of the Bisonite Co., Inc., and a Past-President of the Federation, has retired following 42 years in the paint industry. He is a 1937 chemical engineering graduate of Pratt Institute. In 1943, following an association with Cloverleaf Paint and Varnish Co. and the Buffalo Synthetics Corp., he joined the McDougall-Butler Co., Buffalo, N.Y., and rose to Vice-President in 1961.

M. E. Schleicher

Mr. Schleicher was appointed Vice-President, Research and Manufacturing, of Bisonite following its merger with McDougall-Buffalo in 1968, serving also as a Director and a member of the Executive Committee.

He is a Past-President and former Council Representative and Technical Committee Chairman of the Western New York Society, and is now an honorary member.

In the Federation, Mr. Schleicher has been a member of the Board of Directors and Finance Committee and was Treasurer in 1967 and President-Elect before serving in the position of President in 1968-69. He has also served as Chairman of the Paint Show, Program, Program Awards, By-Laws, Meetings, Finance, and Nominating Committees, as well as ASTM D-10, the Scientific Committee of the Association, and was a Trustee of both PRI and the Paint Industry Education Bureau.

Mr. Schleicher will continue to serve as a Director of the Bisonite Co., and as a Consultant.

Dr. Kenneth S. Karsten, Vice-President, Research and Development Div., R.T. Vanderbilt Co., Inc., has retired after 31 years of service. He will continue to be associated with the company on a daily basis as a consultant.

Werner T. Meyer has been elected President of the Lead Industries Association and the Zinc Institute. His headquarters will be in New York City.

Richard G. Fayter has been promoted to Manager of Central Research of Emery Industries, Inc., Cleveland, Ohio.

Robert J. Mitchell has been promoted to Business Manager, Pigments Div., Degussa Corp. He served most recently as National Sales Manager of the division.

Kenneth X. Charbonneau, of Benjamin Moore & Co., Montvale, N.J., has been elected President of the Color Marketing Group along with the following officers: **Robert W. Miracle,** of Interpace Corp., Los Angeles, Calif., Vice-President; **William C. Capehart,** of Tenneco Chemical Co., Piscataway, N.J., Treasurer; and **Joyce Davenport,** of DeSoto, Inc., Des Plaines, Ill., Secretary. Ms. Davenport is a member of the Chicago Society for Coatings Technology.

Air Products and Chemicals, Inc. has appointed **Leo J. Theilman** to the position of Midwest Regional Sales Manager.

Dr. Herman J. Lanson, of Poly Chem Resins, Inc., St. Louis, Mo., was presented the Gateway Award of the St. Louis Society for Coatings Technology "for outstanding service to the Society, the Federation, and the local & national coatings industry." The award was presented to Dr. Lanson, a Society Past-President, on January 16.

The Sherwin-Williams Co., Cleveland, Ohio, has elected **John G. Breen** President and Chief Executive Officer. At the same time, **William C. Fine,** who has been President of the company since 1975, has assumed the post of Chairman.

Dr. William J. Bailey, Research Professor of Chemistry at the University of Maryland and Director-at-Large of the American Chemical Society, has been elected 1979 Chairman of the society's Board of Directors.

DeSoto, Inc., Des Plaines, Ill., has named **Les Nack** Technical Manager, Packaging Coatings. Mr. Nack is a member of the Chicago Society for Coatings Technology.

H.B. Fuller Co., St. Paul, Minn., has promoted **Jerald L. Scott** to the position of General Manager, Polymer Div.

Walter F. Schlauch has been named Marketing Manager, Industrial Resins and Permasorb, at National Starch and Chemical Corp.'s headquarters in Bridgewater, N.J. Mr. Schlauch is a member of the New York Society of Coatings Technology, the American Chemical Society, and the Paint and Coatings Assoc.

Macbeth, Div. of Kollmorgen Corp., has promoted **James G. Davidson** to the position of Vice-President, Color Communications. Mr. Davidson is Chairman of the ASTM subcommittee on Color Measurement and President of the Manufacturers Council on Color and Appearance, as well as a member of the Inter-Society Color Council and the American Chemical Society.

Dr. Geraldine V. Cox has been named Vice-President and Technical Director of the Manufacturing Chemists Association. **Albert C. Clark,** who previously held the position, will continue to work with the Association by applying his 32 years of experience to the problems of transportation of chemicals.

Dr. Howard L. Gerhart, Coatings Scientist And Educator, Dies at 69

Dr. Howard L. Gerhart, retired Vice-President of Research and Development, Coatings and Resins Div., of PPG Industries, Inc., and a prominent coatings scientist, educator and lecturer, died of cancer at the age of 69 in Pittsburgh, January 27, 1979.

Dr. H. L. Gerhart

A member of the Pittsburgh Society for Coatings Technology, Dr. Gerhart served as a Trustee of the Paint Research Institute of the Federation of Societies for Coatings Technology from 1970 to 1975, and was an Honorary Trustee of PRI at the time of his death. As Chairman of the Liaison Committee (1973-78) of the Federation, he served as the contact between industry groups overseas and U.S. coatings organizations. He was a well-known figure in the European FATIPEC organization.

Dr. Gerhart was the recipient of the 1972 George Baugh Heckel Award of the National Paint and Coatings Association. In 1973 he delivered the Keynote Address, "Making Coatings Science Useful," at the Federation's Annual Meeting, and in 1976, presented the Joseph J. Mattiello Lecture at the 54th Annual Meeting of the Federation, speaking on the topic, "Coatings Engineers and the Companies They Keep—Profitable."

He graduated with Phi Beta Kappa honors from Franklin and Marshall College where he also received an Honorary Doctor of Science Degree. He received a Ph.D. Degree in Chemistry from Northwestern University.

In 1937 he joined PPG Industries as a bench chemist and was appointed Director of Research at the company's Milwaukee laboratory in 1947. He was named Director of Research and Development of the Coatings and Resins Div. in 1958 and, 10 years later, was appointed the Division's Vice-President of Research and Development.

Following his retirement from PPG in 1974, Dr. Gerhart became Director of the Coatings Research Center at Carnegie-Mellon University. He also served as an adjunct professor on the faculty of chemical engineering.

As a lecturer and keynoter, Dr. Gerhart brought nearly 40 years of experience and expertise to his talks, which were frequently presented with low-key humor and subtle analogies, to many scientific and management organizations. Some of his more familiar lectures include: "Signals of Science;" "Domination Index;" "Basic Research Can Be Useful;" and "Return of Research Investment."

Dr. Gerhart, a respected leader in both the Federation and the NPCA, also served as an Editor of *Industrial and Engineering Chemistry,* a publication of the American Chemical Society, of which he was a member. He was also a member of the American Institute of Chemists and the Chemists' Club of New York.

Survivors include his wife, Anne; a daughter, Ann McNealey; three sons, Peter M., Bruce B., and the Rev. Andrew Gerhart; and five grandchildren.

The Burgess Pigment Co. has announced that the E.W. Kaufmann Co. will represent and distribute its product to the coatings and related industries. The distribution facility in Southampton, Pa. will service eastern Pennsylvania, southern New Jersey, and Delaware.

Reuben O. Feuge, research leader in edible oils at the USDA's Southern Regional Research Center in New Orleans, La., has received the 1979 Alton E. Bailey Award from the North Central Chapter of the American Oil Chemists' Society.

Alcolac, Inc. has engaged **Dr. Joseph M. Sandri** as Director of Research. He will be relocating to the Baltimore, Md. area.

Pfizer Minerals, Pigments and Metals Div., has named **Herbert W. Flandreau, Jr.** Vice-President, Production. **James K. Barr** has joined the company in the newly created position of Vice-President, Research. He will be located at the company's research center in Easton, Pa.

Dr. Mohamed S. El-Aasser, Associate Professor of Chemical Engineering at Lehigh University, has been appointed co-director of the Emulsion Polymers Institute at the university.

Schenectady Chemicals, Inc. has appointed **Kenneth C. Petersen** Vice-President of Manufacturing. He will have overall responsibility for the company's domestic operations.

Obituary

James J. Filippone, Plant Manager of MCI Corp., died December 29, 1978. He was employed by the Mary Carter Paint Co. for over 20 years. Mr. Filippone was a member of the Southern Society for Coatings Technology.

Frank X. Ritter, an executive of Tenneco Chemicals, Inc., died January 5, 1979. He had been associated with the coatings industry for over 28 years.

Donald Kosnick, a 25-year member of the Detroit Society, and an employee of Valspar Corp., died January 29, 1979.

Literature

Petrochemicals

A new 12-page brochure which provides specifications and use information on certain petrochemical products has been released. Items featured in the publication include benzene, toluene, xylene, napthalene, cumene, maleic anhydride, and a number of alphatic hydrocarbon solvents. Copies of bulletin 1374 may be obtained by writing to Ashland Chemical Co., Petrochemicals Div., Box 2219, Columbus, Ohio 43216.

Epoxy Curing Agents

The 1979 editions of "Summary Chart of Ancamine Epoxy Curing Agents" and "Comparison Chart of Competitive Epoxy Curing Agents" are now available. The literature includes descriptions of several new products. Copies may be obtained by writing to Pacific Anchor Chemical Corp., 1145 Harbour Way South, Richmond, Calif. 94804.

Elcometer

A data sheet describing a new magnetic elcometer dry film coating thickness gage for nondestructive measurement of nonmagnetic coatings applied to ferrous substrates has been released. Specifications and special features are listed. To obtain a copy, write Mr. F. Rueter, Zormco, 8520 Garfield Blvd., Cleveland, Ohio 44125.

Exterior and Interior Paints

A 20-page booklet containing formulation guidelines for a variety of exterior and interior trade sales paints based on a terpolymer emulsion has been recently issued. Among the topics discussed are the effective use of such materials as filming aids, plasticizers, and defoamers for optimization of paint properties; flow and leveling; and the compatibility of the emulsion with pigments, extenders, and colorants. Performance properties of paints are listed and typical physical properties of the terpolymer emulsion are presented in table form. Booklet F-46580A may be obtained by contacting Union Carbide Corp., Coatings Materials, Dept. JLS, 19th Floor, 270 Park Ave., N.Y., N.Y. 10017.

Synthetic Wax

An ethylene-based, synthetic wax with typical microcrystalline structure is described in literature now available. It is compatible with petroleum waxes, hydrocarbon resins, and various solvents, and displays even suspension in various solvents so that it can be used as a mold release agent. For complete technical data on Veba waxes, write Durachem Div., Dura Commodities Corp., 111 Calvert St., Harrison, N.Y. 10528.

Plant Safety

Guidelines for a Chemical Plant Safety Program and Audit is a new booklet which emphasizes audit procedures that will assist in the establishment, measurement, and maintenance of an aggressive safety program in the chemical industry. The audit includes management commitment and responsibilities, planning and organizing, employee selection, hazard identification and control, accident management, and public relations. Copies may be obtained for $2.50 from Publications Service, Manufacturing Chemists Association, 1825 Conn. Ave., N.W., Washington, D.C. 20009.

Instrument Handbook

A 376-page handbook of paint testing and laboratory instruments is now available. This book includes complete descriptions, instructions for use, and many specification references. Some of the categories covered are fineness of grind, reflectance, hardness, and flash point. Instruments described include paint thickness gages, viscometers, and gel timers. A free copy of this catalog is available from the Paul N. Gardner Co., P.O. Box 6633, Stn. 9, Fort Lauderdale, Fla. 33316.

Dust Collectors

A 22-page brochure, containing technical data and 30 application photographs, which describes a complete line of fabric filter dust collectors is now available. Some of the areas of usage shown are in metal finishing operations, tablet coating and polishing operations, and glass works. To obtain a copy of the literature, write DCE Vokes, Inc., Suite 900, Plainview Plaza, 10101 Linn Station Rd., Jeffersontown, Ky. 40223.

Epoxy Powder Coating

Literature is now available which describes suggested applications of a new epoxy powder coating, including gas and oil transmission and distribution, construction subjected to deicing or marine environments, and power generating plants. For additional information about this new product, write The O'Brien Corp., Industrial Coatings Div., 450 E. Grand Ave., S. San Francisco, Calif. 94080.

Particle Size Analysis

Edited by M.J. Groves, this book consists of 45 research and review papers presented at the 1977 Third Particle Size Analysis Conference, held by the Analytical Div. of the Chemical Society. Seven major analytical methods are examined including areas such as analysis of aerosol particles and spray droplets in flight and characterization of shape. It is available for $60. from Heyden & Son, Inc., 247 S. 41st., Phila., Pa. 19104.

Chelating Agent

A new chelating agent, available in developmental quantities, is described in recently published literature. It is described as the trisodium salt of N, N-di (2-hydroxy-5-sulfonic acid benzyl) glycine and is known to form complexes with calcium, cobalt, copper, iron, manganese, and nickel. For additional information on Hamplex DPS, write Richard Young, New Product Development Dept., Organic Chemicals Div., Poisson Ave., Nashua, N.H.

Lubricant

A surface active lubricant, which can be used to improve the release or mar-resistant properties of organic coatings when added either as a formulation ingredient or as a surface treatment, is described in literature now available. This lubricant has been approved for use in food packaging, and improves release characteristics of lining varnish in cans. Additional information on Hodag Model MR-216 may be obtained by contacting Hodag Chemical Corp., 7247 N. Central Park Ave., Skokie, Ill. 60076.

Color Control Systems

A new full-color, six-page brochure which describes a range of computer color control systems has been prepared. A pocket flap supplements technical data with information on specifications on individual system components and cost justification brochures directed to specific industries such as paint and plastics, textiles, and ink and printing. To obtain copies of "Modular Color Control Systems to Match Your Needs," write Applied Color Systems, Inc., Princeton Service Center, P.O. Box 5800, Princeton, N.J. 08540.

Spectrophotometers

Detailed technical reports describe the design and capabilities of a series of high performance spectrophotometers. The series, designed for turbid sampling and qualitative analysis, feature photometric fidelity and wavelength precision. Available options are also described in five data sheets which are included in the report. Options include automatic five cell programmer, background corrector, semi-automatic sampling system, and a series of thermoelectric temperature controls. For copies of brochures T-328A, B-41, B-42, B-44, B-47, and B-52, write Perkin-Elmer Corp., Instrument Div., Main Ave., Mail Station 12, Norwalk, Conn. 06856.

Economic Censuses

The Miniguide to the 1977 Economic Censuses tells what the censuses cover and outlines the particular kinds of data available in the various tables in the reports. This publication is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, at $1.80 per copy.

The Publication Program, 1977 Economic Censuses gives basic information on the contents of the upcoming reports and the approximate dates of issue. This free booklet may be obtained by writing the Subscriber Services Section (Publications) U.S. Bureau of the Census, Washington, D.C. 20233.

Directory of Instrumentation

A two-part reference manual of instruments, manufacturers, and specifications will be available by June 1979. The directory will be updated each year. The first part, Products and Manufacturers, consists of two sections: Instrumentation and Control Products and Instrumentation and Control Manufacturers. Part Two, Source Information and Specifications, will consist of the following five sections: Sales Outlets in the U.S. and Canada, Product Specifications, Sales Representatives, Trade Name Index, and Specifications and Reference Data. For further information, contact Instrument Society of America, 400 Stanwix St., Pittsburgh, Pa. 15222.

Optical Colorimeter

A new optical colorimeter that uses sphere geometry for color measurement is introduced in literature recently released. The sphere geometrics gives the user the option of two modes of operation: one which sees the "true" color and the second which sees the color as the human eye sees it. To obtain more information about MC1010S, contact Marketing Manager, Color Data Products, Macbeth, Little Britain Rd., Drawer 950, Newburgh, N.Y. 12550.

Calcium Carbonate Filler

A new calcium carbonate filler with a chemically bonded calcium resinate coating is introduced in recently published literature. The coating, which becomes part of the particle surface, will not dust off or separate during shipping and handling. The filler is white and free-flowing, relatively hydrophobic, and disperses rapidly and completely in a variety of materials. For further information, write Georgia Marble Co., 2575 Cumberland Parkway, NW, Atlanta, Ga. 30339.

Coil Coating Vehicle

An eight-page booklet describing the performance properties of a new thermosetting latex for water-borne coil coatings has been released. The brochure provides information on formulating, and offers guidelines for pigment selection and the incorporation of crosslinking agents, filming aids, and other components into formulations for topcoats and primers. Procedures for proper storage and handling are outlined, and a brief discussion of toxicological properties is presented. To obtain copies of booklet F-46707, write Union Carbide Corp., Coatings Materials, Dept. JLS, 19th Floor, 270 Park Ave., New York, N.Y. 10017.

Book Review

N.P.I.R.I. RAW MATERIALS DATA HANDBOOK VOLUME III

Proprietary Solvents

Published by
The National Printing
Ink Research Institute
Lehigh University
Bethlehem, Pa.
$50.00

Reviewed by
Dr. Thomas J. Miranda
Whirlpool Corp.
Benton Harbor, Mich.

This 216-page handbook contains information on 300 proprietary hydrocarbon solvents and 100 proprietary oxygenated solvents used in printing inks. Data tables summarize physical properties, health and fire hazards, and other characteristics by generic groups.

This handbook is a complete reference source for the handling and use of proprietary solvents in every phase of ink and allied industries.

The book includes classification of solvents, hazards, recommended uses, a section on definitions, data sources and references, and data tables by solvent families, including petroleum solvents, light aliphatic naphthas, sorption products, isoparaffins, solvents, alcohol, and other oxygenated solvents. In addition, the book contains a data supplement as well as data sheets and cross index of names. Finally, the names and addresses of producers are also included.

The data sheets are particularly useful to those concerned about environmental control issues since it provides a summary of hazards, typical physical data, fire and explosion hazards, and health hazards. It would be a good addition to the libraries of ink and coating manufacturers, and useful to anyone requiring up-to-date information on solvents.

CLASSIFIED ADVERTISING

Cabot's Stains

Boston, Massachusetts

Plant Superintendant

We are a long established, growing manufacturer of specialized coatings products sold nationally. Our factory in the Boston area employs over 70 people.

This person will work under our Operations Manager and will become personally involved in cost systems development, plant modernization projects, purchasing, industrial relations, as well as direct labor supervision. An engineering degree and 5-10 years plant experience in the chemical or coatings industry is necessary. The capacity to take on greater responsibilities in the future is essential. Please send a resume or letter describing experience to our consultant: Leonard B. Landall, Dept. T, 2 Centre Plaza, Boston, Mass. 02108.

COATINGS OR PAINT CHEMIST

INTERSTAB Chemicals, Inc., New Brunswick, N.J., is seeking a degree chemist having industrial experience with water reducible and water-borne coatings system. Salary will depend on type and length of experience. An Equal Opportunity Employer. Please contact Mr. V.F. Maurer, 500 Jersey Ave., New Brunswick, N.J. 08903, Tel. (201) 247-2202.

RESEARCH MANAGER To $35,000+

Fine opportunity with leading manufacturer of industrial protective coatings to direct the company's R&D activity into new market areas. Minimum of 5 years experience in formulation and utilization of coatings such as paints, waxes, paper coatings, corrosion inhibitors or hot melt adhesives is required. Send resume including salary history in confidence to:

P.O. Box VW 1902
Chicago, Ill. 60690

Coming Events

FEDERATION MEETINGS

(May 17-19)—Federation Spring Meetings. Third-ranking Society Officers—17th; Board of Directors—18th; Executive Committee—19th. Hilton Hotel, New Orleans, La. (FSCT, Suite 832, 1315 Walnut St., Philadelphia, PA 19107).

(Oct. 3-5)—57th Annual Meeting and 44th Paint Industries' Show. St. Louis Convention Center, St. Louis, Mo. (FSCT, Suite 830, 1315 Walnut St., Philadelphia, Pa. 19107).

PAINT RESEARCH INSTITUTE MEETING

(May 1-2)—Paint Research Institute Symposium on Analytical Methods Used to Monitor Product Compliance With Regulations. Battelle Institute, Columbus, Ohio. (Dr. Raymond R. Myers, Chemistry Dept., Kent State University, Kent, Ohio 44242).

SPECIAL SOCIETY MEETINGS

(Apr. 5-7)—Dallas and Houston Societies. Southwestern Paint Convention. Shamrock Hilton Hotel, Houston, Tex. (Don Webb, Jones-Blair Co., P.O. Box 35286, Dallas, Tex. 75235).

(May 3)—Detroit Society FOCUS Seminar, "Recent Advances in Automotive Coatings." Michigan Inn, Detroit, Mich.

(May 3-5)—Pacific Northwest Society. Thirty Second Annual Spring Symposium. Bayshore Inn, Vancouver, B.C., Canada. (B.D. Lamb, Harrisons & Crosfield (Canada) Ltd., 810 Derwent Way, Annacis Industrial Estate, New Westminster, B.C., V3M5R1, Canada).

(May 22)—Pittsburgh Society Spring Symposium, "Controlling Corrosion with Organic Coatings." Duquesne University, Pittsburgh, Pa. (Jim Jones, PPG Industries, Inc., 151 Colfax St., Springdale, Pa. 15144).

(May 30-31)—New York and Philadelphia Societies Joint Symposium, "Maintaining Quality of Coatings Under Pressure." National Conference Center, Hightstown, N.J.

(June 18)—Golden Gate Society Manufacturing Seminar, "Mixing Time '79."

OTHER ORGANIZATIONS

(Mar. 26-Apr. 27)—Paint Short Courses at University of Missouri—Rolla. For Paint Inspectors and Quality Controllers—Mar. 26-30; Tinting, Shading, and Matching of Colored Paints—Apr. 2-6; Advanced Coatings Workshop—Apr. 23-27. (Norma Fleming, Extension Div., University of Missouri—Rolla, 501 W. 11th St., Rolla, Mo. 65401).

(Mar. 27-29)—1979 Industrial Pollution Conference. Philadelphia, Pa. (Alan Krigman, ICON Inc., 211 S. 45th St., Philadelphia, Pa. 19104).

(Mar. 28)—Annual Symposium of North Central Section of American Oil Chemists' Society. North Shore Hilton, Skokie, Ill. (George Willhite, American Oil Chemists' Society, 508 S. Sixth St., Champaign, Il. 61820).

(Mar. 29-30)—International Conference on Spectroscopy. Konover Hotel, Miami Beach, Fla. (V.M. Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ont. K6H 5V7, Canada).

(Mar. 29-30)—"Control of Volatile Organic Compound Emissions," sponsored by the U.S. Environmental Protection Agency, National Paint and Coatings Association, Association of Finishing Processors of the Society of Manufacturing Engineers, and Air Pollution Control Association. Stouffer's Valley Forge Hotel, Valley Forge, Pa. (Mr. Michael R. Taylor, JACA Corp., 550 Pinetown Rd., Fort Washington, Pa. 19034).

(Apr. 1-6)—Pacific Chemical Conference: 1979. Honolulu, Hawaii. (A.T. Winstead, ACS, 1155 - 16th St., N.W., Washington, D.C. 20036).

(Apr. 2-6)—Div. of Organic Coatings and Plastics Chemistry Symposiums and Spring American Chemical Society Meeting. Hyatt Regency-Waikiki Hotel, Hawaii. (American Chemical Society, 1155 16th St., N.W. Washington, D.C. 20036).

(Apr. 3-6)—OCCA-31. Oil and Colour Chemists' Association 31st Annual Technical Exhibition. Alexandra Palace, London, England. (The Director & Secretary, Oil and Colour Chemists' Association, Priory House, 967 Harrow Rd., Wembley, Middlesex, HAO 2SF, England).

(Apr. 4-5)—NPCA Marine Coatings Conference. Omni International Hotel, Norfolk, Va. (Georgene Savickas, National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington.

(Apr. 9-10)—Washington Paint Technical Group 19th Annual Symposium, "Uncle Sam Wants Your Paint—$100 Million Opportunity. Marriott Twin Bridges Motel, Washington, D.C. (WPTG, Box 12025, Washington, D.C. 20005).

(Apr. 19-20)—Second Canadian Chromatography Conference. Hampton Court Hotel, Toronto, Canada. (V.M. Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ont. K6H 5V7, Canada).

(Apr. 20-21)—National Paint and Coatings Association. Production Planning and Inventory Management Seminar, Part I—Fundamentals. Stouffer's Inn On The Square, Cleveland, Ohio. (Everett Call, NPCA, Rhode Island Ave., N.W., Washington, D.C., 20005).

(Apr. 23-24)—Inter-Society Color Council. Annual meeting. Roosevelt Hotel, New York, N.Y.

(Apr. 23-27)—Institute of Applied Technology, Training Course, "Marine Coating Procedures." Pascagoula, Miss. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(Apr. 25-26)—Chemical Institute of Canada, Protective Coatings Div., Spring Symposium, "Coating for Corrosion Control." Apr. 25, 26 at Montreal and Toronto, respectively. (Ken Alcock, Canadian Industries Ltd., P.O. Box 10, Station A, Montreal, Quebec, Canada H3C2R3).

(Apr. 25-26)—"Control of Volatile Organic Compound Emissions," sponsored by the U.S. Environmental Protection Agency, National Paint and Coatings Association, Association of Finishing Processors of the Society of Manufacturing Engineers, and Air Pollution Control Association. Holiday Inn Chicago City Centre, Chicago, Ill. (Mr. Michael R. Taylor, JACA Corp., 550 Pinetown Rd., Fort Washington, Pa. 19034).

(Apr. 25-May 3)—70th Annual Meeting of the American Oil Chemists' Society. Fairmont Hotel, San Francisco, Calif.

(Apr. 29-May 2)—National Coil Coaters Association Annual Meeting. Marco Beach Hotel and Villas, Marco Island, Fla. (Don White, National Coil Coaters Association, 1900 Arch St., Philadelphia, Pa. 19103).

(Apr. 29-May 3)—70th Annual Meeting, American Oil Chemists' Society. Fairmount Hotel, San Francisco, Calif. (James Lyon, Executive Director, American Oil Chemists' Society, 508 S. Sixth St., Champaign, Il. 61820).

(May 3-4)—International Symposium on "Flammability and Fire Retardants." Opryland Hotel, Nashville, Tenn. (V.M. Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ont. K6H 5V7, Canada).

(May 7-10)—Society of Plastics Engineers, 37th Annual Technical Conference, "Plastics—Efficient Use of Resources." Hyatt Regency Hotel, New Orleans, La. (SPE, Eugene E. Wilson, 656 W. Putnam Ave., Greenwich, Conn. 06830).

(May 10-11)—"Control of Volatile Organic Compound Emissions," sponsored by the U.S. Environmental Protection Agency, National Paint and Coatings Association, Association of Finishing Processors of the Society of Manufacturing Engineers, and Air Pollution Control Association. New Otani Hotel, Los Angeles, Calif. (Mr. Michael R. Taylor, JACA Corp., 550 Pinetown Rd., Fort Washington, Pa. 19034).

(May 11-12)—National Paint and Coatings Association.

Production Planning and Inventory Management Seminar, Part II—Advanced. Stouffer's Inn On The Square, Cleveland, Ohio. (Everett Call, NPCA, Rhode Island Ave., N.W., Washington, D.C. 20005).

(May 14-18)—Institute of Applied Technology, Training Course, "Nuclear Quality-Assured Coating Work." Jackson, Mich. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(May 15-17)—Powder and Bulk Solids Conference and Exhibition. The Civic Center, Philadelphia, Pa. (Industrial & Scientific Conference Management, Inc., 222 W. Adams St., Chicago, Ill. 60606).

(May 19-27)—GEC '79, International Exhibition of the Printing, Publishing, Paper and Paper Processing Industries, sponsored by Italian Association of Printing and Converting Machinery Manufucturers. International Fair Grounds, Milan, Italy. (Sim Robbins, U.S. and Canadian Representative, National Expositions Co., Inc., 14 W. 40th St., New York, N.Y. 10018).

(May 21-25)—"Colloids and Surfaces." Carnegie-Mellon University. (Margaret Morrison, Course Coordinator, Post College Professional Education, Carnegie Institute of Technology, Carnegie-Mellon University, Schenley Park, Pittsburgh, Pa. 15213).

(May 21-25)—Polymer Conference Series, "Understanding Polymer Science: Preparation, Properties, and Applications." State University of New York—New Paltz. (Dr. A.V. Patsis, Dept. of Chemistry, SUNY, New Paltz, N.Y. 12562).

(May 22-23)—Institute of Applied Technology, Mini Course, "Coating Inspection: Instruments and Practices." Washington, D.C. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(June 4-8)—Tenth Annual Short Course, "Advances in Emulsion Polymerization and Latex Technology." Lehigh University, Bethlehem, Pa. (Dr. Mohamed S. El-Aasser, Dept. of Chemical Engineering, Whitaker Lab. #5, Lehigh University, Bethlehem, Pa. 18015).

(June 4-8)—Polymer Conference Series, "Advances in Polymer Synthesis, Modification, and Characterization." State University of New York—New Paltz. (Dr. A.V. Patsis, Dept. of Chemistry, SUNY, New Paltz, N.Y. 12562).

(June 8-13, 1980)—XVth Congress of FATIPEC. RAI Congress Centre, Amsterdam, Netherlands. "Activities of the Coatings Industry in the Framework of Ecology, Energy, and Economy Problems." (Congress Secretary is C. Kork, Oostenrijklaan 43, Haarlem, Netherlands).

(June 10-13)—American Oil Chemists' Society short course on "Industrial Fatty Acids." Tamiment Resort, Tamiment, Pa. (James Lyon, Executive Director, American Oil Chemists' Society, 508 S. Sixth St., Champaign, Ill. 61820).

(June 10-13)—ASTM Committee D-1 on Paints and Related Coatings and Materials, Shoreham Hotel, Washington, D.C. (J.H. Bystrom, ASTM, 1916 Race St., Philadelphia, Pa. 19103.)

(June 10-13)—Industrial Fatty Acids Short Course sponsored by the American Oil Chemists' Society. Tamiment Resort and Country Club, Pocono Mountain Region, Pa. (Fatty Acids Short Course, American Oil Chemists' Society, 508 S. Sixth St., Champaign, Ill. 61820.

(June 11-13)—Fourth Annual Atomic Absorption Short Course. Occidental College, Los Angeles, Calif. (C.D. West, Dept. of Chemistry, Occidental College, Los Angeles, Calif. 90041).

(June 11-15)—Institute of Applied Technology, Training Course, "Painting and Coating for Industry." Houston, Tex. (Institute for Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(June 11-15)—Polymer Conference Series, "Polymers in Electronic Applications: Photopolymers, Photoconductors, Conductors, and Insulators." State University of New York—New Paltz. (Dr. A.V. Patsis, Dept. of Chemistry, SUNY, New Paltz, N.Y. 12562).

(June 14-15)—Society of Plastics Engineers, European Sections RETEC, "Lastest Improvements in the Development and Processing of Polyolefins." Ghent, Belgium, (Jacques de Craene, RIGI p.v.b.a. Noorderlaan 98/36 2030-Antwerpen-Belgium).

(June 17-20)—Dry Colors Manufacturers Association, Annual Meeting. The Greenbrier, White Sulpher Springs, W. Va. (J.L. Robinson, DCMA, Suite 100, 1117 N. 19th St., Arlington, Va. 22209).

(June 18-20)—Fourth Annual Liquid Chromatography Short Course. Occidental College, Los Angeles, Calif. (C.D. West, Dept. of Chemistry, Occidental College, Los Angles, Calif. 90041).

(June 18-22)—Polymer Conference Series, "Advances in the Stabilization and Controlled Degradation of Polymers." State University of New York—New Paltz, (Dr. A.V. Patsis, Dept. of Chemistry, SUNY, New Paltz, N.Y. 12562).

(June 19-20)—Society of Plastics Engineers. "Thermoset Processes for Wire and Cable Insulation." Brook Motor Hotel, Oak Brook, Ill. (John Haarsma, U.S. Gypsum Co., 1000 E. Northwest Hwy., Des Plaines, Ill. 60016).

(June 20-23)—Oil and Colour Chemists' Association Conference, "The Challenge to Coatings in a Changing World." Stratford Hilton Hotel, Stratford-on-Avon, England. (The Director and Secretary, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex HAO 2SF, England).

Coming Events (Continued)

(June 24-29)—Air Pollution Control Association 72nd Annual Meeting and Exhibition, Cincinnati Convention-Exposition Center, Cincinnati, Ohio. (Public Relations Dept., Air Pollution Control Association, P.O. Box 2861, Pittsburgh, Pa. 15230).

(June 25-26)—European Conference on Paints and Coatings, "Eurocoatings-79." Excelsior Hotel, Rome, Italy. (V.M. Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ont. K6H 5V7, Canada).

(June 25-29)—Polymer Conference Series, "Understanding and Assessing Paper and Fibrous Structures." State University of New York—New Paltz. (Dr. A.V. Patsis, Dept. of Chemistry, SUNY, New Paltz, N.Y. 12562).

(June 28-29)—3rd European Conference on "Flammability and Fire Retardants." Excelsior Hotel, Rome, Italy. (V.M. Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwal, Ont. K6H 5V7, Canada).

(July 2-3)—World Spectroscopy Conference. Sheraton Hotel, Lisbon, Portugal. (V.M. Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ont. K6H 5V7, Canada).

(July 5-6)—World Chromatography Conference. Sheraton Hotel, Lisbon, Portugal. (V.M. Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ont., K6H 5V7, Canada).

(July 16-20)—International Conference in Organic Coatings sponsored by the State University of New York and Greek Professional Societies. Athens, Greece. (Dr. A.V. Patsis, Conference Director, State University of New York at New Paltz, CSB 209, New Paltz, N.Y. 12562).

(July 17-20)—"Fifth Annual International Conference in Organic Coatings Science and Technology," Athens, Greece. (Angelos V. Patsis Institute in Science & Technology, State University of New York, College at New Paltz, Department of Chemistry, New Paltz, N.Y. 12562).

(Aug. 30-31)—Japan Conference on Polymers and Plastics Palace Hotel, Tokyo, Japan. (Vijay Mohan Bhatnagar, Alena Enterprises of Canada, P.O. Box 1779, Cornwall, Ontario K6H 5V7, Canada).

(Sept. 11-12)—Institute of Applied Technology, Mini Course, "Coating Inspection: Instruments and Practices." St. Louis, Mo. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(Sept. 18-22)—13th National Congress of the F.A.T.P.V. and 7th International Exhibit of Paints and Varnishes, Casino of La Baule, Brittany. (IDEXPO-21, Avenue de la Division Leclerc 94230, Cachan, France).

(Sept. 23-26)—67th CPMA Convention, sponsored by the Ontario Paint Association. Harbour Castle, Toronto, Ont. Canada. (R.E. Green, 1666 Aimco Blvd., Mississauga, Ont. L4W 1V4 Canada).

(Sept. 24-28)—Institute of Applied Technology, Training Course, "Painting and Coating for Industry." Honolulu, Hawaii. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

(Sept. 24-28)—"Colloids and Surfaces." Carnegie-Mellon University. (Margaret Morrison, Course Coordinator, Post College Professional Education, Carnegie Institute of Technology, Carnegie-Mellon University, Schenley Park, Pittsburgh, Pa. 15213).

(Sept. 30-Oct. 2)—National Coil Coaters Association Fall Technical Meeting. Hyatt Regency O'Hare Hotel, Chicago, Ill. (Don White, National Coil Coaters Association, 1900 Arch St., Philadelphia, Pa. 19103).

(Oct. 10-12)—Society of Plastics Engineers. "Photopolymers: Principles, Processes, and Materials." Nevele Country Club, Ellenville, N.Y. (Maung S. Htoo, IBM Corp., Dept. C30701-1, Poughkeepsie, N.Y. 12602).

(Oct. 15-17)—9th Congress of the Federation of Scandanavian Paint and Varnish Technologists. Stockholm, Sweden.

(Oct. 15-18)—Converting Machinery/Materials Conference & Exposition, Philadelphia Civic Center, Phila., Pa. (Sim Robbins, Exhibit Manager, National Expositions Co., Inc., 14 W. 40th St., New York, N.Y. 10018).

(Oct. 15-19)—Institute of Applied Technology, Training Course, "Marine Coating Procedures." Phila., Pa. (Institute of Applied Technology, Suite 600, 1776 K St., N.W., Washington, D.C. 20006).

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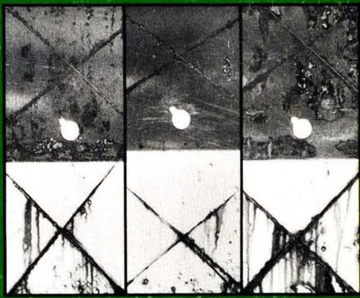

Comparison of Busan® 11-M1 (middle) with zinc phospho oxide (left) and calcium borosilicate (right) in latex emulsion primer. Each primer topcoated with two coats of latex emulsion paint without inhibitor. Panels exposed 200 hours in salt fog cabinet. Panels shown before and after paint was removed.

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