Chemical Microscopy

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MICROSCOPICAL instrumentation and techniques developed in response to the needs of a specific science, or for study of specific materials, can often be adapted with little or no modification to the requirements of another science, or for study of different materials. This fact, coupled with the ubiquitous nature of the microscope, results in a wide scattering throughout the scientific literature of information of possible use to analysts. Regrettably, it has not been possible exhaustively to survey the available literature for items of analytical interest. The references on which the following review is based are for the most part from sources familiar to analytical chemists.

The previous review of the series (*43*) ended with October 1959. The present review covers the two years from that date through October 1961. A few important papers of earlier publication date, missed or unavailable for mention in the previous review, are also included.

SYMPOSIA AND REVIEWS

The ACS sponsored symposium on "Microscopical Scientists: Their Education, Employment, Activities, and Microscopes," held at the Boston meeting in April 1959, and mentioned in the previous review (*43*), is now reported in detail in a two-part article (*3, 4*). The program of the International Symposium on Microchemical Techniques, held at University Park, Pa., in August 1961 (*78*) included several papers on microscopical techniques. These will be available in the "Proceedings, 1961–International Symposium on Microchemical Techniques" which will appear sometime in 1962 as Symposium Volume II of the *Microchemical Journal*. The "Proceedings of the International Symposium on Microchemistry," published in 1960, contains papers given at the Symposium held in Birmingham, England in August 1958. Among them is one in which West (*163*) outlines applications of microscopy to chemical problems and discusses the advantages microscopical techniques sometimes offer for analysis.

The eighth in the series of Chicago symposia on microscopy, sponsored by McCrone Associates (now McCrone Research Institute, Inc.) occupied three days of meetings in June 1960. The large number of short papers presented will be published by Interscience Publishers in book form as the "Symposium Proceedings."

The Royal Microscopical Society joined with the Electron Microscope Group of the Institute of Physics to present a symposium at the University of Leeds in the Spring of 1960 on "The Co-ordination of Light and Electron Microscopy" (*39*). The eight invited papers, all dealing with the advantages of a combined attack on problems with both light and electron microscopy, are published in the October 1960 issue of the *Journal of the Royal Microscopical Society*.

Abstracts of papers given at the fourth meeting of the Polymer and Fiber Microscopy Society, in May 1961, are published in the *Journal of Applied Polymer Science* (*125*). The Royal Microscopical Society sponsored a symposium on applications of interference microscopy, in March 1961, in London (*7*). One interesting application, reported by Goldstaub, uses the interference microscope to study concentration gradients surrounding particles of ion exchange resin immersed in salt solutions, and similar gradient surrounding crystals in their mother liquor.

A brief history of the development and applications of warm and hot stages, as used with microscopes, is the subject of a review by Schmidt (*138*). Gugel and Czedik-Eysenberg (*66*) have reviewed the current status and uses of hot stage microscopes. A review covering various aspects of ultramicrochemistry, including a history of the uses of microscopes and micromanipulators, is given by Gillis (*61*). Methods for measuring the optical constants of crystals have been reviewed (*26*).

BOOKS

The "Encyclopedia of Microscopy" edited by Clark (*33*) is a heterogeneous collection of 140 specialized articles, some authoritative and substantial in content, some disappointingly brief. The useful information contained in the volume is difficult to locate when needed because there is no index. The book has been reviewed (*8, 133*). New editions of the Encyclopaedia Britannica and Encyclopedia Americana contain rewritten articles on "Microscope" (*41, 79*) and "Microscopy" (*42, 129*) which may be consulted for general information. Several articles in the "McGraw-Hill Encyclopedia of Science and Technology" are devoted to microscopy and its applications (*12, 106*). The 3rd edition of Volume I of the "Technique of Organic Chemistry" series contains Jelley's chapter (*80*) on "Light Microscopy," which remains essentially as in the previous edition, with few changes or additions. Two chapters in the book edited by Meredith and Hearle deal with applications of microscopy to textile fiber research and analysis (*6, 55*). Françon (*57*) has discussed some recent developments in microscopy.

Revisions of the well-known texts by Hartshorne and Stuart (*73*) and by Wahlstrom (*159*), and a new book by Bloss (*17*), treat optical crystallography and the analytical uses of the polarizing microscope. The Hartshorne and Stuart book, reviewed (*40, 54*), and Wahlstrom's book, reviewed (*128*), remain practical in approach and are useful reference sources as well as texts. The Bloss book is primarily an introduction to the subject of crystal identification with the polarizing microscope. A translation of Shubnikov's admirable text on theoretical crystallography is now available (*143*), and has been reviewed (*147*). Bunn has revised his "Chemical Crystallography" (*27*). A systematized compilation of optical data for the identification of inorganic substances with the polarizing microscope has been prepared by Kordes (*92*) and has been reviewed (*74, 75*).

The profusely illustrated book by Lawson (*100*) is a modern and concise treatment of almost all aspects of photomicrography. It has been reviewed (*110*). Birchon (*15*) has produced a practical book of instruction in the techniques of microscopy. A work on interference microscopy is available (*94*). Gurr's "Encyclopedia of Microscopic Stains" (*67*), primarily for histologists, contains tabulated data on a large number of dyes, and may be of interest to microscopists who use stains on other than histological specimens.

The microscopical properties of sedimentary rocks and the use of these

properties for recognition and interpretation are detailed in the book by Carozzi (*31*) which has been reviewed (*160, 161*). Multiple-beam interferometry, as practiced by Tolansky and his students, and cogent arguments for the general use of the method in the study of surfaces, are presented in Tolansky's book (*155*). His techniques constitute a kind of three-dimensional light microscopy capable of great magnification and resolution. The book has been reviewed (*60*).

Manuals of interest to analysts concerned with feeding stuffs (*2*), and with analytical methods in food and drug microscopy (*69*) are available.

INSTRUMENTS AND ACCESSORIES

Lens systems on the "zoom" principle, providing for continuously variable magnification, have been applied to Greenough-type stereoscopic (*10*) and laboratory compound (*11*) microscopes. The firm of Carl Zeiss, Inc., has calculated glycerol immersion objectives corrected for all spectral wavelengths from 2400 A. in the ultraviolet to 7000 A. in the visible (*30*). Image-splitting by optical means, first used in the heliometer, an instrument for making precise astronomical measurements, has been applied to the microscope by both Dyson (*50, 51*) and Barer (*6*). Both designs are modifications of a Mach-Zehnder interferometer. Barer's instrument replaces the microscope body tube; Dyson's is substituted for the eyepiece. Both instruments are capable of much greater precision than is possible with graticules or a filar micrometer. Measurements smaller than the resolving power of the microscope by a factor of 10 are readily made, even on specimens in motion.

Norris *et al.* (*117*) have published a design for a photomicrographic instrument with interchangeable components, for macro and micro work, which can double as a precision enlarger for film strip transparencies. A late model of the Casella automatic particle counter and sizer, with five amplitude discrimination channels and newly designed illuminating system and reciprocating microscope stage, has been evaluated in detail for general performance and reproducibility of sizing data (*114*). Rapid counting of "reasonably opaque particles" suspended in a low viscosity liquid is achieved by photoelectric detection as the particles move by axial flow in a glass capillary tube across the field of view (*38*). Signals from the photocell are amplified and fed to a counter.

Hartley (*71*) has reviewed the status of the water-immersion objective—its former position of high repute, its inherent limitations, and the objections to its use that were responsible for its decline. It is his conviction that the objective deserves a place in modern microscopy. A note by Needham (*115*) refutes the arguments advanced by Hartley for revival of the water-immersion objective. A microscope objective of N.A. 0.65, essentially free of field curvature, a defect common to most objectives of this type, has been computed by Wynne (*165*). An apertometer for measuring numerical aperture of microscope objectives more accurately than can be done with the Abbe or Beck designs is described (*151*). A brief history of microscopes using aspheric reflecting optics, with a forecast of future possibilities for these instruments, is given by Burch (*28*).

Descriptions of hot stages incorporating design features for greater accuracy of temperature recording, or for special applications, continue to appear in the literature, attesting to the popularity of high temperature microscopy. Better accuracy in determining melting points of crystalline polymers was attained by covering a Kofler stage with a second electrically heated block similar in construction to the original (*91*). A metallographic stage in which the specimen is heated by its own electrical resistance, thus eliminating an external heating element, has provision for rapid gas quenching of the specimen, and a top operating temperature of about 1200° C. (*150*). A stage for studying the supercooling of tiny droplets of metals and alloys has been described by Sundquist (*153*). Lott (*104*) describes a simple hot stage fashioned from a carbon block. Temperature effects on selected individual mineral grains may be observed microscopically as they are heated by a microcoil (*87*). An apparatus for studying thermal behavior of crystalline materials uses a beam-splitter above a polarizing microscope for simultaneous visual observation and photometric recording (*130*).

A brief review of single crystal rotating devices for use with the polarizing microscope is given by Wilcox (*164*). He describes the construction of one such device—a spindle stage—and discusses its performance in orthoscopic and conoscopic studies of crystal optical properties. A similar apparatus, designed for the study of transparent whiskers, is described by Edwards (*53*). Clark and Clarke (*34*) have designed and built a 3-axis plastic universal stage, using Perspex. Hanson (*68*) has constructed a simple goniometer for use with a stereomicroscope. In use, a crystal face is illuminated through one eyepiece of the microscope and its reflection viewed through the other. A brief description of the Benford substage mica plate, an aid in the study of interference figures, is given by Craig (*44*).

Mixtures of perfluorotributylamine and polymers of chlorotrifluoroethylene have been proposed as low refractive index immersion oils, spanning the range 1.292 to 1.411 (*162*). Aroclor resin is suggested as a high refractive index mounting medium (*102*). Lambeck (*98*) lists nontoxic oils for refractive index determinations by the immersion method and describes an air heated microscope stage. Nonfluorescing immersion fluids, for use in ultraviolet fluorescence microscopy, are composed of solutions of sublimated naphthalene or of thymol in dimethyl phthalate (*97*). Immersion liquids suitable for crystal measurements at low temperatures (to −100° C.) have been proposed (*18*).

The construction of microring dishes in which crystallization studies are carried out under the microscope is described by Monkman (*113*). Gamble (*59*) has designed a small reservoir with an observation chamber for making microscopical observations of reactants mixed under controlled conditions. The entire surfaces of cylindrical fibers are replicated by a rolling technique (*111*). Apparatus for producing the replicas is described. Using an optical wedge made from two microscope slides, Nishijima and Oster (*116*) constructed a microdiffusion apparatus with which they follow diffusion processes in liquids by noting and measuring interference fringes produced by refractive index gradients.

A variable phase contrast system of considerable flexibility has been devised by Meyer-Arendt (*109*). A beam-splitter is used to obtain a wide separation of deviated and undeviated rays, permitting independent insertion of phase-shifting or absorbing elements into the two optical paths. Modification of the AO Baker interference microscope permits measurements of differences in transmittance between object and surround, when the object is an absorber (*89*), without affecting the instrument's ability to make the usual measurements of differences in optical path. A simple interference microscope for use with reflected light is described by Schulz (*140*).

THEORY

Norris (*118*) made a detailed study of commercially available microscope cover glasses and found that only a very small percentage of those examined satisfied the specifications set up by the Royal Microscopical Society. He discusses the nature of the imperfections and variations in properties, and their import for critical microscopy. Spinell and Loveland (*152*) also investigated the deterioration of images formed by various microscope objectives when used with cover glasses or immersion fluids of incorrect properties. Most objectives are designed for use with a cover glass of specified thickness and refractive index. Departure from the

specifications results in serious loss of image quality, particularly with high numerical aperture objectives. The use of immersion oil of improper refractive index, when observing with an immersion objective, engenders a similar loss of image quality. The authors found that adjustment of microscope tube length compensates for improper object space properties and restores image quality.

A theoretical and experimental study (*65*) has demonstrated the effect of depth on phase relations in a phase contrast microscope, in a specimen of finite thickness which is not in focus throughout its thickness. Osterberg and Smith (*120*) conducted a series of experiments to show the effect on contrast in ordinary microscopy of various combinations of condenser and objective numerical aperture. They interpret their experimental findings and establish qualitative agreement with theory. Theoretical studies by the same authors (*119*) are concerned with image formation by a microscope adjusted for Köhler illumination. Osterberg and Smith (*121*) have also reported a study which demonstrates how lateral resolution can be significantly increased by observing at selected out-of-focus image planes. Kubota and Saito (*95*) studied the diffraction images produced in a polarizing microscope with crossed polars.

ANALYSIS

For purposes of description, qualitative analytical methods employing the microscope are conveniently grouped into two principal categories. In the first, identification is made by recognition of morphological structures previously seen; in the second, by determination of physical constants previously recorded. In practice, the distinction is often obscure.

A system for identification of coniferous woods is outlined by Kukachka (*96*). Diagnostic data applicable to either wood pieces or pulped fibers are presented in a form suitable for entering on punch cards. Observations reported in a brief communication by Kallmes and Newman (*81*) are alleged to be the first of intact outer secondary wall of coniferous fibers. The microscope has been used to observe the effectiveness of dry cleaning on synthetically soiled fibers of various kinds (*112*). Harris (*70*) has devised a technique for replicating nonvolatile droplets, for observation by either light or electron microscopy. A method for isolating air-borne radioactive particles from a mixture of active and inactive dust, after which the active particles can be more conveniently identified and studied, is described by Sisefsky (*145*). In a later paper (*146*) he illustrates the use of the method for detection of air-borne debris from nuclear weapon tests. Tufts (*158*) describes a technique for estimating air-borne particulate fluorides and distinguishing them from phosphates and sulfates. Sheinbaum (*141*) has evaluated the phase contrast microscope for dust counting and particle size analysis. Phase contrast microscopy has been used to identify 11 types of asbestos (*137*).

Microscopy has been employed to gain an insight into the meaning of dislocation patterns produced on cleavage surfaces of MgO crystals by a diamond indentor (*83*). The electroluminescent emission spots and nonluminescent segregations of copper sulfide in ZnS:Cu phosphor particles have been observed microscopically (*101*). The particles were excited to luminescence in an electric field applied through electrodes of evaporated aluminum on a slide mount. Electroluminescent brightness of single phosphor particles, as affected by factors in production or treatment of the phosphors, has been studied microscopically, using neutral density step filters for making brightness comparisons (*93*).

Powers (*126*) has studied growth and solution of sucrose crystals in a solution kept slightly subsaturated or slightly supersaturated by temperature variation. Giuffria (*63*) studied the low molecular weight fraction that can be solvent-extracted from Mylar polyester film and subsequently crystallized. A procedure for preparing dried samples of triple superphosphate for thin sectioning by impregnating with a mixture of styrene and polyester resin and polymerizing with methyl ethyl ketone peroxide catalyst, is discussed by Bristow and Hardesty (*25*). Crystalline high explosives have been differentiated by a staining technique, using dimethylaniline (*166*). Traylor (*157*) has applied phase contrast microscopy to the study of thin sections of polystyrene-type polymers.

Using a Kofler hot stage fitted with a sublimation block, Petrucci and Weygandt (*124*) succeeded in detecting as little as a few hundredths to a few thousandths of 1% impurity in organic solids. The temperature at which droplets of liquid condensate appear indicates the temperature of eutectic sublimation, which is related to amount of impurity. A significant paper by Alimarin and Petrikova (*1*) discusses problems peculiar to ultramicroanalysis and points of technique which need special consideration when manipulating minute amounts of sample or reactants. Micromanipulative techniques were developed for chemical experimentation on a microscope stage. These included electrolysis with platinum and mercury electrodes, and potentiometric and amperometric titration. Cheronis (*32*) has given an interesting discussion of what constitutes proof of identification of organic compounds. Under microscopical methods of identification he lists three procedures: reactions under the microscope, crystallographic properties, and fusion techniques. The proofs customarily used for detection of the active principles in marihuana are presented by way of illustration.

Five parts in the "Organic Chemical Microscopy" series by Dunbar and coworkers have appeared since those mentioned in the last review (*43*). All five are concerned with preparation of crystalline derivatives of various organic compounds. Crystal habits of the prepared derivatives are illustrated in photomicrographs, and in some instances, certain optical properties are given. Part VI (*49*) reports conversion of 34 organic acids, mostly carboxylic, to *p*-toluidides and amides. Parts VII (*46*) and VIII (*47*) are concerned with conversion of amino acids and amines, respectively, to their dibenzofuran-2-sulfonates. In Part IX (*45*) preparation of amide derivatives of certain organic acids, anhydrides, and acid chlorides is described. Part X (*48*) proposes dibenzofuran-2-sulfonic acid as a general purpose reagent for preparation of derivatives of cations. Characteristic derivatives prepared from soluble salts of 29 different metals, some in different valence states, are illustrated in photomicrographs.

Microscopical tests for sulfur-containing anions, which form crystals with Pt tetrathiourea chloride (*144*), and for zinc with 3-ethyl-2-methyl-4,5-benzobenzothiazole tosylate (*5*) are described. Quantitative mineralogical analyses of rocks can furnish data from which a chemical analysis (elemental) can be calculated (*58*). The calculated analysis, from modal analyses of petrographic thin sections, is in good agreement with analyses made by chemical methods, at least for rocks such as granite, whose constituent minerals are easily identified by optical means.

Identification of crystalline substances by their optical crystallographic properties, as determined with the polarizing microscope, is rapid and requires only very small amounts of material. Its effectiveness as an analytical method depends, like that of all instrumental methods which determine physical constants, on availability of usable data from determinations on known substances.

Optical crystallographic properties of 11 antihistaminic compounds have been published by Shell, Witt, and Poe (*142*). As the authors remind us, the data are valid for only one polymorph of each compound, therefore it is essential that conditions of crystallization, including the solvent used, be precisely specified. Since most, if not all, organic solids exist in more than one crystalline form, this is an important consideration

whenever optical crystallographic data are offered as properties useful for identification. Biles (*14*) has reported optical crystallographic properties of 17 water-insoluble glucocorticoids. He points out how this type of data is of value not only for identification, but also for use in conjunction with x-ray diffraction data for illucidation of molecular orientation.

Bishop and Marshall (*16*) have used the optical crystallographic properties of members of the homologous series of α,ω-dimethanesulfonoxyalkanes to examine the anomalous physical properties of the member with four methylene groups. They found a strict correlation between chemical and optical properties in members containing seven or more methylene groups, but no simple relationship in members with six or less methylene groups. They suggest that optical and crystallographic properties are controlled by the number of methylene groups (n) when $n \geq 7$, but that the relatively large methanesulfonoxy end groups are influential when $n \leq 6$. Clarke (*35*, *36*) has given crystal and color tests for 51 analgesic and 48 atropine-like drugs.

Two papers by Otani (*122*, *123*) are concerned with crystal habit modification of strontium sulfate by various substances, and with the peculiar effect of triphosphate ion on strontium sulfate crystallization. Growth of crystals from aqueous solutions of alcohols, cooled to liquid nitrogen temperature, was studied by Yamaji (*167*). Tomopulos (*156*) has published studies, made with the polarizing microscope, on the mesomorphic state in some organic compounds.

Cameron and coworkers (*29*) have published optical rotation data on 82 anisotropic ore minerals. This is part of an extensive investigation to ascertain the value, for identification purposes, of the rotation properties of ore minerals in reflected polarized light. Gray and Millman (*64*) have plotted per cent reflectivity against wavelength of incident polarized light for oriented crystals of a number of anisotropic opaque ore minerals.

Crystallization phenomena in high polymers are studied with profit by polarizing microscope techniques.

Magill (*107*) used a photomultiplier-recorder system to measure the intensity of depolarized light transmitted by isotactic polypropylene as it crystallized isothermally from a melt on a hot stage fitted on a polarizing microscope. A similar apparatus has been put together by Hock and Arbogast (*77*) for recording changes in brightness between crossed polars. They used the equipment to record melting points of crystalline polymers, by noting the disappearance of birefringence, and to determine crystallization rates of polymers.

Spherulitic crystallization in high polymers has received attention from numerous investigators, most of whom have made the polarizing microscope a major tool. Keller (*86*) has summarized his work on banded spherulites in a polyester, polytrimethylene glutarate, and a nonpolymer, resorcinol containing a few per cent of D-tartaric acid. His observations support the twisted crystal model of spherulitic structure and enable him to reconcile conflicting views put forth by other investigators in this field. A theoretical treatment of extinction patterns shown by biaxial arrays in high polymer spherulites is given by Keith and Padden (*84*). The idealized models used for their calculations are shown to be valid by a series of experiments with the polarizing microscope on a number of different polymers (*85*). The extinction patterns of uniaxial arrays in high polymer spherulites have received theoretical treatment by Price (*127*). Lindegren (*103*) found spherulites in nylon 610 and nylon 66 of both positive and negative optic sign. Hellwege and Hoff (*76*) have made polarizing microscope studies of polyethylene spherulites.

Hippuric acid spherulites were shown by Hartshorne (*72*) to have extinction effects similar to those demonstrated in high polymer spherulites. Spherulites of the enzyme, carboxypeptidase, exhibit characteristics similar to spherulites in other natural and synthetic high polymers (*37*). Cracking of spherulitic structures in polypropylene film during oxidative aging at elevated temperatures has been observed (*139*).

Smith (*148*, *149*) has revised and extended his series of papers on identification of synthetic textile fibers to include a discussion of micro fusion techniques and diagnostic data on the newer fibers. Microscopical methods are included in the fiber identification scheme proposed by Merkel (*108*). A method for differentiating and classifying certain synthetic fibers is presented by Ebert (*52*).

A staining method using an acid and a basic dye has been developed for differentiating skin and core in nylon 6 and nylon 66 fibers (*13*). Triphenyl tetrazolium chloride is used as a stain for distinguishing between skin and core in rayon fibers (*154*). A stain specific for acrylic fibers, which is also useful for detecting the presence of acrylonitrile polymer on other fibers, has been described (*82*). Physical and chemical damage to rayon fibers is detected with a staining technique (*56*).

Mixtures of methylmethacrylic acid ester and polyethylene glycol, polymerized with benzoyl peroxide catalyst, are suggested by Kirchberg (*88*) for embedding textile fibers prior to thin sectioning. By varying the ingredient proportions, hardness of the matrix can be matched to that of the fiber. Braun and Monshausen (*24*) have surveyed the methods used for embedding hard textile materials and proposed a method of their own, using Versamid 950.

Ritter and Reumuth (*134–136*) have published a three-part, detailed study of the wool fiber, with particular attention to bilateral structure. An informative series on textile microscopy—its historical development and its application to research in the textile industry—is being written by Reumuth (*131*, *132*). Botty, Felton, and Anderson (*19*) have described a procedure for the evaluation of experimental textile fibers which makes use of light microscope techniques in conjunction with electron microscopy and microradiography.

The suitability of quinones as subclassification reagents in mixed fusion analysis, for further classifying compounds which do not form addition compounds with 2,4,7-trinitrofluorenone, was investigated by Laskowski (*99*). He tested addition compound forming tendencies between each of nine nonhalogenated quinones and 30 aromatic hydrocarbons and concluded that quinones would make satisfactory reagents for subclassification in microscopical mixed fusion analysis studies.

McCrone (*105*) has reported his work, done during World War II, in developing a microscopical fusion method for rapid identification of high explosives. Members of a group of 27 high explosives, all crystalline solids, were readily differentiated by their crystallization behavior and crystal habit when recrystallized from solution in molten thymol. Microscopical fusion analysis has been assessed by Gilpin (*62*) for use in the pulp and paper industry. He observed fusion and mixed fusion (with thymol) behavior in a series of selected organic compounds.

Brandstätter-Kuhnert and coworkers give optical and crystallographic data, including melting points and eutectic temperatures, for the characterization and identification of 73 drugs (*21*, *22*) and for 16 natural sex hormones and related synthetic compounds (*21*). They also studied ternary mixtures of carbromal-phenacetin-salicyamide and phenazone-phenacetin-phenobarbitone (*23*). Kofler (*90*) has tabulated optical and thermal data for crystal polymorphs of several organic compounds.

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Review of Fundamental Developments in Analysis

Electron Microscopy

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THIS REVIEW covers the period from 1960 to 1962. During this time, manufacturers of electron microscopes have continued to simplify the operation and maintenance of these inherently complicated instruments. The advantages to the research scientist are manifold; more time can be spent developing techniques for examining materials that have previously defied preparation; a wider range of research personnel can participate more directly in the actual micrography of their samples; and more extensive research efforts can be directed toward the examination of basic structures and properties of matter. These have the additive effect of promoting the more versatile use of the instrument and, most important of all, of bringing about more productive communication among the members of the research team. The result is a better understanding for solving complex problems and a more effective utilization of the abilities of the specializing microscopist. That this has occurred to a considerable extent is reflected by the numerous papers on electron microscopy, many of which are coauthored and cover a wide variety of subjects.

INSTRUMENTATION

Canalco is a relative newcomer to the list of manufacturers of electron microscopes. Their M-61 is designed for resolving powers of 15 A. or better and covers a magnification range of 1000 to 120,000X in 12 steps with a continuous "Zoom" feature. The stabilized power supply at levels of 10, 20, 40, 60, and 80 kv. accelerating voltages offers a wide selection of operating conditions for obtaining maximum contrast or penetration. It appears that voltage selectivity over this range could have many other applications for the supplementary examination or treatment of materials. While it is still too early to evaluate this new instrument under the somewhat rigorous conditions encountered in the field, the established reputation of this firm indicates a strong contender.

Well established manufacturers of electron microscopes have introduced new models. The Philips EM-200, being used in cellular aging studies at the University of Pittsburgh, is a powerful instrument with 6- to 10-A. resolving power and appears to combine optimum versatility, stability, and simplicity of operation (*97*). Among other advantages, it is claimed that focusing and astigmatic compensation, enabling high quality micrography, can be accomplished in about 1 minute. Fisher Scientific, distributor of the JEMscope line developed by Japan Electron Optics Laboratory Company, Ltd., has introduced the very versatile JEM 6A. Among the numerous attachments available for this instrument, the reflection device, permitting the study of the surface topography of thick specimens, is unique. Resolution of detail, as depicted by this method, has been improved over that of their previous models. Also, there is available a rotating stage and a camera for exposing ciné film directly to the electron beam in the vacuum.

Other instrument manufacturers continue to make improvements in basic design or have programs for modernizing older models currently in use. RCA's nominally priced modernization kits will improve performance and relia-