Review of

APPLIED ANALYSIS

PETROLEUM

R. L. LeTourneau
California Research Corp., Richmond, Calif.

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THIS is a comprehensive and selective review of the literature on the analysis and testing of petroleum which has appeared since the previous review (*13A*) until about October 1, 1958. It is somewhat longer than the last one because of the effort made to cover more of the foreign references which parallel work in the English language. Because of the enormity of the subject, space does not permit interpretative comments except in a few instances. The review is, however, intended as a guide to most of the important literature on the subject within the last 2 years. An excellent review on present and discussion of future trends in petroleum analysis was done by Powell and Thomas (*15A*), emphasizing the newer physical methods which will be suitable for automatic analysis. At the St. Andrews' Congress on Modern Analytical Chemistry in Industry, Densham and Gough (*10A*) reviewed applications of physical methods of analysis in the gas industry and Keulemans (*12A*) reviewed applications of gas chromatography in the petroleum industry.

An ASTM symposium on chemical composition of petroleum oils (*4A*), held February 1957 in New Orleans, brought together all the latest knowledge on the subject. Of particular interest were papers covering the use of the newer techniques with information not available anywhere else. This is true of the reports on use of thermal diffusion by Jones and by Melpolder, Sauer, and Washall; and of applications of nuclear magnetic resonance by Williams and by Zimmerman and Lasater. The record of a half-day discussion held at this symposium under the leadership of H. M. Smith is also presented. Other ASTM special publications (*3A*) cover the analysis of used railroad lubricating oils, emission spectrographic analysis of oils (*1A*), and a third edition of the "Manual on Measurement and Sampling of Petroleum and Petroleum Products" (*2A*).

Bonnar, Dimbat, and Stross (*6A*) did a book on the fundamentals and determination of number-average molecular weights by cryoscopic, ebullioscopic, osmotic pressure, vapor pressure lowering, vapor density, and functional groups methods. Besides reviewing the field, this book gives a lot of practical experience in one company's laboratories. Glasgow and Ross (*11A*) described a new separation process consisting of freezing and fractional melting under equilibrium conditions which is now the popular technique called zone melting. An entire issue of *Analytica Chimica Acta* (*5A*) was devoted to the use of the freezing point and calorimetric data in the determination of purity with many examples from petroleum materials. Waterman, well known for his work on the relation between physical constants and chemical structure, published 17 papers in the past 2 years, most of which have been summarized in his recent book (*17A*). Articles appearing since the book are on determination of naphthenes (*14A*), graphs for aromatic and naphthenic carbon determination (*7A*), and the ring analysis of saturated petroleum oil samples (*8A*, *9A*). Reilly (*16A*) covered the applications of nuclear magnetic resonance in a recent review; but while this subject is an active one in the petroleum analysis field, there has been little reporting.

GAS CHROMATOGRAPHY

Applications of gas chromatography have grown enormously, and the subject has been reviewed in many countries and languages (*19B*, *21B*, *26B*, *51B*, *52B*, *59B*, *63B*, *75B*, *90B*, *99B*, *100B*). The first International Symposium on Gas Chromatography has now appeared in book form, edited by Desty (*32B*), with the discussion which took place at the meeting. A symposium held in the United States under the auspices of the Instrument Society of America also appeared in book form edited by Coates, Noebels, and Fagerson (*23B*). This book has an excellent bibliography covering 1952 through 1957 and includes 489 references. It is, however, arranged only by author and not by subject, so that this review will serve as a handy guide to some of that literature. A second International Symposiun on Gas Chromatography was held May 1958 at the Royal Tropical Institute, Amsterdam. The editor again is Desty (*31B*), and the symposium has been preprinted by Butterworths Scientific Publications. At this meeting Grant described an emissivity detector for gas chromatography. Golay discussed the theory of chromatography in open and coated tubular columns, as did Dijkstra and De Goey. Adlard and Whitham described applications of high temperature gas-liquid chromatography in the petroleum industry. A Symposium on Advances in Gas Chromatography was held at the September 1957 meeting of the American Chemical Society with Coggeshall and Williams (*24B*) as co-chairmen. Most of these papers have already been published. Of those which have not, Gohike's description of the application of the time of flight mass spectrometer as a detector, Davis and Schreiber's double column chromatograph, and Dietz and Dudenbostel's applications to petroleum processes were of particular interest. The ISA-sponsored (*49B*) International Symposium on Instrumental Methods held May 1958 in Houston, Tex., covered many more applications of gas chromatography.

A bibliography on gas chromatography was published by Consolidated Electrodynamics Corp. (*25B*) containing 260 references through 1957. It contains many references to editorial material of interest not normally covered by bibliographers. Two books have appeared. Keulemans' book (*56B*) on gas chromatography provides an excellent practical background for the petroleum analyst starting in the field. Lederer's book (*61B*) on chromatography is in a second revised and enlarged edition. The standardization of chromatographic data is being studied in this country by an appropriate ASTM committee, and their tentative conclusions are presented by Johnson and Stross (*54B*). The subject is also under study in Great Britain and their conclusions to date have been presented by Desty (*29B*) and by Ambrose, Keulemans, and Purnell (*1B*). Jones and Kieselbach (*55B*) suggested a set of units for measurement in gas chromatography, and Spencer and Johnson (*92B*) described an IBM punch card storage system for gas chromatographic data.

Theory. Anderson (*2B*) defined a partition coefficient in gas chromatog-

raphy. Van Deemter, Zuiderweg, and Klinkenberg (*98B*) developed a rate theory to explain band broadening. De Wet and Pretorius (*33B*) studied factors influencing efficiency and found them to be in agreement with this rate theory. Turkel'taub and Zhukhovitskiĭ (*96B*) made a theoretical analysis of the role of certain factors in gas chromatograhy. Turkel'taub (*94B*) found that the poor separation obtained with reduced column cross section indicated the effect of the walls upon the widening of the band. Graf and Toth (*38B*) developed a theory of elution and frontal gas chromatography. Said (*85B*) described a method for determination of the number of theoretical plates in a chromatographic column. Beynon, Clough, Crooks, and Lester (*10B*) developed an expression for the HETP. Golay (*37B*) proposed a performance index for gas chromatographic columns and (*36B*) a mathematical theory of the kinetics of gas chromatography. Bohemen and Purnell (*15B*) showed the importance of determining the theoretical plate numbers at several different filament temperatures of the katharometer. Brennan and Kemball (*17B*) carried out various experiments on factors affecting resolution. Nunez, Armstrong, and Cogswell (*77B*) showed that peak areas agree more closely with weight per cent than mole per cent for a blend of hydrocarbons. Keulemans, Kwantes, and Rijnders (*58B*) discussed principles and applications of the calibration of katharometers for use with hydrocarbon mixtures. Maurel (*74B*), Rosie and Grob (*82B*), and Browning and Watts (*18B*) showed the need for the direct calibration of thermal conductivity cells with individual hydrocarbons for strictly quantitative results. Wilzbach and Riesz (*105B*) showed isotope effects with deuterium and tritium.

Detectors. Ryce, Kebarle, and Bryce (*84B*) described an inexpensive thermal conductivity cell. Bohemen and Purnell (*16B*) studied the performance of hot wire thermal conductivity cells and showed convection to be an important factor in katharometer operation in nitrogen. Madden, Quigg, and Kemball (*70B*) developed an electrical method for improving the null point of a thermal conductivity detector. Zmitko, Brodsky, and Biza (*108B*) used a mirror galvanometer projected on a rotating drum of photographic paper to record. Thermistor detectors were described by Walker and Westenberg (*101B*); Sekerka, Spevak, and Friedrich (*88B*); and Davis and Howard (*27B*). Martin and James (*72B, 73B*) developed a gas density balance for use as a detector; and Liberti, Conti, and Crescenzi (*65B*) used such a device in determining the molecular weight of components in gas phase chromatography.

Harley, Nel, and Pretorius (*44B*) described a detector operating on ionization of the effluent gas in a hydrogen flame. McWilliam and Dewar (*69B*) described a flame ionization detector using a nitrogen-hydrogen flame. Harley and Pretorius (*45B*) using the normal glow discharge between a platinum-disk cathode and a tungsten-wire anode detected easily 10^{-12} mole of a substance. Ryce and Bryce (*83B*) used an RCA ionization gage as a detector. Lovelock (*67B*) described an ionization detector which employs the properties possessed by argon, used as a carrier gas, of producing long-lived metastable atoms when irradiated with a 10-millicurie source of strontium-90, these atoms causing ionization of organic molecules by collision; 2×10^{-12} mole of most organic compounds can be detected.

Martin (*71B*) oxidized the effluent to carbon dioxide and detected with an infrared analyzer. Blom and Edelhausen (*13B*) measured carbon dioxide, formed by oxidation, by immediate titration in a pyridine solution with sodium methoxide. Liberti (*64B*) advised titration of the eluted gases, without conversion, photometrically, potentiometrically, or coulometrically. Green (*40B*) advised conversion of water, after burning, to hydrogen and detection of the hydrogen. Zlatkis and Ridgway (*107B*) advised conversion of hydrocarbons by hydrocracking to methane for detection. Schlierf (*86B*) used impregnated cotton yarn or filter paper for the detection of phenols, cresols, and xylenols. Dielectric constant cells were used by Grant (*39B*) and Turner (*97B*). Holmes and Morrell (*48B*) described the oscillographic mass spectrometer monitoring of gas chromatography. The system in which carbon dioxide as the eluting gas is removed by absorption in potassium hydroxide and in which the components are measured gasometrically is described by Leibnitz, Hrapia, and Konnecke (*62B*); and Janak and Tesarik (*53B*). Deal, Otvos, Smith, and Zucco (*28B*) described a radiological detector for gas chromatography.

Apparatus. Keulemans and Kwantes (*57B*) patented an apparatus in which essentially all of the parts including the detector are controlled at a single temperature. A two-stage apparatus in which a nonpolar column is connected to a polar column is described by Simmons and Snyder (*89B*). Nogare and Safranski (*76B*) described apparatus which will operate up to 350° C. using a platinum filament detector operating 100° C. higher than the column to avoid condensation. Programmed-temperature chromatography was studied by Clark (*22B*). Ashbury, Davies, and Drinkwater (*6B*) described a versatile apparatus in which one recorder is connected to several furnace column units, and which is capable of operation up to 300° C. Trace analysis apparatuses were described by Boggus and Adams (*14B*) and Bennett, Nogare, Safranski, and Lewis (*9B*).

Greene and Roy (*42B*) studied the effects of different carrier gases on retention time. Desty (*30B*) listed a variety of column packings. Cheshire and Scott (*20B*) showed the importance of mesh size of the support in highly efficient columns. Sørenson and Søltoft (*91B*) further reduced the pressure drop by using 1.6 × 1.6 mm. gauze stainless steel helices as packing. The effect of silica gel moisture on separations was discussed by Turkel'taub, Kolyubyakina, and Selenkina (*95B*) and by Blair and Amis (*12B*). Tenney (*93B*) discussed the selectivity of various liquid substrates. Eggertsen and Knight (*34B*) studied partitioning agents for separating saturated hydrocarbons. McFadden (*68B*) used mixed stationary liquid phases. Andronikashvili, Kuz'mina and Shishkova (*4B, 5B*) studied the use of natural sorbents such as natrolite, tripoli, diatomite, and kaolin for the separation of saturated hydrocarbons. White (*103B*) and White and Cowan (*104B*) used organic montmorillonite compounds in gas chromatography such as dimethyldioctadecyl ammonium bentonite. Barrer and Hampton (*7B*) studied sorption by alkyl ammonium bentonite. Gregg and Stock (*43B*) studied ammonium phosphomolybdate as an adsorbent for gas chromatography.

Miscellaneous Applications. In this section are listed various applications of gas chromatography. Most of the applications to fuels, lubricants, and other petroleum products are listed in the appropriate sections in later portions of the review. Zlatkis, O'Brien, and Scholly (*106B*) and Scott and Cheshire (*87B*) achieved the separation of the difficultly separable hydrocarbons, *m*- and *p*-xylenes, by using long columns and suitable partitioning agents. Bernhard (*11B*) separated and identified a number of terpenes. Kovats, Simon, and Heilbronner (*60B*) used an automatic chromatograph for repeated separations of mixed organic compounds to prepare larger fractions. Bellis and Slowinski (*8B*) used chromatography to purify standards for infrared spectroscopy. Franc and Jokl (*35B*) combined chromatography and ultraviolet spectrophotometry to determine the isomeric xylenes. Haslam and Jeffs (*47B*) used a combination of chromatography and infrared to identify solvents from plastic adhesives and spray lacquers. Halocarbons were separated by Pollard and Hardy (*80B*), and fluori-

nated hydrocarbons by Percival (*79B*) and by Reed (*81B*). James (*50B*) separated and identified saturated and unsaturated fatty acids from formic to dodecanoic. Orr and Callen (*78B*) separated fatty acid methyl esters on Apiezon vacuum greases, and Lipsky and Landowne (*66B*) used the adipate polyester of diethylene glycol for the same purpose, achieving complete resolution of the saturated versus unsaturated species. Haskin, Warren, Priestley, and Yarborough (*46B*) determined the composition of azeotropes by gas chromatography. Greene and Pust (*41B*) determined heats of adsorption, and Anderson and Napier (*3B*) determined heats and entropies of solution. Weinstein (*102B*) described a fraction cutter for gas chromatography.

PROCESS INSTRUMENTATION

Fourroux (*6C*), Denny (*5C*), Hickerson (*10C*), Locke (*15C*), Altom (*1C*), Miller (*18C*), and Hybl and Lhotsky (*12C*) discussed monitoring applications of gas chromatography in their respective companies. Fraade (*7C*) reviewed mass spectrometers, infrared spectrometers, refractometers, viscometers, and vapor phase chromatographs in their applications as automatic stream analyzers in refinery operations. Wallis and Townend (*27C*) discussed trends in the instrumentation of refinery processes in terms of automatic data logging, quality analyzers, electronic control systems, presentation of information, and integration of process plants using computer techniques. Various analyzer applications were also mentioned by Noebels (*20C*) and Karasek (*13C*). Automation in natural gasoline plants was discussed by Wagner (*24C*). Wall (*25C*) in his work book features on continuous analyzers has presented much detailed information on colorimetric, titromatic, dielectric constant, thermal conductivity, and electrolytic analyzers not available elsewhere.

Wall (*26C*) discussed infrared analyzers for in-plant process control, as did Quarendon (*21C*) and Martin, Reid, and Smart (*17C*). Simonsen and Crouch (*23C*) sensitized an infrared analyzer to indicate the explosibility of a nine-solvent mixture in air. Miller (*19C*) described an infrared analyzer especially for the control of fractionation of ethane and ethylene. Berton (*3C*) described a simple, nondispersive ultraviolet photometer with mercury, zinc, and cadmium vapor lamp sources for monitoring concentrations of such things as aromatic hydrocarbons, acetates, and ketones. Glasser (*8C*) described applications of infrared, ultraviolet, and refractometer analyzers. Glasser and Troy (*9C*) described the construction of a robust, sensitive differential refractometer and its application in the process analysis of mixed chlorinated hydrocarbons. Wherry and Berger (*28C*) outlined the use of automatic control of fractionators in natural gasoline plants. For control of the depropanizer an infrared instrument was sensitized for isobutane in the presence of ethane, propane, and normal butane; for the debutanizer a differential refractometer was used with pure *n*-butane as the reference; for the deisobutanizer an infrared instrument was sensitized for isobutane in *n*-butane and isopentane.

Landsberg (*14C*) described the use of a process monitor mass spectrometer in petroleum production, a sulfur recovery plant, pilot plant studies, a selective absorption operation, and ammonia production. Dielectric constant continuous analyzers, described by Chamberlin, Thomas, Beaugh, and Land (*4C*), were used for monitoring the feed in the control of sulfur dioxide solvent extraction, measuring the feed and wax products in solvent dewaxing, and measuring feed and raffinate in phenol solvent extraction. Hull (*11C*) described a new principle in flow measurements based on the total number of counts registered when a measured quantity of a radioisotope flows downstream past the counter. This technique is used in the measurement of flow in refinery units and also in open streams and rivers. A direct-reading spectrograph was used for the control of lubricating oil additive manufacture by Rappold and Ramsay (*22C*). The use of an x-ray spectrograph for monitoring lead or bromine in gasoline was described by McCune, Mueller, and Dunton (*16C*). Process control with continuous viscometers was described by Beerbower (*2C*).

CRUDE OIL

The Bureau of Mines published a report (*26D*) on the analysis of crude oil from 470 important oil fields in the United States. Rossini (*22D*) summarized the work of API Project 6 and the identification of 159 hydrocarbons from one petroleum. The composition of the C_{18} to C_{25} fraction was described by Mair, Marculaitis, and Rossini (*19D*). Mair, Eberly, Li, and Rossini (*18D*) showed that only 59 of the 1520 possible bicycloparaffins, C_4 to C_9, are probable constituents of petroleum. Hood, Clerc, and O'Neal (*12D*) discussed mass spectral evidence pointing toward a simple picture of the molecular structure of heavy petroleum compounds.

Javes and Liddell (*14D*) described a micromethod for analysis of petroleum suitable for the assay of a 5-ml. sample. Blumer (*1D*) used active copper powder to separate elemental sulfur from hydrocarbon mixtures obtained from sedimentary rocks prior to analysis. Evans, Kenny, Meinschein, and Bray (*8D*) used chromatography and mass spectrometry to study saturated hydrocarbons from marine sediments. Gutowsky, Ray, Rutledge, and Unterberger (*10D*) studied carbonaceous free radicals in crude petroleum by electron paramagnetic resonance. Kusakov and Petrov (*16D*) used a torsion pendulum apparatus for investigation of the rheological properties of the surface layers at the crude oil–water interface to study their role in the stability of crude oil emulsions. Glogoczowski (*9D*) concluded that a mass spectrometer is the most promising tool for determining trace quantities of hydrocarbons in oil prospecting. Dunning and Johansen (*5D*) measured crude oil wetting tendencies with an interfacial tension capillarimeter. Howell and Jessen (*13D*) used the Ultraviscoson for a quick and simple method of determining the cloud point of crude oil under dynamic conditions. Stoffer (*23D*) compared direct flame photometry with water extraction for the determination of salt in crude oil. Dunning and Moore (*7D*) determined asphaltene yields and nitrogen content of the asphaltenes and raffinates from crudes by deasphaltizing with various propane-oil ratios throughout the temperature range 120° to 180° F. The colloidal characteristics of petroleum were studied with the ultracentrifuge by Ray, Witherspoon, and Grim (*21D*) who obtained four characteristic fractions. A crystalline porphyrin deoxophyllerythroetioporphyrin was isolated from Gilsonite by Sughara and McGee (*24D*). Moore and Dunning (*20D*) studied metal porphyrin complexes in an asphaltic mid-continent crude oil, and (*6D*) found carboxylated porphyrins in some crudes, indicating low temperature thermal history. Hodgson and Baker (*11D*) studied the effect of heat on the vanadium and nickel content of crude oils up to 420° C. for 150 hours. In a separate experiment added porphyrins were found to be removed at a distinctly higher rate than the metals.

Kaishev (*15D*) described a thorough investigation of a Bulgarian crude oil made by methods in common use in the Soviet Union. Among other techniques, Luther and Jesse (*17D*) used the Craig countercurrent apparatus in the evaluation of a German crude oil. Topchiev and coworkers (*25D*) isolated a number of normal paraffins from a Romashkin kerosine by the use of urea. Creanga and coworkers (*4D*) made a comparative study of two hydrocarbon structural group analysis methods in the analysis of 98 fractions of a Rumanian crude oil. Coleman, Thompson, Ward, and Rall (*3D*) identified 11 sulfur compounds in Agha Jara, Iran, crude oil by gas-liquid chro-

matography. Carruthers and Douglas (*2D*) isolated and identified five polycyclic hydrocarbons in a Kuwait oil.

GASES

Boreham (*1E*) surveyed sampling analysis and testing of gaseous fuels over the last 8 years. Verrien (*36E*) reviewed methods of analysis of natural gas. Stott (*31E*) described a transistorized sonic gas analyzer for measuring carbon dioxide in air. Kavan and Base (*18E*) described a new reagent for the absorption of oxygen composed of sodium dithionite, pyrogallol, and anthraquinone-2-sulfonate that has 10 times the absorptive capacity of alkaline pyrogallol. Morlet and Angleraud (*23E*) determined sulfur in commercial propane and butane by catalytic hydrogeneration over platinum to hydrogen sulfide followed by colorimetric determination as methylene blue. Zel'venskiĭ and coworkers (*37E*) studied sulfur corrosion in compressors and gas mains by the use of radioactive H_2S^{35} and COS^{35}. Getoff and Sattler-Dornbacher (*10E*) described an analysis scheme for hydrocarbons and impurities in liquid gas using rectification, gas chromatography, and mass spectroscopy. Turkel'taub and Abramovich (*35E*) checked the operation of chromatothermographs by means of a mass spectrometer and recommend such periodic testing of these instruments. Bucur (*2E*) discussed the importance of controlling the temperature gradient of chromatographic columns. Esayan and Esayan (*7E*) described the separation of ethylene, hydrogen, and methane by adsorption on charcoal. Garner and coworkers (*9E*) summarized information on the separation of low boiling hydrocarbons by vapor phase absorption. Coates and Brenner (*4E*) described a two-stage chromatographic apparatus in which hydrogen through propane was separated on dry silica and heavier hydrocarbons were separated on tetraisobutylene-saturated silica. Kaufman and Zlatkis (*17E*) analyzed butadiene and vinyl acetylene in mixtures in 20 minutes by gas chromatography. Sokolov and Kuz'mina (*30E*) used a three-column apparatus to analyze C_1 to C_4 hydrocarbons containing also hydrogen, carbon monoxide, and carbon dioxide. Janak and Novak (*15E*) determined the individual paraffins and olefins in 1,3-butadiene on a dimethyl formamide column after removal of the butadiene with maleic anhydride.

Toth and Graf (*34E*) determined the helium and hydrogen content of natural gases with elution chromatography. Greene and Pust (*11E*) compared carbon dioxide adsorption on silica and alumina gel. Szulczewski and Higuchi (*32E*) showed that chilled silica gel is satisfactory for separating the so-called permanent gases, oxygen, nitrogen, nitric oxide, and carbon monoxide. Kyryacos and Boord (*19E*) achieved the separation of the permanent gases with a Type 5A Molecular Sieve column. Nitrogen, nitrous oxide, nitric oxide, carbon monoxide, and carbon dioxide were analyzed in a two-stage column separated by iodine pentoxide in 10 minutes by Smith, Swinehart, and Lesnini (*29E*). Greene and Pust (*12E*) determined nitrogen dioxide on wet alumina, wet silica, or wet Molecular Sieve.

Nelson, Grimes, Smith, and Heinrich (*25E*) separated traces of carbon monoxide from gaseous hydrocarbons by distillation with added methane and detection of iodine liberated over hot iodine pentoxide. Toren and Heinrich (*33E*) described a method for determination of as little as 1 p.p.m. of carbon dioxide in a gas stream which is suitable for automatic recording. The continuous recording of the odorant concentration in gas may be done with the Titrilog as described by Mason (*21E*). Perry and Bain (*27E*) analyzed a six-component C_4 hydrocarbon gas by infrared differential analysis. Kapisinsky (*16E*) described an ethylene analyzer based on the estimation of the heat evolved in the chlorination of ethylene.

Pietsch (*28E*) showed that very small amounts of oxygen, carbon monoxide, methane, and nitrogen can be determined on 5A Molecular Sieve where silica gel and 4A sieve failed. In the manufacture of acetylene from methane, Nemeth and Cirlogan (*26E*) determined acetylene by infrared absorption and oxygen based on its paramagnetism. Guiden, Harvey, and Wilkerson (*13E*) gave data for the quantitative infrared analysis of isobutane, butane, isopentane, and pentane. Mott and Moulson (*24E*) studied the corrections involved in the determination of naphthalene in town gas by the picrate method. Densham and Ravald (*6E*) and Creusot and Pommel (*5E*) also studied the corrections necessitated by the dissociation of napthalene picrate.

Caldecourt (*3E*) described a digital recorder for mass spectra. Fritts and Peattie (*8E*) used a telereader for the rapid reduction of mass spectrometer data. The machine computation of mass spectrometer analyses was described by Hopp and Wertzler (*14E*) and by McAdams (*20E*). The transmission of mass spectrometer data to a remote computing center 350 miles away was described by Mihm, Pollock, and Shelton (*22E*).

FUELS

The National Bureau of Standards (*27F*) developed a new method for estimating the heat of combustion of aircraft fuels based on the proportions of the various hydrocarbon types present. Variables of lamp design that affect smoke point were studied by Rakowsky and Hunt (*30F*). A new apparatus for determining octane number on a sample as small as 60 ml. was described by Chitty (*9F*). Callinan, Roe, and Romans (*5F*) described the use of dielectric methods at frequencies from 10 kc. to 75 mc. in the determination of sea water in Navy special fuel. Tourret and Bale (*40F*) proposed improvements in the demerit system for rating the performance of fuels and lubricating oils in reciprocating internal combustion engines.

McCoy (*21F*) described a systematic chemical analysis scheme for deposits from oil-fired furnaces. Christian, Chiantella, Johnson, and Carhart (*10F*) showed that soft glass affects the rate of degradation of some distillate fuels and recommended the use of borosilicate containers in fuel stability studies. In a study of the causes of deposit formation in diesel fuel during storage, Sergienko and Galich (*35F*) showed that aromatic hydrocarbons were most susceptible to deposit formation. Bernelin (*2F*) described a photometric method for measuring the deposition tendency of diesel fuel. Budarov (*4F*) described an apparatus for measuring the gum content in fuel by passing steam through the fuel at a constant temperature. In a study of the thermal stability of the paraffinic hydrocarbons, Gavrilov and Bagratyan (*15F*) found a direct correlation between octane numbers of the investigated hydrocarbons and the thermal stability. Rowe and Nicolaysen (*32F*) showed the usefulness of phase and polarized light microscopy in studying diesel fuels. Carls (*7F*) and Habar (*19F*) used the electron microscope in the evaluation of cracked diesel fuel and residual fuel. The effectiveness of additives was studied by this technique.

Mottlau (*26F*) described a rapid, precise micro vapor-pressure method using only 1 ml. of sample which is suitable for replacing the Reid method, with further advantages of speed and precision. A modified Reid vapor pressure apparatus with vapor-liquid ratio 25 to 1 is recommended by Caplan and Brady (*6F*) as a single number method for correlation with vapor locking tendency. A specially designed apparatus for determination of the explosion limits of vapor-air mixtures is described by Micus and Taranczewski (*24F*). Stewart and Starkman (*36F*) measured flammability limits at low pressures in vessels of 12.5-cu. foot capacity at low pressures with a spark plug as the ignition source.

Desty and Whyman (*11F*) gave the

relative retention volumes of 81 hydrocarbons and seven sulfur compounds boiling in the range 30° to 150° C. on both hexatriacontane and benzyldiphenyl. Normal paraffins were determined in olefin-free petroleum distillates by use of Molecular Sieves by Schwartz and Brasseaux (*34F*) and Brenner and Coates (*3F*). Nelson, Grimes, and Heinrich (*28F*) determined normal paraffins plus normal olefins in the presence of other hydrocarbons using Type 5A Molecular Sieves. Eggertsen and Groennings (*12F*) determined all of the individual saturated hydrocarbons in a C_5 to C_7 blend of 25 compounds except 3-ethylpentane. Zlatkis (*42F*) described a chromatographic procedure for resolving the isomeric hexanes. Knight (*20F*) described conditions for the determination of pentenes and hexenes in gasoline.

Araki and Nozawa (*1F*) described a mass spectrometric procedure for the determination of aromatic hydrocarbons in reformed gasoline. Benzenesulfenyl chloride was used by Mikkelsen, Hopkins, and Yee (*25F*) for the quantitative removal of olefins from gasolines for mass spectrometer-type analysis. By comparison of mass spectra before and after treatment with this reagent, the olefin, monocycloparaffin, coda, and dicycloparaffin mass peaks may be derived separately. Ferguson and Howard (*14F*) described a rapid mass spectrometric prodecure for the determination of isoparaffins and normal paraffins in olefin-free gasoline. Groennings (*18F*) published a chart on refractivity intercept analysis of total naphthenes in naphthas which has actually been in use for a number of years, by its availability on a private basis to many laboratories. Schindel (*33F*) extended the fluorescent indicator adsorption method to include a naphthene-paraffin split based on refractive index. Gaylor, Conrad, and Landerl (*16F*) determined antioxidants in gasoline by polarography using a wax-impregnated graphite electrode. A rapid polarographic method for determining hydroperoxides in gasolines was described by Whisman and Eccleston (*41F*).

The physical properties of 17 hexenes were tabulated by Rossini and coworkers (*31F*). This group (*13F*, *17F*) also identified 27 hydrocarbons from a particular gasoline boiling between 116° and 132° C. Mair, Eberly, Krouskop, and Rossini (*22F*) reported on the identification of four bicycloparaffins in the same gasoline. Chang and coworkers (*8F*) identified 52 hydrocarbons in the boiling range 85 to 125° C. in a Yu-Men gasoline. Podkletnov (*29F*) isolated 14 aromatic hydrocarbons in the gasoline fraction from Sakhalin crude oil. Topchiev and coworkers (*37F*) identified a number of hexanes and heptanes in Makhachkala petroleum, and they (*38F*) identified a number of naphthalene compounds in a Romaskin kerosine. Mamedaliev, Dalin, and Shikhmamedbekova (*23F*) identified a number of pentenes in catalytically cracked gasoline by use of bromination, oxidation, and Raman spectra. Topchiev and coworkers (*39F*) studied the aromatic and naphthenic compounds in a thermally cracked gasoline by means of the Raman effect.

LUBRICANTS

Tourret and Bale (*45G*) tried to substitute the Petter engine for the Caterpillar engine in testing diesel lubricating oils but concluded that there is an appreciable difference and no correlation between them is possible. Bondi and Diamond (*3G*) studied deflocculation in oils in terms of electrical conductivity changes. Schwarz (*38G*) described a simple method for the chromatographic separation of lubricating oils as a preliminary to further analysis of the fraction. The importance of optimum chemical composition of lubricating oil was discussed by Krein, Mitrofanov, and Fuchkov (*25G*). Mair, Marculaitis, and Rossini (*28G*) described the composition of a C_{18} to C_{25} fraction of petroleum.

Simpson (*41G*) recommended a procedure for the sampling of lubricating oils from diesel electric locomotives for spectrographic analysis. The rapid analysis of such oils by direct reading spectrograph was described by Barth (*2G*). The chromatography of used lubricating oils was described by Thomas (*44G*) and Hadfy-Kovacs (*20G*). Ungar and Trozzolo (*47G*) developed an infrared method for identifying the source of reclaimed oil. Peri (*37G*) studied the state of dispersion of detergent additives in lubricating oil with the electron microscope and the ultracentrifuge. Milz and Kipp (*31G*) suggested the substitution of the 75-hour Alcoa oxygen absorption test for the 500-hour ASTM D 943 turbine oil stability test. Furby, Hanly, and Vincent (*14G*) described a method for measuring rusting in turbine oil systems, and Brennan and Moyer (*4G*) a laboratory device for the water leaching of additives in turbine oils.

Melpolder and coworkers (*30G*) used a 20-stage molecular still, silica gel chromatography, and liquid thermal diffusion in the analysis of lubricating oils followed by mass, ultraviolet, and infrared spectrometry. Groszek (*19G*) separated methacrylate polymers above 10,000 molecular weight from mineral oil by chromatography of silica gel. A new color scale to measure the degree of refinement of petroleum products was devised by the National Bureau of Standards (*33G*) in cooperation with ASTM. McConnell (*27G*) summarized 10 years of study of the evaluation of electrical insulating oil. Massey, Murty, and Thompson (*29G*) suggested modifications to the test for measurement of the surface tension and interfacial tension of insulating oil.

Siripongse, Rogers, and Cameron (*42G*) used the voltage current characteristic of thin oil films to study the operating of the four-ball machine. Godfrey (*16G*) discussed the role of electron diffraction in lubrication research. The effect of metal to metal friction on the rate of gum formation of a film of oil 50 microns thick was studied with the use of a specially designed laboratory machine by Kyuregyan (*26G*). Scott (*39G*) modified the rolling four-ball test rig for use at elevated temperatures. White (*48G*) used the modified SAE and McKee EP Lubricants testing machines for evaluating the antiwear and load carrying properties of turboprop lubricants. Davidson and Ku (*8G*) developed a laboratory test procedure for studying the effects of lubricants on gear tooth surface fatigue. Carter and coworkers (*5G*) described a simple bench test for evaluating lubricants under actual rolling contact stress. Paleari, Girelli, and Siniramed (*35G*) used the Four-Ball EP testing machine to assess the antiseizing as well as the recovery from seizure properties of EP oils. Colwell (*6G*) described refinements in a friction and wear machine for studying the behavior of cutting fluids. Goodwin and Hunstad (*18G*) described a bench test apparatus for evaluation of chassis grease. In radioactive piston ring wear studies, Abowd (*1G*) stresses the development of a technique which permits a separate, simultaneous record of the wear occurring on the face and on the side of the radioactive piston ring. Fisher and coworkers (*12G*) made a radiotracer study of the effect of lubricants on metal transfer in drawing brass. Furey and Kunc (*15G*) described a technique for measuring wear in the engine valve train by the use of radioactive valve lifters.

Umstätter (*46G*) explained viscosity measurement dependence on the diameter of the capillary used, on the basis of absorption on the walls. Drucker (*9G*) discussed viscometer corrections arising from nonuniform diameter of capillaries. Nagano and Oguma (*32G*) studied the kinetic-energy correction for a capillary viscometer. Automatic Oswald viscometers with phototransistors operating the clutch of an electronic timing device were described by Goldfinger and Greatbatch (*17G*). Eisenberg (*10G*) described a rotation viscometer which may be used over a wide range of viscosity and rates of shear. An immersion

viscometer for the measurement of the viscosity of heavy oils in storage tanks was described by Penny and Ackroyd (*36G*). Ellis (*11G*) reviewed the present status of viscosity-temperature relationships of lubricating oils and showed the clear need for fundamental research into this problem.

Needs (*34G*) showed differences in friction and operating temperature when heavily loaded partial journal bearings were operated with two different oils in the same viscosity range but of widely different viscosity index and viscosity pressure characteristics. Kaverina (*22G*) degraded polyisobutylene in mineral oil solution mechanically in a coaxial cylinder apparatus. Horowitz (*21G*) presented equations and graphs for predicting effects of temperature and shear rate on the viscosity of lubricants containing significant amounts of polymeric viscosity index improvers. Klaus and Fenske (*23G*) studied the flow properties of hydraulic fluid and lubricants up to 700° F. Selby (*40G*) discussed the shear dependence of polymer containing lubricating oil. Krause (*24G*) gave a detailed description of a couette-type viscometer used in the study of lubricating oils. The use of the plunger rheometer was described by Smith (*43G*). Frei, Treves, and Eisenberg (*13G*) described an improved rotation viscometer for the study of low viscosity liquids at low and intermediate rates of shear. Criddle (*7G*) measured the surface viscosity and elasticity of a film of lubricating oil with a torsion pendulum surface viscometer.

WAX, ASPHALT, GREASE

The construction of a test floor for the evaluation of floor waxes is described by Schoenholz and Burns (*36H*). Hunter and Lofland (*17H*) developed a gloss test for waxed paper which compares favorably with visual gloss ranking by paper technologists. Hughes and Walker (*16H*) discussed gloss stability. Arabian (*2H*) studied the relationship between composition and blocking temperature of paraffin waxes. Phillips (*31H*) used the Navy exudation test in a study of factors influncing the staining tendency of waxes. Edwards (*11H*) studied the crystal habit of paraffin wax, and Fox (*12H*) showed a relationship between wax crystal structure and the transmission rate of water vapor to wax films. Martin, Johnston, Cannon, and O'Neal (*26H*) measured phase transitions of waxes by infrared in the 13.5- to 14.0-micron range. Fujiwara and Yamaguchi (*14H*) studied phase transitions and crystallinity in petroleum waxes by nuclear magnetic resonance. A laboratory apparatus for applying wax to paper for evaluation tests for packaging purposes is described by Walter, Evans, Walker, and Askevold (*42H*). Lauer (*23H*) showed the possibilities of thermal capillary analysis in studying the aging of oils and waxes. Sanin, Melent'eva, and Zelenova (*34H*) studied the adsorption of surface active substances on paraffin wax. Topchiev and coworkers (*28H*, *40H*) established phase diagrams for the normal paraffin-hydrocarbon pairs C_{20-30}, C_{30-32}, C_{30-34}, and C_{30-36}. Starobintsev and Bol'shova (*38H*) determined normal hydrocarbons in paraffins by adsorption from carbon tetrachloride solution on urea. Ogilvie, Simmons, and Hinds (*29H*) used high temperature gas-liquid chromatography for the determination of normal paraffin distribution of waxes.

Schweyer (*37H*) reported an exploratory study of ultraviolet and infrared absorption of asphalt solutions and thin films. Green (*15H*) showed that the use of silicone grease for stopcock lubrication in IP 105 or of silicone antifoam in IP 27 causes the penetration of the recovered or residual bitumen to be significantly improved. Stewart (*39H*) discussed the composition of chromatographically fractionated asphalts in terms of their infrared spectra. Fuchs and Nettesheim (*13H*) analyzed asphalts chromatographically and concluded that the aromatic portion of a bitumen is the raw material for asphaltene formation on blowing. Cindea (*6H*) identified various constituents in road asphalts by paper chromatography under ultraviolet illumination. Letters (*24H*) studied road asphalts by means of thin spread films 0.3 to 2 microns thick on water and (*25H*) determined the shrinkage of bituminous coatings on immersion in water. Krenkler (*22H*) suggested accurate determination of the plasticity of road asphalts because of the poor reproducibility of the breaking point test of Fraas. A method for the rapid evaluation of the serviceability of roof coating asphalts was described by Wilkinson, Striker, and Traxler (*43H*). Dewhust and Deadman (*9H*) described an evaporation test for paving asphalts. Zube and Skog (*45H*) showed that the flash point viscosity and penetration tests for asphalts require further work to increase their reliability. Knotnerus (*21H*) presented a chemical analysis scheme for determining the oxygen-containing functional groups in blowing asphaltic bitumens. Kleinschmidt and Snoke (*20H*) studied changes in asphalt during the blowing operation. Zemplen and Szabo (*44H*) described a pressure viscometer for determining the viscosity of bitumens at 20-atm. pressure. Schlosser and Hempel (*35H*) related viscosity-temperature diagrams at constant shearing stress to softening point, pour point, and dynamic viscosity.

A chromatographic method was developed by Powers and Piehl (*32H*) for the determination of soap and oil in grease, which will permit the analysis of four to six samples in 8 hours with precision equivalent to the ASTM extraction method. Kaiser (*19H*) also used chromatographic methods in the analysis of greases. Kabes, Cejka, and Vesely (*18H*) observed structural changes in the oxidation of sodium lubricating grease with the electron microscope. Orr (*30H*) proposed a standard vocabulary of terms for describing the sensory observations of lubricating grease. Cox and McGlynn (*8H*) studied phase changes in greases by differential thermal analysis. Brunstrum and Leer (*4H*) discussed the interpretation of capillary flow measurements of greases; and Miller, Walsh, and Slaymaker (*27H*) studied the effect of capillary length to diameter ratio on grease viscosity. Connors (*7H*) described an automatic worker-type viscometer for evaluating the consistency of lubricating greases. Calhoun (*5H*) studied grease bleeding. Dreher (*10H*) had considerable success with a static thin film test in the study of high temperature performance of lubricating grease. Tourret and Baker (*41H*) discussed methods of testing for incompatibility of greases. Adams (*1H*) discussed a study of the CRC Laboratory technique for determining rust preventive properties of greases. Asseff and coworkers (*3H*) described a proposed ASTM standard method for the determination of the load carrying capacity of lubricating greases by using the Timken EP tester. Roach and Jordan (*33H*) discussed apparatus for the high-speed rotative testing of grease-lubricated ball bearings.

CATALYSTS

The micromerograph, a new instrument for particle size distribution analysis based on air sedimentation in a pressure-tight system, was described by Eadie and Payne (*4J*). Permeability apparatus for determining the surface area of powders was described by Spillane (*23J*). Jiru and Brull (*9J*) studied some Czechoslovak siliceous earths by physical adsorption of nitrogen and apparent actual densities. Nelson and Eggertsen (*14J*) described a new surface area measuring apparatus using the techniques of gas chromatography. Rubinshtein and Afanas'ev (*18J*) used a dynamic method for measuring the adsorption of vapors to determine the size of catalyst surface, and (*20J*) recommended a single measurement of adsorption equilibrium.

Cochran and Cosgrove (*3J*) found pore size measurements with a mercury porosimeter to agree well with distributions found by measuring sorption of normal butane at 0° C. with a quartz helix balance. Innes (*8J*) described a method of computation of pore size distribution.

Stone and Rase (*24J*) studied silica-alumina catalysts by differential thermal analysis. Gunn (*6J*) used x-ray low angle scattering to study silica-alumina cracking, platinum-alumina reforming, and cobaltia-molybdena-alumina hydrogenation catalysts. Rubinshtein, Dashevsky, and Pribytkova (*19J*) described a microtome procedure for slicing catalyst to a thickness not exceeding 0.01 micron for electron microscopic investigation. Benesi (*1J*) studied the qualitative and quantitative aspects of acid strength of catalyst surfaces using Hammett indicators and amine titrations. The exchange of catalyst water with deuterium gas on catalyst was studied by Lee and Weller (*10J*) and was made the basis for a method of determining water on catalyst. Hindin, Lee, and Weller (*7J*) described a method for determination of carbon and hydrogen in coke on catalyst. Markova (*12J*) studied the interaction of olefins for isobutylene polymerization on aluminosilicate catalysts by infrared spectroscopy. Selwood (*21J*) studied the mechanism of chemisorption of benzene and cyclohexane on nickel by magnetization. The interaction of aromatic compounds adsorbed on silicic acid by ultraviolet absorption was studied by Robin and Trueblood (*15J*). Fuschillo and Renton (*5J*) made a nuclear magnetic study of methane adsorbed on titanium dioxide. Maxsted and Josephs (*13J*) studied the strength of poison-to-catalyst bonds by measuring the heat of adsorption of ethyl sulfide and thiophene on platinum. Rothrock and coworkers (*17J*) measured feed stock contamination by using the catalyst itself in a test, since the level of contaminants was too low to be measured directly. Burwell and coworkers (*2J*) measured the exchange between hydrocarbons and deuterium on palladium catalysts. Roginsky and Andrianova (*16J*) studied the redistribution of hydrogen between hydrocarbons on aluminosilicate catalyst using carbon-14. Leibnitz, Könnecke, and Knopel (*11J*) showed the dependence of macro pore radius on the catalytic activity of vanadium oxide in the oxidation of *o*-xylene to phthalic acid. Sokol'skiĭ and Malakhov (*22J*) studied powdered metal catalysts dispersed in liquids by an electrical conductivity method. Waterman (*25J*) presented a graphical method for the study of the performance of catalysts.

HYDROCARBON AND HYDROCARBON-TYPE ANALYSIS

Correlations between molecular structure and physical properties of hydrocarbons were reported by Greenshields and Rossini (*44K*). Rossini and coworkers (*97K*) also reported the physical properties of 20 more hydrocarbons of the API standard and API research series. Wood, Martin, and Lipkin (*110K*) reported a more precise method for determining saturate impurities in high purity aromatics based upon differential refractive indexes of pure saturates and raffinates. Asatoor and Dalgliesh (*4K*) used deactivated charcoals for the isolation of aromatic substances. Knight and Groennings (*57K*) extended the fluorescent indicator adsorption method for hydrocarbon-type analysis to smaller than normal concentrations and to the analysis of cracked gas oils and lubricating oils. Mair and Shamaiengar (*76K*) used molecular sieve adsorbents for the fractionation of mono-, di-, and trinuclear aromatic hydrocarbons from heavy gas oil and light lubricating oil distillate. Areshidze and Benashvili (*3K*) determined normal paraffins in the 200° to 250° C. fraction of Noriisk crude oil by means of urea. Panetti (*83K*) used a colloid mill in the formation of urea adducts. Brook and Whitham (*18K*) used elution chromatography followed by a simple filter paper spotting technique to separate aromatics from petroleum fractions boiling above the kerosine range. Anderson and Napier (*2K*) used polyether glycols as a stationary phase in the separation of aromatics from saturated and olefinic hydrocarbons. Brown (*19K*) summarized the chemical behavior of five- and six-membered ring compounds.

Liquid partition chromatography with aniline as a stationary phase was used by Sauer, Washall, and Melpolder (*91K*) for the separation of paraffins and cycloparaffins. Schaeffer and coworkers (*93K*) found suitable compounds for separation of xylenes, cymenes, and methylnaphthalenes from mixtures by clathration. Bown (*15K*) discovered that durene could be separated from mixtures by cocrystallization with symmetrical tetrachloroethane. Boer and Dunker (*13K*) used calcium hexammine for the selective reduction of aromatic hydrocarbons. Geelen and coworkers (*39K*) carried out ring analysis for aromatics in mineral oil. Kurtz and coworkers (*59K*) developed a type analysis scheme for viscous petroleum fractions using viscosity-gravity constant and refractivity intercept and (*60K*) using density and refractivity intercept. They (*61K*) used these methods in determining the composition of rubber processing oils. Linnig and Stewart (*69K*) studied rubber compounding oil by infrared. Crozier (*25K*) used type analysis methods in the study of a 200° to 300° F. fraction of Staffelden crude and to another crude in which adamantane was found.

Kühnhanss and coworkers (*58K*) did a systematic analysis of diesel oil fractions and assembled mathematical tables to permit the rapid characterization of hydrocarbon mixtures. Terres (*102K*) supplemented the *n-d-M* method by a study of 500 hydrocarbons. Sidlyaronok, Zherdeva, and Potanina (*95K*) compared five methods of hydrocarbon type analysis applied to lubricating oils and found the Dinsley and Carlton method to be best for aromatics. Feng (*33K*) verified the *n-d-M* method by comparing its results for 28 petroleum fractions which were more exhaustively analyzed.

Lauer and King (*66K*) described an apparatus for determining refractive index at elevated temperatures. Eby and Klett (*28K*) published a handy conversion table for correlation of refractive dispersions obtained by mercury and hydrogen light. Sullivan, Fries, McClenahan, and Willingham (*98K*) described apparatus for determining physical properties of small samples of high boiling hydrocarbons.

Further studies with 2,4,7-trinitrofluorenone as a reagent for the identification of polynuclear aromatics was presented by Laskowski and McCrone (*65K*). Takeuchi and Furusawa (*100K*) worked out a rapid determination of anthracene in mixtures by using an excess of maleic anhydride. Mixtures of three isomeric methylcyclohexenes and methylenecyclohexane were separated by gas chromatography on a saturated silver nitrate glycol solution by Gil-Av, Herling, and Shabtai (*41K*). Paper chromatography of polynuclear aromatics was described by Wieland and Kracht (*108K*), Bergmann and Gruenwald (*11K*), and Maly (*77K*). Terent'ev and Rozenberg (*101K*) detected isoalkanes by partial chlorination in aqueous ferric chloride. Geiseler and Bauman (*40K*) used silica gel chromatography for the determination of the molecular weight distribution of olefin polymers in the molecular weight range 500 to 3000 and higher.

Wheeler and Mateos (*105K*) determined the ultraviolet absorption of isolated double bonds in 39 acyclic and cyclic compounds. Goddu (*42K*) suggested near infrared spectrophotometry as a replacement for bromination or hydrogenation in determining terminal and cis double bonds. Yakubchik and Kasatkina (*111K*) studied the analytical applications of ozonization to the determination of unsaturates. Kazanskiĭ and coworkers (*55K*) compared three bromination procedures for the determination of unsaturation in mixtures of isopentane, isoprene, and isoamylene. Petrov (*85K*) studied the

bromination of 120 compounds with bromine in methanol. In some compounds bromination is accompanied by separation of hydrogen bromide and a method is proposed for determining the number of branches in alkenes and cyclenes from the results of bromination. Wood (*109K*) showed that the elimination of mercuric chloride catalyst from the ASTM solvent of the electrometric titration method gives more reliable results for propylene and butylene polymers and olefins occurring in cracked gasolines. In a study of 45 API standard olefins Unger (*103K*) also concluded that the omission of mercuric chloride is best. Leisey and Grutsch (*68K*) described a coulometric method for determining trace unsaturation of hydrocarbons. Miller and DeFord (*80K*) titrated olefins with electrically generated bromine and determined the end point by a spectrophotometric titration. They (*81K*) also described a method for determining olefin based on hydrogenation with electrically generated hydrogen. Flaschka and Hochenegger (*36K*) also determined double bonds by coulometric measurement of hydrogenation rates.

Engelbrecht (*31K*) described a sample technique for handling hydrogen compounds in microhydrogenation. Ritter and Gude (*88K*) described a rapid method for determining dicyclopentadiene based on liberation of nitrogen from an addition compound with phenyl azide. Budesinsky (*20K*) determined double bonds by addition of an excess of mercuric acetate and back-titration with (ethylenedinitrilo) tetraacetic acid. Fenske and Jones (*34K*) quantitatively removed olefins from hydrocarbon mixtures by reaction with an excess of a perfluoro organic acid.

Sedivec (*94K*) determined benzene in the presence of its homologs by nitration and polarographic measurement of the nitrate. Mlodecka (*82K*) resolved the xylene isomers by nitration and solvent and crystallization separation of the product. Popowicz (*87K*) determined the *p*-xylene content in xylene fractions cryoscopically. Kerenyi, Szepesy, and Kovats (*56K*) developed a quick solvent separation for toluene-xylene blends.

Hendriks, Soemantri, and Waterman (*48K*) separated the six-component mixture biphenyl, cyclohexylbenzene, bicyclohexyl, naphthalene, Tetralin, and Decalin by vapor phase chromatography. Polyphenyls were separated on alumina by Hellman, Alexander, and Coyle (*47K*). Silverman and Shideler (*96K*) determined biphenyl in the presence of polyphenyls by a water solubility method. The mass spectra and relative sensitivities of some polyphenyls were recorded by Bradt and Mohler (*16K*). Infrared and ultraviolet spectra were recorded by Dale (*26K*). Beaven, James, and Johnson (*9K*) showed that the changes in the ultraviolet absorption spectra of some alkylbiphenyls closely parallel corresponding changes in the relative retention volumes of the compounds in gas chromatography. Colichman, Fish, and Bjarke (*23K*) analyzed some radiation damaged terphenyls by micro distillation and infrared absorption in potassium bromide pellets.

The far ultraviolet absorption spectra of some small ring hydrocarbons was measured by Loeffler, Eberlin, and Pickett (*70K*). Differences in the ultraviolet spectra of di-*p*-xylylene and an alkylated benzene were discussed by Ingraham (*53K*). Friedel (*38K*) graphed some properties of the ultraviolet spectra of polynuclear aromatics. Evans (*32K*) discussed the strong ultraviolet absorption of iodine dissolved in a number of saturated hydrocarbons. Drexler (*27K*) gave data for the determination of naphthalene in cracked 1-methylnaphthalene; Hopson (*51K*) for cumene and α-methylstyrene, in crude α-methylstyrene; Frankel and Johnson (*37K*) for *o*-, *m*-, and *p*-xylene in mixtures; Ehlers (*30K*) for three methylethylbenzenes. Luther and Oelert (*74K*) gave the absorption coefficients at some key infrared frequencies of five- and six-membered ring naphthenes. Egorov and Petrov (*29K*) used infrared spectroscopy to measure the degree of branching of paraffin hydrocarbon. Brandes (*17K*) gave examples of structural group analysis with infrared spectroscopy in the 290 to 500 molecular weight range. The infrared spectroscopic analysis of alkylbenzenes was discussed by Ledwoch (*67K*), and the infrared spectra of solutions of iodine in alkylbenzenes by Ferguson (*35K*). Washburn and Mahoney (*104K*) gave new cyclopropyl correlations in the near infrared region. Infrared spectra of normal paraffin hydrocarbons were recorded by Jones (*54K*) and the characteristic infrared spectra of substituted naphthalenes by Hawkins, Ward, and Whiffen (*46K*). Groenewege (*45K*) studied the infrared spectra of 75 polynuclear aromatic compounds and their irregularity in the C-H wagging region.

White, Weiner, Alpert, and Ward (*106K*) described a device for handling micro volume samples in infrared analysis. Baker (*5K*) discussed infrared discrepancies in hydrocarbon mulls.

Chang, Kwan, and Hsu (*21K*) described a Raman analysis scheme for quantitative analysis of petroleum fractions using quinine sulfate as a reference. Aleksanyan and Sterin (*1K*) report accurate Raman intensities for a number of hydrocarbons which they suggest as standards. Bazhulin and coworkers (*8K*) give the Raman spectra of some naphthenes; Batuev, Bardyshev, and Matveeva (*7K*) of some terpene hydrocarbons. Boog and Kunst (*14K*) quantitatively determined butyl groups in hydrocarbons by their Raman and infrared spectra. Sushchinskiĭ (*99K*) described a structural analysis scheme of hydrocarbons based on their Raman spectra and with Landsburg and Bazhulin (*63K*) published a book covering the principal parameters of the Raman spectra of hydrocarbons. The ultraviolet, Raman, and infrared spectra of a number of partially hydrogenated aromatic hydrocarbons were given by Hueckel, Vevera, and Woerffel (*52K*).

Lumpkin (*72K*) described a mass spectrometric procedure for characterizing the saturate fraction of heavy petroleum hydrocarbons. He (*73K*) also proposed a low voltage technique for simplifying spectra and subsequent interpretation. Gordon, Moore, and Muller (*43K*) combined ultraviolet spectrophotometry and low voltage spectrometry in analyzing cracked oils. Lampe, Franklin, and Field (*62K*) measured the ionization cross sections for a number of hydrocarbons. This is the basis for using total ion intensity as a measure of sample size as proposed by Hood (*50K*) and Crable and Coggeshall (*24K*). Meyerson and Rylander (*78K*) proposed the tropylium ion to explain the mass spectra of toluene, cycloheptatriene, and alkylbenzene. Studies on the dissociation of *p*-xylene under electron impact are also given (*79K*). Langer and Johnson (*64K*) studied the rearrangement peaks in the mass spectrum of neopentane with both terminal and central labeling with C-13. Some advantages of rhenium filaments for mass spectrometry are described by Robinson and Sharkey (*90K*). Lossing and Tanaka (*71K*) suggest that photoionization sources for mass spectrometers may provide higher resolving power than electron impact. Herzog and Marmo (*49K*) determined mass spectrometrically the photoionization products of a number of hydrocarbons.

Barieau (*6K*) described a method of determining the hydrogen content of substances using gamma ray absorption. Bobranski (*12K*) described an automatic carbon-hydrogen apparatus in which the pressure in the combustion tube was used to regulate automatically the high frequency heating. White and co-workers (*107K*) also described an automatic apparatus in which they control with a cooling air blast. Robertson, Jett, and Dorfman (*89K*) described a rapid (20 minutes) apparatus for the micro determination of carbon and hydrogen. Charlton (*22K*) described further improvements in the quantitative microdetermination, and McCoy and Bastin (*75K*) provided for the determination in fluorine compounds. Belcher, Thompson, and West (*10K*)

found succinyl chloride to be a satisfactory titrimetric reagent for water as it came from a combustion train. Panicker and Banerjee (*84K*) described handling techniques for volatile samples such as gasoline and other petroleum distillates. Pickhardt, Safranski, and Mitchell (*86K*) covered the handling of pyrophoric and hygroscopic compounds by weighing and transferring in a polyethylene bag. Sax and Stross (*92K*) proposed squalane as a useful liquid standard for carbon-hydrogen molecular weight, refractive index, and viscosity determinations.

SULFUR

Birch and coworkers (*9L, 10L*) synthesized three sulfur compounds and reported their properties. Weinstein and Pierson (*54L*) synthesized several sulfur derivatives of naphthalene and recorded their ultraviolet absorption spectra. The chemistry of carbonyl sulfide and methods for its analytical determination were reviewed by Ferm (*22L*). Bruss, Wyld, and Peters (*13L*) described a potentiometric method for the determination of carbonyl sulfide in petroleum gases. Jezl and Stuart (*31L*) found that calcination at 700° C. greatly enhances the specificity of alumina adsorbants for removal of sulfur compound from mineral oil fractions. Coulometric detection of thiols separated by gas chromatography was used by Liberti and Cartoni (*36L*). Amberg (*4L*) gave gas chromatographic retention times for eight mercaptans, five sulfides, and 11 thiophenes whose identity were checked by mass spectrometer. Mercaptans and sulfides commonly found in commercial gas odorants were analyzed by gas-liquid partition chromatography by Spencer, Baumann, and Johnson (*45L*). Ryce and Bryce (*44L*) also described a procedure for separation of sulfur compounds by gas partition chromatography. Thompson, Coleman, Ward, and Rall (*50L*) obtained excellent separations of organic sulfur compounds by liquid thermal diffusion on a semimicrocolumn of 0.95 ml. capacity. Carson and Wong (*15L*) separated and identified aliphatic mercaptans by chromatography of the 2,4-dinitrophenyl sulfides. Böhme and Stachel (*11L*) tabulated the melting points of the derivatives of a number of aliphatic and aromatic mercaptans with 2,4-dinitrobenzenesulfenyl chloride.

Vecera, Gasparic, Snobl, and Jurecek (*51L*) studied the addition compounds of aliphatic sulfides with mercuric chloride and discussed the possibility of their identification by x-ray means. They (*24L*) also considered the corresponding dialkyl-*p*-bromophenacylsulfonium bromides, picrates, and perchlorates for identification purposes. A number of identifying infrared absorption bands have been assigned to the alkylthio groups by Menefee, Alford, and Scott (*40L*). Susi, Koenig, Parker, and Swern (*49L*) showed the infrared spectral effects produced by introducing sulfide, sulfoxide, or sulfone groups into the fatty acid chain. A method for thiol determination based on the reaction with iodoacetamide at pH 9 titration of the acidity produced was described by Benesch and Benesch (*6L*).

The Humble scheme for determining sulfur compounds in petroleum naphtha was outlined by Karchmer (*34L*). This is a comprehensive integrated scheme for determining mercaptans, hydrogen sulfide, elemental sulfur, aliphatic and cyclic sulfides, disulfides, thiophene, and total sulfur in liquid petroleum samples. Polarographic potentiometric, spectrophotometric, mass spectrometric, and chemical techniques are used. Drushel and Miller (*16L–18L*) studied the polarographic determination of aliphatic and cyclic sulfides, thiophenes, and aromatic sulfides. Hubbard, Haines, and Ball (*29L*) compared three chemical reduction procedures and a polarographic method for determining disulfides in petroleum on 15 pure disulfides. The acid reflux method is recommended for routine work. Karchmer and Walker (*35L*) studied the details of the acetic acid zinc reflux method and recommended modifications. Stahl and Siggia (*46L*) determined disulfides by reduction with sodium borohydride. Karchmer (*33L*) described precautions necessary in the potentiometric determination of mercaptans in the presence of elemental sulfur. The determination of elemental sulfur by polarographic methods was studied by Drushel, Miller, Hubis, and Clark (*19L*) and by Obolentsev, Aivazov, and Ratovskaya (*41L*). Stinsky (*47L*) titrated dissolved sulfur in mineral oils and greases with potassium cyanide. Ory, Warren, and Williams (*42L*) used the reagent *N*-(4,4′-dimethoxybenzohydrilidene) benzylamine in a direct colorimetric qualitative test for free sulfur. Huber (*30L*) suggested the use of silver in place of copper strips in detecting traces of active sulfur in solvents.

Kannuna (*32L*) described a tritium bremsstrahlung source of x-rays which is suitable for the determination of sulfur compounds and tetraethyllead in gasoline. Eccleston and Whisman (*20L*) used monochromatic x-ray absorption in a rapid method for the determination of total sulfur in hydrocarbons. Rapid burning in oxygen for the determination of traces of sulfur or halogens is possible with apparatus described by Wickbold (*55L*), Martin and Floret (*38L*), Hinsvark and O'Hara (*27L*), and Houghton (*28L*). Agazzi, Fredericks, and Brooks (*1L*) accomplished a similar thing with more conventional combustion-type apparatus. Improvements in the operation of wick lamps for sulfur determination were described by Battles (*5L*) and Hale, Quiram, McDaniel, and Stringer (*26L*). Gerhardt and Dyroff (*25L*) determined sulfur and phosphorus simultaneously in petroleum products by rapid high temperature combustion with a zinc oxide matrix. Vecera and Spevak (*52L*) decomposed organic sulfur compounds with metallic potassium and determined the sulfide formed colorimetrically with *N,N*-dimethyl-*p*-phenylenediamine. The method was found to be suitable over the range 0.005 to 8%. Etienne and Leger (*21L*) decomposed organic sulfur compounds in oxygen in an empty quartz tube collecting the sulfur on silver gauze as silver sulfide where it is determined gravimetrically. If halogens are present the weight of the silver sulfate is obtained by water washing the gauze. The method is applied to light and heavy fuel oils. Schoniger's method of decomposing organic sulfur compounds was used in rapid methods described by Lysyj and Zarembo (*37L*), Alicino (*3L*), and Ottosson and Snellman (*43L*).

Stratmann (*48L*) determined as little as 0.1 γ of sulfur by reduction to hydrogen sulfide and determination by the molybdenum blue reaction. Wagner (*53L*) found a minimum of interference in the microdetermination of sulfur due to phosphate, nitrate, or chloride in the direct oxidation, provided a platinum catalyst was not used. Massie (*39L*) described a titrimetric finish for the microdetermination of sulfur in compounds containing nitrogen. Bovee and Robinson (*12L*) used tetrahydroxyquinone as a sulfate titration indicator with the aid of a suitable light filter. Ahmed and Lawson (*2L*) determined small amounts of sulfur with the reagent 4-amino-4′-chlorodiphenyl. Bertolacini and Barney (*7L*) proposed barium chloranilate as a reagent for the rapid colorimetric determination of sulfate and (*8L*) increased the sensitivity so that as little as 0.06 p.p.m. of sulfate can be determined by measuring the absorption at 330 mμ instead of 530 mμ. Fritz, Yamamura, and Richard (*23L*) removed interfering salts formed in the peroxide bomb combustion of sulfur samples by passing the washings over alumina before titration. Burriel, Munoz, and de Lizarduy (*14L*) determined sulfate ion by indirect flame photometry with barium or strontium ion.

OXYGEN

A review article covering many of the problems in direct oxygen determination

by the Unterzaucher method has been done by Fort (*14M*). Imaeda (*22M*) studied the efficiency of reduced copper in removing oxygen from nitrogen gas used in the direct determination of oxygen. Bürger (*7M*) used hydrogen as the carrier gas to increase the scope of the determination. Schöniger (*44M*) showed that graphitization of the contact tube filling leads to low results and recommended frequent recharging. Kono, Sato, Suzuki, and Isobe (*28M*) removed oxygen from the nitrogen carrier gas as water by combining it with electrically generated hydrogen continuously supplied. Dixon (*9M*) described a procedure for eliminating interferences due to hydrogen and sulfur from petroleum in the direct determination of oxygen. Kainz (*24M*) reviewed recent developments in elementary analysis for carbon-hydrogen and oxygen. An isotope dilution method was used for oxygen. Sheft and Katz (*45M*) used BrF_2SbF_6 as a reagent for the direct determination of oxygen.

Polarographic methods for monitoring dissolved oxygen were described by Gualandi (*18M*) and Briggs, Dyke, and Knowles (*6M*). Wall (*52M*) described the development of a galvanic cell oxygen analyzer suitable for analyzing oxygen in the parts per million range based on a patent by Hersch (*20M*).

Several reagents have been used for the determination of traces of water vapor in gases. Linde and Rogers (*32M*) used calcium hydride; and Kusakov, Landau, Lubman, and Shchetsko (*30M*) studied the kinetics of the reaction applied to water in liquid hydrocarbons. Singliar and Zubak (*46M*) used magnesium nitride, determining the ammonia formed colorimetrically. Mardanov (*35M*) applied magnesium nitride to olefins. Rapoport, Khodak, and Shatrovskaya (*41M*) determined moisture in ethylene by scrubbing with ethylene glycol and titration with Karl Fischer reagent. Keidel (*26M*) described an electrolytic hygrometer which has become popular in several commercial versions. Loveland, Webster, Hablitzel, and Reed (*34M*) outlined the precautions necessary in determining less than 50 p.p.m. of water in hydrocarbon mixtures by the Karl Fischer reagent. Barr and Yarwood (*3M*) described a moisture by distillation apparatus with a siloxane coating. Matsuyama (*37M*) determined water in methanethiol and ethanethiol by measuring the cloud point.

Gas-liquid chromatography of some low boiling phenols is described by Karr and coworkers (*25M*); liquid-liquid and silica gel partition by White and Vaughan (*53M*) and Franc (*15M*). Paper chromatography of phenols is described by Hudecek and Beranova (*21M*) and by Franc (*16M*). The high frequency titration of phenols is described by Ershov, Pokrovskaya, Zarinskiĭ, and Koshkin (*11M*). The bromometric analysis of phenol solutions was covered by Ingberman (*23M*), Smith (*47M*), and Ettre, Heredy, and Kovacs (*12M*). Commins and Lindsey (*8M*) studied the determination of phenols by chromatography and spectrophotometry of their methyl ethers. Tanaka (*50M*) studied the integrated areas and intensities of the characteristic frequencies of 18 alkylphenols. Padhye and Sule (*38M*) analyzed metacresol and paracresol mixtures by ultraviolet spectrophotometry. Bavin and Canady (*4M*) correlated the O—H stretching frequencies with pK values for some phenols. Bain (*2M*) gave a direct infrared method for determining 4 - methyl - 2,6 - di - *tert* - butylphenol in mineral oil; Scheddel and Kiley (*43M*) gave data for the determination of phenol; *o* - *tert* - butylphenol, *p* - *tert*-butylphenol; 2,4-di-*tert*-butylphenol; and 2,4,6-tri-*tert*-butylphenol in *tert*-butylphenol mixtures. Long and Neuzil (*33M*) determined 4-methoxyphenol in 2-*tert*-butyl-4-methoxyphenol by partition chromatography and ultraviolet spectroscopy.

Saier and Hughes (*42M*) determined oxygenated materials as group types by infrared absorption. Bodnar and Mayeux (*5M*) estimated trace and major quantities of lower alcohols, ethers, and acetone. Ellis, Gaddis, and Currie (*10M*) used paper chromatography of the 2,4-dinitrophenyl - hydrazones for determination of aliphatic aldehydes; and Sundt and Winter (*49M*) for determination of aromatic carbonyl compounds. Langer, Friedel, Wender, and Sharkey (*31M*) determined alcohols and water in mixtures mass spectrometrically by conversion to the silyl ethers. Lithium aluminum hydride was used by Steinmark and Weiss (*48M*) in the determination of hydroxyl groups. Pinchas (*39M*) studied the infrared absorption of 16 benzaldehydes. Gyenes (*19M*) described a titration for the determination of phenols and carboxylic acids in the presence of each other, even in the same molecule. Van Meurs and Dahmen (*51M*) illustrated the titration of a number of carboxylic and phenolic acids in nonaqueous solutions. Kukin (*29M*) also discussed nonaqueous titrations of petroleum acids. Knotnerus (*27M*) summarized work on the chemical constitution of some naphthenic acids. The separation and identification of ketones as 2,4-dinitrophenylhydrazones by paper chromatography was shown by Gasparic and Vecera (*17M*); on alumina by Forss and Dunstone (*13M*); and on silicic acid–Celite by Pippen, Eyring, and Nonaka (*40M*). Maruyama, Onoe, and Goto (*36M*) separated organic oxides on a chromatostrip; and Abraham, Davies, Llewellyn, and Thain (*1M*) on silicone-treated paper.

OTHER ELEMENTS

Ball and Wenger (*2N*) concluded that there is very little crude oil production in which the nitrogen content is negligible. Helm, Latham, Ferrin, and Ball (*33N*) studied the boiling range distribution of nitrogen compounds in a Wilmington, Calif., crude. Muhs and Weiss (*49N*) described a colorimetric determination for pyrrolic nitrogen which is applicable to gasoline, jet fuels, rubber extenders, and aromatic solvents. Tests for detecting nitriles and amides were described by Trofimenko and Sease (*63N*). Takayama and Ohashi (*62N*) proposed differentiating between pyridine-type and other nitrogen compounds by the difference in decomposition temperature with H_3PO_4-HIO_3 reagent. Bruss and Wyld (*12N*) showed the advantages of methyl isobutyl ketone as a solvent in the titration of nitrogen bases.

Bond and Harriz (*10N*) concentrated nitrogen compounds on silica gel for the determination of trace amounts of nitrogen in petroleum distillates. Milner, Zahner, Hepner, and Cowell (*47N*) accomplished the same objective by extraction with 92% sulfuric acid. Razumov and Zhestkov (*53N*) determined nitrogen in petroleum products rapidly by omitting the Kjeldahl distillation step. Belcher, West, and Williams (*6N*) and Takagi and Hayashi (*61N*) described microprocedures for nitrogen determinations in organic compounds. Improvements in the Kjeldahl determination were suggested by Bradstreet (*11N*), Eder (*18N*), and Morris (*48N*). A number of workers (*17N*, *31N*, *35N*, *39N*, *40N*, *57N*, *66N*) suggested improvements in the Dumas method for nitrogen determination.

Beach and Shewmaker (*5N*) studied the nature of vanadium in petroleum and concluded that there are both volatile and nonvolatile prophyrin compounds. Erdman, Ramsey, Kalenda, and Hansons (*21N*) prepared several porphyrin vanadium complexes and studied their spectroscopic properties. Blumer (*9N*) semiquantitatively determined porphyrins by paper chromatography. Gregorowicz (*29N*) determined vanadium and nickel in petroleum ashes and deposits photometrically. Hansen and Hodgkins (*32N*) used copper metal powder as a carrier matrix for spectrochemical determination of vanadium, nickel, and iron in wet ash residues of petroleum fractions. Nagashima and Machin (*50N*) determined copper, nickel, and vanadium in crude petroleum spectrographically with a high voltage spark. Frisque (*25N*)

suggested germanium dioxide and graphite as spectrographic internal standards and buffer, respectively. Automatic computation of emission spectrographic data was described by Anderson and Moser (*1N*).

Flum (*24N*) found that silver diethyldithiocarbamate reagent is accurate and sensitive and requires fewer precautions in the determination of arsenic than the Gutzeit method. Maranowski, Snyder, and Clark (*45N*) determined as low as 1 p.p.b. of arsenic in petroleum distillates by wet oxidation and a modified Gutzeit test. Neutron activation analysis of arsenic in platinum alumina reforming catalysts was shown to be effective only to concentrations as low as 1 p.p.m. by Shipman and Milner (*58N*). Liederman, Bowen, and Milner (*42N*) described a sensitive colorimetric test for arsenic in naphthas and catalysts.

Sweetser (*59N*) used the Wickbold oxyhydrogen burner for decomposing organic fluorine compounds in the determination of fluorine. Rapid combustion of petroleum fractions for the determination of trace halogen compounds was described by Granatelli (*28N*) and Cali, Loveland, and Partikian (*14N*). Bergmann and Sanik (*7N*) used lamp combustion and sodium biphenyl reduction in determining traces of chloride. Chapman and Sherwood (*16N*) determined traces of halogens by ultraviolet absorption of the complex formed with palladous sulfate. Barney and Bertolacini (*4N*) used mercuric chloranilate for detecting traces of chloride, and Juliard (*37N*) titrated micro amounts of chloride amperometrically. Buell (*13N*) determined boron in lubricating oils by direct flame photometry. Inagaki and Moriya (*36N*) determined boron in a wide variety of petroleum fractions and products using a sensitive colorimetric procedure.

The high frequency titration of lead was described by Sawyer and Farrington (*55N*); the direct polarographic determination of tetraethyllead in gasoline was patented by Offutt and Sorg (*51N*). Linne and Wuelfken (*43N*) determined tetraethyllead in gasoline by direct flame photometry. Russ and Reeder (*54N*) eliminated interference due to iron or dye in the complexometric titration of tetraethyllead in gasoline. Tagliarini (*60N*) determined tetraethyllead by shaking gasoline with silver nitrate solution and determining the resulting metallic silver after filtration. Griffing, Rozek, Snyder, and Henderson (*30N*) described two dithizone procedures for determining parts per billion of tetraethyllead in naphthas. A spot test for traces of tetraethyllead was described by Ogloblina, El'nikovskaya, and Kamakin (*52N*).

Koltypin (*41N*) determined the barium content of greases by standard methods. Grabowski and Unice (*27N*) developed a sensitive spectrochemical determination for barium and strontium. Schuhknecht and Schinkel (*56N*) described a flame photometric procedure for the determination of calcium, strontium, and barium in the presence of each other. Tsuchihashi and Sekido (*64N*) and Erdey and Svehla (*20N*) described ways around the phosphate interference in the flame photometry of calcium. Yofe and Finkelstein (*67N*) used lanthanum ion to restore the intensity of calcium emission lines in the presence of phosphate and sulfate which normally depress the emission. Vallee and Bartholomay (*65N*) described a cyanogen-oxygen burner which, because of its high temperature, 4800° K., will excite lines not obtainable in the hydrogen-oxygen flame. An ultramicro flame spectrophotometer procedure with an integrating circuit was described by Exley and Sproat (*22N*). Bertolacini (*8N*) determined barium, calcium, and zinc complexometrically as did Gerhardt and Hartmann (*26N*). Marple, Matsuyama, and Burdett (*46N*) determined zinc in lubricating oil by photometric titration with dithizone. Barieau (*3N*) used the x-ray absorption edge in the quantitative determination of molybdenum and zinc. Lucchesi (*44N*) measured strontium by x-ray fluorescence.

Eggertsen and Weiss (*19N*) determined microgram amounts of phosphorus in organic compounds by reduction to phosphine with lithium aluminum hydride and Gutzeit detection. Jurecek and Jenik (*38N*) fixed the phosphorus in organic compounds by burning with metallic magnesium and conversion of the magnesium phosphide to phosphine. Fleischer, Southworth, Hodecker, and Tuckerman (*23N*) used the Schöniger method for burning phosphorus compounds. Chalmers and Thomson (*15N*) decomposed organic phosphorus compounds for analysis by simple heating with nitric and sulfuric acids. Hoffman, Jones, Robbins, and Alsberg (*34N*) described a colorimetric determination of phosphorus for gasolines containing tritolyl phosphate. Zall, McMichael, and Fisher (*68N*) used neocuproine in the determination of soluble copper in fuel oil.

POLLUTION

An air pollution handbook appeared by Magill, Holden, and Ackley (*49P*). Kay (*38P*, *39P*) did two air pollution reviews during this period, and an air pollution bibliography was started by the U. S. Department of Health, Education and Welfare (*26P*). Thomas (*77P*) also reviewed the field.

Rogers (*66P*) described the applications of several continuous recorders for the analysis of hydrocarbons and ozone in atmosphere. Schultz (*71P*) suggested Freon 12 as a tracer for atmospheric diffusion studies. Haines, Hemeon, and Cember (*28P*) traced ground-level distribution of stack emissions by using antimony oxide powder and neutron activation analysis. Todd and Wilson (*80P*) studied stack loss of catalysts from commercial catalytic cracking units with radioactive tracers uniformly deposited on the catalyst. Katz, Sanderson, and Ferguson (*36P*) studied the relation between absorbance of stains on filter paper and the carbon content of airborne particulates.

Hirt, Doughman, and Gisclard (*31P*) showed that x-ray studies of air-borne dust on a filter disk can reveal such things as platinum and vanadium from catalysts. Thompson (*79P*) described a jet impactor–light scattering technique for determination of aerosol size distributions. A cascade impactor for adiabatic measurements was described by Brink (*7P*). Techniques in the evaluation of atmospheric aerosols were also discussed by Vonnegut, Moore, Ehrenfeld, and Smallman (*81P*); Lodge and Tufts (*44P*); and Schadt and Cadle (*70P*). Barnebey and Davis (*3P*) described a system of cold traps for concentration of both organics and water for subsequent analysis. Weaver and coworkers (*84P*) interpreted the mass spectra of condensates from urban atmosphere. Mader, Heddon, Eye, and Hammig (*48P*) studied the effect of olefinic fuels on air pollution. Friedel (*23P*) used mass spectrometer and infrared techniques in the investigation of atmospheric pollution. A procedure using gas chromatography for determining trace hydrocarbons in an air separation plant which may be of wider applicability was described by Gaulin, Michaelsen, Alexander, and Sauer (*25P*). Thomas, Tebbens, Mukai, and Sanborn (*76P*) used paper strip chromatography and electrophoresis in the determination of aromatic compounds in polluted air. A gas-liquid chromatography procedure for air sampling was described by West, Sen, and Gibson (*86P*). Mohler, Bradt, and Dibeler (*52P*) studied the aromatic hydrocarbons filtered from smoky air by mass spectrometry. Quiram and Biller (*63P*) described a freeze-out mass spectrometer technique for determining trace quantities of hydrocarbons in the atmosphere. Krivoruchko and Turkel'taub (*42P*) described conditions under which butadiene, ethylbenzene, and styrene may be desorbed from silica gel for analysis. Chemodanova and Turkel'taub (*11P*) described a procedure for determination of traces of benzene, toluene, isopentane, hexane, and iso-

octane in the air. Rapid colorimetric detection methods for determining ethylene oxide in the atmosphere were described by Gage (*24P*) and Kobayashi (*40P*). The fixation of atmospheric carbonyl compounds by sodium bisulfite was described by Wilson (*88P*). Dixon, Hands, and Bartlett (*16P*) developed a field test for parts per million of hydrogen cyanide in air based on the formation of Prussian blue color. McKelvey and Hoelscher (*46P*) described an apparatus for preparation of very dilute gas mixtures which can be used for calibrating instruments.

Johnstone and Coughanowr (*35P*) studied the factors affecting the absorption of sulfur dioxide into fog droplets and conversion to sulfuric acid droplets. Patterson and Mellon (*60P*) and McConnaughey (*45P*) described colorimetric reagents for the detection of sulfur dioxide in a silica gel tube. Seidman (*72P*), Matty and Diehl (*50P*), and Mott and Parramore (*56P*) proposed modifications of the isopropyl alcohol extraction method for the determination of sulfur trioxide in flue gases. Crumley, Howe, and Wilson (*14P*) made an automatic apparatus for the same determination. Crumley and Fletcher (*13P*) sampled and determined the sulfur gases from domestic coal and coke fires under a variety of operating conditions. Anderson and Manlik (*2P*) determined the sulfur trioxide content of flue gases indirectly by measuring the corrosion on a steel specimen maintained at a controlled temperature. Cummings and Redfearn (*15P*) and Suzuki, Koshi, Kita, and Yamaguchi (*75P*) described portable apparatus for the determination of sulfur dioxide in atmosphere in the parts per million range and below. West and Gaeke (*85P*) proposed fixation of sulfur dioxide from the atmosphere for analysis as the disulfitomercurate (II).

Foran, Gibbons, and Wellington (*22P*) measured sulfur dioxide in the atmosphere by exposure of lead peroxide coated 10-cm. squares of cotton gauze and subsequent determination of the sulfate formed. Strange (*74P*) described apparatus for recording hydrogen sulfide and hydrogen cyanide concentrations in the range 4 p.p.b. to 50 p.p.m. Parts per million of sulfides in air were determined by Jacobs, Braverman, and Hochheiser (*32P*) by the methylene blue method. Moore, Cole, and Katz (*54P*) described methods for the concurrent determination of sulfur dioxide and nitrogen dioxide in the atmosphere. Apparatus and indicators for the determination of nitrogen oxides in atmosphere were described by Thomas and coworkers (*78P*), Kontorovich (*41P*), Filyanskaya (*20P*), Mokhov and coworkers (*53P*), Fedotov (*19P*), Jacobs and Hochheiser (*33P*), and Borok (*6P*). Renzetti (*65P*) used a long path ultraviolet spectrometer and Stephens, Hanst, Doerr, and Scott (*73P*) a long path infrared spectrometer to determine ozone in the atmosphere. Saltzman (*67P*) used a fast mass spectrometer and chemical methods to study ozone-olefin reactions. Allison, Delman, Ruff, and Simms (*1P*) and Wadelin (*82P*) proposed reagents for the determination of ozone in air.

Eggertsen and Nelsen (*18P*) determined the C_2 to C_5 hydrocarbons in engine exhaust and atmosphere chromatographically. Fitton (*21P*) studied the composition of the exhaust from motor vehicles; and Parsons, Neerman, Lifsitz, and Bryan (*59P*) used an interference filter photometer for monitoring carbon dioxide in engine exhaust at 4.29 microns. Doyle and Renzetti (*17P*) studied the formation of aerosols in irradiated auto exhaust. Mader, Gliksman, Eye, and Chambers (*47P*) studied the automobile exhaust from two fuels of different composition. Particles 10 to 400 $m\mu$ in diameter were observed in the exhaust of leaded fuels by Giubileo (*27P*). Hirschler (*30P*) studied the amount, composition, and size of lead particles present in engine exhaust; and Morriss, Bolze, and Goodwin (*55P*) studied the hydrocarbon, nitrogen oxides, and oxidants effluent concentration from engine exhaust with leaded and unleaded fuels. Analyzers for carbon monoxide in atmosphere were described by Waitman and Macoveanu (*83P*), Wilkins (*87P*), and Kavan (*37P*).

Johne, Kleiss and Reuter (*34P*) and Commins (*12P*) described the analysis of 3,4-benzopyrene in diesel motor exhaust. Further improvements in the determination of benzo-α-pyrene and other polynuclear hydrocarbons were described by Cahnmann (*9P*), Sawicki and Miller (*68P*), Sawicki, Miller, Stanley, and Hauser (*69P*), Buu-Hoi and Jacquignon (*8P*), Patton and Touey (*61P*), and Bentley and Burgan (*4P*).

Rather (*64P*) reported on API committee work on three methods for the determination of oil in refinery effluent waters which show that the infrared method is the best of the three. Nietsch (*58P*) described a method for determining petroleum products in natural waters by fluorescence after adsorption on magnesium oxide. Lindgren (*43P*) determined gasoline in water by extraction with carbon tetrachloride, chromatography, and infrared absorption. Happ, Stewart, and Cooper (*29P*) detected volatile organic compounds dissolved in water with the mass spectrometer. Cahnmann and Kuratsune (*10P*) determined aromatic hydrocarbons in oysters collected in polluted water. The determination of phenols in waste water was discussed by Mohler and Jacob (*51P*) and Pueschel and Grubitsch (*62P*). Meuller, Larson, and Lennarz (*57P*) showed that adsorption chromatography can quantitatively separate small concentrations of organic acids in water for later identification. Bertram, Carlisle, Murray, Warren, and Connell (*5P*) modified the standard catalytic reflux procedure for determining chemical oxygen demand in industrial waste to eliminate chloride interference.

MISCELLANEOUS

Nerheim (*29R*) described a spinning band column in which the band was fabricated from Teflon. Rosseau (*34R*) described performance tests on a spinning band distillation column. Mair, Krouskop, and Rossini (*24R*) described laboratory tests on a rotary concentric tube distilling column 4.871 inches in diameter and 60 inches high. The column did not give anticipated results because of heat generated by friction in the vapor phase. Some further data on the Kuhn (*22R*) column mentioned in the last review are now available. Bancroft and Rae (*3R*) described a wetted wall type of packing consisting of closely spaced, parallel vertical sheets of aluminum. Bench-scale continuous distillation apparatus designed to simulate full commercial operation at throughput rates of 0.5 to 5 liters per hour was described by Biribauer, Oakley, Porter, Staib, and Stewart (*4R*). Detailed tests on petroleum materials of some high vacuum laboratory distillation equipment of various design were described by Buckland, Freitas, and Anderson (*5R*), Nester (*30R*), Jones (*20R*), and Malyusov and coworkers (*25R*). A vacuum multifraction collector was described by Jacobson and Miller (*18R*). A new recirculation-type vapor-liquid equilibrium still is described by Harper and Moore (*14R*). Sullivan, Ruppel, and Willingham (*39R*) studied the effect of annular spacing and packing density in packed thermal diffusion columns. Ten articles on apparatus and technique improvements in the determination of molecular weight are listed in the bibliography (*2R, 8R, 10R, 13R, 15R, 32R, 35R, 36R, 38R, 41R*). Four improvements in cryometric techniques are also listed in the bibliography (*9R, 27R, 28R, 40R*).

Nettescheim (*31R*) described a drop time ascension method for the determination of the specific gravity of very small samples. Pillay, Rao, Nair, and Varkey (*33R*) claimed improvements in liquid chromatographic columns by a unique method of filling. Hull (*17R*) described a detailed technique for the use of a microchemical balance which

speeds accurate routine weighings. Jennings (*19R*) described an apparatus for measuring very low interfacial tensions in a water-oil system. Loprest (*23R*) described apparatus for the determination of the solubility of gases in liquids and gave as an example hydrogen in *n*-heptane. Challoner and Powell (*6R*) described a guarded hot-plate apparatus for determining the thermal conductivities of liquid.

Management problems in a spectroscopy laboratory were discussed by a number of petroleum industry people (*7R*). Addison, Spencer, and Charlet (*1R*) discussed the utilization of business machines punch card procedures in the operation of a petroleum analytical laboratory. Huff and Tingey (*16R*) discussed a statistically designed training program for an analytical control laboratory. Mandel and Linnig (*26R*) showed a scheme for studying accuracy in chemical analysis. Smith (*37R*) suggested the compound 5-chloro-4-hydroxy - 3 - methoxybenzylisothiourea phosphate as a multipurpose microchemical standard. It contains carbon, hydrogen, nitrogen, oxygen, chlorine, sulfur, phosphorus, and a methoxyl group. Duncan (*11R*) described a method of statistical quality control in a petroleum control laboratory in some detail. Field (*12R*) described the evaluation of the repeatability and reproducibility of new test methods. Kincannon and Baker (*21R*) designed a distillation laboratory containing 18 column stalls for efficiency and versatility. At the SAE National West Coast Meeting in Los Angeles, August 1958, detailed descriptions were given of new engine laboratory facilities at California Research Corp., Gulf Research and Development Co., Shell Oil Co., the Pure Oil Co., and Union Oil Co.

LITERATURE CITED

(1A) Am. Soc. Testing Materials, Committee E-2 publication, "Methods for Emission Spectrochemical Analysis," October 1957.
(2A) Am. Soc. Testing Materials, "Manual on Measurement and Sampling of Petroleum and Petroleum Products," 3rd ed., December 1957.
(3A) Am. Soc. Testing Materials, Spec. Tech. Publ. **214** (1957).
(4A) *Ibid.*, No. **224** (1958).
(5A) *Anal. Chim. Acta* **17**, No. 1 (July 1957).
(6A) Bonnar, R. U., Dimbat, M., Stross, F. H., "Number-Average Molecular Weights," Interscience, New York, 1958.
(7A) Cornelissen, J., Waterman, H. I., *Chim. & Ind. (Paris)* **79**, 26–9 (1958).
(8A) Cornelissen, J., Waterman, J. A., Waterman, H. I., *Brennstoff-Chem.* **39**, 84–6 (1958).
(9A) *Ibid.*, pp. 141–5.
(10A) Densham, A. B., Gough, G., "Proceedings of Congress on Modern Analytical Chemistry in Industry held at Univ. of St. Andrews, June 1957," pp. 56–66, W. Heffer & Sons, Cambridge, England.
(11A) Glasgow, A. R., Ross, G., *J. Research Natl. Bur. Standards* **57**, 137–42 (1956).
(12A) Keulemans, A. I. M., "Proceedings of Congress on Modern Analytical Chemistry in Industry, Univ. of St. Andrews, June 1957," pp. 217–27, W. Heffer & Sons, Cambridge, England.
(13A) LeTourneau, R. L., ANAL. CHEM. **29**, 684–97 (1957).
(14A) Meys, J. A., Waterman, H. I., Krevelan, D. W., *Erdöl u. Kohle* **10**, 752–3 (1957).
(15A) Powell, H., Thomas, W. H., *J. Inst. Petrol.* **44**, 19–28 (1958).
(16A) Reilly, C. A., ANAL. CHEM. **30**, 839–48 (1958).
(17A) Waterman, H. I., Boelhouwer, C., Cornelissen, J., "Correlation between Physical Constants and Chemical Structure," Elsevier, Amsterdam, 1958.

Gas Chromatography

(1B) Ambrose, D. A., Keulemans, A. I. M., Purnell, J. A., ANAL. CHEM. **30**, 1582–86 (1958).
(2B) Anderson, J. R., *J. Am. Chem. Soc.* **78**, 5692–3 (1956).
(3B) Anderson, J. R., Napier, K. H., *Australian J. Chem.* **10**, 250–5 (1957).
(4B) Andronikashvili, T. G., Kuz'mina, L. P., Shishkova, V. P., *Khim. i Tekhnol. Topliva i Masel* **1957**, No. 10, 61–5.
(5B) Andronikashvili, T. G., Kuz'mina, L. P., *Zavodskaya Lab.* **22**, 1403–6 (1956).
(6B) Ashbury, G. K., Davies, A. J., Drinkwater, J. W., ANAL. CHEM. **29**, 918–25 (1957).
(7B) Barrer, R. M., Hampton, M. G., *Trans. Faraday Soc.* **53**, 1462–75 (1957).
(8B) Bellis, H. E., Slowinski, E. J., *J. Chem. Phys.* **25**, 794 (1956).
(9B) Bennett, C. E., Nogare, S. D., Safranski, L. W., Lewis, C. D., ANAL. CHEM. **30**, 898–902 (1958).
(10B) Beynon, J. H., Clough, S., Crooks, D. A., Lester, G. R., *Trans. Faraday Soc.* **54**, 705–14 (1958).
(11B) Bernhard, R. A., *J. Assoc. Offic. Agr. Chemists* **40**, 915–21 (1957).
(12B) Blair, J. W., Amis, E. S., ANAL. CHEM. **30**, 329–32 (1958).
(13B) Blom, L., Edelhausen, L., *Anal. Chim. Acta* **15**, 559–66 (1956).
(14B) Boggus, J. D., Adams, N. G., ANAL. CHEM. **30**, 1471–3 (1958).
(15B) Bohemen, J., Purnell, J. H., *Chem. & Ind. (London)* **1957**, 815–17.
(16B) Bohemen, J., Purnell, J. H., *J. Appl. Chem. (London)* **8**, 433–40 (1958).
(17B) Brennan, D., Kemball, C., *J. Inst. Petrol.* **44**, 14–7 (1958).
(18B) Browning, L. C., Watts, J. O., ANAL. CHEM. **29**, 24–7 (1957).
(19B) Callisen, F. I., *Ind. y quím. (Buenos Aires)* **18**, 226–9 (1957).
(20B) Cheshire, J. D., Scott, R. P. W., *J. Inst. Petrol.* **44**, 74–9 (1958).
(21B) Chovin, P., *Bull. soc. chim. France* **1957**, 83–100.
(22B) Clark, L. J., ANAL. CHEM. **30**, 1157–8 (1958).
(23B) Coates, V. J., Noebels, H. J., Fagerson, I. S., "Gas Chromatography," Academic, New York, 1958.
(24B) Coggeshall, N. D., Williams, E. F., Division of Petroleum Chemistry, ACS, Preprint **2**, No. 4, D1-D177 (September 1957).
(25B) Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif., "Bibliography on Gas Chromatography," includes Supplement 1, undated.
(26B) Cordon, J. L. M., Lopez, G. Z., *Combustibles* **16**, 65–75 (1956).
(27B) Davis, A. D., Howard, G. A., *J. Appl. Chem. (London)* **8**, 183–6 (1958).
(28B) Deal, C. H., Otvos, J. W., Smith, V. N., Zucco, P. S., ANAL. CHEM. **28**, 1958–64 (1956).
(29B) Desty, D. H., *Nature* **179**, 241–2 (1957).
(30B) *Ibid.*, **181**, 604 (1958).
(31B) Desty, D. H., preprints 2nd Symposium on Gas Chromatography, Butterworths, London, 1958.
(32B) Desty, D. H., "Vapour Phase Chromatography," Butterworths, London, 1957.
(33B) De Wet, W. J., Pretorius, V., ANAL. CHEM. **30**, 325–9 (1958).
(34B) Eggertsen, F. T., Knight, H. S., *Ibid.*, **30**, 15–20 (1958).
(35B) Franc, J., Jokl, J., *Chem. listy* **52**, 276–82 (1958).
(36B) Golay, M. J. E., ANAL. CHEM. **29**, 928–32 (1957).
(37B) Golay, M. J. E., *Nature* **180**, 435 (1957).
(38B) Graf, L., Toth, J., *Acta Chim. Acad. Sci. Hung.* **13**, 403–27 (1958).
(39B) Grant, R. A., *J. Appl. Chem. (London)* **8**, 136–40 (1958).
(40B) Green, G. E., *Nature* **180**, 295–6 (1957).
(41B) Greene, S. A., Pust, H., *J. Phys. Chem.* **62**, 55–8 (1958).
(42B) Greene, S. A., Roy, H. E., ANAL. CHEM. **29**, 569–70 (1957).
(43B) Gregg, S. J., Stock, R., *Trans. Faraday Soc.* **53**, 1355–62 (1957).
(44B) Harley, J., Nel, W., Pretorius, V., *Nature* **181**, 177–8 (1958).
(45B) Harley, J., Pretorius, V., *Ibid.*, **178**, 1244 (1956).
(46B) Haskin, J. F., Warren, G. W., Priestley, L. J. Jr., Yarborough, V. A., ANAL. CHEM. **30**, 217–9 (1958).
(47B) Haslam, J., Jeffs, A. R., *Analyst* **83**, 455–62 (1958).
(48B) Holmes, J. C., Morrell, F. A., *Appl. Spectroscopy* **11**, 86–7 (1957).
(49B) Instrument Society America, International Symposium on Instrumental Methods, Houston, Tex., May 1958; ANAL. CHEM. **30**, 51A (April 1958).
(50B) James, A. T., *Fette u. Seifen* **59**, 73–7 (1957).
(51B) Janak, J., *Erdöl u. Kohle* **10**, 442–4 (1957).
(52B) Janak, J., *Mikrochim. Acta* **1956**, 1038–49.
(53B) Janak, J., Tesarik, K., *Chem. listy* **51**, 2048–54 (1957).
(54B) Johnson, H. W., Stross, F. H., ANAL. CHEM. **30**, 1586–9 (1958).
(55B) Jones, W. L., Kieselbach, R., *Ibid.*, **30**, 1590–2 (1958).
(56B) Keulemans, A. I. M., "Gas Chromatography," Reinhold, New York, 1957.
(57B) Keulemans, A. I. M., Kwantes, A., Brit. Patent **784,169** (Oct. 2, 1957).
(58B) Keulemans, A. I. M., Kwantes, A., Rijnders, G. W. A., *Anal. Chim. Acta* **16**, 29–39 (1957).
(59B) Knox, J. H., *Sci. Progr.* **45**, 227–44 (1957).
(60B) Kovats, E., Simon, W., Heilbronner, E., *Helv. Chim. Acta* **41**, 275–88 (1958).
(61B) Lederer, Edgar and Michael, "Chromatography," 2nd ed., Van Nostrand, Princeton, N. J., 1958.
(62B) Leibnitz, E., Hrapia, H., Konnecke, H. G., *Brennstoff-Chem.* **38**, 14–6 (1957).
(63B) Leithe, W., *Österr. Chem. Ztg.* **58**, 141–8 (1957).
(64B) Liberti, A., *Anal. Chim. Acta* **17**, 247–53 (1957).
(65B) Liberti, A., Conti, L., Crescenzi, V., *Nature* **178**, 1067–69 (1956).
(66B) Lipsky, S. R., Landowne, R. A.,

Biochim. et Biophys. Acta **27**, 666–7 (1958).
(67B) Lovelock, J. E., *J. Chromatography* **1**, 35–46 (1958).
(68B) McFadden, W. H., ANAL. CHEM. **30**, 479–81 (1958).
(69B) McWilliam, I. G., Dewar, R. A., *Nature* **181**, 760 (1958).
(70B) Madden, W. F., Quigg, R. K., Kemball, C., *Chem. & Ind. (London)* **1957**, 892.
(71B) Martin, A. E., Brit. Patent **790,-217** (Feb. 5, 1958).
(72B) Martin, A. J. P., *Ibid.*, **788,392** (Jan. 2, 1957).
(73B) Martin, A. J. P., James, A. T., *Biochem. J. (London)* **63**, 138–43 (1956).
(74B) Maurel, R., *Compt. rend.* **244**, 3157–59 (1957).
(75B) Munch, R. H., *Record Chem. Progr. (Kresge-Hooker Sci. Lib.)* **18**, 69–108 (1957).
(76B) Nogare, S. D., Safranski, L. W., ANAL. CHEM. **30**, 894–8 (1958).
(77B) Nunez, L. J., Armstrong, W. H., Cogswell, H. W., *Ibid.*, **29**, 1164–5 (1957).
(78B) Orr, C. H., Callen, J. E., *J. Am. Chem. Soc.* **80**, 249 (1958).
(79B) Percival, W. C., ANAL. CHEM. **29**, 20–4 (1957).
(80B) Pollard, E. H., Hardy, C. J., *Anal. Chim. Acta* **16**, 135–43 (1957).
(81B) Reed, T. M. III, ANAL. CHEM. **30**, 221–8 (1958).
(82B) Rosie, D. M., Grob, R. L., *Ibid.*, **29**, 1263–4 (1957).
(83B) Ryce, S. A., Bryce, W. A., *Can. J. Chem.* **35**, 1293–7 (1957).
(84B) Ryce, S. A., Kebarle, P., Bryce, W. A., ANAL. CHEM. **29**, 1386–87 (1957).
(85B) Said, A. S., *A.I.Ch.E. Journal* **2**, 477–81 (1956).
(86B) Schlierf, H., *Z. anal. Chem.* **159**, 118–23 (1957).
(87B) Scott, R. P. W., Cheshire, J. D., *Nature* **180**, 702–3 (1957).
(88B) Sekerka, B., Spevak, A., Friedrich, K., *Chem. Prumysl* **7**, 602–4 (1957).
(89B) Simmons, M. C., Snyder, L. R., ANAL. CHEM. **30**, 32–5 (1958).
(90B) Smith, J. W., *Sci. Progr.* **45**, 259–69 (1957).
(91B) Sørenson, I., Søltoft, P., *Acta Chem. Scand.* **10**, 1673–4 (1956).
(92B) Spencer, C. F., Johnson, J. F., ANAL. CHEM. **30**, 893–4 (1958).
(93B) Tenney, H. M., *Ibid.*, **30**, 2–8 (1958).
(94B) Turkel'taub, N. M., *Zhur. Fiz. Khim.* **31**, 2102–8 (1957).
(95B) Turkel'taub, N. M., Kolyubyakina, A. I., Selenkina, M. S., *J. Anal. Chem. U.S.S.R.* (Eng. trans.) **12**, 311–21 (1957).
(96B) Turkel'taub, N. M., Zhukhovitskiĭ, A. A., *Zavodskaya Lab.*, **23**, 1023–34 (1957).
(97B) Turner, D. W., *Nature* **181**, 1265–6 (1958).
(98B) Van Deemter, J. J., Zuiderweg, F. J., Klinkenberg, A., *Chem. Eng. Sci.* **5**, 271–89 (1956).
(99B) Voss, G., Hessenauer, F., *Erdöl u. Kohle* **10**, 161–3 (1957).
(100B) Waksmundski, A., *Wiadomości Chem.* **11**, 617–33 (1957).
(101B) Walker, R. E., Westenberg, A. A., *Rev. Sci. Instr.* **28**, 789–92 (1957).
(102B) Weinstein, A., ANAL. CHEM. **29**, 1899–900 (1957).
(103B) White, D., *Nature* **179**, 1075–6 (1957).
(104B) White, D., Cowan, C. T., *Trans. Faraday Soc.* **54**, 557–61 (1958).
(105B) Wilzbach, K. E., Riesz, P., *Science* **126**, 748–9 (1957).
(106B) Zlatkis, A., O'Brien, L. O., Scholly, P. R., *Nature* **181**, 1794 (1958).
(107B) Zlatkis, A., Ridgway, J. A., *Ibid.*, **182**, 130 (1958).
(108B) Zmitko, J., Brodsky, J., Biza, V., *Chem. Tech. (Berlin)* **9**, 458–9 (1957).

Process Instrumentation

(1C) Altom, A. B., *Oil Gas J.*, **56**, No. 16, 123–6 (1958).
(2C) Beerbower, A., *Control Engr.* **5**, No. 6, 107–12 (1958).
(3C) Berton, A., *Compt. rend.* **243**, 949–51 (1956).
(4C) Chamberlin, N. F., Thomas, B. W., Beaugh, J. B., Land, P. B., *Ind. Eng. Chem.* **48**, 1990–5 (1956).
(5C) Denny, B., *Oil Gas J.* **56**, No. 16, 117–18 (1958).
(6C) Fourroux, M. M., *Ibid.*, **56**, No. 16, 114–16 (1958).
(7C) Fraade, D. J., *Ibid.*, **55**, No. 42, 93–103 (1957).
(8C) Glasser, L. G., *Proc. Natl. Conf. Instr. Methods Anal.*, Chicago **1957**, Paper A157-2-1.
(9C) Glasser, L. G., Troy, D. J., *Ind. Eng. Chem.* **50**, 1149–52 (1958).
(10C) Hickerson, J. F., *Oil Gas J.* **56**, No. 16, 119–20 (1958).
(11C) Hull, D. E., *Ind. Eng. Chem.* **50**, 199–200 (1958).
(12C) Hybl, C., Lhotsky, O., *Chem. průmysl* **7**, 405–7 (1957).
(13C) Karasek, F. W., *Proc. Natural Gas Assoc. Am.*, 36th Ann. Convention 1957, pp. 12–7.
(14C) Landsberg, H., *Oil Gas J.* **55**, No. 42, 104–8 (1957).
(15C) Locke, L. N., *Ibid.*, **56**, No. 16, 120–1 (1958).
(16C) McCune, R. A., Mueller, W. M., Dunton, P. J., 6th Proc., Conf. Ind. Appl. X-Ray Anal., 1957, 399–407.
(17C) Martin, A. E., Reid, A. M., Smart, J., *Research Appl. in Ind.* **11**, 258–65 (1958).
(18C) Miller, A. J., *Oil Gas J.* **56**, No. 9, 88–91 (1958).
(19C) Miller, E. C., U. S. Patent **2,835,-116** (May 20, 1958).
(20C) Noebels, H. J., *Petrol. Engr.* **29**, No. 10, C24-29 (1957).
(21C) Quarendon, R., *Chem. & Process Eng.* **38**, 317–23 (1957).
(22C) Rappold, W. A., Ramsay, R. E., Am. Soc. Testing Materials, Spec. Tech. Publ. **214**, 109–13 (1957).
(23C) Simonsen, D. R., Crouch, H. W., *Ind. Eng. Chem.* **49**, 1741–3 (1957).
(24C) Wagner, A. R., *Proc. Nat. Gas Assoc. Am.*, 36th Ann. Convention 1957, pp. 10–2.
(25C) Wall, R. F., *Ind. Eng. Chem.* **50**, No. 2, 73A-74A; No. 4, 67A-68A; No. 5, 69A-70A; No. 6, 69A-70A; No. 7, 65A-66A., etc. (1958).
(26C) Wall, R. F., *ISA Journal* **4**, 267–71 (1957).
(27C) Wallis, S. W. J., Townend, D. S., *J. Inst. Petrol.* **44**, 29–40 (1958).
(28C) Wherry, T. C., Berger, D. E., *Petrol. Refiner* **37**, No. 5, 219–24 (1958).

Crude Oil

(1D) Blumer, M., ANAL. CHEM. **29**, 1039–41 (1957).
(2D) Carruthers, W., Douglas, A. G., *J. Chem. Soc.* **1957**, 278–85.
(3D) Coleman, H. J., Thompson, C. J., Ward, C. C., Rall, H. T., ANAL. CHEM. **30**, 1592–4 (1958).
(4D) Creanga, C., and others, *Lucrarile inst. petrol sigaze Bucuresti* **2**, 79–104 (1956).
(5D) Dunning, H. N., Johansen, R. T., *Petrol. Engr.* **30**, No. 1, B26-B28 (1958).
(6D) Dunning, H. N., Moore, J. W., *Bull. Am. Assoc. Petroleum Geol.* **41**, 2403–12 (1957).
(7D) Dunning, H. N., Moore, J. W., *Petrol. Refiner* **36**, No. 5, 247–50 (1957).
(8D) Evans, E. D., Kenny, G. S., Meinschein, W. G., Bray, E. E., ANAL. CHEM. **29**, 1858–61 (1957).
(9D) Glogoczowski, J. J., *Chem. Anal. (Warsaw)* **1**, 5–19 (1956).
(10D) Gutowsky, H. S., Ray, B. R., Rutledge, R. L., Unterberger, R. R., *J. Chem. Phys.* **28**, 744–5 (1958).
(11D) Hodgson, G. W., Baker, B. L., *Bull. Am. Assoc. Petrol. Geol.* **41**, 2413–26 (1957).
(12D) Hood, A., Clerc, R. J., O'Neal, M. J., Division of Petroleum Chemistry, ACS, Preprints **2**, No. 1, 221–9 (April 1957).
(13D) Howell, J. N., Jessen, F. W., *J. Petrol. Technol.* **8**, No. 9, 95–7 (1956).
(14D) Javes, A. R., Liddell, C., ANAL. CHEM. **30**, 1570–5 (1958).
(15D) Kaishev, K., *Godishnik Khim.-Tekhnol. Inst.* **3**, 99–193 (1956).
(16D) Kusakov, M. M., Petrov, A. A., *Doklady Akad. Nauk S.S.S.R.* **116**, 637–40 (1957).
(17D) Luther, M., Jesse, H., *Brennstoff-Chem.* **38**, 23–7 (1957).
(18D) Mair, B. J., Eberly, P. E., Li, K., Rossini, F. D., *Ind. Eng. Chem.* **50**, 115–6 (1958).
(19D) Mair, B. J., Marculaitis, W. J., Rossini, F. D., ANAL. CHEM. **29**, 92–100 (1957).
(20D) Moore, J. W., Dunning, H. N., U. S. Bur. Mines, Rept. Invest. **5370** (1957).
(21D) Ray, B. R., Witherspoon, P. A., Grim, R. E., *J. Phys. Chem.* **61**, 1296–302 (1957).
(22D) Rossini, F. D., *J. Inst. Petrol.* **44**, 97–107 (1958).
(23D) Stoffer, K. G., *Oil Gas J.* **56**, No. 2, 115; No. 6, 129 (1958)
(24D) Sughara, J. M., McGee, L. R., *J. Org. Chem.* **22**, 795–8 (1957).
(25D) Topchiev, A. V., Nifontova, S. S., Sushchik, R. Y., Suchkova, A. A., *Doklady Akad. Nauk S.S.S.R.* **111**, 1045–7 (1956).
(26D) U. S. Bur. Mines, Rept. Invest. **5376**, "Analysis of Crude Oils from 470 Important Oil Fields in the United States," December 1957.

Gases

(1E) Boreham, G. R., *J. Inst. Fuel* **31**, 304–7 (1958).
(2E) Bucur, R., *Rev. chim. (Bucharest)* **7**, 163–5 (1956).
(3E) Caldecourt, V. J., *Appl. Spectroscopy* **12**, 40–6 (1958).
(4E) Coates, V. J., Brenner, N., *Petrol. Refiner* **35**, No. 11, 197–201 (1956).
(5E) Creusot, L., Pommel, G., *Compt. rend. ind. gaz 74e Congr., Bordeaux*, **1957**, 151–80.
(6E) Densham, A. B., Ravald, L. A., *J. Appl. Chem. (London)* **8**, 267–70 (1958).
(7E) Esayan, I. L., Esayan, M., *Rev. chim. (Bucharest)* **8**, 447–52 (1957).
(8E) Fritts, B. K., Peattie, C. G., ANAL. CHEM. **28**, 1518–9 (1956).
(9E) Garner, F. H., Ellis, S. R. M., Steer, D. C., Thompson, D. W., *Génie chim. Suppl.* **78**, No. 5, 124–51 (1957).
(10E) Getoff, N., Sattler-Dornbacher, E., *Prakt. Chem.* **7**, 159–62, 192, 194, 197 (1956).
(11E) Greene, S. A., Pust, H., ANAL. CHEM. **29**, 1055 (1957).
(12E) *Ibid.*, **30**, 1039–40 (1958).
(13E) Guiden, R. M., Harvey, M. C., Wilkerson, R. C., *Ibid.*, **30**, 454 (1958).

(14E) Hopp, H. F., Wertzler, R., *Ibid.*, **30**, 877–9 (1958).
(15E) Janak, J., Novak, J., *Chem. listy* **51**, 1832–7 (1957).
(16E) Kapisinsky, Z., *Chem. průmysl* **7**, 66–7 (1957).
(17E) Kaufman, H. R., Zlatkis, A., *Chem. & Ind. (London)* **1958**, 1001.
(18E) Kavan, I., Base, J., *Paliva* **37**, 385–6 (1957).
(19E) Kyryacos, G., Boord, C. E., ANAL. CHEM. **29**, 787–8 (1957).
(20E) McAdams, D. R., *Ibid.*, **30**, 881–4 (1958).
(21E) Mason, D. M., *Am. Gas J.* **184**, No. 8, 18–20 (1957).
(22E) Mihm, C. H., Pollock, L. W., Shelton, R. O., ANAL. CHEM. **30**, 874–6 (1958).
(23E) Morlet, J., Angleraud, O., *Compt. rend. ind. gaz 74e Congr., Bordeaux*, **1957**, 189–202.
(24E) Mott, R. A., Moulson, I., *J. Appl. Chem. (London)* **7**, 546–62 (1957).
(25E) Nelson, K. H., Grimes, M. D., Smith, D. E., Heinrich, B. J., ANAL. CHEM. **29**, 180–3 (1957).
(26E) Nemeth, A., Cirlogan, C., *Rev. chim. (Bucharest)* **8**, 93–9 (1957).
(27E) Perry, J. A., Bain, G. H., ANAL. CHEM. **29**, 1123–7 (1957).
(28E) Pietsch, H., *Erdöl u. Kohle* **11**, 157–9 (1958).
(29E) Smith, R. N., Swinehart, J., Lesnini, D. G., ANAL. CHEM. **30**, 1217–8 (1958).
(30E) Sokolov, V. A., Kuz'mina, L. P., *Zavodskaya Lab.* **23**, 1034–7 (1957).
(31E) Stott, F. D., *Rev. Sci. Instr.* **28**, 914–5 (1957).
(32E) Szulczewski, D. H., Higuchi, T., ANAL. CHEM. **29**, 1541–3 (1957).
(33E) Toren, P. E., Heinrich, B. J., *Ibid.*, **29**, 1854–6 (1957).
(34E) Toth, J., Graf, L., *Magyar Kém. Folyóirat* **63**, 216–21 (1957).
(35E) Turkel'taub, N. M., Abramovich, L. Y., *Zhur. Anal. Khim.* **13**, 43–7 (1958).
(36E) Verrien, J. P., *Rev. inst. franç. pétrole et Ann. combustibles liquides* **11**, 641–83 (1956).
(37E) Zel'venskiĭ, Y. D., Kollerov, D. K., Tyrsin, A. A., Shalygin, V. A., *Gazovaya Prom.* **1958**, No. 5, 41–5.

Fuels

(1F) Araki, S., Nozawa, G., *Kogyo Kawagaku Zasshi* **59**, 675–80 (1956).
(2F) Bernelin, B., *Rev. inst. franç. pétrole et Ann. combustibles liquides* **13**, 259–66 (1958).
(3F) Brenner, N., Coates, V. J., *Nature* **181**, 1401–2 (1958).
(4F) Budarov, I. P., *Khim. i. Tekhnol. Topliva i Masel* **1957**, No. 10, 66–71.
(5F) Callinan, T. D., Roe, R. M., Romans, J. B., ANAL. CHEM. **28**, 1911–6 (1956).
(6F) Caplan, J. D., Brady, C. J., *S.A.E. Journal* **65**, No. 9, 62–3 (1957).
(7F) Carls, W. H., *Petrol. Engr.* **29**, No. 12, C20–C22 (1957).
(8F) Chang, M., others, *Jan. Liao Hsüeh Pao* **2**, No. 3, 203–12 (1957).
(9F) Chitty, D. B., *J. Inst. Petrol.* **44**, 255–6 (1958).
(10F) Christian, J. G., Chiantella, A. J., Johnson, J. E., Carhart, H. W., *Ind. Eng. Chem.* **50**, 1153–6 (1958).
(11F) Desty, D. H., Whyman, B. H. F., ANAL. CHEM. **29**, 320–9 (1957).
(12F) Eggertsen, F. T., Groennings, S., *Ibid.*, **30**, 20–5 (1958).
(13F) Epstein, M. B., Willingham, C. B., Mair, B. J., Rossini, F. D., *Ibid.*, **28**, 1924–7 (1956).
(14F) Ferguson, W. C., Howard, H. E., *Ibid.*, **30**, 314–7 (1958).
(15F) Gavrilov, B. G., Bagratyan, L. S., *Zhur. Obshcheĭ Khim.* **26**, 1777–8 (1956).
(16F) Gaylor, V. F., Conrad, A. L., Landerl, J. H., ANAL. CHEM. **29**, 228–32 (1957).
(17F) Glasgow, A. R. Jr., Gordon, R. J., Willingham, C. B., Mair, B. J., Rossini, F. D., *Ibid.*, **29**, 357–60 (1957).
(18F) Groennings, S., *ASTM Bull.*, No. **227**, 64–7 (1958).
(19F) Haber, M. C., *Norelco Reptr.* **5**, 39+, 52 (1958).
(20F) Knight, H. S., ANAL. CHEM. **30**, 9–15 (1958).
(21F) McCoy, J. W., *ASTM Bull.*, No. **221**, 59–63 (1957).
(22F) Mair, B. J., Eberly, P. E., Krouskop, N. C., Rossini, F. D., ANAL. CHEM. **30**, 393–9 (1958).
(23F) Mamedaliev, Y. G., Dalin, M. A., Shikhmamedbekova, A. Z., *Doklady Akad. Nauk Azerbaĭdzhan. S.S.R.* **13**, 1159–64 (1957).
(24F) Micus, G., Taranczewski, B., *Chem. Ing.-Tech.* **29**, 274–7 (1957).
(25F) Mikkelsen, L., Hopkins, R. L., Yee, D. Y., ANAL. CHEM. **30**, 317–21 (1958).
(26F) Mottlau, A. Y., *Ibid.*, **29**, 1196–202 (1958).
(27F) Natl. Bur. Standards (U. S.), *Tech. News Bull.* **41**, 151–2 (1957).
(28F) Nelson, K. H., Grimes, M. D., Heinrich, B. J., ANAL. CHEM. **29**, 1026–9 (1957).
(29F) Podkletnov, N. E., *Doklady Akad. Nauk S.S.S.R.* **116**, 973–5 (1957).
(30F) Rakowsky, F. W., Hunt, R. A. Jr., ANAL. CHEM. **28**, 1583–6 (1956).
(31F) Rossini, F. D., *J. Phys. Chem.* **60**, 1446–51 (1956).
(32F) Rowe, F. G., Nicolaysen, H. F., *Petrol. Engr.* **29**, No. 13, C45–C49 (1957).
(33F) Schindel, K., *Erdöl u. Kohle* **10**, 754–7 (1957).
(34F) Schwartz, R. D., Brasseaux, D. J., ANAL. CHEM. **29**, 1022–6 (1957).
(35F) Sergienko, S. R., Galich, P. N., *Zhur. Priklad. Khim.* **30**, 1653–60 (1957).
(36F) Stewart, P. B., Starkman, E. S., *Chem. Engr. Progr.* **53**, 41–5 (1957).
(37F) Topchiev, A. V., Ergorova, G. M., Alieva, G. A., Brazilevich, V. V., *Doklady Akad. Nauk. S.S.S.R.* **118**, 110–3 (1958).
(38F) Topchiev, A. V., Kusakov, M. M., Nifontova, S. S., Suchkova, A. A., Shishkina, M. V., *Khim. i Tekhnol. Topliva i Masel* **1957**, No. 9, 1–7.
(39F) Topchiev, A. V., Musaev, I. A., Iskhakova, E. K., Kislinskiĭ, A. N., Gal'pern, G. D., *Doklady Akad. Nauk Azerbaĭdzhan S.S.R.* **14**, 291–8 (1958).
(40F) Tourret, R., Bale, R. W., *J. Inst. Petrol.* **42**, 292–7 (1956).
(41F) Whisman, M. L., Eccleston, B. H., ANAL. CHEM. **30**, 1638–40 (1958).
(42F) Zlatkis, A., *Ibid.*, **30**, 332–3 (1958).

Lubricants

(1G) Abowd, R. G. Jr., *ASLE Trans.* **1**, 91–5 (1958).
(2G) Barth, V. C., Am. Soc. Testing Materials, Spec. Tech. Publ. **214**, 140–5 (1957).
(3G) Bondi, A., Diamond, H., *J. Colloid Sci.* **12**, 510–22 (1957).
(4G) Brennan, E. W., Moyer, R. G., Am. Soc. Testing Materials, Spec. Tech. Publ., **211**, 69–75 (1956).
(5G) Carter, T. L., Butler, R. H., Bear, H. R., Anderson, W. J., *ASLE Trans.* **1**, 23–32 (1958).
(6G) Colwell, L. V., *Trans. Am. Soc. Mech. Engrs.* **80**, 1054–8 (1958).
(7G) Criddle, D. W., *Lubrication Eng.* **13**, 131–5 (1957).
(8G) Davidson, T. F., Ku, P. M., *ASLE Trans.* **1**, 40–50 (1958).
(9G) Drucker, C., *Acta Chem. Scand.* **10**, 1372–6 (1956).
(10G) Eisenberg, H., *Rev. Sci. Instr.* **28**, 927–9 (1957).
(11G) Ellis, E. G., *Petroleum (London)* **20**, 294–8 (1957).
(12G) Fisher, C., Shapiro, A., Berk, S., Petronio, M., Teitell, L., Gisser, H., *Lubrication Eng.* **14**, 310–15 (1958).
(13G) Frei, E. H., Treves, D., Eisenberg, H., *J. Polymer Sci.* **25**, 273–8 (1957).
(14G) Furby, N. W., Hanly, F. J., Vincent, J. A., Am. Soc. Testing Materials, Spec. Tech. Publ. **211**, 40–54 (1956).
(15G) Furey, M. J., Kunc, J. F., Jr., *Lubrication Eng.* **14**, 302–9 (1958).
(16G) Godfrey, D., *Ibid.*, **13**, 598–601, 612 (1957).
(17G) Goldfinger, G., Greatbatch, W., *Instrumentation & Automation* **30**, No. 1, 88 (1957).
(18G) Goodwin, M. C., Hunstad, N. A., *NLGI Spokesman* **21**, No. 1, 10–6 (1957).
(19G) Groszek, A., *J. Inst. Petrol.* **43**, 184–5 (1957).
(20G) Hadfy-Kovacs, I., *Magyar Kém. Lapja* **6**, 106–9 (1956).
(21G) Horowitz, H. H., *Ind. Eng. Chem.* **50**, 1089–94 (1958).
(22G) Kaverina, N. I., *J. Appl. Chem. U.S.S.R.* (English trans.) **29**, 1565–8 (1956).
(23G) Klaus, E. E., Fenske, M. R., *Lubrication Eng.* **14**, 266–73 (1958).
(24G) Krause, R., *Erdöl u. Kohle* **9**, 241–5 (1956).
(25G) Krein, S. E., Mitrofanov, M. G., Fuchkov, N. G., *Khim. i Tekhnol. Topliva i Masel* **1957**, No. 12, 13–22.
(26G) Kyuregyan, S. K., *Ibid.*, **1958**, No. 4, 23–5.
(27G) McConnell, T. A., Am. Soc. Testing Materials, Spec. Tech. Publ., **218**, 3–15 (1957).
(28G) Mair, B. J., Marculaitis, W. J., Rossini, F. D., ANAL. CHEM. **29**, 92–100 (1957).
(29G) Massey, L., Murty, N. N., Thompson, C. N., *J. Inst. Petrol.* **43**, 282–7 (1957).
(30G) Melpolder, F. W., Brown, R. A., Washall, T. A., Doherty, W., Headington, C. E., ANAL. CHEM. **28**, 1936–45 (1956).
(31G) Milz, W. C., Kipp, E. M., *Lubrication Eng.* **12**, 396–400 (1956).
(32G) Nagano, T., Oguma, M., *Chem. High Polymers (Japan)* **14**, 397–401 (1957).
(33G) Natl. Bur. Standards (U. S.), *Tech. News Bull.* **41**, 152–3 (1957).
(34G) Needs, S. J., *Trans. Am. Soc. Mech. Engrs.* **80**, 1099–103 (1958).
(35G) Paleari, C., Girelli, A., Siniramed, C., *J. Inst. Petrol.* **44**, 178 (1958).
(36G) Penny, F. D., Ackroyd, G. C., *Petroleum (London)* **21**, 196 (1958).
(37G) Peri, J. B., *J. Am. Oil Chemists' Soc.* **35**, 37–41, 110–7 (1958).
(38G) Schwarz, G., *Erdöl u. Kohle* **10**, 588–92 (1957).
(39G) Scott, D., *Engineering* **185**, 660–2 (1958).
(40G) Selby, T. W., *ASLE Trans.* **1**, 68–81 (1958).
(41G) Simpson, W. K., Am. Soc. Testing Materials, Spec. Tech. Publ. **214**, 124–6 (1957).
(42G) Siripongse, C., Rogers, P. R., Cameron, A., *Engineering* **186**, 146–9 (1958).
(43G) Smith, G. S., *J. Inst. Petrol.* **43**, 227–30 (1957).
(44G) Thomas, E. R., Am. Soc. Testing Materials, Spec. Tech. Publ. **214**, 146–50 (1957).
(45G) Tourret, R., Bale, R. W., *J. Inst. Petrol.* **44**, 273–81 (1957).
(46G) Umstätter, H., *Makromol. Chem.* **25**, 199–204 (1958).

(47G) Ungar, A., Trozzolo, A. M., ANAL. CHEM. **30**, 187–91 (1958).
(48G) White, H. S., *ASLE Trans.* **1**, 51–67 (1958).

Wax, Asphalt, Grease

(1H) Adams, E. W., *NLGI Spokesman* **22**, 186–91 (1958).
(2H) Arabian, K. G., *Tappi* **41**, 275–80 (1958).
(3H) Asseff, P. A., *ASTM Bull.* No. **228**, 28–32 (1958).
(4H) Brunstrum, L. C., Leer, R. H., *Lubrication Eng.* **12**, 316–22 (1956).
(5H) Calhoun, S. F., *NLGI Spokesman* **22**, 69–85 (1958).
(6H) Cindea, C., *Rev. minelor (Bucharest)* **8**, 416–8 (1957).
(7H) Connors, H. J., *Lubrication Eng.* **14**, 22–6, 40 (1958).
(8H) Cox, D. B., McGlynn, J. F., ANAL. CHEM. **29**, 960–3 (1957).
(9H) Dewhust, J. R., Deadman, A. L., *Chem. & Ind. (London)* **1956**, 938–41.
(10H) Dreher, J. L., *NLGI Spokesman* **21**, 13–5 (1957).
(11H) Edwards, R. T., *Ind. Eng. Chem.* **49**, 750–7 (1957).
(12H) Fox, R. C., *Tappi* **41**, 283–9 (1958).
(13H) Fuchs, W., Nettesheim, G., *Erdöl u. Kohle* **10**, 15–20 (1957).
(14H) Fujiwara, S., Yamaguchi, I., *Bull. Chem. Soc. Japan* **30**, 779–82 (1957).
(15H) Green, E. H., *J. Inst. Petrol.* **42**, 298–9 (1956).
(16H) Hughes, F. J., Walker, D. C., *Tappi* **41**, 280–3 (1958).
(17H) Hunter, R. S., Lofland, C. A., *Ibid.*, **39**, 833–41 (1956).
(18H) Kabes, V., Cejka, M., Vesely, S., *Chem. průmysl* **7**, 590–3 (1957).
(19H) Kaiser, R., *Chem. Tech. (Berlin)* **8**, 388–95 (1956).
(20H) Kleinschmidt, L. R., Snoke, H. R., *J. Research Natl. Bur. Standards* **60**, 169–72 (1958).
(21H) Knotnerus, J., *J. Inst. Petrol.* **42**, 355–60 (1956).
(22H) Krenkler, K., *Bitumen, Teere, Asphalte, Peche* **9**, 146–51 (1958).
(23H) Lauer, F. J., *Fette u. Seifen* **59**, 140–2 (1957).
(24H) Letters, K., *Bitumen, Teere, Asphalte, Peche* **7**, 89–92 (1956).
(25H) *Ibid.*, **8**, 415–20 (1957).
(26H) Martin, J. M., Jr., Johnston, R. W. B., Cannon, H. J., O'Neal, M. J., ANAL. CHEM. **30**, 1005–9 (1958).
(27H) Miller, W. R., Walsh, T. J., Slaymaker, R. R., *Lubrication Eng.* **14**, 216–21 (1958).
(28H) Nechitailo, N. A., Rozenberg, L. M., Terent'eva, E. M., Topchiev, A. V., *Doklady Akad. Nauk S.S.S.R.* **116**, 613–6 (1957).
(29H) Ogilvie, J. L., Simmons, M. C., Hinds, G. P. Jr., ANAL. CHEM. **30**, 25–7 (1958).
(30H) Orr, A. S., *NLGI Spokesman* **22**, 221–5 (1958).
(31H) Phillips, J., *Tappi* **41**, 290–5 (1958).
(32H) Powers, G. W., Piehl, F. J., ANAL. CHEM. **30**, 28–31 (1958).
(33H) Roach, J. R., Jordan, T. B., *NLGI Spokesman* **21**, 18–22 (1957).
(34H) Sanin, P. I., Melent'eva, N. V., Zelenova, Y. M., *Colloid J. (U.S.S.R.)* (Eng. trans.) **18**, 743–5 (1956).
(35H) Schlosser, F., Hempel, F., *Erdöl. u. Kohle* **10**, 232–8 (1957).
(36H) Schoenholz, D., Burns, G. D., *Soap Chem. Specialties* **33**, No. 10, 82 (1957).
(37H) Schweyer, H. E., ANAL. CHEM. **30**, 205–9 (1958).
(38H) Starobintsev, G. L., Bol'shova, T. A., *Zhur. Anal. Khim.* **13**, 235–41 (1958).
(39H) Stewart, J. E., *J. Research Natl. Bur. Standards* **58**, 265–9 (1957).
(40H) Topchiev, A. V., Nechitailo, N. A., Rozenberg, L. M., Terent'eva, E. M., *Doklady Akad. Nauk S.S.S.R.* **117**, 629–31 (1957).
(41H) Tourret, R., Baker, A. J. S., *J. Inst. Petrol.* **44**, 9–13 (1958).
(42H) Walter, F., Evans, R. R., Walker, J., Askevold, R. J., *ASTM Bull.* No. **227**, 58–9 (1958).
(43H) Wilkinson, C. E., Striker, L., Traxler, R. N., *Ibid.*, **230**, 42–4 (1958).
(44H) Zemplen, J., Szabo, P., *Kolloid-Z.* **153**, 36–8 (1957).
(45H) Zube, E., Skog, J. B., Am. Soc. Testing Materials, Spec. Tech. Publ. **212**, 13–34 (1957).

Catalysts

(1J) Benesi, H. A., *J. Phys. Chem.* **61**, 970–3 (1957).
(2J) Burwell, R. L., Shim, B. K. C., Rowlinson, H. C., *J. Am. Chem. Soc.* **79**, 5142–8 (1957).
(3J) Cochran, C. N., Cosgrove, L. A., *J. Phys. Chem.* **61**, 1417–9 (1957).
(4J) Eadie, F. S., Payne, R. E., *Brit. Chem. Eng.* **1**, 306–11 (1956).
(5J) Fuschillo, N., Renton, C. A., *Nature* **180**, 1063–4 (1957).
(6J) Gunn, E. L., ANAL. CHEM. **29**, 184–9 (1957).
(7J) Hindin, S. G., Lee, J. K., Weller, S. W., *Ibid.*, **29**, 1850–2 (1957).
(8J) Innes, W. B., *Ibid.*, **29**, 1069–73 (1957).
(9J) Jiru, P., Brull, J., *Chem. listy* **51**, 2189–94 (1957).
(10J) Lee, J. K., Weller, S. W., ANAL. CHEM. **30**, 1057–8 (1958).
(11J) Leibnitz, E., Könnecke, H. G., Knopel, H., *J. prakt. Chem.* (4) **4**, 298–305 (1957).
(12J) Markova, Z. A., *Optika i Spektroskopiya* **2**, 814–6 (1957).
(13J) Maxsted, E. B., Josephs, M., *J. Chem. Soc.* **1956**, 2635–39.
(14J) Nelsen, F. J., Eggertsen, F. T., ANAL. CHEM. **30**, 1387–90 (1958).
(15J) Robin, M., Trueblood, K. N., *J. Am. Chem. Soc.* **79**, 5138–42 (1957).
(16J) Roginsky, S. Z., Andrianova, T. I., *J. Gen. Chem. U.S.S.R.* (Eng. trans.) **26**, 2403–6 (1956).
(17J) Rothrock, J. J., Birkhimer, E. R., Leum, L. N., *Ind. Eng. Chem.* **49**, 272–6 (1957).
(18J) Rubinshtein, A. M., Afanas'ev, V. A., *Bull. acad. sci. U.R.S.S., Classe sci. chim.* (Eng. trans.) **1956**, 1329–37.
(19J) Rubinshtein, A. M., Dashevsky, M. I., Pribytkova, N. A., *Ibid.*, **1957**, 441–44.
(20J) Rubinshtein, A. M., Slinkin, A. A., Afanasyev, V. A., *Ibid.*, **1957**, 33–7.
(21J) Selwood, P. W., *J. Am. Chem. Soc.* **79**, 4637–40 (1957).
(22J) Sokol'skiĭ, D. V., Malakhov, V. V., *Doklady Akad. Nauk S.S.S.R.* **117**, 455–7 (1957).
(23J) Spillane, F. J., *Analyst* **82**, 712–5 (1957).
(24J) Stone, R. L., Rase, H. F., ANAL. CHEM. **29**, 1273–77 (1957).
(25J) Waterman, H. J., *Riv. combustibili* **11**, 287–99 (1957).

Hydrocarbon and Hydrocarbon-Type Analysis

(1K) Aleksanyan, V. T., Sterin, Kh. E., *Optika i Spektroskopiya* **2**, 562–7 (1957).
(2K) Anderson, J. R., Napier, K. H., *Australian J. Chem.* **9**, 541–3 (1956).
(3K) Areshidze, Kh. I., Benashvili, E. M., *Proc. Acad. Sci U.S.S.R., Sec. Chem.* (Eng. trans.) **110**, 569–71 (1956).
(4K) Asatoor, A., Dalgliesh, C. E., *J. Chem. Soc.* **1956**, 2291–9.
(5K) Baker, A. W., *J. Phys. Chem.* **61**, 450–8 (1957).
(6K) Barieau, R. E., U.S. Patent **2,584,248** (May 6, 1958).
(7K) Batuev, M. I., Bardyshev, I. I., Matveeva, A. D., *Izvest. Akad. Nauk S.S.S.R., Otdel Khim. Nauk* **1958**, 232–3.
(8K) Bazhulin, F. A., others, *Bull. acad. sci. U.R.S.S., Classe sci. chim.* (Eng. trans.) **1956**, 1147–51; **1957**, 39–43.
(9K) Beaven, G. H., James, A. T., Johnson, E. A., *Nature* **179**, 490–1 (1957).
(10K) Belcher, R., Thompson, J. H., West, T. S., *Anal. Chim. Acta* **19**, 148–53 (1958).
(11K) Bergmann, E. D., Gruenwald, T., *J. Appl. Chem. (London)* **7**, 15–24 (1957).
(12K) Bobranski, B., *Mikrochim. Acta* **1956**, 1735–46.
(13K) Boer, H., Dunker, P. M., *Rec. trav. chim.* **77**, 346–59 (1958).
(14K) Boog, W., Kunst, E. D., "Colloquim Spectroscopicum, Internationale VI," Pergamon Press, Amsterdam, 1956.
(15K) Bown, D. E., U.S. Patent **2,815,392** (Dec. 3, 1957).
(16K) Bradt, P., Mohler, F. L., *J. Research Natl. Bur. Standards* **60**, 143–5 (1958).
(17K) Brandes, G., *Brennstoff-Chem.* **37**, 263–7 (1956).
(18K) Brook, B. M., Whitham, B. T., *J. Inst. Petrol.* **44**, 212–5 (1958).
(19K) Brown, H. D., *J. Org. Chem.* **22**, 439–41 (1957).
(20K) Budesinsky, B., *Chem. listy* **51**, 259–63 (1957).
(21K) Chang, C. S., Kwan, T. S., Hsu, W. T., *Hua Hsüeh Hsüeh Pao* **22**, 524–31 (1956).
(22K) Charlton, F. E., *Analyst* **81**, 582–7 (1956).
(23K) Colichman, E. L., Fish, R. F., Bjarke, G. O., *Anal. Chim. Acta* **16**, 250–8 (1957).
(24K) Crable, G. F., Coggeshall, N. D., ANAL. CHEM. **30**, 310–3 (1958).
(25K) Crozier, A., *Rev. inst. franc. pétrole et Ann. combustibles liquides* **11**, 869–912, 1129–60, 1232–68 (1956).
(26K) Dale, K., *Acta Chem. Scand.* **11**, 640–59 (1957).
(27K) Drexler, S., ANAL. CHEM. **30**, 549–50 (1958).
(28K) Eby, H. M., Klett, R. A., *Ibid.*, **30**, 100–3 (1958).
(29K) Egorov, Y. P., Petrov, A. A., *Zhur. Anal. Khim.* **11**, 483–8 (1956).
(30K) Ehlers, J. G., ANAL. CHEM. **30**, 549–50 (1958).
(31K) Engelbrecht, R. M., *Ibid.*, **29**, 1556–7 (1957).
(32K) Evans, D. F., *J. Chem. Soc.* **1957**, 4229–34.
(33K) Feng, Y. S., *Jan Liao Hsueh Pao* **2**, No. 4, 323–32 (1957).
(34K) Fenske, M. R., Jones, J. H., U.S. Patent **2,775,633** (Dec. 25, 1956).
(35K) Ferguson, E. E., *Spectrochim. Acta* **10**, 123–4 (1957).
(36K) Flaschka, H., Hochenegger, M., *Mikrochim. Acta* **1957**, 587–93.
(37K) Frankel, D. M., Johnson, C. E., ANAL. CHEM. **30**, 549–50 (1958).
(38K) Friedel, R. A., *Appl. Spectroscopy* **11**, 13–24 (1957).
(39K) Geelen, H., Waterman, H. I., Westerdijk, J. B., *J. Inst. Petrol.* **43**, 14–20 (1957).
(40K) Geiseler, F., Bauman, H. P., *Z. Elektrochem.* **62**, 209–14 (1958).
(41K) Gil-Av, E., Herling, J., Shabtai, J., *Chem. & Ind. (London)* **1957**, 1483–4.
(42K) Goddu, R. F., ANAL. CHEM. **29**, 1790–4 (1957).

(43K) Gordon, R. J., Moore, R. J., Muller, C. E., *Ibid.*, **30**, 1221–4 (1958).
(44K) Greenshields, J. B., Rossini, F. D., *J. Phys. Chem.* **62**, 271–80 (1958).
(45K) Groenewege, M. P., "Colloquim Spectroscopicum Internationale VI," Pergamon Press, Amsterdam, 1956.
(46K) Hawkins, T. G., Ward, E. R., Whiffen, D. H., *Spectrochim. Acta* **10**, 105–9 (1957).
(47K) Hellman, M., Alexander, R. L., Coyle, C. F., ANAL. CHEM. **30**, 1206–10 (1958).
(48K) Hendriks, W. J., Soemantri, R. M., Waterman, H. I., *J. Inst. Petrol.* **43**, 288–91 (1957).
(49K) Herzog, R. F., Marmo, F. F., *J. Chem. Phys.* **27**, 1202–5 (1957).
(50K) Hood, A., ANAL. CHEM. **30**, 1218–20 (1958).
(51K) Hopson, J. V., *Ibid.*, **30**, 549–50 (1958).
(52K) Hueckel, W., Vevera, E., Woerffel, U., *Chem. Ber.* **90**, 901–9 (1957).
(53K) Ingraham, L. L., *J. Chem. Phys.* **27**, 1228–9 (1957).
(54K) Jones, R. N., *Natl. Research Council Bull. (Ottawa)* No. 5, 1957.
(55K) Kazanskiĭ, B. B., Sterligov, O. D., Belen'kaya, A. P., Kondrat'eva, G. Ya., Pavlova, P. S., *Izvest. Akad. Nauk S.S.S.R., Otdel, Khim. Nauk* **1957**, 1399–400.
(56K) Kerenyi, E., Szepesy, L., Kovats, G., *Magyar Kém. Folyóirat* **59**, 53–4 (1953).
(57K) Knight, H. S., Groennings, S., ANAL. CHEM. **28**, 1949–54 (1956).
(58K) Kühnhanss, G., Rösner, H., Hüttig, E., Wagner, M., Tischendorf, G., *Erdöl u. Kohle* **10**, 372–5, 435–41 (1957).
(59K) Kurtz, S. S., Jr., King, R. W., Stout, W. J., Partikian, D. G., Skrabek, E. A., ANAL. CHEM. **28**, 1928–36 (1956).
(60K) Kurtz, S. S., Jr., King, R. W., Stout, W. J., Peterkin, M. E., *Ibid.*, **30**, 1224–36 (1958).
(61K) Kurtz, S. S., Jr., King, R. W., Sweely, J. S., *Ind. Eng. Chem.* **48**, 2232–4 (1956).
(62K) Lampe, F. W., Franklin, J. L., Field, F. H., *J. Am. Chem. Soc.* **79**, 6129–32 (1957).
(63K) Landsburg, G. S., Bazhulin, P. A., Sushchinski, M. M., "Principal Parameters of the Raman Spectra of Hydrocarbons," Izvest. Akad. Nauk S.S.S.R., 1956.
(64K) Langer, A., Johnson, C. P., *J. Phys. Chem.* **61**, 891–3 (1957).
(65K) Laskowski, D. E., McCrone, W. C., ANAL. CHEM. **30**, 542–4 (1958).
(66K) Lauer, J. L., King, R. W., *Ibid.*, **28**, 1697–700 (1956).
(67K) Ledwoch, K. D., *Erdöl u. Kohle* **10**, 595–96 (1957).
(68K) Leisey, F. A., Grutsch, J. F., ANAL. CHEM. **28**, 1553–5 (1956).
(69K) Linnig, F. J., Stewart, J. E., *J. Research Natl. Bur. Standards* **59**, 27–40 (1957).
(70K) Loeffler, B. B., Eberlin, E., Pickett, L. W., *J. Chem. Phys.* **28**, 345–7 (1958).
(71K) Lossing, F. P., Tanaka, I., *Ibid.*, **25**, 1031–4 (1956).
(72K) Lumpkin, H. E., ANAL. CHEM. **28**, 1946–8 (1956).
(73K) *Ibid.*, **30**, 321–5 (1958).
(74K) Luther, H., Oelert, H., *Angew. Chem.* **69**, 262–6 (1957).
(75K) McCoy, R. N., Bastin, E. L., ANAL. CHEM. **28**, 1776–80 (1956).
(76K) Mair, B. J., Shamaiengar, M., *Ibid.*, **30**, 276–9 (1958).
(77K) Maly, E., *Nature* **181**, 698–9 (1958).
(78K) Meyerson, S., Rylander, P. N., *J. Chem. Phys.* **27**, 901–4 (1957).
(79K) Meyerson, S., Rylander, P. N., *J. Phys. Chem.* **62**, 2–5 (1958).
(80K) Miller, J. W., DeFord, D. D., ANAL. CHEM. **29**, 475–9 (1957).
(81K) *Ibid.*, **30**, 295–8 (1958).
(82K) Mlodecka, J., *Przemysł Chem.* **11**, 315–17 (1955).
(83K) Panetti, M., *Riv. combustibili* **12**, 187–95 (1958).
(84K) Panicker, A. R., Banerjee, N. G., *Analyst* **83**, 296–9 (1958).
(85K) Petrov, A. A., *Khim. i Tekhnol. Topliva i Masel* **1956**, No. 6, 24–32.
(86K) Pickhardt, W. P., Safranski, L. W., Mitchell, J., Jr., ANAL. CHEM. **30**, 1298–301 (1958).
(87K) Popowicz, M., *Chem. Anal. (Warsaw)* **2**, 358–65 (1957).
(88K) Ritter, H., Gude, F., *Brennstoff-Chem.* **38**, 173–4 (1957).
(89K) Robertson, G. I., Jett, L. M., Dorfman, L., ANAL. CHEM. **30**, 132–5 (1958).
(90K) Robinson, C. F., Sharkey, A. G. Jr., *Rev. Sci. Instr.* **29**, 250–1 (1958).
(91K) Sauer, R. W., Washall, T. A., Melpolder, F. W., ANAL. CHEM. **29**, 1327–31 (1957).
(92K) Sax, K. J., Stross, F. H., *Ibid.*, **29**, 1700–2 (1957).
(93K) Schaeffer, W. D., Dorsey, W. S., Skinner, D. A., Christian, C. G., *J. Am. Chem. Soc.* **79**, 5870–6 (1957).
(94K) Sedivec, V., *Chem. listy* **51**, 249–53 (1957).
(95K) Sidlyaronok, F. G., Zherdeva, L. G., Potanina, V. A., *Khim. i Tekhnol. Topliva i Masel* **1957**, No. 12, 22–31.
(96K) Silverman, L., Shideler, M. E., *Anal. Chim. Acta* **18**, 540–6 (1958).
(97K) Streiff, A. J., Schulz, L. H., Hulme, A. R., Tucker, J. A., Krouskop, N. C., Rossini, F. D., ANAL. CHEM. **29**, 361–4 (1957).
(98K) Sullivan, L. J., Fries, R. J., McClenahan, W. S., Willingham, C. B., *Ibid.*, **29**, 1333–8 (1957).
(99K) Sushchinskiĭ, M. M., Inst. of Petroleum Hydrocarbon Group Conference on Molecular Spectroscopy, London, February 1958, preprint, Pergamon Press, London.
(100K) Takeuchi, T., Furusawa, M., *Bunseki Kagaku* **6**, 621–5 (1957).
(101K) Terent'ev, E. M., Rozenberg, L. M., *Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk* **1957**, 1144.
(102K) Terres, E., *Brenstoff-Chem.* **39**, 97–110 (1958).
(103K) Unger, E. H., ANAL. CHEM. **30**, 375–80 (1958).
(104K) Washburn, W. H., Mahoney, M. J., *J. Am. Chem. Soc.* **80**, 504–5 (1958).
(105K) Wheeler, O. H., Mateos, J. L., *J. Org. Chem.* **21**, 1110–2 (1956).
(106K) White, J. U., Weiner, S., Alpert, N. L., Ward, W. M., ANAL. CHEM. **30**, 1694–8 (1958).
(107K) White, T. T., Campanile, V. A., Agazzi, E. J., TeSelle, L. D., Tait, P. C., Brooks, F. R., Peters, E. D., *Ibid.*, **30**, 409–14 (1958).
(108K) Wieland, T., Kracht, W., *Angew. Chem.* **69**, 172–4 (1957).
(109K) Wood, J. C. S., ANAL. CHEM. **30**, 372–5 (1958).
(110K) Wood, J. C. S., Martin, C. C., Lipkin, M. R., *Ibid.*, **30**, 1530–4 (1958).
(111K) Yakubchik, A. I., Kasatkina, N. G., *J. Gen. Chem. U.S.S.R.* (Eng. trans.) **26**, 803–9 (1956).

Sulfur

(1L) Agazzi, E. J., Fredericks, E. M., Brooks, F. R., ANAL. CHEM. **30**, 1566–8 (1958).
(2L) Ahmed, M. N., Lawson, G. J., *Talanta* **1**, 142–6 (1958).
(3L) Alicino, J. F., *Microchem. J.* **2**, 83–90 (1958).
(4L) Amberg, C. H., *Can. J. Chem.* **36**, 590–2 (1958).
(5L) Battles, W. R., ANAL. CHEM. **29**, 1338–46 (1957).
(6L) Benesch, R., Benesch, R. E., *Biochim. et Biophys. Acta* **23**, 643–4 (1957).
(7L) Bertolacini, R. J., Barney, J. E., II, ANAL. CHEM. **29**, 281–3 (1957).
(8L) *Ibid.*, **30**, 202–5 (1958).
(9L) Birch, S. F., Dean, R. A., Hunter, N. J., *J. Org. Chem.* **23**, 1026–30 (1958).
(10L) *Birch, S. F., Dean, R. A., Whitehead, E. V., *Ibid.*, **23**, 783–6 (1958).
(11L) Böhme, H., Stachel, H., *Z. anal. Chem.* **154**, 27–8 (1957).
(12L) Bovee, H. H., Robinson, R. J., ANAL. CHEM. **29**, 1353–5 (1957).
(13L) Bruss, D. B., Wyld, G. E. A., Peters, E. D., *Ibid.*, **29**, 807–9 (1957).
(14L) Burriel, F., Munoz, J. R., de Lizarduy, M. L., *Rev. cienc. apl. (Madrid)* **12**, 16–25 (1958).
(15L) Carson, J. F., Wong, F. F., *J. Org. Chem.* **22**, 1725–6 (1957).
(16L) Drushel, H. V., Miller, J. F., *Anal. Chim. Acta* **15**, 389–93 (1956).
(17L) Drushel, H. V., Miller, J. F., ANAL. CHEM. **29**, 1456–61 (1957).
(18L) *Ibid.*, **30**, 1271–80 (1957).
(19L) Drushel, H. V., Miller, J. F., Hubis, W., Clark, R. O., *Anal. Chim. Acta* **15**, 394–400 (1956).
(20L) Eccleston, B. H., Whisman, M. L., *Norelco Reptr.* **5**, 38 (1958).
(21L) Etienne, A., Leger, J., *Chim. anal.* **40**, 43–6 (1958).
(22L) Ferm, R. J., *Chem. Revs.* **57**, 621–40 (1957).
(23L) Fritz, J. S., Yamamura, S. S., Richard, M. J., ANAL. CHEM. **29**, 158–61 (1957).
(24L) Gasparic, J., Vecera, M., Jurecek, M., *Chem. listy* **51**, 660–6 (1957).
(25L) Gerhardt, P. B., Dyroff, G. V., ANAL. CHEM. **28**, 1725–8 (1956).
(26L) Hale, C. C., Quiram, E. R., McDaniel, J. E., N. J., Stringer, R. F., *Ibid.* **29**, 383–8 (1957).
(27L) Hinsvark, O. N., O'Hara, F. J., *Ibid.* **29**, 1318–22 (1957).
(28L) Houghton, N. W., *Ibid.*, **29**, 1513–5 (1957).
(29L) Hubbard, R. L., Haines, W. E., Ball, J. S., *Ibid.*, **30**, 91–3 (1958).
(30L) Huber, M., *Schweiz. Arch. angew. Wiss. u. Tech.* **23**, 95 (1957).
(31L) Jezl, J. L., Stuart, A. P., *Ind. Eng. Chem.* **50**, 943–6 (1958).
(32L) Kannuna, M. M., *J. Inst. Petrol.* **43**, 198–202 (1957).
(33L) Karchmer, J. H., ANAL. CHEM. **29**, 425–31 (1957).
(34L) *Ibid.*, **30**, 80–5 (1958).
(35L) Karchmer, J. H., Walker, M. T., *Ibid.*, **30**, 85–90 (1958).
(36L) Liberti, A., Cartoni, G. P., *Chim. e ind. (Milan)* **39**, 821–4 (1957).
(37L) Lysyj, I., Zarembo, J. E., ANAL. CHEM. **30**, 428–30 (1958).
(38L) Martin, F., Floret, A., *Chim. anal.* **40**, 120–6 (1958).
(39L) Massie, W. H. S., *Analyst* **82**, 352–8 (1957).
(40L) Menefee, A., Alford, D. O., Scott, C. B., *J. Org. Chem.* **22**, 792–5 (1957).
(41L) Obolentsev, R. D., Aivazov, B. V., Ratovskaya, A. A., *Zhur. Anal. Khim.* **12**, 134–8 (1957).
(42L) Ory, H. A., Warren, V. I., Williams, H. B., *Analyst* **82**, 189–92 (1957).
(43L) Ottosson, R., Snellman, O., *Acta Chem. Scand.* **11**, 185–7 (1957).
(44L) Ryce, S. A., Bryce, W. A., ANAL. CHEM. **29**, 925–8 (1957).
(45L) Spencer, C. F., Baumann, F., Johnson, J. F., *Ibid.*, **30**, 1473–4 (1958).
(46L) Stahl, C. R., Siggia, S., *Ibid.*, **29**, 154–5 (1957).
(47L) Stinsky, F., *Erdöl u. Kohle* **10**, 231 (1957).

(48L) Stratmann, H., *Mikrochim. Acta* **1956**, 1031–7.
(49L) Susi, H., Koenig, N. H., Parker, W. E., Swern, D., ANAL. CHEM. **30**, 443–6 (1958).
(50L) Thompson, C. J., Coleman, H. J., Ward, C. C., Rall, H. T., *Ibid.*, **29**, 1601–11 (1957).
(51L) Vecera, M., Gasparic, J., Snobl, D., Jurecek, M., *Chem. listy* **50**, 770–8 (1956).
(52L) Vecera, M., Spevak, A., *Ibid.*, **50**, 765–9 (1956).
(53L) Wagner, H., *Mikrochim. Acta* **1957**, 19–23.
(54L) Weinstein, A. H., Pierson, R. M., *J. Org. Chem.* **23**, 554–60 (1958).
(55L) Wickbold, R., *Angew. Chem.* **69**, 530–3 (1957).

Oxygen

(1M) Abraham, M. H., Davies, A. G., Llewellyn, D. R., Thain, E. M., *Anal. Chim. Acta* **17**, 499–503 (1957).
(2M) Bain, G. H., *Appl. Spectroscopy* **10**, 193–4 (1956).
(3M) Barr, T., Yarwood, J. I., *Chem. & Ind. (London)* **1957**, 803–5.
(4M) Bavin, P. M. G., Canady, W. J., *Can. J. Chem.* **35**, 1555–60 (1957).
(5M) Bodnar, S. J., Mayeux, S. J., ANAL. CHEM. **30**, 1384–7 (1958).
(6M) Briggs, R., Dyke, G. V., Knowles, G., *Analyst* **83**, 304–11 (1958).
(7M) Bürger, K., *Mikrochim. Acta* **1957**, 313–7.
(8M) Commins, B. T., Lindsey, A. J., *Anal. Chim. Acta* **15**, 446–50, 551–6 (1956).
(9M) Dixon, J. P., *Ibid.*, **19**, 141–7 (1958).
(10M) Ellis, R., Gaddis, A. M., Currie, G. T., ANAL. CHEM. **30**, 475–9 (1958).
(11M) Ershov, B. P., Pokrovskaya, V. L., Zarinskiĭ, V. A., Koshkin, D. I., *Khim. Prom.* **1957**, No. 2, 106–7.
(12M) Ettre, L., Heredy, L., Kovacs, M., *Magyar Kem. Lapja* **10**, 23–9 (1955).
(13M) Forss, D. A., Dunstone, E. A., *Chem. & Ind. (London)* **1958**, 127–8.
(14M) Fort, R., *Chim. anal.* **39**, 366–74 (1957).
(15M) Franc, J., *Chem. listy* **50**, 547–52 (1956).
(16M) *Ibid.*, **52**, 55–9 (1958).
(17M) Gasparic, J., Vecera, M., *Collection Czechoslov. Chem. Communs.* **22**, 1427–31 (1957).
(18M) Gualandi, G., *Ricerca sci.* **27**, Suppl. A. Polarografia **3**,, 46–52 (1957).
(19M) Gyenes, I., *Magyar Chem. Folyóirat* **63**, 95 (1957).
(20M) Hersch, P., U.S. Patent **2,805,191** (Sept. 3, 1957).
(21M) Hudecek, S., Beranova, D., *Chem. listy* **50**, 1456–8 (1956).
(22M) Imaeda, K., *J. Pharm. Soc. Japan* **77**, 1192–5 (1957).
(23M) Ingberman, A. K., ANAL. CHEM. **30**, 1003–4 (1958).
(24M) Kainz, G., *Österr. Chem.-Ztg.* **57**, 216–21 (1956).
(25M) Karr, C., Jr., others, ANAL. CHEM. **30**, 1413–6 (1958).
(26M) Keidel, F. A., U.S. Patent **2,830,945** (April 15, 1958).
(27M) Knotnerus, J., *J. Inst. Petrol.* **43**, 307–12 (1957).
(28M) Kono, T., Sato, K., Suzuki, M., Isobe, I., *Nippon Nogeikagaku Kaishi* **31**, 587–92 (1957).
(29M) Kukin, I., ANAL. CHEM. **30**, 1114–7 (1958).
(30M) Kusakov, M. M., Landau, M. A., Lubman, N. M., Shchetsko, M. I., *Khim. i Tekhnol. Topliva i Masel* **3**, No. 4, 55–61 (1958).
(31M) Langer, S. H., Friedel, R. A., Wender, I., Sharkey, A. G., ANAL. CHEM. **30**, 1353–6 (1958).
(32M) Linde, H. W., Rogers, L. B., *Ibid.*, **30**, 1250–2 (1958).
(33M) Long, D. R., Neuzil, R. W., *Ibid.*, **28**, 1547–9 (1956).
(34M) Loveland, J. W., Webster, T. B., Hablitzel, C. P., Reed, G. W., *Ibid.*, **30**, 1316–21 (1958).
(35M) Mardanov, M. A., *Azerbaĭdzhan. Neftyanol Khoz.* **36**, No. 4, 27–8 (1957).
(36M) Maruyama, K., Onoe, K., Goto, R., *J. Chem. Soc. Japan* **77**, 1496–9 (1956).
(37M) Matsuyama, G., ANAL. CHEM. **29**, 196–8 (1957).
(38M) Padhye, M. R., Sule, B. S., *J. Sci. Ind. Research (India)* 16B, 426–7 (1957).
(39M) Pinchas, S., ANAL. CHEM. **29**, 334–9 (1957).
(40M) Pippen, E. L., Eyring, E. J., Nonaka, M., *Ibid.*, **29**, 1305–7 (1957).
(41M) Rapoport, F. M., Khodak, P. A., Shatrovskaya, T. I., *Trudy Gosudarst. Nauch. i. Proektn. Inst. Azotn. Prom.* **1956**, No. 5, 364–7.
(42M) Saier, E. L., Hughes, R. H., ANAL. CHEM. **30**, 513–7 (1958).
(43M) Scheddel, R. T., Kiley, L. R., *Ibid.*, **29**, 1552 (1957).
(44M) Schöniger, W., *Mikrochim. Acta* **1956**, 863–8.
(45M) Sheft, I., Katz, J. J., ANAL. CHEM. **29**, 1322–5 (1957).
(46M) Singliar, M., Zubak, J., *Chem. průmsyl* **6**, 426–7 (1956).
(47M) Smith, B., *Acta Chem. Scand.* **10**, 1589–96 (1956).
(48M) Steinmark, G. A., Weiss, F. T., ANAL. CHEM. **28**, 1784–7 (1956).
(49M) Sundt, E., Winter, M., *Ibid.*, **30**, 1620–2 (1958).
(50M) Tanaka, S., *Bunseki Kagaku* **6**, 168–71 (1957).
(51M) Van Meurs, N., Dahmen, E. A., *Anal. Chim. Acta* **19**, 64–73 (1958).
(52M) Wall, R., *Ind. Eng. Chem.* **49**, No. 10, 77A–78A (1957).
(53M) White, D., Vaughan, G. A., *Anal. Chim. Acta* **16**, 439–49 (1957).

Other Elements

(1N) Anderson, F. W., Moser, H., ANAL. CHEM. **30**, 879–81 (1958).
(2N) Ball, J. S., Wenger, W. J., *Petrol. Refiner* **37**, No. 4, 207–9 (1958).
(3N) Barieau, R. E., ANAL. CHEM. **29**, 348–52 (1957).
(4N) Barney, J. E., II, Bertolacini, R. J., *Ibid.*, **29**, 1187–8 (1957).
(5N) Beach, L. K., Shewmaker, J. E., *Ind. Eng. Chem.* **49**, 1157–64 (1957).
(6N) Belcher, R., West, T. S., Williams, M., *J. Chem. Soc.* **1957**, 4323–8.
(7N) Bergmann, J. G., Sanik, J., Jr., ANAL. CHEM. **29**, 241–3 (1957).
(8N) Bertolacini, R. J., *Petrol. Refiner* **37**, No. 2, 147–9 (1957).
(9N) Blumer, M., ANAL. CHEM. **28**, 1640–4 (1956).
(10N) Bond, G. R., Jr., Harriz, C. G., *Ibid.*, **29**, 177–80 (1957).
(11N) Bradstreet, R. B., *Ibid.*, **29**, 944–7 (1957).
(12N) Bruss, D. B., Wyld, G. E. A., *Ibid.*, **29**, 232–5 (1957).
(13N) Buell, B. E., *Ibid.*, **30**, 1514–7 (1958).
(14N) Cali, L. J., Loveland, J. W., Partikian, D. G., *Ibid.*, **30**, 74–7 (1958).
(15N) Chalmers, R. A., Thomson, D. A., *Anal. Chim. Acta* **18**, 575–7 (1958).
(16N) Chapman, F. W., Jr., Sherwood, R. M., ANAL. CHEM. **29**, 172–6 (1957).
(17N) Charlton, F. E., *Analyst* **82**, 643–8 (1957).
(18N) Eder, K., *Mikrochim. Acta* **1957**, 227–9.
(19N) Eggertsen, F. T., Weiss, F. T., ANAL. CHEM. **29**, 453–5 (1957).
(20N) Erdey, L., Svehla, G., *Magyar Kem. Folyóirat* **62**, 180–3 (1957).
(21N) Erdman, J. G., Ramsey, V. G., Kalenda, N. W., Hansons, W. E., *J. Am. Chem. Soc.* **78**, 5844–7 (1956).
(22N) Exley, D., Sproat, D., *J. Sci. Instr.* **35**, 202–6 (1958).
(23N) Fleischer, K. D., Southworth, B. C., Hodecker, J. H., Tuckerman, M. M., ANAL. CHEM. **30**, 152–4 (1958).
(24N) Flum, Z., *Paliva* **37**, 33–6 (1957).
(25N) Frisque, A. J., ANAL. CHEM. **29**, 1277–9 (1957).
(26N) Gerhardt, P. B., Hartmann, E. R., *Ibid.*, **29**, 1223 (1957).
(27N) Grabowski, R. J., Unice, R. C., *Ibid.*, **30**, 1374–9 (1958).
(28N) Granatelli, L., *Ibid.*, **29**, 238–41 (1957).
(29N) Gregorowicz, Z., *Nafta (Poland)* **13**, 39–41 (1957).
(30N) Griffing, M. E., Rozek, A., Snyder, L. J., Henderson, S. R., ANAL. CHEM. **29**, 190–5 (1957).
(31N) Gustin, G. M., *Microchem. J.* **1**, 75–87 (1957).
(32N) Hansen, J., Hodgkins, C. R., ANAL. CHEM. **30**, 368–72 (1958).
(33N) Helm, R. V., Latham, D. R., Ferrin, C. R., Ball, J. S., *Ind. Eng. Chem., Chem. & Eng. Data Ser.* **2**, No. 1, 95–100 (1957).
(34N) Hoffman, F. F., Jones, L. C., Jr., Robbins, O. E., Jr., Alsberg, F. R., ANAL. CHEM. **30**, 1334–6 (1958).
(35N) Hozumi, K., Kinoshita, S., *J. Pharm. Soc. Japan* **76**, 1157–60 (1956).
(36N) Inagaki, M., Moriya, S., *Tanken* **8**, 225–9 (1957).
(37N) Juliard, A. L., ANAL. CHEM. **30**, 136–40 (1958).
(38N) Jurecek, M., Jenik, J., *Chem. listy* **51**, 1312–5 (1957).
(39N) Kirsten, W. J., ANAL. CHEM. **29**, 1084–9 (1957).
(40N) Klimova, V. A., Dubinina, I. F., *Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk* **1958**, 129–32.
(41N) Koltypin, S. G., *Standartizatsiya* **1957**, No. 6, 64–5.
(42N) Liederman, D., Bowen, J. E., Milner, O. I., ANAL. CHEM. **30**, 1543–6 (1958).
(43N) Linne, W., Wuelfken, H. D., *Erdöl u. Kohle* **10**, 757–8 (1957).
(44N) Lucchesi, C. A., ANAL. CHEM. **29**, 370–3 (1957).
(45N) Maranowski, N. C., Snyder, R. E., Clark, R. O., *Ibid.*, **29**, 353–7 (1957).
(46N) Marple, T. L., Matsuyama, G., Burdett, L. W., *Ibid.*, **30**, 937–40 (1958).
(47N) Milner, O. I., Zahner, R. J., Hepner, L. S., Cowell, W. H., *Ibid.*, **30**, 1528–30 (1958).
(48N) Morris, G. M., U. S. Patent **2,820,699** (Jan. 21, 1958).
(49N) Muhs, M. A., Weiss, F. T., ANAL. CHEM. **30**, 259–66 (1958).
(50N) Nagashima, K., Machin, J. S., Illinois State Geol. Survey, Circ. **235**, (1957).
(51N) Offutt, E. B., Sorg, L. V., U. S. Patent **2,773,020** (Dec. 4, 1956).
(52N) Ogloblina, L. I., El'nikovskaya, N. V., Kamakin, N. M., *Khim. i Tekhnol. Topliva i Masel* **1957**, No. 11, 72–3.
(53N) Razumov, N. V., Zhestkov, D. K., *Izvest. Vostoch. Filialov Akad. Nauk S.S.S.R.* **1957**, No. 11, 60–2.
(54N) Russ, J. J., Reeder, W., ANAL. CHEM. **29**, 1331–2 (1957).
(55N) Sawyer, D. T., Farrington, P. S., *Ibid.*, **29**, 1688–90 (1957).
(56N) Schuhknecht, W., Schinkel, H., *Z. anal. Chem.* **160**, 22–33 (1958).
(57N) Shah, G. D., Pansare, V. S., Mulay, V. N., *Mikrochim. Acta* **1956**, 1140–3.

(58N) Shipman, G. F., Milner, O. I., ANAL. CHEM. **30**, 210–2 (1958).
(59N) Sweetser, P. B., *Ibid.*, **28**, 1766–71 (1956).
(60N) Tagliarini, G., *Chim. e ind. (Milan)* **39**, 902–4 (1957).
(61N) Takagi, T., Hayashi, N., *J. Chem. Soc. Japan* **78**, 445–9 (1957).
(62N) Takayama, Y., Ohashi, S., *Bull. Chem. Soc. Japan* **30**, 606–7 (1957).
(63N) Trofimenko, S., Sease, J. W., ANAL. CHEM. **30**, 1432–44 (1958).
(64N) Tsuchihashi, S., Sekido, E., *J. Chem. Soc. Japan* **77**, 708–12 (1956).
(65N) Vallee, B. L., Bartholomay, A. F., ANAL. CHEM. **28**, 1753–5 (1956).
(66N) Vango, S. P., *Chemist Analyst* **46**, 72 (1957).
(67N) Yofe, J., Finkelstein, R., *Anal. Chim. Acta* **19**, 166–73 (1958).
(68N) Zall, D., McMichael, R. E., Fisher, D. W., ANAL. CHEM. **29**, 88–90 (1957).

Pollution

(1P) Allison, A. R., Delman, A. D., Ruff, A. E., Simms, B. B., U. S. Patent **2,849,291** (Aug. 26, 1958).
(2P) Anderson, D. R., Manlik, F. P., *Trans. Am. Soc. Mech. Engrs.* **80**, 1231–8 (1958).
(3P) Barnebey, H. L., Davis, W. L., *J. Air Pollution Control Assoc.* **7**, 86–7 (1957).
(4P) Bentley, H. R., Burgan, J. G., *Analyst* **83**, 442–7 (1958).
(5P) Bertram, F. W., Carlisle, O. T., Murray, J. E., Warren, G. W., Connell, C. H., ANAL. CHEM. **30**, 1482–5 (1958).
(6P) Borok, M. T., *Zavodskaya Lab.* **23**, 1420–4 (1957).
(7P) Brink, J. A., Jr., *Ind. Eng. Chem.* **50**, 645–8 (1958).
(8P) Buu-Hoi, N. P., Jacquignon, P., *Experientia* **13**, 375–6 (1957).
(9P) Cahnmann, H. J., ANAL. CHEM. **29**, 1307–11 (1957).
(10P) Cahnmann, H. J., Kuratsune, M., *Ibid.*, **29**, 1312–17 (1957).
(11P) Chemodanova, L. S., Turkel'taub, N. M., *Zavodskaya Lab.* **22**, 1406–7 (1956).
(12P) Commins, B. T., *Analyst* **83**, 386–9 (1958).
(13P) Crumley, P. H., Fletcher, A. W., *J. Inst. Fuel* **30**, 608–12 (1957).
(14P) Crumley, P. H., Howe, H., Wilson, D. S., *Ibid.*, **31**, 378–82 (1958).
(15P) Cummings, W. G., Redfearn, M. W. *Ibid.*, **30**, 628–35 (1957).
(16P) Dixon, B. E., Hands, G. C., Bartlett, A. F. F., *Analyst* **83**, 199–202 (1958).
(17P) Doyle, G. J., Renzetti, N. A., *J. Air Pollution Control Assoc.* **8**, 23–31 (1958).
(18P) Eggertsen, F. T., Nelsen, F. M., ANAL. CHEM. **30**, 1040–3 (1958).
(19P) Fedotov, V. G., *Gigiena i Sanit.* **21**, No. 9, 85–6 (1956).
(20P) Filyanskaya, E. D., *Trudy Nauch. Sessii Vsesoyuz. Nauch.-Tekh. Inst. Okhrany Truda* **1954**, No. 1, 205–9 (1955).
(21P) Fitton, A., *Roy. Soc. Promotion Health J.* **76**, 664–7 (1956).
(22P) Foran, M. R., Gibbons, E. V., Wellington, J. R., *Chem. in Can.* **10**, No. 5, 33–41 (1958).
(23P) Friedel, R. A., ANAL. CHEM. **28**, 1806–10 (1956).
(24P) Gage, J. C., *Analyst* **82**, 587–9 (1957).
(25P) Gaulin, C. A., Michaelsen, E. R., Alexander, A. B., Jr., Sauer, R. W., *Chem. Eng. Progr.* **54**, No. 10, 49–52 (1958).
(26P) Gibson, J. R., Culver, W. E., Kurz, M. E., "Air Pollution Bibliography, Vol. I," U. S. Public Health Service, Dept. of Health, Education and Welfare, July 1957.
(27P) Giubileo, M., *Riv. combustibili* **11**, 157–66 (1957).
(28P) Haines, G. F., Hemeon, W. C. L., Cember, H., *J. Air Pollution Control Assoc.* **7**, 262–5 (1958).
(29P) Happ, G. P., Stewart, D. W., Cooper, H. C., ANAL. CHEM. **29**, 68–71 (1957).
(30P) Hirschler, D. A., *Ind. Eng. Chem.* **49**, 1131–42 (1957).
(31P) Hirt, R. C., Doughman, W. R., Gisclard, J. B., ANAL. CHEM. **28**, 1649–51 (1956).
(32P) Jacobs, M. B., Braverman, M. M., Hochheiser, S., *Ibid.*, **29**, 1349–51 (1957).
(33P) Jacobs, M. B., Hochheiser, S., *Ibid.*, **30**, 426–8 (1958).
(34P) Johne, K., Kleiss, I., Reuter, A., *Angew. Chem.* **69**, 675 (1957).
(35P) Johnstone, H. F., Coughanowr, D. R., *Ind. Eng. Chem.* **50**, 1169–72 (1958).
(36P) Katz, M., Sanderson, H. P., Ferguson, M. B., ANAL. CHEM. **30**, 1172–80 (1958).
(37P) Kavan, I., *Paliva* **36**, 157–8 (1956).
(38P) Kay, K., ANAL. CHEM. **29**, 589–604 (1957).
(39P) Kay, K., *Ind. Eng. Chem.* **50**, 1175–80 (1958).
(40P) Kobayashi, Y., *Yaki Gôsei Kagaku Kyôkai Shi* **14**, 137–41 (1956).
(41P) Kontorovich, L. M., *Trudy, Gosudarst. Nauch. i. Proektn. Inst. Azont. Prom.* **1954**, No. 3, 218–24.
(42P) Krivoruchko, F. D., Turkel'taub, N. M., *Zavodskaya Lab.* **22**, 1408–9 (1956).
(43P) Lindgren, C. G., *J. Am. Water Works Assoc.* **49**, No. 1, 55–62 (1957).
(44P) Lodge, J. P., Jr., Tufts, B. J., Artificial Stimulation Rain, 1st Proc. Conf. Phys. Cloud Precipitation Particles, Woods Hole, **1955**, 43–6 (pub. 1957).
(45P) McConnaughey, P. W., Brit. Patent **793,727** (Apr. 23, 1958).
(46P) McKelvey, J. M., Hoelscher, H. E., ANAL. CHEM. **29**, 123 (1957).
(47P) Mader, P. P., Gliksman, J., Eye, M., Chambers, L. A., *Ind. Eng. Chem.* **50**, 1173–4 (1958).
(48P) Mader, P. P., Heddon, M. W., Eye, M. G., Hammig, W. J., *Ibid.*, **48**, 1508–11 (1956).
(49P) Magill, P. L., Holden, F. R., Ackley, C., "Air Pollution Handbook," McGraw-Hill, New York, 1956.
(50P) Matty, R. E., Diehl, E. K., *Power* **101**, No. 11, 94–7 (1957).
(51P) Mohler, E. F., Jr., Jacob, L. N., ANAL. CHEM. **29**, 1369–74 (1957).
(52P) Mohler, F. L., Bradt, P., Dibeler, V. H., *J. Research Natl. Bur. Standards* **60**, 615–18 (1958).
(53P) Mokhov, L. A., Udalov, Y. F., Khalturin, V. S., U.S.S.R. Patent **110,047** (June 25, 1958).
(54P) Moore, G. E., Cole, A. F. W., Katz, M., *J. Air Pollution Control Assoc.* **7**, 25–8 (1957).
(55P) Morriss, F. V., Bolze, C., Goodwin, J. T., Jr., *Ind. Eng. Chem.* **50**, 673–6 (1958).
(56P) Mott, R. A., Parramore, K., *J. Inst. Fuel* **30**, 123–6 (1957).
(57P) Mueller, H. F., Larson, T. E., Lennarz, W. J., ANAL. CHEM. **30**, 41–4 (1958).
(58P) Nietsch, B., *Mikrochim. Acta* **1956**, 171–8.
(59P) Parsons, J. L., Neerman, J. C., Lifsitz, J. R., Bryan, F. R., ANAL. CHEM. **30**, 1055–7 (1958).
(60P) Patterson, G. D., Mellon, M. G., U. S. Patent **2,785,959** (March 19, 1957).
(61P) Patton, H. W., Touey, G. P., ANAL. CHEM. **28**, 1685–8 (1956).
(62P) Pueschel, R., Grubitsch, H., *Brennstoff-Chem.* **38**, 266–70 (1957).
(63P) Quiram, E. R., Biller, W. F., ANAL. CHEM. **30**, 1166–71 (1958).
(64P) Rather, J. B., Jr., *Ibid.*, **30**, 36–40 (1958).
(65P) Renzetti, N. A., *Ibid.*, **29**, 869–74 (1957).
(66P) Rogers, L. H., *Chem. Eng. Progr.* **53**, No. 8, 381–4 (1957).
(67P) Saltzman, B. E., *Ind. Eng. Chem.* **50**, 677–82 (1958).
(68P) Sawicki, E., Miller, R. R., ANAL. CHEM. **30**, 109–10 (1958).
(69P) Sawicki, E., Miller, R., Stanley, T., Hauser, T., *Ibid.*, **40**, 1130–3 (1958).
(70P) Schadt, C., Cadle, R. D., *Ibid.*, **29**, 864–8 (1957).
(71P) Schultz, H. A., *Ibid.*, **29**, 1840–2 (1957).
(72P) Seidman, E. B., *Ibid.*, **30**, 1680–2 (1958).
(73P) Stephens, E. R., Hanst, P. L., Doerr, R. C., Scott, W. E., *Ind. Eng. Chem.* **48**, 1498–504 (1956).
(74P) Strange, J. P., ANAL. CHEM. **29**, 1878–81 (1957).
(75P) Suzuki, T., Koshi, S., Kita, H., Yamaguchi, H., *Koshu Eiseiin Kenkyû Hûkoku* **6**, 53–7 (1957).
(76P) Thomas, J. F., Tebbens, B. D., Mukai, M., Sanborn, E. N., ANAL. CHEM. **29**, 1835–40 (1957).
(77P) Thomas, M. D., *Ind. Eng. Chem.* **48**, 1522–7 (1956).
(78P) Thomas, M. D., MacLeod, J. A., Robbins, R. C., Goettelman, R. C., Eldridge, R. W., Rogers, L. H., ANAL. CHEM. **28**, 1810–16 (1956).
(79P) Thompson, J. K., *Ibid.*, **29**, 1847–50 (1957).
(80P) Todd, D. B., Wilson, W. B., *Ind. Eng. Chem.* **49**, 20–4 (1957).
(81P) Vonnegut, B., Moore, C. B., Ehrenfeld, J., Smallman, C. R., Artificial Stimulation Rain, Proc. 1st, Conf. Phys. Cloud Precipitation Particles, Woods Hole, **1955**, 122–30 (pub. 1957).
(82P) Wadelin, C. W., ANAL. CHEM. **29**, 441–2 (1957).
(83P) Waitman, A., Macoveanu, L., *Rev. chim. (Bucharest)* **7**, 468–72 (1956).
(84P) Weaver, E. R., Hughes, E. E., Gunther, S. M., Schuhmann, S., Redfearn, N. T., Gordon, R., *J. Research Natl. Bur. Standards* **59**, 383–404 (1957).
(85P) West, P. W., Gaeke, G. C., ANAL. CHEM. **28**, 1816–19 (1956).
(86P) West, P. W., Sen, B., Gibson, N. A., *Ibid.*, **30**, 1390–7 (1958).
(87P) Wilkins, E. T., *Roy. Soc. Promotion Health J.* **76**, 677–84 (1956).
(88P) Wilson, K. W., ANAL. CHEM. **30**, 1127–9 (1958).

Miscellaneous

(1R) Addison, L. M., Spencer, E. H., Charlet, E. M., ANAL. CHEM. **30**, 885–91 (1958).
(2R) Anderson, H. H., Shubin, L. D., *Ibid.*, **29**, 852–5 (1957).
(3R) Bancroft, A. R., Rae, H. K., *Can. J. Chem. Eng.* **35**, No. 2, 77–85 (1957).
(4R) Biribauer, F. A., Oakley, H. T., Porter, C. E., Staib, J. H., Stewart, J., *Ind. Eng. Chem.* **49**, 1673–8 (1957).
(5R) Buckland, J. A., Freitas, E. R., Anderson, E. A., Natl. Symposium Vacuum Technol., Chicago, **1956**, Trans., 155–60.
(6R) Challoner, A. R., Powell, R. W., *Proc. Roy. Soc.* **A238**, 90–106 (1956).
(7R) Coggeshall, N. D., Lumpkin, H. E., Wright, N., Field, H. W., Colvin, H. F., ANAL. CHEM. **28**, No. 11, 7A–18A (1956).

(8R) Colson, A. F., *Analyst* **83**, 169–76 (1958).
(9R) Dettre, R. H., Andrews, D. H., *J. Phys. Chem.* **62**, 559–65 (1958).
(10R) Dimbat, M., Stross, F. H., ANAL. CHEM. **29**, 1517–20 (1957).
(11R) Duncan, J. M., *ASTM Bull.*, No. 219, 40–3 (1957).
(12R) Field, E. A., *J. Inst. Petroleum* **43**, 233–4 (1957).
(13R) Guerrant, G. O., ANAL. CHEM. **30**, 143–9 1958).
(14R) Harper, B. G., Moore, J. C., *Ind. Eng. Chem.* **49**, 411–4 (1957).
(15R) Heitler, C., *Analyst* **83**, 223–9 (1958).
(16R) Huff, G. A., Tingey, F. H., ANAL. CHEM. **29**, No. 8, 19A–22A (1957).
(17R) Hull, D. E., *Ibid.*, **29**, 1202–4 (1957).
(18R) Jacobson, N. W., Miller, J., *Chem. & Ind. (London)* **1957**, 1621.
(19R) Jennings, H. Y., *Rev. Sci. Instr.* **28**, 774–7 (1957).
(20R) Jones, W. C., Natl. Symposium Vacuum Technol., Chicago, **1956**, Trans., 161–3.
(21R) Kincannon, C. B., Baker, M. O., ANAL. CHEM. **29**, 1189–93 (1957).
(22R) Kuhn, W., *Chem.-Ing.-Tech.* **29**, No. 1, 6–16 (1957).
(23R) Loprest, F. J., *J. Phys. Chem.* **61**, 1128–30 (1957).
(24R) Mair, B. J., Krouskop, N. C., Rossini, F. D., ANAL. CHEM. **29**, 1065–8 (1957).
(25R) Malyusov, V. A., Umnik, N. N., Malafeev, N. A., Zhavoronkov, N. M., *Doklady Akad. Nauk S.S.S.R.* **109**, 828–31 (1956).
(26R) Mandel, J., Linnig, F. J., ANAL. CHEM. **29**, 743–9 (1957).
(27R) Mastrangelo, S. V. R., *Ibid.*, **29**, 841–5 (1957).
(28R) Nelson, K. L., *Ibid.*, **29**, 512–8 (1957).
(29R) Nerheim, A. G., *Ibid.*, **29**, 1546–8 (1957).
(30R) Nester, R. G., Natl. Symposium Vacuum Technol., Chicago, **1956**, Trans. 147–50.
(31R) Nettescheim, G., *Erdöl u. Kohle* **10**, 73–4 (1957).
(32R) Parrette, R., *J. Polymer Sci.* **15**, 447–58 (1955).
(33R) Pillay, P. P., Rao, D. S., Nair, C. P. N., Varkey, E. T., *Chem. & Ind. (London)* **1958**, 258–9.
(34R) Rosseau, M., *Chim. anal.* **39**, 94–101 (1957).
(35R) Shuter, L. M., Gordinskiĭ, B. Yu., *Zhur. Anal. Khim.* **13**, 150–2 (1958).
(36R) Simons, E. L., ANAL. CHEM. **30**, 979–82 (1958).
(37R) Smith, W. H., *Ibid.*, **30**, 149 (1958).
(38R) Sullivan, L. J., Fries, R. J., McClenahan, W. S., Willingham, C. B., *Ibid.*, **29**, 1333–8 (1957).
(39R) Sullivan, L. J., Ruppel, T. C., Willingham, C. B., *Ind. Eng. Chem.* **49**, 110–13 (1957).
(40R) Thomas, M., *Chim. anal.* **39**, 404–12 (1957).
(41R) Zeitler, V. A., Brown, C. A., ANAL. CHEM. **29**, 1904–6 (1957).

Review of

APPLIED ANALYSIS

PHARMACEUTICALS AND RELATED DRUGS

C. R. Rehm, S. C. Slack, and W. J. Mader
Ciba Pharmaceutical Products Inc., Summit, N. J.

THIS review covers the analytical procedures of interest to pharmaceutical analysts reported in the readily available journals for the period of July 1956 to July 1958, and in addition, articles abstracted by *Chemical Abstracts*, *Analytical Abstracts*, or the *Zeitschrift für analytische Chemie* for this same period. Over 2500 articles or their abstracts dealing with pharmaceutical analysis were available, which attest to the increased interest of analysts in the specific, accurate, and reliable analytical procedures for the identification and analysis of pharmaceutical products. It is impossible to review all these articles in a report of this type. Consequently, some selectivity was required, and the authors apologize to authors whose papers they may have overlooked or deleted.

ALKALOIDS

Quaternary ammonium salts of atropine, hyoscine, etc. (*352*), are estimated by titration with hydrochloric acid using the Tashiro indicator after aqueous solutions have been passed through a suitable ion exchange resin. A detailed description of methods of analyzing atropine, hyoscyamine, strychnine, and brucine by precipitation with potassium iodobismuthate is given by Poethke and Trabert (*496*). Amperometric titration is used by Ogawa (*456*) with tungstosilicic acid in an acidified medium in the determination of atropine, hyoscyamine, brucine, and related alkaloids. Micro quantities of atropine (*570*), extracted from biological material, can be separated from tropine by descending paper chromatography and subsequent determination by scanning with a densitometer after development with Dragendorff's reagent. Mathis and Duquénois have separated aconitine from related alkaloids by ascending paper chromatography (*411*). Descending chromatography, followed by spectrophotometry (*431*), has been reported for the quantitative estimation of the aconite alkaloids. Betaine in glutamate process liquor is assayed colorimetrically (*185*) by measuring the color of the reineckate ion in 70% acetone at 525 mμ. Optimum conditions have been established for a concentration range of 1 to 5 mg.

Micro quantities of strychnine nitrate have been determined by amperometric methods (*454*) using tungstosilicic acid in acidic solution. Strychnine and brucine are estimated colorimetrically as the reineckates (*329*). A new color reaction for strychnine using Na_2SeO_3 (*480*) is reported by Pécar.

Codeine can be assayed colorimetrically by oxidation with potassium permanganate in hydrochloric acid and the addition of sodium chromotropate and sulfuric acid (*5*). The developed color is read at 580 mμ. Codeine and hydrocodeine are separated by paper chromatography using BuOH-NH_4OH and water (*16*). Densitometric readings are taken at the ultraviolet absorption peaks. Cocaine, benzoylecgonine, and ecgonine (*102*) are separated by ascending chromatography. Densitometric measurements are made after developing with Dragendorff's reagent.

Sjöström (*598*) presented a method for separating caffeine from antipyrine by utilizing the ability of antipyrine to form complexes with ferric ion. A solution of the two alkaloids is passed through a cation exchanger in the ferric ion form. Antipyrine is quantitatively taken up and caffeine is displaced from the column and may be estimated spectrophotometrically.

Diazotized sulfanilic acid in alkaline ethyl alcohol solution is used to determine capsaicin (*606*) after its extraction. Tattje (*635*) determines carvone colorimetrically with ethyl-3,5-dinitrobenzoate and sodium hydroxide in methanol. The color is read at 537.5 mμ.

The cinchona alkaloids and their salts have been titrated potentiometrically by Kashima (*332*) in glacial acetic acid with 0.05*N* $HClO_4$. The relative basicity of the compounds was determined from their titration curves. Cinchophen is determined gravimetrically (*659*) in the presence of salicylic and acetylsalicylic acid by treating the ammonium salts with ammonium molyb-