U.D.C. 543.31

Methods for the Determination of Water in Substances in Different States of Aggregation

V.A.Drozdov, A.P.Kreshkov, and S.I.Petrov

The most important data on methods widely used at present to determine the concentration of moisture in substances in different states of aggregation are examined. The bibliography contains 715 references.

CONTENTS

I. Introduction 47
II. Methods for the determination of water based on its separation 47
III. Methods for the determination of water based on the use of chemical reagents 48
IV. Physical and physicochemical methods for the determination of water 52

I. INTRODUCTION

Since the publication of Mitchell and Smith's monograph[1], the Karl Fischer method for the determination of water has been improved, and new chemical, physical, and physicochemical methods for its determination, which have been widely used in various fields of science, industry, and the new technology, have been described.

Simultaneously, the requirements made of the methods themselves have become more severe, since the modern tendency in analytical chemistry is directed towards automation of the continuous control and regulation of technological processes, with minimal expenditure of effort on the actual analysis. This has led to the introduction and development of completely new and highly sensitive methods of analysis, such as infrared spectroscopy, coulometry, gas-liquid chromatography, etc.

Published reviews[2-30] of methods for the determination of water do not claim to examine this problem exhaustively.

In the present paper an attempt has been made to give a complete review of all methods for the determination of water in substances in different states of aggregation.

II. METHODS FOR THE DETERMINATION OF WATER BASED ON ITS SEPARATION

1. The Drying Method. The simplest and oldest method for the determination of water is based on the drying of the specimen to be analysed to constant weight. The water content is estimated from the loss in weight. The rate and efficiency of dehydration are determined by a number of factors: the way in which heat is supplied to the specimen being tested, the rate of removal of the water liberated, the establishment of an optimal temperature of drying, at which decomposition of the specimen being analysed is not observed[31,32], the state of the water molecules in the material being studied, and also diffusion conditions.

The drying process is influenced considerably by the depth of the layer and the friability of the specimen[33]. The reproducibility of the results depends on such factors as the design of the drying oven, the nature of the material from which the drying vessel is made, and the shape of the evaporation dishes. The rate of removal of water from the surface of a solid phase is a function of the water vapour pressure and the temperature of drying.

When moist organic substances are heated, changes in the weight of the substance being analysed may be due not only to the liberation of water, but also to the liberation of CO_2, CO, H_2, and CH_4. In the analysis of thermally unstable inorganic compounds (iron and aluminium sulphates), selective absorbers for water and sulphur dioxide are used.

The temperature at which the specimen is heated during drying is determined by the nature of the substance being analysed.

In addition to the determination of water of crystallisation in salts[34], the drying method can be used with different degrees of accuracy for the determination of the concentration of water in cheese[35], jam[36], sheeps' milk cheese[37], tungstosilicates[38], xanthates[39], wood[40,41], castor beans[42], grain and grain products[43,44], clay[45], natural glasses[33], cadmium thiobarbiturate[46], [iron ore] charges[47], carbon black[48], the raw material for opium[49], meat products[50], brown coals[51,52], nuts, raisins, and poppyseed[53], dried fruit[54], and malt[55].

In order to use lower temperatures for drying and hence prevent thermal decomposition of the specimen, the use of infrared radiation and reduced pressure has been proposed for the determination of water in salts[56,57] and serum[58,59].

By combining the drying oven and analytical balance, it is possible to determine losses in weight during drying, with elimination of the operations involving the transfer of the specimen to a desiccator, and the time required to cool the substance being analysed.

A number of authors have proposed the more rapid determination of water by the drying method using a combination of hot air circulation, infrared radiation, vacuum drying ovens, and special evaporating dishes. The methods cover the analysis of grain, starch, and foodstuffs[60-62], pharmaceutical products[63], fertilisers[64], grain and coffee[65], dried grapes[66], and hops[67].

New apparatus and procedures for studying the mechanism of the drying of colloidal capillary-porous materials have been published[68]. The British Standards Institute has published standards for vacuum drying ovens[69].

Various techniques[70], attachments, and automatic instruments for the determination of water by drying have been described[17,71-83].

The drying method has found most extensive application in the determination of hydrate water in inorganic compounds. The method is less satisfactory for organic compounds. The sources of error encountered in the drying method have been examined[84].

The drying method is time-consuming, has a low accuracy when the water concentration is low, and for practical utilisation it requires the establishment of standard conditions for each specific instance. A number of the proposed improvements (infrared radiation, vacuum drying apparatus, automatic balances, etc.), however, make it possible to reduce the time required for the determination of water to 15–20 min. The error in weighing determines the limit of the minimal quantities of water which can be detected. The chief disadvantage of the method is that it cannot distinguish between water and other volatile substances present. The drying method is irreplaceable, however, for the routine determination of water in heterogeneous materials (fresh fruit, grain, silage, etc.). The drying method can serve as a relative criterion in the development of new and improved methods for the determination of water.

2. The Sorption Method. The sorption method for the determination of water is based on the use of sorbents to trap water vapour removed by a current of carrier gas, with gradual heating of the substances being analysed. The absorption tube containing the sorbent is weighed before and after the passage of the carrier gas, and the increase in weight gives the water concentration.

Various solid and liquid reagents have been used as absorbents: $CaCl_2$, P_2O_5, $CoCl_2$, drierite, anhydrone, sulphuric acid phosphoric acid, etc. The characteristics of various drying agents have been compared[85].

Dry air or argon are often used as carrier gas. The choice of carrier gas for a particular example of the determination of water is determined by the nature of the substance being analysed.

The sorption method is used for the determination of water in liquid and gaseous chlorine[86], liquids[87], silicate and carbonate minerals[88,89], beryllium carbide[90], wool[91], and potassium fertilisers[92], and for the determination of oxides and water in metal powders[93] and cable insulating paper[94]. In the simultaneous determination of water and CO_2 in rocks and minerals[89], a mixture of sodium carbonate and asbestos is used as absorbent to trap CO_2.

The sorption method is regarded as superior to the drying method, but it is very tedious and time-consuming, and cannot be automated. The accuracy of the method depends on the nature of the substance being analysed, the concentration of water being determined, the sensitivity of the analytical balance, and the selective absorbing power of the sorbent. By varying the absorbent, it is possible to carry out the separate determination of water and thermal decomposition products. The sorption method is also used as a means of separating water for its subsequent determination by chemical and physicochemical methods.

3. The Distillation Method. A weighed specimen of the substance being analysed is boiled in a special apparatus with an excess of a liquid which is immiscible with water (C_6H_6, toluene, xylene, CCl_4, tetrachloroethane, dioxan, perchloroethylene, aniline, mineral oils, petroleum fractions, etc.). The mixture of vapours distilled is condensed in a special distillate receiver, the liquids separate into layers, and the volume of distilled water is read off from the meniscus. The choice of solvent and the time for which the specimen is boiled are determined by the ease with which the boiling liquid penetrates into the pores of the finely ground specimen. The solvent chosen should distil in the form of an azeotropic mixture at a temperature at which chemical reactions do not take place. By creating an inert gas atmosphere in the distillation apparatus it is possible to avoid redox processes.

The accuracy of the determination of water by the distillation method depends to a considerable extent on the design of the condensate trap and the boiling assembly. Various trap designs cater for instances when the boiling liquid is lighter or heavier than water. Highly accurate results can be obtained by fine graduation of the measuring vessels and by placing the traps in a thermostat. In order to reduce the consumption of solvent during the determination and hence decrease the error in the determination due to the mutual solubility of the liquids, traps capable of returning part of the distilled liquid, after separation into layers, into the boiler assembly have been proposed.

The use of different solvents makes possible the separate determination of moisture and water of crystallisation in the same material. When azeotropic distillation with benzene and xylene are used for calcium sulphate and superphosphate fertiliser specimens, both free water and water of crystallisation are removed using xylene, whereas only free water is removed using benzene[95].

The time required for the distillation varies from 15–30 min to several hours, and is determined by the properties of the material being studied (solid or liquid, degree of subdivision, solvent chosen, temperature of distillation, etc.).

An extensive review of literature on the distillation method has been given in a paper[96] which describes the history of the development of the distillation method, gives various designs of distillation assembly, and examines critically a large number of practical examples of the use of the method. The construction of apparatus for the distillation is being constantly improved[96-108].

Satisfactory results have been given by the distillation method in the determination of water in soap[109-111], printing dyes[109], sugar-containing products[112], food products[113-115], silage[116], gypsum and superphosphates[95], furfural[117], diesel fuel, petrol, and sump oils[106], glycols and glycerol[118], diethylene glycol[119], polyethylene glycol[120], textile materials[101], petroleum and petroleum products[121], polycaprolactam[122], and DDT and HCCH emulsions[123]. A USSR State Standard has been published on the distillation method[124].

The distillation method uses simple apparatus, and all the operations are straightforward. Analytical chemists often use this method when the drying and sorption methods are inapplicable, and also when it is necessary to obtain comparative results in the development of new methods for the determination of water. In the last instance, the distillation method serves as a criterion. When the concentration of water in the substances being analysed is low, the distillation method is combined with other chemical and physicochemical methods of analysis.

III. METHODS FOR THE DETERMINATION OF WATER BASED ON THE USE OF CHEMICAL REACTIONS

1. Gas-volumetric methods. Calcium hydride reacts vigorously with water with the liberation of hydrogen, which can be measured quantitatively by volumetric or manometric methods. If the water to be determined is first extracted with a solvent, the reaction can be used for the quantitative determination of water. The solvent should be inert towards CaH_2. The first material to be proposed as extracting agent for water was degassed ethanol[125-127], and this was subsequently replaced by dioxan and pyridine[128,129].

Calculation of the thermodynamic potentials of the CaH_2–H_2O system has shown [130] that different quantities of hydrogen are liberated, depending on the temperature. In gas-volumetric determinations, strict control of the conditions of the analysis is necessary. The method can then be used for the quantitative determination of water with satisfactory accuracy in a variety of substances: inorganic crystal hydrates, liquid fuels, furfural, petroleum products, uranium hexafluoride, etc. [131-139]. The determination of traces of water vapour in gases has been described [140]. The calcium hydride method is the subject of a USSR State Standard [141].

The formation of acetylene by the reaction of water with CaC_2 has been made the basis of a method for the determination of water in substances in different states of aggregation. Since alcohols react with CaC_2 to form C_2H_2, they are unsuitable for use as media in the analysis. Inert solvents are recommended. The quantity of acetylene liberated can be measured by gas-volumetric methods, from the increase in pressure in the system, from the loss in weight of the reagent after volatilisation of the C_2H_2, by flame intensity measurements, or by measuring the quantity of oxygen required for combustion of the acetylene. In a number of instances it is considered more rational not to carry out the reaction between CaC_2 and the water-containing liquid in a heterogeneous system, and the preliminary extraction of the water by an inert carrier gas is recommended.

The carbide method for the determination of water has a number of disadvantages and limitations [130,139,142] and requires strict control of the conditions during the analysis. The method is used for the rapid determination of water in various materials: liquid coking and pyrolysis products [136], furfural [117], ores, brown coals [143], gypsum [144], rubber [146], ethyl acetate and chloroaldehyde [146], soils and building materials [147], industrial oils [148], cresol [149], metallurgical slags [150], hydrocarbons [151], leather, paper [152], grain [152,153], groats [154], peat, and wood [155].

The carbide method cannot be used for the determination of water in substances which react with CaC_2, CaO, or $Ca(OH)_2$.

Some authors consider that magnesium nitride is more convenient for the analysis than CaC_2, since the ammonia formed can be determined quantitatively by acid-base titration. Ethanol, dioxan, and a CH_3OH–C_2H_5OH mixture have been recommended as media. The analysis can be carried out in an ordinary Kjeldahl apparatus. High accuracy can be achieved in the determinations if the water is removed beforehand from the materials being studied, using a carrier gas. The method cannot be used to analyse substances which liberate NH_3 when heated. Temperature has a significant influence on the course of the reaction between Mg_3N_2 and water [130].

Noteworthy papers have been published on the use of magnesium nitride for the determination of water in divinyl distillate [156,157], gases [158], spirits and eau de Cologne [159], and transformer oil [160].

Tserevitinov's method for the determination of active hydrogen has been modified for the determination of water. The substance to be analysed is dissolved in pyridine or other inert solvent which does not react with CH_3MgI. Various compounds which contain active hydrogen atoms or which react with the Grignard reagent interfere in the determination of water. Tserevitinov's method has been proposed for the determination of water in oil [161] and gypsum [144].

Among other gas-volumetric methods, mention must be made of the determination of combined water in silica gel using diborane [162] and in solvents using alkali metals and their alloys.

Gas-volumetric methods (particularly the carbide and hydride methods) are distinguished by the rapid reaction of the reagent with the water being determined, and they have found extensive application in technology, as a result of the variety of methods for measuring the gas liberated. The required speed, accuracy, and sensitivity can be achieved.

2. Titrimetric Method. The Karl Fischer method [1] occupies a unique position among titrimetric methods for the determination of water. Study of the nature of the Karl Fischer reagent has established [163-165] that the quantity of methanol taking part in the titration has a significant influence on the results of the water determination. The titre of the reagent is a function of the ratio $H_2O : CH_3OH$. It has been proved experimentally [166] that for a solution of the reagent containing no methanol the ratio of the reacting I_2 and H_2O is 1 : 0.53, and that this ratio increases when CH_3OH is added. At a CH_3OH concentration of 24 vol.%, the ratio is equal to 1 : 1.5, and it subsequently remains almost constant over a considerable range (as far as 70%). When the reaction medium contains a large quantity of CH_3OH or C_5H_5N, additional complications, depending on the quantity of water being titrated, are observed. The deviations from the ratio 1 : 1.5 are greater, the smaller the quantity of water being titrated. The following equation has been proposed [11]

$$2H_2O + 4CH_3OH + 3C_5H_5N \cdot SO_2 + 3I_2 + 6C_5H_5N \rightarrow$$
$$\rightarrow 2C_5H_5N\begin{matrix}CH_3\\SO_4H\end{matrix} + C_5H_5N\begin{matrix}CH_3\\SO_4CH_3\end{matrix} + 6C_5H_5N \cdot HI .$$

The observed dependence of the water equivalent of the Karl Fischer reagent on the ratio $CH_3OH : C_5H_5N$ requires that the titration be carried out correctly. The standardisation of the Karl Fischer reagent and the determination of water must be carried out in a methanol + pyridine mixture with the same composition as that used for the Karl Fischer reagent. The value for the blank titration of the solvent cannot be found by titrating a smaller quantity and then multiplying the results of the titration by an appropriate factor.

The Karl Fischer reagent is prepared by mixing all the components together at the same time [1,166] (in this instance, however, the reagent may undergo a considerable loss of activity during storage [167]) or by mixing methanol and pyridine solutions of sulphur dioxide and iodine before use [168-172]. To decrease the time required for the preparation of the reagent, a simplified method for dehydrating the components with bromine or chlorine has been described [173]. It has been recommended [168] that the titration be carried out by dissolving the specimen to be analysed in a pyridine–methanol solution of sulphur dioxide. The titrant is a methanol solution of iodine.

A large number of attempts have been made by research workers to replace the components of the reagent in order to make it cheaper and to achieve greater stability. The replacement of pyridine by hexamethylenetetramine has been proposed [168], but sparingly soluble reaction products are formed. The replacement of methanol by the monomethyl ester of ethylene glycol [174] gives a more stable reagent, which has been shown to have valuable qualities [175]. It has been reported [176] that methanol can be replaced by chloroform. The preparation of an improved and stabilised reagent has been described [177].

For work in inert solvents (dioxan, benzene, CH_3CN, etc.), the use of a chloroform solution of bromine and sulphur dioxide has been proposed [178]. Substances containing HO-groups cannot be titrated with the recommended reagent. Pyridine and HCOOH also interfere.

The preparation of an improved reagent [179], designed for the determination of water in caprolactam and alcohols [180,181], has been patented. An alkoxide, phenoxide, or salts of organic acids are added to the reagent to combine with the hydrogen ions formed during the analysis. Patents [182-184] have recommended the addition to the reagent of one or more of the products of the spontaneous reaction which takes place in the reagent in the absence of water (NaI, pyridinium hydrogen, di-iodide, and secondary or tertiary amines).

The working solution is standardised by titrating accurately weighed specimens of H_2O in an inert solvent [163,164] or mixed solvent $C_5H_5N + CH_3OH$ (3 : 7) [11]. If the reagent is standardised using a standard solution of water in methanol, the determination gives its apparent water number [185], which may not coincide with the true value. It is recommended that the modified reagent be standardised using accurately weighed specimens of water or by titrating accurately measured volumes of aqueous solutions of methanol or ethanol.

Crystal hydrates have been used to standardise the Karl Fischer reagent [1,186,187].

Allowance must be made for the temperature factor [188] when the temperature of the surrounding medium during the standardisation differs from the temperature at which the analysis is carried out.

Methanol and its mixtures with pyridine, ether [189], chloroform [190], or propanol [172] are most frequently used as media for the titration. Ethylene glycol and glycerol are used only if it is necessary to determine water in gases after its absorption by these solvents. Dioxan has also been recommended [163,164,191,192]. Chloroform is usually employed for substances insoluble in methanol [193-195]. Toluene is used [196] if water is being determined after azeotropic distillation. Formamide [197], because of its high dielectric constant, is an excellent solvent and extracting agent. Acetic acid [170,197] or its mixtures with pyridine [198] are used for special purposes.

The use of *N*-ethylpiperidine as catalyst to increase the rate of the reaction between H_2O and the titrant has been recommended [199].

The analytical control of the Karl Fischer reagent has been described [200]. The spent reagent can be regenerated [11].

A variety of methods are used to detect the equivalence point in the titration. The technique of visual titration has been described in detail [1]. A new feature in this field is the attempt to introduce indicators [201-203]. Various modifications of the visual titration technique have been examined [204,205].

A photometric method for the detection of the equivalence point has been proposed for the determination of water in coloured liquids [167,206-209].

Electrometric titration is widely used to detect the equivalence point. Direct and back potentiometric titration using a bimetallic electrode couple has been described [1,210]. The so-called "dead stop" method of titration is most widely used [1,211,212]. The mechanism of the titration using polarised electrodes has been examined [213]. The sharp change in current strength at the equivalence point can be recorded using a qualitatively-operating electric eye [214]. The development of electronic apparatus has led to the production of various automatic assemblies [215-220].

There is a wide range of apparatus for electrometric Karl Fischer titration [216-234] by macro-, semimicro-, and micro-methods with complete or partial automation. In addition to standard cells attached to the titrator, various original modifications of the cell vessels and pipettes have been described [222,235-241].

Coulometric titration with the Karl Fischer reagent, based on the electrolytic generation of iodine, has been recommended for the automatic continuous control of traces of water [242-252].

Titration with the Karl Fischer reagent is used for the determination of water in various forms in the following inorganic substances: liquid ammonia [1,253], hydrogen fluoride [254,255], crystal hydrates [182,256], concentrated sulphuric [204] and nitric acids and their mixtures [257,258], ammonium perchlorate [259], uranium tetrafluoride and uranium oxide [260], mineral pigments [261], contaminated acids in sulphonation processes [262], minerals [263], calcium chloride [264], titanium(III) and vanadium(III) chlorides [265], pigments and paints [266,267], sodium tetraborate [268], granulated fertilisers [269-271], the inorganic components of solid rocket fuel [272], complex salts [273], inorganic reagents [274], and sulphuryl chloride derivatives [275].

In the determination of water using the Karl Fischer reagent, it is necessary to make allowance for the reaction of the components of the reagent with various inorganic compounds [1,261]. Thus in the determination of water in iron(III) salts a redox reaction takes place, but this can be prevented by adding 8-quinolinol [276] and carrying out the titration in quinoline.

The total concentration of water in sulphuric acid is usually determined by titrating in pyridine or a mixed pyridine + dioxan solvent, in order to reduce to a minimum the participation of methanol in the reaction. Water in fuming nitric acid is determined by titration in dimethyl formamide + pyridine [257] or dichloroethane [258]. An original method has been proposed for the determination of water and alkali metal oxide with selenium and tellurium [277].

Unsatisfactory results are obtained in the direct titration of anhydrous sodium carbonate [278], sodium carbonate, borate, and perborate, glycerophosphate, $CaCO_3$, calcium and magnesium oxides, hydrogen carbonate [63], acid salts, and $CuSO_4.5H_2O$ [279]. In these instances, preliminary xylene distillation of H_2O or its extraction with methanol [280], tetrahydrofuran, or dioxan [279] are recommended. The quantity of basic substance passing into solution during extraction is determined by titration with acid.

It is possible to determine water by direct titration in a number of organic compounds: salts of organic acids [164], sodium alkylarylsulphonate [281], dynamite glycerol [282], amines and amides [1,168,204], rubber [283,284], medical raw materials [285], pharmaceutical products [286-292], alkaloids [170,175,288], antibiotics [288,293,294], vegetable oils [195,295,296], solvents [171,204,264,297,298], powders and explosives [272,282,292,300], petroleum and petroleum products [301-303], insulating and lubricating oils [304-306], insecticide aerosols [307], oils and fats [195,261], aviation fuel [190], xanthates [308], potassium xanthate [168], cellophane [208], polymers and plastics [292,309-311], polyvinylpyrrolidone [312], vitamin C [168], milk powder and cheeses [313], starch [197,314], leather and tanning agents [315-317], dried vegetables [197,318], grain products [25,319], textile materials [320,321], soap and wetting agents [322], coals [204,323], formaldehyde polymers with low molecular weight [324], seeds [325], treacle [326,327], honey [328], cocoa [329], chocolate [330], flour and flour products [331,332], hydrocarbons [303], glycol and glycerol frost-resistant solvents [118], vinyl esters [322], ketones [234-336], tributyl phosphate and kerosene [337], ion exchange resins [338], laminated polyamides [339], aerosol coatings [340], malt [55], serum [59], gelatin [341], and alginates [342].

The determination of water by the Karl Fischer method in aldehydes and ketones requires appropriate modifications [1,334-336,343]. Ascorbic acid is oxidised by the reagent to dehydroascorbic acid, and quinone is reduced to hydroquinone. Thiols are oxidised slowly, but their influence can be eliminated by adding alkenes before the titration.

Various silanols react quantitatively with the Karl Fischer reagent [344,345]. The determination of H_2O in silicones in the presence of silanols has been examined [346].

In the determination of water in gases, for example hydrocarbons [347-350], hydrogen chloride [351], the atmosphere of furnaces used for the annealing of porcelain and enamel [352], oxygen, nitrogen, and other gases [350,353], the gases are bubbled through anhydrous methanol and the absorbed water is determined by titration.

In evaluating the Karl Fischer titration, it should be noted that the method is applicable to the direct determination of water in quantities varying from one part per million to 100% in all types of compound which do not react with the components of the reagent. In order to achieve the highest sensitivity in the determination, it is recommended that the solvent (preferably a pyridine + methanol mixture) be titrated first, followed by analysis of the specimen in the same medium. Direct titration gives the total concentration of water (free and combined). The Karl Fischer titration is readily automated. The coulometric method for the generation of iodine for the Karl Fischer reagent has made possible the continuous automatic regulation and control of moisture content in industry. In view of the universal and highly sensitive nature of the method, it is often used as a standard in the development of new methods for the determination of moisture.

Among other titrimetric methods, mention must be made of those based on the reaction of water with various inorganic chlorides and organic acid chlorides. The hydrogen chloride liberated is distilled off and titrated. Of the readily hydrolysed chlorides, aluminium chloride has proved the most suitable.

The acetyl chloride method [354] is convenient for the determination of water in substances which present difficulties in the Karl Fischer method. The method is based on the difference in the behaviour towards water and alcohol shown by acetyl chloride, prepared in dioxan, toluene, or CCl_4. In the first instance, 1 mole of water liberates 2 moles of titratable acids (CH_3COOH + HCl) whereas in the second instance 1 mole of CH_3OH liberates 1 mole of acid (HCl). When the reaction of the reagent with water-containing inert solvents is complete, the excess of CH_3COCl is treated with alcohol and titrated with alkali solution. A blank titration is carried out for the calculations.

The method is used to determine water in liquid hydrocarbons, esters [354], gaseous hydrocarbons [355], acetone [354,356], edible oils, margarine, and fats [357], alcohols [358], and coals [359].

CH_3OH cannot be used as extracting agent in the acetyl chloride method, because it reacts with CH_3COCl. Formic acid, aldehydes, and high concentrations of lower alcohols and glycols interfere in the determination. Strong amines and esters which are readily hydrolysed in the acidimetric titration may distort the results of the analyses considerably.

The use of *p*-nitrobenzoyl chloride [360], lauryl chloride, stearyl chloride, or benzoyl chloride in place of acetyl chloride has been proposed, but these are not all successful. Studies have shown [361] that the addition of organic bases facilitates the rapid and quantitative hydrolysis of acid chlorides by water.

Succinoyl dichloride has been used as hydrolytic reagent for the determination of the water content of gases and crystal hydrates [362,363].

The hydrolysis of acid anhydrides and chlorides can be used for the determination of water. The use of acetic [364] and benzoic anhydrides for this purpose has been described. The water to be determined is collected in a 1:3 anhydride + pyridine mixture by azeotropic distillation, for example with dioxan or toluene, after which the hydrolysis is carried out and the excess of the anhydride is eliminated using aniline. A blank titration is carried out for the calculation. The time required for the hydrolysis is reduced considerably if catalysts ($HClO_4$ or 2,4-dinitrobenzenesulphonic acid [365]) are added to the reaction mixture.

The reaction of sodium alkoxide with water has been used to determine small quantities of water in alcohol, dioxan, crotonylidene-acetone, and anthraquinone [366]. The sodium hydroxide liberated reacts further with ethyl acetate to form CH_3COONa, and the excess of sodium alkoxide is determined by titration.

Lead tetra-acetate in benzene solution reacts with water to form PbO_2, which is determined iodometrically [367].

Organic compounds of the alkali metals (triphenylmethylsodium) react vigorously with water. Since organic compounds of the alkali metals are coloured, and the products of their reaction with water colourless, water can be titrated without using indicators [368].

By making use of the limited mutual solubility of the liquids in the presence of water, it is possible to determine water in furfural by titration with a mixture of hexanol and cotton-seed oil [369], in blood and biological materials with xylene [370], and in crystal hydrates with a mixture of C_2H_5OH and 2-methylpropanol [371]. Extensive material on the determination of the moisture content of substances by titration of the water has been published [372].

Papers have been published on the determination of water in organic compounds by a new chemical method based on the hydrolysis of t-butyl vanadate in the presence of NH_3 or acridine [373,374]. The precipitate formed in the reaction—a salt of vanadic acid—is determined by titration with a solution of Mohr's salt. The method can be used to determine water in hydrocarbons, alkyl halides, esters, ketones, benzaldehyde, and pyridine. A semi-automated version of the method has been proposed.

A method for the determination of water in alcohols has been developed, based on the hydrolysis of dimethyl oxalate in alkaline solution [375].

Water can be determined by acid-base titration in non-aqueous media. Thus water has been determined by titration in anhydrous sulphuric acid [376,377]. $HClO_4$ was used as titrant.

Other titrimetric methods have found less extensive practical application than the Karl Fischer method, due to the characteristic features of the reagents. The most widespread is the acetyl chloride method, use of which is recommended when the Karl Fischer method is inapplicable. The most promising method is that based on the hydrolysis of t-butyl vanadate.

3. Gravimetric Methods. Methods for the quantitative determination of water have been based on the water-removing properties of anhydrous copper sulphate (in alcohols, aldehydes, and acids). Aluminium and magnesium ethoxides react with water to form equivalent quantities of the hydroxides, which are determined by weighing. Large quantities of water in alcohols and in mixtures of alcohol with benzene, petrol, and trichloroethylene are determined by making use of the hydrolysis of

ethyl formate. The product is weighed as sodium formate.

The determination of water in bromine is based on the oxidation of sulphur dioxide by bromine in the presence of water. The sulphate formed is determined gravimetrically [378].

Water at concentrations of 10–100 mg per 100 ml specimen can be determined in the organic solvents ether, $CHCl_3$, CCl_4, and hydrocarbons using an ethereal solution of LiBr, which reacts with water to precipitate $LiBr.H_2O$, determined by weighing [379].

An automatic gravimetric hygrometer for the determination of moisture in gases has been described [380].

Gravimetric methods find only limited application, because of the tedious nature of the operations, the time required, and the specific character of the method.

IV. PHYSICAL AND PHYSICOCHEMICAL METHODS FOR THE DETERMINATION OF WATER

1. Methods Based on Measurement of the Specific Gravity, Viscosity, Angle of Rotation of Polarised Light, Refractive Index, Mutual Solubility, Etc. Methods recommended for the determination of water have been based on measurement of the specific gravity of the substance being studied (determination of water in alcohols [381]), measurement of the viscosity (in acetone, alcohol [382], concrete, cement, and other building materials [383]), and the ability of an optically active water-containing substance to rotate the plane of polarisation of plane-polarised light to an extent proportional to the water concentration (determination of water in sugar refinery pulp [384] and in sugar [385]). A refractometric method can be used to determine water in two- and three-component systems (analysis of furfural [117], sugar products [54,386], mixtures of formaldehyde and HNO_3 [387], and C_2H_5OH and ethyl cellosolve [388]). Methods of analysis making use of the difference in the temperatures of boiling sugar sap and the vapour [389], the thermal conductivity of gases [390], the critical temperature of mixing of liquids (determination of water in aniline [391]), the change in pressure accompanying the freezing of water (in air [392] or gases [393]) and the change in the specific enthalpy of the moist material during the desorption of water [394] have been described. Surface moisture can be determined by weighing the specimen in air and in two liquids which have different densities and which are miscible with water [395,396].

In the determination of the moisture content of gases, extensive use is made of the "dew point" method [397,398], for which a large number of instruments, constructed on different principles, have been described: with thermoelectric cooling [399,400], with cooling in a Dewar vessel [401], pneumatic [402], with electrical contact [403], and with photoelectric recording [404]. A method [405] and apparatus [406] for controlling the moisture content of organic solvents, based on measurement of the concentration of water in the vapour above the solvent, have been patented. The moisture content of board and other porous materials is determined by measuring the equilibrium vapour pressure [407].

In the utilisation of the psychrometric method for the determination of the moisture content of gases, particular attention is being paid to the theoretical principles of the method [398,408], particularly at high temperatures [409]. Various psychrometers have been described [404,410-412].

2. Methods Based on Measurement of the Dielectric Constant. The determination of H_2O in various materials is based on measurement of the dielectric constant (DC) of the system. The DC of water (80.57) differs significantly from that of other solvents. The theoretical principles of the method based on DC measurements have been described [413,414]; the empirical relationship $DC = f(H_2O)$ is used for each specific water-containing system. The sensitivity of the determination when the DC of the solvent is sufficiently constant may reach several parts per million. Measurements of the DC losses are more sensitive.

For the determination of water in hydrocarbons, dioxan, which is a common cosolvent for H_2O and hydrocarbons, is recommended, since the DC of dissolved and emulsified water are quite different [415]. Measurements of the DC of an emulsion of NaOH solution in transformer oil have been given [416]. The method is widely used to control the concentration of water in petroleum and petroleum products [417-426]. Continuous measurement and recording are possible even at water concentrations reaching 60% [427]. The measurements are often carried out by comparing the DC of water-containing petroleum and anhydrous petroleum [428-430]. The determination of water in hydrazine and phenylhydrazine [431], monohydric and polyhydric alcohols [432], pyridine bases [433], ethyl acetate [434,435], dioxan [433], the diethyl ether of diethyleneglycol [436], the three-component methanol–propan-2-ol–water system [437], and mineral oils [438] has been described.

For multi-component systems, determination of water by loss measurements is in most instances impossible, since the dielectric loss factor may be altered for reasons other than a change in the water concentration [413].

To determine water in solids, use is made of preliminary extraction by a solvent [414], for example in the determination of water in soil [439], spinach [440], quartz sand, manganese ores, coal, clay [441], wheat, ammonium sulphate, etc. [442]. The limits of applicability of the method involving preliminary extraction are made narrower when the extracting solvent does not extract water completely, or when complete extraction takes a long time. This has led to the development of the immersion method [443]. The substance being analysed is immersed in a liquid with known DC value, and the final DC of the system is measured. The H_2O concentration is found from a calibration curve. This method has been proposed for the analysis of inorganic fertilisers [443,444].

Water can be determined in many materials by immersing electrodes directly in the substance being studied: molecular sieves [445], grain [445-448], hops [446], peat [449], soil [450], packing materials [451], tobacco [452-454], [iron ore] charges [455], textile fibres [456], loose materials [457,458], moulding mixtures [459,460], paper and cardboard [461], granulated materials, Nitrophos [462], and trinitrotoluene [463]. In some instances it is necessary to keep the pressure of the electrodes on the material being studied strictly constant [452].

The dielectric loss method is particularly promising for the analysis of loose materials. Thus it is possible to measure the moisture content of pigments without weighing a specimen [413].

Special cell designs have been developed, making it possible to determine the concentration of water in films [413,464]. A portable hygrometer for the determination of the moisture content of air from DC measurements has been described [465,466]. An analyser for the continuous determination of moisture in gases containing HF has been described [467].

Various types of apparatus for carrying out the determination have been described [17,421,468-475].

3. Methods Based on Measurement of the Electrical Conductivity. The moisture content of

gases absorbed by a solvent is determined by measuring the electrical conductivity of the water-containing extracting agent [476]. Sulphuric acid is used as absorbent for the moisture in natural gas [477]. The electrical resistance of LiCl is a function of the moisture content of the gas in contact with the salt [478].

The moisture content of soil [479] is determined by measuring the electrical resistance of a mixed solvent saturated with NaCl after the extraction of water from the soil. The measurement of the moisture content of transformer oil from the change in the electrical resistance of a fabric placed between perforated metal plates has been described [480]. Specific resistance measurements have been used for the continuous control of the moisture content of the rocket fuel dinitrogen tetroxide [481]. The method involving electrical conductivity measurements has been used to determine water in liquids—hydrogen fluoride [482,483], propane [484], petroleum residue [485], and pyridine [486].

The continuous determination of the electrical conductivity of solids can be carried out usually at high water concentrations. The electrical conductivity depends on the source voltage, the shape and arrangement of the electrodes, the chemical composition of the material, temperature, the degree of uniformity, the state and the distribution of the water, the degree of polarisation, the state of the surface of the individual granules and pieces and the degree of compactness and contact in the material [17]. Methods and apparatus have been described for the rapid determination of moisture from electrical conductivity measurements in sawn timber and wood [487-489], salt [490], leather [491], chromium oxide [492], paper, textiles [493], peat [494], copra [495], and chromatograms [496].

In radiosondes, moisture is determined using a hygrometer element of oxidised aluminium, whose resistance is a function of the moisture content of the atmosphere [497].

Various forms of apparatus have been described [10,17,21,469-471,488-501].

4. Electrometric Methods. The coulometric method is based on the determination of the quantity of electricity required for the electrolysis of water absorbed by a thin film of absorbent (H_3PO_4, H_2SO_4, or their mixtures, P_2O_5, KOH, K_2CO_3, etc.) [502-511] from a measured quantity of gas. In the analysis of liquids [503,512-515] and solids [17,503], the water is first transferred to the gaseous phase by evaporation or by using a current of heated dry gas [512]. The quantity of current used in the electrolysis is recorded graphically from a curve giving the change in current, by means of integrators [17,514], or from the magnitude of the current [515]. The rate of carrier gas [flow] depends on the design of the recorder, the nature and moisture content of the specimen, and the weight taken. For solids, a method involving the extraction of moisture by a gas, combined with heating by high-frequency currents, has been described [17,512,513].

Procedures [516,517] and apparatus have been described for determination of moisture by comparing the pressures of the gas being analysed and a reference gas for the same resistance of the hygroscopic film.

The efficiency of analysers for the determination of water in gas streams and liquid streams has been studied [518].

The coulometric method can be used to determine water in cracking gases, petrol vapour, natural gas [504,519], air [520], aromatic hydrocarbons [521], organic liquids [512,514,516], the technological product streams in petroleum refineries [522], circulating freon refrigerant [516,517], and solids [523,524].

Water in ϵ-caprolactam can be determined polarographically [525,526]. It is suggested that water in various organic compounds can be determined by the reaction of the substance with phenylchloro-oxophosphorus, which leads to an increase in the polarographic current of the solution at a given potential [527]. An improvement of the method has also been determined [528].

5. Optical Methods. Water in liquid products can be detected qualitatively using indicator paper [529-531] impregnated with salts $CoCl_2$, $CuBr_2$, BiI_3, SbI_3 or mixtures $K_3Fe(CN)_6 + CoCl_2$, $K_2CrO_4 + MnCl_2$ + resorcinol, activated silica gel treated with $CoBr_2$ solution [532], or molecular sieve A [533].

The change in the colour of solutions of a number of compounds as a result of hydration of the reagent can be used for colorimetric analysis. Thus cobalt compounds can be used to determine water with satisfactory accuracy in $CHCl_3$, salicylaldehyde, crotonaldehyde, and benzaldehyde [534], acetone [534-536], Cl_2CF_2, Cl_3CF, $ClCF_3$, petrol, methyl chloride [537], refined sugars [538], alcohols, acetone, ethyl acetate [539], maize, and Indian corn [540]. Water in solid specimens is extracted beforehand using a solvent.

With increase in the concentration of water in alcohol, there is an increase in solubility and a development of the colour of $K_2Cr_2O_7$ [541], and in reactive fuels, hexachlorane, and turbine oils a similar effect is shown by the dye Methylene Blue [542,543]. The concentration of H_2O is determined from the decrease in the colour of the Karl Fischer reagent after passage of the moist gas through the reagent [544].

The oxidising properties of $K_2Cr_2O_7$ are used to determine water in various biological materials [545]. The intensity of the colour of the reduced form of chromium depends on the water concentration. Using a scale of standards, it is possible to determine moisture using anhydrous copper sulphate [546,547].

Ether and ketones saturated with anhydrous LiCl acquire the orange-red colour characteristic of $LiCuCl_3$ in the presence of H_2O and copper perchlorate [548]. Moisture can alter the colour of solutions of chloranilic acid [549], hexanitrobenzene [550], complexes of diethylaluminium hydride with isoquinoline [551], and an acetone solution of anhydrous copper chloride [536].

Water in gaseous nitrogen can be determined by vacuum spectrophotometry in the ultraviolet range [552].

Various reagents ($SiCl_4$ [553] and $TiCl_4$ [554]) in contact with water-containing solvents form stable suspensions of hydrolysis products, whose light absorption depends on the moisture content.

The moisture content of monomers is determined by measuring the optical density of specimens cooled to −50°. The turbidity is proportional to the water content [555]. The turbidity at a CH_3COOH–toluene interface can be used to determine the concentration of moisture in the acid [556].

The turbidimetric method is used to determine water in methyl and ethyl thiols [557] and in fuels for aviation turbines [558]. The moisture content of gas is measured from the light extinction of the aerosol formed by passing the moist gas through oleum [559]. Water in liquid hydrocarbons [554] and motor fuel [560] can be determined nephelometrically.

Infrared spectroscopy can be used to determine water in gases, liquids, and solids over a wide range of water concentrations. The choice of analytical absorption band is determined by the chemical composition of the substance being analysed and the concentration of water being determined. At high concentrations of water (fractions of one percent and above) the bands in the range 5100–5300 cm^{-1} and 7100–6200 cm^{-1} due to the overtones and combination

frequencies of the stretching and bending vibrations of the HO groups of the water molecules are used[20,561-574]. The weak absorption bands at 1550–1650 cm^{-1} and 3590–3710 cm^{-1} due to the symmetric bending and asymmetric stretching vibrations of the HOH and HO groups are used to determine traces of water[575-582].

Infrared spectroscopy is widely used to determine water in various organic liquids: alcohols[561,575,577,582-585], glycols[561,582], dioxan[561,582,586,587], ketones[573,575,577,582,583,586,588], 1,1-dimethylhydrazine, diethylenetriamine, monomethylhydrazine[562,563,589], glycerol[565,583], esters[573], aldehydes[580], benzene, toluene, xylene[590], CCl_4[586,587,590,591], chloroform[582,586,587], ethyl bromide[589], homologues of pyridine[592], aniline[582,586,587], tetrabutyl phthalate[578], tetrahydrofuran[587], tributyl phosphate[593], dimethyldioxan[581], freon-22 refrigerant[594], organic solvents[585-599], and lubricating oils[600]. The limits of sensitivity of the determination of water in non-associated solvents and the relationship between the limits of sensitivity and the transmission coefficient of the background have been examined[590].

The methods of molecular spectroscopy are extremely effective and make it possible not only to determine the concentration of water in organic solvents but also to obtain considerable information on its state in solution, the bonds formed with the solvent molecules, and processes of hydration and extraction[20,601].

Special procedures are required for the determination of water in strongly corrosive inorganic liquids. Thus in the determination of water in liquid sulphur dioxide the NaCl or KCl cells are fitted with polyethylene and lead linings[576]. The conditions for the determination of water in liquid bromine[579,602] and fuming nitric acid[571] have been examined in detail.

Alkali metal halide discs, suspensions in Nujol, or solutions in D_2O have been proposed for the analysis of salts[568]. Methods have been developed for the determination of water of crystallisation[564,566,570,595,603], and water in carbohydrates[604] and milk fat[605].

In the analysis of vegetable materials by infrared spectroscopy the water is extracted beforehand with methanol[606], and in the analysis of coffee the water is separated by azeotropic distillation with dioxan[113]. The determination of water in complex minerals[607], silicates[568], silica gel[574], polymers[608], elastomers[609], films[569,596], and aluminium acetylsalicylate[610] has been described.

Infrared spectroscopy is sometimes used to analyse the products of the reaction of water with various reagents—2,2-dimethoxypropane[595] (acetone and CH_3OH are formed) and CaC_2, which liberates acetylene[609,611]. Various forms of apparatus have been described[12,83,571,583,584,595,608,609].

Infrared hygrometers for measuring the moisture content of air have been described[612,613]. The conditions for the analysis of gases at elevated temperatures and pressures have been examined[614].

6. NMR Spectroscopy. Nuclear magnetic resonance (NMR) can be used to measure the moisture content of liquids and solids. The determination of the moisture content of solid, loose, and fibrous materials is based on the fact that the water molecules are relatively mobile compared with the molecules of the main hydrogen-containing substance, so that the proton absorption curve obtained on a low-resolution instrument has the form of a very broad signal, on which the narrow line from the protons of water is superimposed[615,616]. At a concentration of water greater than 10%, the amplitude of the signal is linearly dependent on the moisture content[617-619]. At lower water concentrations, the bonding between its molecules and the adsorbent changes, and the dependence of the amplitude of the signal on the water concentration becomes more complex. In such instances, a calibration curve is used. Various instruments have been described[12,620-624].

The determination of water by the EPR method in wood, cellulose, fruit, starch[618,619,625-627], pectin[618], nylon[628], various granulated materials[619], peat[629], corn syrup and chewing gum[630], and a moving stream of coal[631] has been described. Small concentrations of water can be measured by determining the width of the absorption line[618]. The relaxation times have been used to determine the concentration of water in hardened epoxide resins and polyamides[632].

High-resolution NMR spectroscopy can be used to determine H_2O in acetone[633] and other liquids[634]. The dependence of the magnitude of the chemical shift of the protons of the water on its concentration can be used to determine water in, for example, CH_3CN, piperidine[635], and tributyl phosphate[636].

The NMR method is effective in the study of the sorption of water on various materials. It makes it possible to measure moisture contents over a wide range, rapidly, accurately, and without decomposition of the specimens. The control of technological processes from moisture content measurements is possible[621,622,637].

7. The Chromatographic Method. The chromatographic determination of water can be carried out either by direct separation of a mixture or by chromatographic study of the products of the previous reaction of appropriate reagents with water. The first version is carried out by the gas-liquid method, which is used to analyse mixtures with high water content. The liquid phase may consist of polyethylene glycol on refractory brick[638], Teflon[639,643], or porous glass[644], stearic or 12-hydroxystearic acids[645], and diiso-octyl phthalate on teflon[646], and tetrahydroxyethylenediamine on chromosorb[562]. The following reagents have been recommended for the determination of water by the second method: CaC_2[151,639,647-651], $LiAlH_4$[652], $NaAlH_4$[653,654], CaH_2[639,647,655], organic isocyanates[647], 2,2-dimethoxypropane[656,659], and lead tetra-acetate[660]. The gases formed and the organic liquids are analysed by absorption or gas-liquid chromatography.

The determination of water in the following materials has been described: butane[638], alcohols[661], mixtures of NH_3 and amines and mixtures of ethanol and butanol and ammonium carbonate[640], methanol, ethanol, CH_3COOH[641], pyridine[641,662], aliphatic acids[645], hydrocarbons[151,652,646], gases[654,663], hydrazine, monomethylhydrazine, 1,1-dimethylhydrazine, diethylenetriamine, and their mixtures[562,664], mixtures of the gases H_2, O_2, N_2, CH_4, and CO[651], pharmaceutical products[665], liquid alkenes, diene monomers, and various oxygen-containing compounds[653,666], sodium acetate and copper sulphate (with preliminary extraction of the water by methanol)[624], CH_3OH–aldehyde mixtures[644,650], the products of the manufacture of C_6H_5OH from isopropylbenzene[667], fruit[668], and water in the moon's crust[669].

Water in gases and hygroscopic liquids can be determined by reverse chromatography: a moist carrier gas with a water concentration greater than that of the substance being analysed is used, so that negative peaks appear on the gas chromatogram[670].

8. Other Methods. When a beam of β- or γ-radiation is passed through a material of uniform density,

a decrease in the intensity of the radiation beam is observed, depending on the moisture content. This phenomenon is used for the quantitative determination of the moisture content of soils, building materials and other loose materials, asphalt, wood[671,672], textiles[673], and petroleum[674]. A portable instrument for this purpose has been described[675].

A new method has been proposed for the determination of water in methanol[676] using kryptonates. In the presence of water, ^{85}Kr is liberated, and this is removed by a stream of nitrogen into a counting chamber and determined quantitatively.

Methods have been described for the determination of water by the third-component method using a radioactive substance in crystal hydrates[677,678], pharmaceutical products[679], sesame oil[680], silica gel, and iron ores[678]. The concentration of water in synthetic pigments and biopolymers can be determined by mass-spectrometric measurements after deuterium exchange[681].

A method for the determination of moisture has been based on the ability of hydrogen atoms to weaken a beam of fast neutrons[10,671]. The results of the measurements are little influenced by the salt content and density of the material and are not influenced by temperature and the moisture distribution. The use of the neutron method to measure the moisture content of lime raw materials[682], concrete[683,684], soil[684], wood, sand, moist salts[685,686], and lamp black[687] has been described. The development of a neutron moisture meter whose operation does not depend on the density of the material has been described[688-690].

The use of an ultrasonic method for the determination of small quantities of water in CH_3OH has been proposed[691].

It has been suggested that very small quantities of water can be determined by hygrophotography. An illuminated light-sensitive plate (a double complex of mercury and silver iodide) can undergo a restoration of colour with time. Moisture increases the rate of this process, and this makes possible the quantitative and qualitative determination of water in alcohols, medical products, soil, etc.[692-697].

A number of papers[698-700] and a draft standard[701] have been published on the determination of the moisture content of petroleum products and reactive fuel by centrifuging. Glass-fibre filters have been recommended for the determination of H_2O in sludges[702].

The absorption of radiowaves in the centimetre range by water has been made the basis of a method for the determination of moisture in polymers[703], foodstuffs[704,705], clay, sand, coal, tobacco, fertilisers, and oil[705]. Various moisture meters have been described[704-706].

The determination of water from the extinction of the luminescence of 4-chloro-2-sulphobenzalacetophenone in hydrocarbons has been described[707,708].

The thermal characteristics of the medium can be used as criteria for the determination of moisture in capillary-porous[709,710], dispersed, and fibrous[711] materials, magnesium perchlorate[712], sulphuric acid[713], fluorocarbons[714], and unsaturated hydrocarbons[715].

A review of methods for the determination of water by physical and physicochemical methods shows that these methods extend considerably the possibilities for the control and automation of production, are extremely rapid, and also extremely effective in the study of the state of water in substances in different states of aggregation.

REFERENCES

1. J. Mitchell and D. M. Smith, "Aquametry. The Application of the Karl Fischer Reagent to Quantitative Analyses Involving Water" (Translated into Russian), Inostr. Lit., 1952.
2. A. S. Johnson, Chem. a. Ind., 1949, 511.
3. R. Cuneo, Bull. Ecole Meunerie Belge, 13, 134 (1951).
4. A. H. Ward, J. Inst. Fuel, 24, 16 (1951).
5. D. Clamann, Osterr. Chem. Ztg., 54, 165 (1963).
6. D. I. Ryabchikov and V. K. Belyaeva, Uspekhi Khim., 24, 240 (1955).
7. J. H. Thompson, Ind. Chemist, 34, 451 (1958)
8. Z. Lada, Chem. Anal., Warsaw, 1, 235 (1956).
9. W. Lück, Arch. techn. Messen, 312, 25 (1962).
10. W. Luck, Ztschr. fur Messen, Steuern, Regeln, 1960, 341, 343, 535.
11. E. Eberius, Ztschr. analyt. Chem., 181, 172 (1961).
12. A. Pande, C. S. Pande, Instrument Practice, London, 16, 896, 988, 1104 (1962).
13. A. Pande, C. S. Pande, Lab. Pract., 12, 432, 661, 741 (1963).
14. Humidity and Moisture: measurement and control in science and industry. Washington, Vol. 1–4 (1964).
15. Funasaka Wataru, Bunseki Kagaku, 13, 818 (1964); Ref. Zhur. Khim., 4G94 (1965).
16. E. E. Esher, J. Schaffer, Analys. Instrumentat., 1963. Pittsburg, Pa, Instrum. Soc. America, 1963, p. 189.
17. V. I. Istomin, Zavod. Lab., 29, 568 (1963).
18. S. J. Broadbent, Automat. Progr., 1959, No. 6, 192.
19. K. Muroi, Homen, 3, 120 (1965); Ref. Zhur. Khim., 4G89 (1966).
20. A. V. Karyakin and A. V. Petrov, "Sovremennye Metody Analiza" (Modern Methods of Analysis), Izd. Akad. Nauk SSSR, Moscow, 1965, p. 185.
21. H. J. Eeisentraut, Lebensmittel-Ind., 10, 281 (1963).
22. A. N. Brusintsov, Candidate's Thesis, Moscow Pharmaceutical Institute, 1953.
23. D. Mala, B. Malichar, J. Maly, Farmacia, 24, 2 (1955).
24. N. G. Gokhale, Assam Rev. and Tea News, 45, 87 (1955).
25. A. Bennett, J. R. Hudson, J. Inst. Brew., 60, 29 (1954).
26. S. J. M. Pleeth, J. Inst. Petrol., 36, 345 (1950).
27. Sato Yoshishige and Takahashi Tadao, Bunseki Kagaku, 9, 456 (1960); Ref. Zhur. Khim., 96115 (1960).
28. Muroi Kaname, Bunseki Kagaku, 11, 351 (1962); Ref. Zhur. Khim., 3G188 (1963).
29. A. F. Bennett, Refrig. Cold. Storage, Air Condit., 41, 7087 (1947).
30. M. Meitina, Az. Neft. Xoz., No. 3, 69 (1934).
31. T. J. Mitchell, Chem. a. Ind., 1950, 751.
32. C. O. Willits, Analyt. Chem., 23, 1058 (1951).
33. D. J. Drysdale, E. D. Lacy, J. Tarney, Analyst., 88, 131 (1963).
34. T. Kimura and Y. Asami, Sinku Kagaku, 11, 198, (1963); Ref. Zhur. Khim., 14G120 (1964).
35. M. E. Schulz, G. Mrowetz, Milchwiss., 8, 93 (1953).
36. M. Nagahara, Bunseki Kagaku, 5, 42 (1956); Ref. Zhur. Khim., 28974 (1957).
37. D. Rosu, Rev. ind. aliment. prod. anim., 1957, No. 7, 14.
38. E. A. Nikitina and A. S. Kokurina, Zhur. Obshch. Khim., 23, 1263 (1953).
39. C. Du. Rietz, Svensk Kem. tidskr., 69, 310 (1957).
40. B. N. Filippov, Gidroliz. i Lesokhim. Prom., No. 5, 25 (1957).

41. T. Grzeczyński, Przem. drzewny Golska, 11, No. 11, 18 (1953).
42. R. J. Demint, A. F. Cucully, C. L. Hoffpauir, J. Amer. Oil Chem. Soc., 30, 225 (1953).
43. W. Schäfer, W. Seibel, Muhle, 94, 663 (1957).
44. T. A. Oxley, S. W. Pixon, R. W. Howe, J. Sci. Food., 11, 18 (1960).
45. M. E. Stedham, Trans. Brit. Ceram. Soc., 57, 381 (1958).
46. J. Ristici, S. Gal, G. Liptay, Period polytechn. Chem. Engng., 7, 21 (1963).
47. P. P. Goloborod'ko, Zavod. Lab., 7, 1304 (1938).
48. V. E. Kiseleva, ibid., 6, 555 (1937).
49. S. M. Kabanov, S. S. Vasil'ev and A. M. Zakharov, Med. Prom. SSSR, No. 4, 39 (1966).
50. B. Lorant, G. Pollak, Fleischwirtschaft, 45, 1188 (1965).
51. M. S. Burns. D. J. Swaine, Fuel, 42, 505 (1963).
52. A. I. Kozko and A. A. Grigor'ev, Trudy Vses. Proektno-Konstr. i Nauch.-Issled. Inst. po Obogashcheniyu i Briketir. Uglei, 30, 101 (1963).
53. G. A. Kocharyan, Khlebopek. i Kondit. Prom., No. 4, 30 (1963).
54. H. R. Bolin, F. S. Nury, J. Agric. Food Chem., 13, 590 (1965).
55. A. F. Bennett, J. R. Hudson, J. Inst. Brew., 60, 35 (1954).
56. Harada, Nippon Shio Gakkaishi, 11, 112, (1957); Ref. Zhur. Khim., 24864 (1958).
57. L. M. Kantorovich and G. T. Levchenko, Trudy Gos. Inst. Nauch.-Issled. i Proekt. Inst. Azotn. Prom., 8, 246 (1957).
58. A. Macdonald, J. S. Pomeroy, M. H. Gardner, Amer. J. Clin. Path., 31, 563 (1959).
59. P. Paaby, Scand. J. Clin. Lab. Invest., 11, 117 (1959).
60. I. Salganik, Mukomol.-Elevator. Prom., 9, 14 (1956).
61. A. Guilbot, Meunerie franc., 1957 (No. 122), 31.
62. F. Schierbaum, Dtsch. Lebensmitt, 53, 173 (1957).
63. L. Domange, S. Longuevalle. Ann. Pharm. Franc., 11, 530 (1953).
64. J. H. Caro, J. H. L. Marshall, J. Assoc. Offic. Agric. Chem., 44, 224 (1961).
65. N. Valli Castiglioni, Ind. aliment., 4, No. 18, 65 (1965)
66. F. Radler, M. Grncarevic, Food Technol. Austral., 16, 732 (1964).
67. A. Maton, J. van de Vyver, Brauwissenschaft, 18, 475 (1965).
68. I. I. Morachevskii, R. B. Angenitskaya, E. A. Chumakova and I. G. Bushev, Inzh. Fiz. Zhur., 3, 13 (1960).
69. British Standarts Institution, B. S., 1428, part G2: 1957, 11 p.p.
70. Th. F. Mach, Food Engng., 37, 90 (1965).
71. M. Parlapanski, Khim. i Industr. (Bulgaria), 36, 227 (1964).
72. A. Purr, Fette und Seifen, 56, 1006 (1956).
73. K. Göhde, Papier-Fabr., 37, 320 (1939).
74. D. S. Binnington, W. F. Geddes, Ind. Eng. Chem. (Anal. Ed.], 8, 76 (1936).
75. A. Nazir, Proc. Natl. Inst., India, 7, 79 (1941).
76. S. G. Simonyan and N. N. Dolgopolov, Zavod. Lab., 31, 252 (1965).
77. E. S. Khoroshaya, K. D. Korol'kova, Yu. I. Kuznetsova and E. A. Roitman, ibid., 29, 239 (1963).
78. O. Vlachovský, Stavivio, 37, 295 (1959).
79. M. I. Tarasenko and T. I. Bulenkov, Sbornik Nauchn. Rabot Moskov. Farm. Inst., 2, 172 (1958).
80. G. Wirzing, Ztschr. anal. Chem., 198, 267 (1963).
81. A. C. Thomas, Analyst, 85, 771 (1960).
82. E. A. Gershkovich, Zavod. Lab., 31, 1541 (1965).
83. Export-Markt. Electrotehn., 43, No. D3(34), 16 (1963).
84. J. F. Reith, D. A. Mossel, J. H. Van de Kamer, Analyt. chim. acta, 2, 359 (1948).
85. F. Trussell, H. Diehl, Analyt. Chem., 35, 674 (1963).
86. M. M. Jakšic, B. A. Bulimbasič, Kemija u industriji, 12, 447 (1963); Ref. Zhur. Khim., 7G118 (1964).
87. Sh. D. Christian, H. E. Affsprung, Analyt. chim. acta, 29, 586 (1963).
88. J. P. Rilley, H. P. Williams, Mikrochim. acta, 1959, (4), 525.
89. J. P. Rilley, Analyst, 83, 42 (1958).
90. S. A. Reed, E. S. Funston, W. L. Bridges, Analyt. chim. acta, 10, 429 (1954).
91. G. C. Le Compte, H. H. Lipp, Amer. Dyestuff Reporter, 38, 484 (1949).
92. H. Döring, Landwirtsch. Forsch., 16, 221 (1963).).
93. M. Dévényi, I. Kása, G. Liptay, Magyar kém. lapja, 18, 291 (1963); Ref. Zhur. Khim., 12G131 (1964).
94. R. N. Evans, J. E. Devenport, A. G. Reyukas, Ind. Eng. Chem. (Anal. Ed.), 11, 553 (1939); 13, 589 (1941).
95. S. Harel, A. Talmi, Analyt. Chem., 29, 1694 (1957).
96. W. R. Fetzer, ibid., 23, 1062 (1951).
97. E. Myshkin, Neft', No. 12, 22 (1937).
98. A. W. Billitzer, Australien Chem. Inst. J. and Pract., 15, 165 (1948).
99. A. W. Billitzer, Analyt. Chem., 25, 533 (1953).
100. J. Tausz, H. Kumm, Chem. Rundschau, 6, 320 (1953); Seifen-Öle-Fette-Wachse, 79, 466 (1953).
101. B. Mihalik, J. Asbóth, Textil-Praxis, 11, 897 (1956).
102. H. Davidge, Chem. a. Ind., 1957, 1507.
103. T. Barr, J. I. Yarwood, ibid., 1957, 803.
104. L. Hübschen, Ztsch. Lebensmittel Untersuchung und Forsch., 111, 371 (1960).
105. S. N. Balasubrahmanyam, J. Chem. Educ., 37, 475 (1960).
106. R. K. Siegfiedt, O. A. DeWoody, Proc. Amer. Petrol. Inst. Sect., 40, 416 (1960).
107. B. V. Volkov, Zavod. Lab., 30, 112 (1964).
108. Laoto Heimo, Suomen kem., 38, (9), B 188 (1965).
109. Jun. Matusdaira, Kaname Muroi, Japan Analyst., 8, 429 (1959).
110. R. B. Trasler, Oil and Soap, 16, 239 (1939).
111. R. B. Trasler, Ind. Eng. Chem. (Anal. Ed.), 12, 509 (1939).
112. J. Terrier, Mitt. Geb. Lebensmitteluntersuch und Hyg., 44, 302 (1953).
113. H. Branderberger, H. Bader, Analyt. Chem., 33, 1947 (1961).
114. N. O. Schmidt, L. F. Wiggins, R. D. E. Yearwood, Internat. Sugar J., 55, 41 (1953).
115. K. Rauscher, O. Korn, Nahrung, 5, 656 (1961).
116. W. A. Dewar, P. McDonald, J. Sci. Food Agric., 12, 790 (1961).
117. Z. Lada, A. Rycerz-Komorowska, M. Brudnicka, Chem. Analit. (Polska), 6, 565 (1961).
118. C. B. Jordan, V. O. Hatch, Analyt. Chem., 22, 177 (1950).
119. E. A. Drabkin, Gaz. Prom., No. 7, 32 (1961).
120. M. Isihuro, Yakugaku Zasshi, J. Pharmac. Soc. Japan, 75, 1418 (1955); Ref. Zhur. Khim., 30907 (1957).
121. B. M. Rybak, "Analiz Nefti i Nefteproduktov" (The Analysis of Petroleum and Petroleum Products), 1962, p. 15.
122. V. S. Klimova, N. D. Katorzhnov, G. I. Kudryavtsev and A. V. Beschastnov, Khim. Volokna, No. 6, 64 (1963).

123. S. A. Charkin, Med. Prom., No. 6, 44 (1959).
124. "Standartnyi Metod Dina i Starka" (The Standard Method of Dean and Stark), USSR State Standard 2477-44.
125. A. G. Elitsur, Zhur. Obshch. Khim., 10, 1981 (1940).
126. A. G. Elitsur, Zhur. Prikl. Khim., 14, 682 (1941).
127. A. G. Elitsur, Zhur. Obshch. Khim., 14, 924 (1944).
128. A. G. Elitsur, Izv. Sektora Platiny Inst. Obshch. Neorg. Khim. Akad. Nauk SSSR, 22, 149 (1948).
129. G. M. Toptygina, Zhur. Anal. Khim., 16, 201 (1961).
130. A. L. Gol'dinov, V. I. Lukovitskii and G. Ya. Mal'kova, ibid., 16, 724 (1961).
131. L. G. Berg and L. M. Gromakova, Trudy Kazan. Filiala Akad. Nauk SSSR, Ser. Khim. Nauk, 3, 37 (1956).
132. P. A. Rybakov and T. D. Lysenko, Khim. i Tekhnol. Topliv i Masel, No. 7, 57 (1956).
133. M. M. Usakov, I. A. Landau, N. M. Lubman and M. I. Shitsko, ibid., No. 4, 55 (1958).
134. T. D. Lysenko, V. G. Malanichev, N. V. Ogareva, M. E. Tararyshkin, V. M. Tugolukov and M. I. Shetsko, ibid., No. 8, 71 (1958).
135. Yu. I. Tsarlin, Sbornik Trudov Vses. Nauch.-Issled. Inst. Gidroliz. i Sul'fitno-Sport. Prom., 13, 140 (1965).
136. D. A. Aliev, Neftepererabotka i Neftekhimiya, Nauch.-Tekhn. Sbornik TsNIITEI Neftegaza, No. 1, 25 (1963).
137. A. A. Sirotenko, Mikrochim. acta, 1955, 917.
138. J. Krotký, Zpravod. VZLÚ, 1964, No. 4, 31; Zhur. Khim., 5P279 (1966).
139. L. Kao, S. S. Chang, Y. T. Ch'e Yuan Tzu Neng, No. 4, 320 (1965); Ref. Zhur. Khim., 15G142 (1966).
140. F. E. Harris, L. K. Nash, Analyt. Chem., 23, 736 (1951).
141. USSR State Standard 8287-57, "Gidridkal'tsievyi Metod" (The Calcium Hydride Method).
142. J. Minczewski, J. Tromszszynski, Przem. Chem., 11, 147 (1955).
143. N. I. Stognii and F. P. Dorosh, Zavod. Lab., 17, 633 (1951).
144. N. V. Koshkin and N. M. Shreiner, Trudy Leningrad. Tekhnol. Inst. Pishchev. Prom., 13, 161 (1956).
145. E. D. Mikhlin, Zavod. Lab., 23, 1466 (1958).
146. S. R. Ellis, R. D. Garbett, H. N. Sadler, Ind. Chem., 35, 498 (1959).
147. E. Kohl, Industrie, 53, No. 16, 15 (1953).
148. F. Reis, Energietechnik, DDR, 3, 44 (1953).
149. F. Sikora, Nafta (Kraków), 10, 61 (1954).
150. K. H. Obst, H. Malissa, Arch. Eisenhüttenw., 30, 601 (1959).
151. H. S. Knight, F. T. Weiss, Analyt. Chem., 34, 749 (1962).
152. Nat. Bur. Standards Techn. Wevs Bull., 49, 45 (1965).
153. W. R. Coyne, U. S. P. 2866690 (30th December 1958); Ref. Zhur. Khim., 47463 (1960).
154. S. Dahl, Mater. Res. and Stand., 5, 446 (1965).
155. M. I. Karpman, "Ekspress-metod Opredeleniya Vlagi v Nesypuchikh Materialakh s Pomoshch'yu CaC_2" (A Rapid Method for the Determination of Moisture in Non-friable Materials Using CaC_2), Kazan', 1957.
156. V. P. Shatalov, Sintetich. Kauchuk, 5, 31 (1936).
157. A. V. Sokolov, N. K. Mikhailyan and G. F. Korotaeva, Zavod. Lab., 23, 800 (1957).
158. M. Singliar, J. Zubák, Chem. průmysl., 6, 426 (1956).
159. A. Ady, L. Hunyady, Fette, Seifen, Anstrichmittel, 58, 768 (1956)
160. H. Grüss, Elektrotech. Z., 14, 6 (1962).
161. R. G. Larson, Ind. Eng. Chem. (Anal. Ed.), 10, 195 (1938).
162. J. Shapiro, H. G. Weiss, J. Phys. Chem., 57, 219 (1953).
163. E. Bonauguri, G. Seniga, Ztschr. analyt. Chem., 144, 161 (1954).
164. E. Bonauguri, Ann. Chimica, 45, 805 (1955).
165. W. Schmid, Lab. Prax., 16, 2 (1964).
166. V. A. Tsirul', Zavod. Lab., 24, 903 (1958).
167. E. Eberius, Ztschr. Analyt. Chem., 137, 81 (1952).
168. A. Johanson, Analyt. Chem., 28, 1166 (1956).
169. W. Seaman, H. W. McComas, G. A. Allen, ibid., 21, 510 (1949).
170. T. Canbeack, Pharmac. Belgique, N. S., 7, 391 (1952).
171. A. R. Martin, A. C. Lloyd, J. Amer. Oil Chem. Soc., 30, 594, (1953).
172. J. G. van Pelt, H. Keuker, Chem. Weekbl., 51, 97 (1955).
173. E. Eberius, W. Kowalski, Chemiker Ztg., 81, 75 (1957).
174. E. D. Peters, J. L. Jungnickel, Analyt. Chem., 27, 450 (1955).
175. E. Brochmann-Hanssen, Ph. Pong., J. Amer. Pharmac. Assoc., 41, 177 (1952).
176. K. Muroi, Jap. P., Class 113A2 No. 2598 (8th December 1960, published 26th March 1963); Ref. Zhur. Khim., 17G11P (1964).
177. E. Eberius, H. Bohnes, Ztschr. analyt. Chem., 168, 330 (1959).
178. R. Belcher, T. S. West, J. Chem. Soc., 1953, 1772.
179. J. H. Van Der Meulen, B. P. 728947 (27th April 1955); Ref. Zhur. Khim., 31047 (1957).
180. J. Majewska, Chem. analit. (Polska), 9, 373 (1964).
181. Z. Lada, K. Malinowska, ibid, 3, 663 (1958).
182. Aktiebolaget Pharmacia, B. P. 722963 (2nd February 1955); C. A., 49, 12204b (1955).
183. E. Blomgren, H. Jenner, U. S. P. 2780601 (5th February 1957); Ref. Zhur. Khim., 53480 (1958).
184. E. Blomgren, H. Jenner, Swed. P., 174429 (28th February 1961) (AB Pharmacia); Ref. Zhur. Khim., 19D116 (1961).
185. E. Eberius, W. Kowalski, Ztschr. analyt. Chem., 150, 13 (1956).
186. L. Doražil, Chem. průmysl., 7, 362 (1957).
187. A. C. Shead, Analyt. Chem., 24, 1451 (1952).
188. V. G. Jensen, Denst. tidsskr. farmaci, 29, 77 (1955).
189. C. G. Scott, Analyst, 76, 237 (1951).
190. R. W. Sneed, R. W. Altman, J. S. Mosteller, Analyt. Chem., 26, 1018 (1954).
191. J. Mitchell, ibid., 23, 1069 (1951).
192. J. V. Karabinos, G. E. Bartels, A. T. Ballum, Chemist-Analyst, 43, 37 (1954).
193. J. S. Wiberley, Analyt. chem. 23, 656 (1951).
194. H. P. Kaufmann, Pharmaz. Zentralhalle, 91, 379 (1952).
195. V. G. Jensen, Dansk Tiddskr. Farmaci, 26, 145, 170 (1952); 30, 133 (1956).
196. R. Y. Meekheim, J. N. Roark, Analyt. Chem., 25, 348 (1953).
197. E. Eberius, W. Kowalski, Ztschr. Erzbergbau Metallhüttenwessen, 7, 229, 339 (1954).
198. L. Barnes, Jnr., M. S. Pawlak, Analyt. Chem., 31, 1875 (1959).
199. E. E. Archer, H. W. Jeater, Analyst, 90, 351 (1965).
200. J. H. Van Der Meulen, Chem. Wiekbl., 47, 608 (1951).
201. E. Fischer, Angew. Chem., 64, 592 (1952).

202. J. Michaelis, Pharmazie, **13**, 740 (1958).
203. J. Hochmann, Tavközlesi kulato int. közl., **9**, 53 (1964).
204. E. Eberius, monograph in Angew. Chemie Chemie-Ingenieur-Techni, No. 65, Weinheim (Bergstr., 1958).
205. R. L. Menville, S. R. Henderson, Analyt. Chem., **25**, 840 (1953).
206. H. Sobel, ibid., **25**, 1576 (1953).
207. J. B. Whittum, ibid., **23**, 209 (1951).
208. H. A. Scropp, C. P. Evans, ibid., **28**, 143 (1956).
209. K. A. Connors, T. Higuchi, Chemist-Analyst., **48**, 91 (1959).
210. A. E. Hawkins, Analyst, **89**, 432 (1964).
211. Farmaco Ed. prat., 8, 11 (1953).
212. R. W. Freedman, Analyt. Chem., **31**, 1287 (1959).
213. K. G. Stone, H. G. Seholten, ibid., **24**, 671 (1952).
214. R. Dalbert, J. Tranchart, Chim. et Ind., **61**, 457 (1949).
215. J. Haslam, D. C. M. Squirrell, Analyst, **82**, 511 (1957).
216. B. S. Gukhman, B. I. Petrov and T. I. Yakovlev, Zavod. Lab., **14**, 646 (1948).
217. V. G. Gimpel'son and A. V. Kazakov, in collected papers "Avtomatizatsiya Khimicheskogo i Neftekhimicheskogo Proizvodstva" (Collected Papers on the Automation of Chemical and Petrochemical Production), No. 4, Moscow, 1965, p. 54.
218. D. V. Gurvich, V. A. Balandina, N. I. Brichkin, M. P. Noskova, and V. I. Malikov, Plast. Massy. No. 11, 39 (1961).
219. Chem. Process (Engl.), 11, (11), 36 (1965).
220. A. Campiglo, Farmaco, Ed. scient., **20**, 570 (1965).
221. R. H. Prince, Analyst, **78**, 607 (1953).
222. D. E. Campbell, Analyt. Chem., **25**, 203 (1953).
223. C. A. McCauley, W. J. Gresham, ibid., **27**, 1847 (1955).
224. F. Oheme, Chem. Techn., Berlin, **9**, 340 (1957).
225. J. Kováč, Chem. Zvesti, **11**, 432 (1957).
226. E. H. Unger, A. G. Herzog, Analyt. Chem., **30**, 157 (1958).
227. F. B. Waddington, Lab. Practice, 8, 275 (1958).
228. A. F. Pyrah, R. S. Robertson, J. Inst. Petrol., **45**, 316 (1959).
229. K. Muroi, Bunseki Kagaku, Japan Analyst, **12**, 858 (1963); Ref. Zhur. Khim., 22G91 (1964).
230. Chim. analyt., **42**, 252 (1960).
231. Phillips Serv. Sci. a. Ind., **11**, 38, 39, 40 (1964).
232. G. Hesse, W. Herb, Chem. Techn., **15**, 690 (1963).
233. Analmatic (B. T. L.), **40**, 236 (1965); Ref. Zhur. Khim., 5D17 (1966).
234. A. Dirschel, F. Erne, Mikrochim. acta, **49**, 794 (1962).
235. K. Praeger, Chem. Techn., 7, 480 (1955).
236. M. Vašta, Chem. Listy, **52**, 763 (1958).
237. H. J. Francis, Jnr., P. O. Sawjer, Mikrochem. J., 8, 139 (1964).
238. A. M. L'vov, V. A. Klimova and A. I. Palii, Zhur. Anal. Khim., **19**, 1366 (1964).
239. H. Grus, Erdöl und Kohle, **17**, 630 (1964).
240. G. Nemitz, Chemiker-Ztg., **83**, 364 (1959).
241. J. D. Ponting, D. H. Taylor, Chemist-Analyst, **54**, 123 (1965).
242. G. A. Rechnitz, K. Strinivassan, Ztschr. analyt. Chem. 210, 9 (1965).
243. P. A. Schaffer, Jnr., A. Briglo, Jnr., J. A. Brockmann, Jnr., Analyt. Chem., 20, 1008 (1948).
244. E. Barendrecht, Nature, **183**, 1181 (1959).
245. A. S. Meyer, Jnr., C. M. Boyd, Analyt. Chem., **31**, 215 (1959).
246. F. Oheme, French P. 1086918 (2nd February 1961); Ref. Zhur. Khim., 12D153 (1962).
247. E. Barendrecht, J. G. F. Doornekamp, Ztschr. analyt. Chem., **186**, 176 (1962).
248. R. F. Swensen, D. A. Keyworth, Analyt. Chem., **35**, 863 (1963).
249. Dutch P. 94380 (16th May 1960); Ref. Zhur. Khim., 6E101 (1961).
250. M. Přibyl, Z. Slovák, Mikrochim. acta, **1964**, 1097.
251. M. R. Lindbeck, H. F. Freund, Analyt. Chem., **37**, 1647 (1965).
252. Y. Yasumori, M. Ikawa and Y. Nozawa, Bunseki Kagaku, Japan Analyst, **14**, 871 (1965); Ref. Zhur. Khim., 13G100 (1966).
253. H. W. Hodgson, J. H. Glover, Analyst, 77, 74 (1952).
254. M. M. Raines, Zavod. Lab., **14**, 284 (1948).
255. N. S. Nikolaev and I. F. Alenchikova, ibid., **24**, 418 (1958).
256. J. Mitchell, Jnr., L. R. Kangas, W. Seaman, Analyt. Chem., **22**, 484 (1950).
257. M. L. Moberg, W. P. Knight, H. M. Kingsvater, ibid., **28**, 412 (1956).
258. E. A. Burns, R. F. Muraca, ibid., **35**, 1967 (1963).
259. E. A. Burns, R. F. Muraca, ibid., **34**, 848 (1962).
260. J. O. Hibbits, Z. Zucker, ibid., **26**, 1093 (1954).
261. C. Whalley, J. Oil a. Colour Chem. Assoc., **36**, No. 391, 20 (1953).
262. W. H. Goff, W. S. Palmer, R. F. Huhndorff, Analyt. Chem., **20**, 344 (1950).
263. C. L. Rulfs, Mikrochem. verein, Mikrochim. acta, **33**, 338 (1948).
264. R. Dalbert, J. Tranchant, Chem. et ind., **68**, 871 (1952).
265. L. Giuffrè, Chim. e ind., **64**, 51 (1964).
266. H. Brinztinger, R. Haug, G. Sachs, Farbe u. Lack, **60**, VI, 59 (1954).
267. E. Stock, H. Hessling, Dtsch. Farben-Ztschr., 1955, 76.
268. C. B. Jordan, Analyt. Chem., **36**, 424 (1964).
269. I. Johnston, E. J. Smith, Chem. a. Ind., **1964**, 315.
270. K. D. Schubert, Bergakademie, **17**, 359 (1965).
271. M. S. Bloom, L. W. Lord, B. P. 1021745 (1st October 1963); Anal. Abstr., **1966**, 3885.
272. G. Cloetens, Explosifs., **17**, 50 (1964).
273. E. P. Zemlyakova, Zhur. Obshch. Khim., **26**, 2687 (1956).
274. G. D. Glebova and G. N. Kosheleva, Trudy Vses. Nauch.-Issled. Inst. Khim. Reaktivov, **22**, 115 (1958).
275. O. Frehden, S. Petroianu, Rev. chim. (RPR), **16**, 223 (1965); Ref. Zhur. Khim., 13G97 (1966).
276. A. H. Laurene, Analyt. Chem., **24**, 1496 (1952).
277. P. T. Chiang-I., W. Ch. Cooper, ibid., **35**, 1693 (1963).
278. W. Vauck, K. H. Kallies, Textil- u. Faserstofftechn., 5, 574 (1955).
279. U. Büttner, Chemie für Labor. und Betrieb., **13**, 493 (1962).
280. L. N. Gard, R. C. Butler, Analyt. Chem., **26**, 1367 (1954).
281. I. W. Compton, L. M. Liggett, J. Amer. Oil Chem. Soc., **28**, 81 (1951).
282. E. Eberius, Angew. Chem., **64**, 195 (1952).
283. O. Ružicka, Chem. Průmysl, 4, 464 (1954).
284. O. Ya. Skochilova and E. Kh. Rud', Zavod. Lab., **24**, 816 (1958).
285. N. H. Hulme, A. Osol, J. Amer. pharm. Assoc., sci Edit., **39**, 471 (1950).

286. U. Biermacher, A. M. Mattocks, Bull. Natl. Formulary Comm., 18, 142 (1950).
287. D. Thorn, G. L. Huyck, Drug Standards, 21 (11–12), 199 (1953).
288. A. Llopis, Galénica acta, 8, 89 (1955).
289. K. F. Porek, Analyst, 81, 728 (1956).
290. K. G. Krebs, J. Matern, Krankenkaus-Apotheker, 7 (4), 29 (1957).
291. K. G. Krebs, J. Matern, Deutsch. Apoth. Ztg., 97, 51 (1957).
292. G. F. Fellers, J. P. Messerly, Chem. Process (USA), 28 (8), 88 (1965).
293. H. Hellberg, Farmac. Rev., 49, 287 (1950).
294. H. A. Frediani, Analyt. Chem., 24, 1126 (1952).
295. K. M. Brobst, ibid., 20, 939 (1948).
296. A. M. Ille, Ind. aliment., 16, 303 (1965); Ref. Zhur. Khim., 7R483 (1966).
297. L. N. Petukhova and V. A. Fomenko, Azerbaidzhan. Khim. Zhur., 6, 121 (1961).
298. G. Wohlleben, Angew, Chem., 67, 741 (1955).
299. E. L. Bastin, S. Siegel, A. B. Bullock, Analyt. Chem., 31, 467 (1959).
300. R. Dalbert, J. Tranchant, Mem. artill. frans., 3, 611 (1953).
301. O. T. Aepli, W. S. McCarter, Ind. Eng. Chem., (Anal. Ed.), 17, 316 (1945).
302. G. Salvi, C. Siniramed, Riv. combust. 4, 94 (1950).
303. W. S. Hanna, A. B. Johnson, Analyt. Chem., 22, 555 (1950).
304. H. Grüss, W. Heineke, Erdöl und Kohle, 14, 714 (1961).
305. H. Kawinski, ibid., 14, 271 (1961).
306. J. Schobert, W. Strittmatter, Bull. Schweiz. electrotechn. Vereins, 55, 471 (1964).
307. R. A. Fulton, R. P. Gelardo, Soap and Sanit Chemicals, 29, 145, 147, 159, 161 (1953).
308. A. L. Linch, Analyt. Chem., 23, 293 (1951).
309. K. Muroi, K. Ogawa, Bull. Chem. Soc. Japan, 36, 965 (1963).
310. V. W. Reid, L. Turner, Analyst, 86, 36 (1961).
311. C. F. Roth, J. Jr. Mitchell, Analyt. Chem., 28, 1502 (1956).
312. G. B. Levy, I. Caldas, D. Fergus, ibid., 24, 1799 (1952).
313. K. Kumetat, G. Demmler, Milchwiss, 4, 111 (1949).
314. E. Eberius, W. Kempf, Stärke, 9, 77 (1957).
315. H. Scholz, Leder, 3, 218 (1952).
316. R. Allegrini, Cuoio-Pelli-Moter. cocianti, 28, 409 (1953).
317. I. A. Sagoschen, E. Mantzell, Leder, 3, 213 (1952).
318. K. Györbiró, Élelm. ipar., 8, 139 (1954).
319. J. R. Hart, M. H. Neustadt, Cereal Chem., 34, 26 (1957).
320. A. Aqster, M. Wandel, Melliand, Textilber., 38, 1411 (1957).
321. J. Haslam, M. Clasper, Analyst, 77, 413 (1952).
322. A. L. Draper, W. O. Milligan, Texas J. Sci., 2, 209 (1950).
323. A. Bryson, W. F. Pickering, J. Inst. Fuel, 26, 28 (1952).
324. K. Muroi, K. Ogawa, Bull. Chem. Soc. Japan, 36, 1278 (1963).
325. R. L. Halmes, J. C. Minor, R. S. McKinner, J. Amer. Oil Chem. Soc., 29, 425 (1952).
326. J. J. Ghyssen, H. P. Suykerbruyk, Chem. Weekbl., 46, 474 (1950).
327. J. J. Ghyssen, H. P. Suykerbruyk, Int. Sugar. J., 52, 390 (1950).
328. E. Abramson, Mitt. Geb. Lebensmittelunters. u. Hyg., 44, 468 (1953).
329. A. Kentel, A. Barreveld, Chem. Weekbl., 46, 833 (1950).
330. K. G. Gloman, E. Baker, M. D. Reisner, J. Agric. Food Chem., 2, 1239 (1954).
331. D. Sandell, J. Sci. Food Agric., 11, 671 (1960).
332. J. Hampl, V. Rašper, Sb. Vys. Sk. Chem.-Technol., Odd. Fak. Potrav. Technol., 4, part 2, 365 (1960).
333. L. Barnes, Jnr., M. S. Pawlak, Analyt. Chem., 31, 1875 (1959).
334. H. K. Mikhailyan, A. V. Sokolov and G. A. Sedova, Zavod. Lab., 29, 1058 (1963).
335. K. Muroi, K. Ogawa and Y. Ishii, Bunseki Kagaku, Japan Analyst, 12, 963 (1963); Ref. Zhur. Khim., 12G234 (1964).
336. F. Fischer, R. Schiene, Ztschr. Chem., 4, 69 (1964).
337. R. I. Alekseev and L. T. Pozdnyakova, Zavod. Lab., 30, 533 (1964).
338. F. X. Pollio, Analyt. Chem., 35, 2164 (1963).
339. J. Majewska, A. Ogorzalek, Chem. analit. (Polska), 10, 491 (1965).
340. J. J. Sciarra, Paint Varn. Prod., 54, (12), 51 (1964); 55, (1) 63 (1965); Anal. Abstr., 13, 3670 (1966).
341. J. Györe, G. Szilágyi, I. Simon, M. Barkics, Magyar. Kém. folyóirat., 72, 7 (1966); Ref. Zhur. Khim., 23 G238 (1966).
342. K. Muroi, K. Ogawa and Y. Ishii, Bunseki Kagaku, Japan Analyst, 14, 649 (1965); Ref. Zhur. Khim., 7R240 (1966).
343. Muroi Kaname, Ogawa Kunihiko, Ishii Yacko, Bull. Chem. Soc. Japan, 38, 1176 (1965); Ref. Zhur. Khim., 7G239 (1966).
344. H. Gilman, L. S. Miller, J. Am. Chem. Soc., 73, 2367 (1951).
345. W. T. Grubb, ibid., 76, 3408 (1954).
346. R. C. Smith, G. F. Kellum, Analyt. Chem., 38, 67 (1966).
347. Yu. S. Khodakov and A. M. L'vov, Zavod. Lab., 32, 678 (1966).
348. C. Capitani, E. Milani, Chim. e ind., 36, 177 (1954).
349. A. N. Korol', N. B. Znamenskaya and L. R. Losev, Zavod. Lab., 25, 1305 (1959).
350. K. Muroi, Bunseki Kagaku, Japan Analyst, 10, 847 (1961); Ref. Zhur. Khim., 14D137 (1962).
351. T. B. Beider, Zavod. Lab., 31, 1327 (1965).
352. F. G. Allenbaugh, Intern. Enamelist, 14 (3), 15 (1964).
353. F. M. Rapoport, Trudy Gos. Nauch.-Issled. i Proektn. Inst. Azotn. Prom., No. 3, 214 (1954).
354. D. M. Smith, W. M. Bryant, J. Am. Chem. Soc., 57, 841 (1935).
355. H. Levin, K. Uhrig, F. M. Roberts, Ind. Eng. Chem. (Anal. Ed.), 17, 212 (1945).
356. K. Jordan, W. R. Fischer, Ztscr. analyt. Chem., 168, 182 (1959).
357. B. Lóránt, Élelmiszervizsg. közl., 7, 194 (1961).
358. B. Lóránt, ibid., 7, 77 (1961).
359. B. Lóránt, G. Pollak, Brennstoff-Chemie, 46, 373 (1965).
360. L. M. Litvinenko, D. M. Aleksandrova, G. D. Titskii and E. G. Irotsenko, Zhur. Anal. Khim., 21, 200 (1966).
361. L. M. Litvinenko, E. S. Rudakov and A. I. Kirichenko, Kinetika i Kataliz, 3, 651 (1962).
362. R. Belcher, J. H. Thompson, T. S. West, Analyt. chim. acta, 19, 148 (1958).
363. R. Belcher, L. Ottendorfer, T. S. West, Talanta, 4, 166 (1960).
364. M. N. Das, J. Indian Chem. Soc., 34, 248 (1957).

365. J. A. Barltrop, K. J. Morgan, Analyt. chim. acta, **16**, 520 (1957).
366. V. S. Markevich, Zhur. Anal. Khim., **21**, 1143 (1966).
367. M. Pesez, Bull. Soc. chim. France, **15**, 1108 (1948).
368. J. H. Simons, E. M. Kipp, Ind. Engng. Chem. (Anal. Ed.), **13**, 328 (1941).
369. J. Griswold, M. E. Klecka, R. V. D. West, ibid., **18**, 696 (1946).
370. O. Harth, W. Kreienberg, D. Mertz, Klin. Wochenschr., **31**, 905 (1953).
371. S. I. Spiridonova, Izv. Vys. Ucheb. Zaved., Khim. i. Khim. Tekhnol., **4**, 186 (1961).
372. S. I. Spiridonov, Doctoral Thesis, Saratov State University, 1948.
373. K. F. Jahr, J. Fuchs, Naturforsch., **145**, 471 (1959).
374. K. F. Jahr, J. Fuchs, Ztschr. analyt. Chem., **176**, 269 (1960).
375. J. Koskikallio, Suomen kem., 30, B108 (1957).
376. M. Usanovich, Acta Ph., **7**, 467 (1937).
377. M. Usanovich and P. Merenkov, Vestnik Uzbek. Filiala Akad. Nauk SSSR, **4**, 30 (1941).
378. L. Nebbia, B. Pagani, Chim. e ind., **39**, 5 (1957)
379. G. Monnier, Ann. Chem., **2**, 14 (1957).
380. Chem. Process (Engl.), **9**, (11), 36 (1963).
381. D. N. Tarasenko and E. N. Polozhintseva, Zhur. Obshch. Khim., **2**, 84 (1932).
382. C. Sălceanu, C.r., **261**, 4403 (1965); Ref. Zhur. Khim., 15G225 (1966).
383. K. Haedicke, Wiss. Z. Hochschule Bauwesen Leipzig, 1960, No. 6, 15.
384. V. M. Kats, Sakharn. Prom., No. 6, 17 (1953).
385. A. Ya. Petrovskaya and Yu. V. Mikhailovskii, Inzh.-Fiz. Zhur., No. 6, 99 (1960).
386. M. Buriánkova, A. Maly, V. Rašper, Listy Curkovarnické, **77**, 90 (1961).
387. A. Brehm, Ztschr. analyt. Chem., **187**, 274 (1962).
388. L. G. Afanas'eva, Trudy po Khim. i Khim. Tekhnol. (Gor'kii), No. 3, 615 (1959).
389. F. Langen, Zucker, **6**, 99 (1953).
390. B. B. Ershov, V. P. Ryabov and L. E. Kocherov, Zavod. Lab., **31**, 887 (1965).
391. W. Seaman, A. R. Norton, J. Jr. Hugonet, Ind. Eng. Chem. (Anal. Ed.), **15**, 322 (1943).
392. J. H. Higgins, J. Scient. Instrum., **36**, 300 (1959).
393. M. Lorant, Chem. Rundschau, **17**, 519 (1964).
394. M. V. Venediktov and N. M. Rudnyi, in collected papers "Teplo- Massobmen v Dispersnykh Sistemakh" (Collected Papers on Heat and Mass Exchange in Disperse Systems), Izd. "Nauka i Tekhnika", Minsk, 1965, p. 142.
395. I. K. Petrov and L. E. Shavgulidze, USSR Author's Certificate 126658 (1st March 1960).
396. Ch'ien Heng-shu, Chienchu, Jianzhu, **1964**, No. 23, 20; Ref. Zhur. Khim., 22G89 (1965).
397. W. Dippel, Arch. techn. Messen, **1965**, 265.
398. R. A. Collacott, Osterr. Chem.-Ztg., **64**, 267 (1963).
399. O. G. Griffin, C. M. Stringfield, J. Scient. Instrum., **41**, 241 (1964).
400. E. A. Kolenko, Zavod. Lab., **31**, 1146 (1965).
401. E. Rey, Chem. Rundschau, **12**, 480 (1959).
402. W. Pappas, Analyt. Chem., **36**, 1885 (1964).
403. V. P. Savinov, Nauchn. Trudy Leningrad. Inst. Tochnoi Mekhaniki i Optiki, No. 37, 108 (1959).
404. K. Guthmann, Elektrotechn. Ztschr. (ETZ), **A-75**, No. 9, 316 (1954).
405. R. Hess, West German P. Class 42 1.9/50 (G. O., In), No. 1085354 (claimed 10th April 1958, published 18th October 1962); Ref. Zhur. Khim., 9D81P (1964).
406. R. Hess, West German P. No. 1082067 (14th June 1962); Ref. Zhur. Khim., 2D62P (1964).
407. P. T. John, Indian J. Pure Appl. Phys., **1**, 392 (1963).
408. P. Weuthen, Glas- Instrum.-Techn., **8**, 767 (1964).
409. I. V. Kryuchkov, Inzh.-Fiz., **1**, 16 (1958).
410. Instruments and Control Systems, vol. 37, No. 10, r. 1, 1964, p. 121.
411. R. R. Freidel', in collected papers "Teploenergeticheskie i Khimiko-tekhnologicheskie Pribory i Regulyatory" (Collected Papers on Thermal-power Engineering and Chemical-Technological Instruments and Regulators), Mashgiz, Moscow–Leningrad, 1959, p. 125.
412. G. I. El'tsov, Izv. Vys. Ucheb. Zaved., Pishchev. Tekhn., No. 4, 144 (1965),
413. F. Oheme, Chem. Rundschau, **13**, 309 (1960).
414. F. Oheme, Dielektrische Messmethoden zur quantitativen Analyse und für chemische Strukturbestimmungen, Verlag Chemie, Weinheim, 1958.
415. F. Oheme, Erdöl und Kohle, **12**, 623 (1959).
416. Yu. F. Deinega, A. V. Dumanskii and O. D. Kurilenko, Kolloid. Zhur., **15**, 361 (1953).
417. F. Oheme, Chem. Technik, **7**, 704 (1955).
418. R. Honorat, Ind. Pétrol, **30**, 30 (1962).
419. C. Guyot, Onde électr., **33**, 421 (1953).
420. B. P. Voinov, "Trudy VNIITB" (Proceedings of the All Union Scientific Research Institute on Safety Techniques in the Petroleum Industry), Nefteizdat, Baku, 1953, No. 6, p. 52.
421. G. Guyot, "IV Mezhdunarodnyi Neftyanoi Kongress" (The 4th International Petroleum Congress), Vol. 6, Moscow, 1956, p. 376.
422. C. Guyot, Fourth World Petrol. Congress. Rome, 1955. Proceedings. Sect. V/E; p. 391.
423. R. Magaril, "Za Tekhnicheskii Progress" (Technical Progress), (Byull. Tekhn. Informatsii Tekhsoveta i NTO, Saratov, NPZ) (Technical Information Bulletin of the Technical Soviet and Scientific and Technical Society, Saratov, Petroleum Refinery), 1958, p. 9.
424. Yu. Yu. Samitov and T. V. Goreshina, Uch. Zap. Kazan. Univ., **116**, Book 1, p. 127 (1956).
425. I. Yu. Klugman, Zavod. Lab., **31**, 899 (1965).
426. L. G. Ovchinnikov, A. F. Potseluev and Yu. V. Burdenko, USSR Author's Certificate, Class 42 1.9/51; (G 01p) No. 178569 (claimed 23rd January 1964, published 4th March 1966).
427. R. S. Wood, Oil and Gas. J., **56** (49), 102 (1958).
428. H. B. Weisbecker, ibid., **53** (24), 118 (1954).
429. A. J. Hond, Contr. Engng., **9**, 139 (1962).
430. A. A. Abdulaev, V. G. Avanesyan, A. I. Vladimirskii and B. E. Kuliev, Azerbaidzhan. Neft. Khoz., 16, 38 (1963).
431. R. D. Weaver, G. C. Whitnack, E. St. C. Gantz, Analyt. Chem., 28, 329 (1956).
432. P. W. West, P. Senise, T. S. Burkhalter, ibid., **28**, 1250 (1952).
433. F. Oheme, Angew. Chem., **71**, 572 (1959).
434. A. P. Altschuller, J. Chem. Phys., **21**, 562 (1953).
435. P. H. Byrne, C. P. Brockett, Analyt. Chem., **28**, 1207 (1956).
436. C. W. Wolfe, ibid., **35**, 1884 (1963).
437. F. Oheme, Chem.-Ing.-Technik, **30**, 521 (1958).
438. T. Szalay, L. Várallyae, E. Porzsolt, Magyar. Kem. folyóirat., **71**, 502 (1965).
439. H. W. van der Merel, Soil Science, **87**, 105 (1959).
440. M. Apperloo, Elektronica, **9** (201), 81 (1956).
441. R. I. Venediktova and I. V. Vlasenko, Zavod. Lab., **30**, 1332 (1964).

442. Tomokazu Arai and Bundziro Itidze, Keisoku Toseige, J. Soc. Instrum. and Control. Engrs. 3, 195 (1964); Ref. Zhur. Khim., 3G105 (1965).
443. F. Oheme, Ztschr. analyt. Chem., **167**, 271 (1959).
444. J. Sverak, ibid., **184**, 349 (1961).
445. F. Oheme, Naturforsch., **14b**, 779 (1959).
446. E. Divernoy, Brouwelt, **B96**, 1173 (1956).
447. A. Fritz, E. Ulonska, W. Lenz. Brauwissensch., **18**, 7 (1965).
448. J. Bourciez, Electronique industrielle, **1959**, No. 24, 15.
449. N. V. Mikulin, Izv. VTI, No. 4, 11 (1949).
450. H. Jäger, Landtechn. Forsch., **7**, 173 (1957).
451. J. L. Shaw, B. P. 709177 (4th November 1952).
452. V. Dukat, Průmysl Potravin, **10**, 290 (1959).
453. A. I. Shchukin and A. E. Bandzemadze, Tabak, No. 3, 50 (1961).
454. P. Poshchov and N. Ivenov, B'lg. Tyutyun, No. 1, 19 (1962).
455. A. Z. Kulishenko, A. S. Kharitonov and I. A. Gridin, Koks i Khim., No. 9, 16 (1962).
456. W. Krolopp, A. Grott, Przegl. papiern., **18**, 222 (1962).
457. V. G. Evdokimov and V. I. Petygin, Priborostroenie, No. 1, 19 (1963).
458. V. I. Ermakov, E. V. Latyshev and F. I. Antroptsev, Zavod. Lab., **31**, 889 (1965).
459. J. Stoicovici, Automat. si electron., **8**, 280 (1964).
460. J. Majewski, Pomiary, automat., kontrola, **6**, 20 (1960).
461. A. P. Grishchenko and N. M. Bratasyuk, Izmerit. Tekhnika, No. 2, 30 (1964).
462. A. I. Ioffe, A. A. Uverskii and V. V. Gavelya, Zavod. Lab., **31**, 1212 (1965).
463. J. Stefania, J. Kleps, St. Wosiek, Chem. analit. (Polska), **10**, 1369 (1965).
464. F. Oheme, Farbe und Lack, **66**, 142 (1960).
465. Inds aliment, **76**, 627 (1959).
466. J. Sargent, Rev. Scient. Instrum., **30**, 348 (1958).
467. W. S. Pappas, Analyt. Chem., **38**, 615 (1966).
468. V. S. Nelyudov, Khim. i Tekhnol. Topliv i Masel, No. 1, 67 (1961).
469. A. F. Gusakova, Vestnik Tekhn. i Ekonom. Inform. NIITEKhIM, No. 1, 25 (1963).
470. M. A. Berliner, "Elektricheskie Metody i Pribory dlya Izmereniya i Regulirovaniya Vlazhnosti" (Electrical Methods and Instruments for the Meament and Control of Moisture Content), Gosenergoizdat, Moscow–Leningrad, 1960, p. 310.
471. D. J. Fraade, Mesures et contrôle industr., **27**, 473 (1962).
472. R. F. Wall, Ind. Eng. Chem., **50** (6), 69A (1958).
473. D. J. Fraade, Process Controll and Automat., **8**, 332 (1961).
474. V. I. Korchagin, S. A. Ginzburg, A. A. Fin'ko, I. V. Davydov and D. A. Lavrinovich, Nov. Neft. i Gazov. Tekhn. GOSINTI, Ser. Neftepererabotka i Neftekhimiya, No. 6, 39 (1962).
475. G. I. Leskov and E. E. Flomina, Zavod. Lab., **24**, 1155 (1958).
476. V. A. Komarov, USSR Author's Certificate 51904 (1937).
477. L. Speel, Erdöl Ztschr. Bohr- und Fordertechnik, **74**, 366 (1958).
478. V. I. Istomin, Neftyan. i Gazovaya Prom., No. 1, 49 (1962).
479. C. K. Hancock, B. L. Burdick, Soil Sci., **83** (3), 137 (1957).
480. M. F. Bervers, S. J. Shimanski, E. F. Timpane, Electr. Eng., **74**, 416 (1955).
481. C. W. Holt, R. F. Turley, Corrosion, **17**, 26 (1961).
482. U. Rokuro, K. Ikuso, Japan Analyst, **9**, 604 (1960).
483. S. V. Usikov and L. K. Vasil'ev, Zhur. Fiz. Khim., **39**, 2394 (1965).
484. J. A. Wickett, Jr., J. Lerner, H. L. Bachofer, Chem. Process (USA), **26**, 30 (1963).
485. E. Zymry, Installat-Klempn.-Zentralheizungbauer, **20**, 2037 (1965).
486. S. V. Trachuk, Yu. A. Saulov and E. I. Matsulevich, in collected papers "Avtomatizatsiya Khimicheskikh Proizvodstv" (Collected Papers on the Automation of Chemical Production), Gostekhizdat Ukrain. SSR, Kiev, 1964, p. 138.
487. H. Borman, Pomiary, automat., kontrola, **1**, 170 (1955).
488. V. G. Konyukhov, Derevoobrab. Prom., No. 10, 24 (1960).
489. A. Radev, Stroitel'stova, **9**, 19 (1962) (Bulgarian).
490. A. I. Zinov'ev, Trudy Vses. Inst. Solyanoi Prom., No. 1, 53 (1954).
491. A. I. Shchukin and A. Z. Yakobishvili, Kozhevenno-obuvn. Prom., No. 6, 33 (1960).
492. A. M. Oleinik, Zavod. Lab., **29**, 1058 (1963).
493. Industr. tekn., **93**, 423 (1965); Ref. Zhur. Khim., 18D71 (1966).
494. S. A. Mishin and A. I. Shchukin, Torf. Prom., No. 6, 35 (1964).
495. Vigyan pragati, **10**, 71 (1961).
496. G. G. Blake, Analyt. Chem., **23**, 10 (1960).
497. C. M. Stover, Rev. Scient. Instrum., **34**, 632 (1963).
498. M. M. Tendler, Derevoobrab. Prom., No. 8, 15 (1959).
499. G. Behmann, Parfüm. und Kosmetik, **40**, 286 (1959).
500. L. Liebetrau, M. Mohuke, East German Patent, Class 421, 9/50 (G 01p), No. 41885, claimed 26th May 1964 (15th October 1965); Ref. Zhur. Khim., 24G72P (1966).
501. Tanaka Igasima, Kagaku to Kogyo, **11**, 1164 (1960); Ref. Zhur. Khim., 16I139 (1962).
502. K. Hamerak, VDI-Nachr., **15**, 10 (1961); Ref. Zhur. Khim., 2I1129 (1962).
503. F. A. Keidel, Analyt. Chem., **31**, 2143 (1959).
504. A. K. Karpov, P. A. Frolovskii, N. R. Shorokhov and Z. S. Filatova, Gazovaya Prom., No. 4, 37 (1962).
505. E. L. Upp, W. F. Barken, Gas Age, **125**, 25 (1960).
506. J. Horski, Chemik, **13**, 427 (1960); Ref. Zhur. Khim., 12E62 (1961).
507. G. E. Vishnevskii and I. E. Vishnevskii, Vodosnabzh. i San. Tekhn., No. 7, 16 (1960).
508. L. Szalai, Közp. élelmiszeripari kutatóint. közl., 1962, No. 2, 10; Ref. Zhur. Khim., 4D65 (1965).
509. J. A. Walker, P. Campion, Analyst, 90, 199 (1965).
510. P. E. Toren, Analyt. Chem., **37**, 922 (1965).
511. E. A. Kochetkov, Zavod. Lab., **31**, 890 (1965).
512. L. G. Cole, M. Czuha, R. W. Mosley, T. D. Sawyer, Analyt. Chem., **31**, 2048 (1959).
513. D. D. Friel, Ind. Eng. Chem., **52**, 494 (1960).
514. J. Souček, M. Přibyl, K. Novák, Collekt. Czechosl. Comm., **27**, 400 (1962).
515. S. G. Polyak, A. V. Nepryakhina, L. N. Tatarinova, and G. V. Vinogradov, Zavod. Lab., **32**, 572 (1966).
516. Labor. Practice, 4 (2), 75 (1955).
517. E. R. Weaver, E. E. Hughes, A. W. Diniak, J. Res. Nat. Bur. Stand., 60, 489 (1958).
518. Chem. Engng., **68** (13), 79 (1961).
519. Collection of translations "Kontrol'no-izmeritel'nye Pribory i Sredstva Avtomatizatsii za Rubezhom" (Control and Measuring Instruments and Devices for

Automation, from Other Countries), TsBTI, Moscow, 1961, p. 27.
520. A. Berton, Bull. soc. chim. France, 1959, 1453.
521. F. Onuška, Chem. zvesti, 17, 359 (1963).
522. R. C. Halter, L. M. Johnson, Oil and Gas., 59 (20), 127 (1961).
523. H. Geagauf, Schweizar Archiv für angew. Wissensch. und Technik, 4, No. 22, 129 (1956).
524. Phillips Serv. Sci. and Ind., 12, No. 2, 14 (1965).
525. Z. Vecera, Chem. Technik, 5, 283 (1953).
526. Z. Vecera, V. Zeman, Chem. průmysl., 4, 60 (1954).
527. H. Dehn, V. Gutmann, G. Schöber, Monatsch. Chem., 93, 1357 (1963).
528. V. Gutmann, J. Scherzer, G. Schöber, ibid., 95, 390 (1964).
529. A. G. Kniga and N. N. Kryachkov, Trudy Leningrad. Inst. Pishchev. Prom., 13, 156 (1956).
530. M. M. Nijland, Mikrochim. acta, 1963, 947.
531. A. J. Cameron, Chem. a. Ind., 1965, 461.
532. W. S. Pappas, Ch. W. Weber, U. S. P. Class 252–408, No. 317880 (claimed 13th July 1961, published 16th March 1965); Ref. Zhur. Khim., 12G272P (1966).
533. West German P., Class 421, 3/01, (G01p), No. 43260 (claimed 3rd August 1964, published 15th November 1965); Ref. Zhur. Khim., 24G22P (1966).
534. Z. Lada, Acta chim. Acad. scient. hung., 28, 217 (1961).
535. A. E. Bender, M. Burnhan, D. S. Miller, Chem. a. Ind., 1953, 293.
536. J. Gažo, J. Truchlý, Chem. zvesti, 18, 655 (1964).
537. R. A. Line, H. Hoftiezer, B. P. 805012 (20th March 1956); C. A., 50, 15351c (1956).
538. S. D. Gardiner, H. J. Keyte, Analyst, 83, 150 (1958).
539. A. K. Babko and L. L. Shevchenko, Dopovidii Akad. Nauk Ukrain. SSSR, 1212 (1958).
540. C. B. Ward (jun), R. G. Tischer, Cereal Chem., 30, 420 (1953).
541. J. de Oliveira-Meditsch, Chemist-Analyst., 45 (2), 49 (1958).
542. F. Nesh, Analyt. Chem., 27, 1842 (1955).
543. F. Nesh, U. S. P. 2950958 (30th August 1960); Ref. Zhur. Khim., 21M183 (1961).
544. R. I. Alekseev and E. A. Tokarskaya, Zhur. Anal. Khim., 20, 983 (1965).
545. G. S. Siddappa, D. P. Das, Curr. Sci., 23, 157 (1954).
546. E. A. Khoroshaya, A. A. Avilov, G. I. Kovrigina and Z. A. Koroleva, Zavod. Lab., 21, 542 (1955).
547. M. G. Morekhin, S. I. Agreev, O. E. Matyash and T. G. Chechina, ibid., 28, 670 (1962).
548. E. Jackwerth, H. Specker, Ztschr. analyt. Chem., 171, 270 (1959).
549. R. C. R. Barreto, H. S. Barreto, Analyt. Chem., 26, 494 (1962).
550. A. I. Cherkesov and L. V. Cherkesova, collected papers "Materialy 22 Nauchnoi Konferentsii Saratovskogo Gosudarstvennogo Pedagogicheskogo Instituta, Fakul'tet Estestvoznaniya, Fiziki, Matematiki" (Proceedings of the 22nd Scientific Conference of Saratov State Pedagogic Institute, Natural Science, Physics, and Mathematics Section), Saratov, 1961, p. 100.
551. T. G. Mangall, J. H. Mitchen, Analyt. Chem., 33, 1330 (1961).
552. W. R. S. Garton, M. S. W. Webb, P. C. Wildy, J. Scient. Instrum., 34, 496 (1957).
553. E. Kwiatkowski, J. Szychliński, Chem. analit. (Polska), 6, 541 (1961).
554. M. Kubinowa, O. Wilimo, V. Svoboda, Collect. Czechosl. Comm., 26, 1320 (1961).
555. V. S. Fikhtengol'ts and R. V. Zolotareva, Vestnik Tekhn. i Ekon. Inform. Nauch.-Issled. Inst. Tekhn.-Ekon. Issled. Gos. Kom. SM SSSR, No. 3, 15 (1961).
556. L. Vaicum, An. Univ. «C. J. Parhon», Ser. s. tun, t. natur, 1956, No. 10, 133.
557. G. Matsuyama, Analyt. Chem., 29, 196 (1957).
558. Engineer, 211, 950 (1961).
559. C. Cherrier, L. Verot, R. Wagner, Spectrochim. acta, 6, 67 (1953).
560. M. M. Kusakov and A. Yu. Koshevnik, Inzhenerno-Fiz. Zhur., 3, (11) 11 (1960).
561. D. A. Keyworth, Talanta, 8, 461 (1961).
562. H. G. Streim, F. A. Boyce, J. R. Smith, Analyt. Chem., 33, 85 (1961).
563. H. F. Cordes, C. W. Tait, ibid., 29, 485 (1957).
564. M. Mamiya and S. Oka, Tokyo Kogyo Shikensho Hokoku, Repts. govt. Chem. Industr. Res. Int., Tokyo, 60, 92 (1965); Ref. Zhur. Khim., 4G146 (1966).
565. D. Chapman, J. F. Nacey, Analyst, 83, 377 (19580.
566. D. S. Gorbenko-Germanov, R. A. Zenkova and T. A. Bolotina, Zhur. Anal. Khim., 13, 590 (1958).
567. H. Scholze, Forschr. Mineral., 38, 122 (1960).
568. S. Oka and M. Mamiya, Bunseki Kagaku, Japan Analyst, 10, 1092 (1961).
569. G. Langbein, W. Seufert, Kolloid-Ztschr. und Ztschr. Polymere, 193, 37 (1963).
570. Bunseki Kagaku, Japan Analyst, 13, 792 (1964); Ref. Zhur. Khim., 6G107 (1965).
571. A. V. Karyakin and A. V. Petrov, Zhur. Anal. Khim., 19, 1486 (1964).
572. A. V. Karyakin and A. V. Petrov, ibid., 18, 1317 (1963).
573. L. Jr. White, W. J. Barrett, Analyt. Chem., 28, 1538 (1956).
574. W. Gunter, Naturwiss., 51, 211 (1964).
575. E. Wiegel, H. H. Kirchner, Ztschr. analyt. Chem., 178, 241 (1961).
576. T. Hata and T. Asano, Tohoku Daigaku Hisui Eeki Kagaku Kenkuse Hokoku, Bull. Chem. Res. Inst. Nonaqueous Solid., Tohoku Univ., 9, 79 (1960); Ref. Zhur. Khim., 8D142 (1961).
577. M. Desnoyer, Bull. Soc. chim. France, 1960, 1754.
578. U. K. A. E. A. Repotr PG 467 (W), 1963, 4.
579. L. Kékedy, Cs. Muzsnay, Ztschr. analyt. Chem., 199, 340 (1964).
580. A. N. Aleksandrov, N. K. Mikhailyan and G. A. Sedova, Khim. Prom., 570 (1962).
581. S. Ya. Karaseva, A. M. Rozhnov and D. N. Andreevskii, Neftekhimiya, 5, 621 (1965).
582. E. Wiegel, H. H. Kirchner, Ztschr. analyt. Chem., 195, 97 (1963).
583. A. N. Aleksandrov and N. K. Mikhailyan, Khim. Prom., 313 (1962).
584. N. N. Roginskii and A. I. Finkel'shtein, Zhur. Anal. Khim., 360 (1959).
585. Pi. P. Ferrer, L. Condal-Bosh, Afinidad, 17, 280 (1960).
586. M. Desnoyer, Rapp. CEA, 1959, No. 1254, 58.
587. Morikawa Takesi, Bunseki Kagaku, Japan Analyst, 13, 255 (1964); Ref. Zhur. Khim., 2G239 (1965).
588. R. L. Jackson, Appl. Spectrosc., 15, 85 (1961).
589. L. R. Kiley, R. T. Scheddel, Analyt. Chem., 30, 1162 (1958).
590. S. Hirano, S. Tanaka and M. Tsuge, Sogo Shikenshe Nempo, Annul Rept. Engng. Res. Inst. Fac. Engng., Univ. Tokyo, 20, 166 (1961); Ref. Zhur. Khim., 9M148 (1961).

591. E. Greinacher, F. Oswald, Angew. Chem., **65**, 291 (1953).
592. F. A. Coulson, J. Z. Hales, J. Chem. Soc., **1951**, 2125.
593. A. V. Karyakin and A. V. Petrov, Zhur. Anal. Khim., **19**, 1234 (1964).
594. W. J. Diamond, Appl. Spectrophotometry, **12**, 10 (1958).
595. F. E. Crichfield, E. T. Bishop, Analyt. Chem., **33**, 1034 (1961).
596. K. Hoffmann, L. Fischer, Chem. Eng. Technik, **27**, 604 (1955).
597. J. Neuvirt, Z. Ksandr, Collect. Czechosl. Chem. Comm., **29**, 1068 (1964).
598. R. C. R. Barreto, H. S. R. Barreto, Analyt. chim. acta, **26**, 494.
599. A. V. Karyakin, A. V. Petrov and E. E. Sukhanovskaya, Zhur. Anal. Khim., **21**, 840 (1966).
600. B. D. Pearson, Analyst, **91**, 247 (1966).
601. A. V. Petrov, Candidate's Thesis, Vernadskii Institute of Geochemistry and Analytical Chemistry, Academy of Sciences of the USSR, Moscow, 1965.
602. R. B. Duvall, L. R. Kiley, Analyt. Chem., **30**, 549 (1958).
603. A. Ya. Groskaufmanis, A. I. Shakaline and L. K. Lepin', Izv. Akad. Nauk Latv. SSR, Ser. Khim., No. 4, 449 (1965).
604. B. Casu, G. Gaglioppa, M. Reggiani, Stärke, **17** (12), 386 (1965).
605. P. G. Kliman, M. J. Pallansch, J. Dairy Sci., **48**, 859 (1965).
606. J. R. Hart, K. H. Norris, C. Golumbic, Cereal Chem., **39**, 94 (1962).
607. C. Duval, Chim. anal., **44**, 102 (1962).
608. E. R. S. Johnes, J. Scient. Instrum., **30**, 132 (1953).
609. S. T. Abrams, V. N. Smith, Analyt. Chem., **34**, 1129 (1962).
610. H. H. Stein, J. M. Amboso, ibid., **35**, 555 (1963).
611. J. W. Forbes, ibid., **34**, 1125 (1962).
612. Pribory i Tekh. Eksper., 227 (1963).
613. Ya. I. Kalinichenko, M. S. Kiseleva and B. S. Neporent, Zavod. Lab., **30**, 758 (1964).
614. J. G. Koren, A. J. Andreatch, Analyt. Chem., **37**, 256 (1965).
615. N. M. Pmerantsev, Zavod. Lab., **26**, 950 (1960).
616. B. V. Vasil'eva and V. Ya. Onuchin, Trudy Ural'sk. Politekhn. Inst., Vol. 3, 123 (1961).
617. T. M. Shaw, R. H. Elsken, J. Chem. Phys., **18**, 1113 (1950).
618. T. M. Shaw, R. H. Elsken, C. H. Kunsman, J. Assoc. Offic. Agr. Chem., **36**, 1070 (1953).
619. T. M. Shaw, R. H. Elsken, J. Appl. Phys., **26**, 313 (1955).
620. L. Rollwitz, Proc. Natl. Electronics conf., **12**, 113 (1956).
621. W. Priestley, B. F. Dudenbostel, Ind. Eng. Chem., **48** (5), 81A (1956).
622. A. R. Aikman, R. K. Codrigton, F. F. Kirchner, Control. Eng., June, 1957.
623. R. F. Wall, Ind. Eng. Chem., 50 (12) 69A (1958).
624. H. Rubin, J. S. A. Journal, **5**, 64 (1958).
625. J. van Harlem, Melliand Textilber., **34**, 350 (1953).
626. R. Collison, M. P. McDonald, Nature, 186, 548 (1960).
627. R. H. Elsken, C. H. Kunsman, J. Assoc. Offic. Agr. Chem., **39**, 434 (1956).
628. J. C. Powles, J. A. Kail, Trans. Faraday Soc., **55**, 1996 (1959).
629. M. P. Volarovich and A. I. Shchukin, Kolloid. Zhur., **27**, 474 (1965).
630. T. F. Conway, R. J. Smith, Electronics, **31**, 51 (1958).
631. W. R. Ladner, A. F. Stacey, Brit. J. Appl. Phys., **13**, 136 (1962).
632. E. Golling, Ztschr. angew. Physik, **1962**, No. 12, 717.
633. P. Olavi, I. Virtanen, J. Paasivierta, Acta chem. fenn., B, 38, (4) 87 (1965).
634. Canad. Chem. Proc., **46**, No. 3, 72 (1962).
635. G. Mavel, J. Phys. et radium, **20**, 834 (1959).
636. B. B. Murray, R. C. Axtemann, Analyt. Chem., **31**, 450 (1959).
637. H. W. Schnauz, Maschinenmarkt, **67**, No. 57, 15 (1961).
638. A. A. Carlstrom, C. F. Spencer, J. F. Johnson, Analyt. Chem., **32**, 1056 (1960).
639. R. Aubeak, L. Champeix, J. Reiss, J. Chromatogr., **16**, 7 (1964).
640. G. Guiochon, C. Landault, Publ. Groupem. avancem méthodes spectrogr., 1962, july–sept., 195.
641. O. F. Bennett, Analyt. Chem., **36**, 684 (1964).
642. I. Lindgren, Acta chem. scand., **19**, 247 (1965).
643. R. I. Sidorov and A. A. Khvostikov, Zhur. Prikl. Khim., **39**, 942 (1966).
644. L. Ya. Gavrilin and N. N. Natal'ina, Izv. Sibir. Otd., Akad. Nauk SSSR, No. 11 (1964), Ser. Khim. Nauk, No. 3, 143.
645. A. Prevot, F. Cabeza, Mlle, Rev. franc. corps gras, **8**, 632 (1961).
646. J. Lukacs, D. B. Robinson, Soc. Petrol. Engrs. J., **3**, 293 (1963).
647. J. A. Favre, D. E. Smith, U. S. P., Class 23-230, No. 3118735 (claimed 8th June 1959; published 21st January 1964); Ref. Zhur. Khim., 22G154P (1965).
648. O. E. Sundberg, C. Maresh, Analyt. Chem., **32**, 274 (1960).
649. A. A. Duswalt, W. W. Brandt, ibid., **32**, 272 (1960).
650. R. K. Sharma, D. R. McLean, J. Bardwell, Indian J. Chem., **3**, 282 (1965).
651. G. O. Guerrant, Analyt. Chem., **39**, 143 (1967).
652. Jajima Seishi, Shiba Koreyuki, Handa Muneo, Bull. chem. soc. Japan., **37**, 800 (1964), Ref. Zhur. Khim., 3G104 (1965).
653. V. G. Berezkin, A. E. Mysak and L. S. Polak, Neftekhimiya, **4**, 156 (1964).
654. V. G. Berezkin, A. E. Mysak and L. S. Polak, Khim. i Tekhnol. Topliv i Masel, No. 2, 67 (1964).
655. I. M. Starshov, Yu. P. Voevodskii and A. A. Khalimov, "Gazovaya Khromatografiya" (Gas Chromatography), Moscow, 1965. No. 3, p. 103.
656. A. Badinand, C. Amincy, R. Guilluy, Trav. Soc. pharmac. Montpellier, 1963, **23**, 207 (1964) Discuss, 213.
657. M. Hager, G. Baker, Proc. Montana Acad. Sci., **22**, 3 (1963) 1962.
658. A. Badinand, C. Quincy, R. Guilluy, J. pharmac. Belg., **20**, 397 (1965).
659. J. H. Bartin, A. M. Knevel, J. Pharmac. Sci., **54**, 1464 (1965).
660. S. Musya and S. Ikeda, Bunseki Kagaku, Japan Analyst, **14**, 803 (1965); Ref. Zhur. Khim., 10G115 (1966).
661. P. Urone, R. L. Pecsok, Analyt. Chem., **35**, 837 (1963).
622. T. Kameo, T. Hirasima, O. Manabe, H. Hiyama, Kgaku To Kagyo, Sci. and Ind., **39**, 22 (1965); Ref. Zhur. Khim., 1G244 (1966).
663. I. M. Starshov and Yu. P. Voevodskii, Neftepererabotka i Neftekhimiya, No. 7, 48 (1965).

664. R. M. Jones, Anal. Chem., **38**, 338 (1966).
665. D. A. Elividge, K. A. Proctor, Analyst, **84**, 461 (1959).
666. A. V. Sagalovich and V. I. Yakerson, Izv. Akad. Nauk SSR, Ser. Khim., 882 (1965).
667. A. N. Korol', Zavod. Lab., **27**, 396 (1961).
668. J. Brekke, R. Conrad, J. Agric. and Food Chem., **13**, 591 (1965).
669. V. I. Oyama, S. P. Vango, E. M. Wilson, ARS Journal, **32**, 354 (1962).
670. S. Ahuja, G. D. Chase, J. G. Nikelly, Analyt. Chem., **37**, 840 (1965).
671. H. Germak, Isotopentechnik, **1**, 140 (1961).
672. P. Obloja, Ind. lemn., 7, 57 (1958).
673. B. Faragó, Megyar textiltechn., **15**, 545 (1963).
674. M.M.Melikadze, Za Tekhn. Progress (Baku), No. 4, 42 (1963).
675. Water Power, **13**, 245 (1961).
676. D. Chleck, R. Maehl, O. Cucchiara, Chemist-Analyst, **54**, 84 (1965).
677. N. A. Milyutina, R. I. Isakova and S. I. Tarabaev, Vestnik Akad. Nauk Kazakh. SSR, No. 3, 89 (1958).
678. P. Krumbiegel, H. Hübner, W. Rolle, Isotopenpraxis, **2**, 220 (1966).
679. T. Takahashi, Shionigi Kenkyusho Nempo, Annual Rept. Shionigi Res. Lab., 1965, No. 15, 152; Ref. Zhur. Khim., 21N470 (1966).
680. K. Kitahara and Y. Tanaka, Yakugaku Zasshi, J. Pharmac. Soc. Japan, **83**, 559 (1963); Ref. Zhur. Khim., 18N256 (1964).
681. L. T. Zhuravleva, A. V. Kiselev, V. P. Naidina and A. L. Polyakov, Zhur. Fiz. Khim., **37**, 2054 (1963).
682. V. Netz, Chem. Techn., **17**, 95 (1965).
683. J. Pawlin, J. W. Spinks, Canad. J. Technol., **34**, 503 (1957).
684. K. Preiss, P. J. Grant, J. Scient. Instrum., **41**, 548 (1964).
685. W. Kühn, Atompraxis, **5**, 133 (1959).
686. R. Berthold, West German P., Class 42, 1, 9/51 (G 01p), No. 114833 (claimed 27th December 1958; published 17th October 1963); Ref. Zhur. Khim., 24D3 (1964).
687. H. Dresia, P. Fischötter, Brennst.-Chem., **46**, 13 (1965).
688. W. Kühn, Atompraxis, **5**, 335 (1959).
689. V. Schuricht, Kernenergie, 7, 44, 45 (1964).
690. V. Schuricht, D. Hiemann, Isotopenpraxis, 1, 82 (1965).
691. E. V. Khamskii, V. F. Levchenko, V. G. Prokhorov and N. I. Smagin, Zavod. Lab., **28**, 312 (1962).
692. M. J. Sivadjian, Bull Soc. franc. photogr. et cinématogr., **3**, 81 (1953).
693. M. J. Sivadjian, Analyt. chim. acta, **9**, 70 (1953); **22**, 284 (1960.
694. M. J. Sivadjian, F. Corral, ibid., **26**, 185 (1962).
695. M. J. Sivadjian, Soil Sci., **90**, 369 (1960).
696. M. J. Sivadjian, F. Corral, J. Appl. Polymer Sci., **6**, 561 (1962).
697. M. J. Sivadjian, Arch. Intern. pharmacodyn., **143**, 377 (1963).
698. L. Gardner, G. Topel, Materials Research and Standards, **1**, 112 (1961).
699. O. A. Tarasov, Avtomobil'n. Transport, No. 9, 15 (1963).
700. O. A. Tarasov, Zavod. Lab., **29**, 733 (1963).
701. DIN 51793, Erdöl und Kohle, **10**, 616 (1957).
702. G. Giebler, T. Kempf, Ztschr. analyt. Chem., **199**, 23 (1964).
703. J. Merritt, Analyt. Chem., **34**, 293 (1962).
704. M. Mauvieux, Teanicien laut, **16**, 32 (1964); Ref. Zhur. Khim., 22R120 (1966).
705. Instrument. Rev., **10**, 137 (1963).
706. C. W. E. Walker, Analyt. Instrumentat.-1963. Pittsburg, Pa, Instrum. Soc. America, 1963, 183.
707. B. M. Krasovitskii and D. G. Pereyaslova, USSR Author's Certificate, Class 42 1, 9/50 (G 01p), No. 170739 (claimed 18th April 1964; published 10th May 1965).
708. B. M. Krasovitskii and D. G. Pereyaslova, Zhur. Vses. Khim. Obshch. im. D. I. Mendeleeva, 704 (1965).
709. A. F. Chudnovskii, Zhur. Tekh. Fiz., **24**, 2190 (1954).
710. V. N. Ershov and N. M. Ershova, ibid., **26**, 1301 (1956).
711. V. N. Ershov, Zavod. Lab., **27**, 212 (1961).
712. G. S. Smith, Talanta, **5**, 189 (1960).
713. G. S. Sapunov and M. G. Kuznetsova, "Sovershenstvovanie Tekhnologii i Kontrolya Proizvodstva na Novo-Ufimskom Neftepererabotnom Zavode" (Improvement of Technology and Production Control in the Novo-Ufimskii Petroleum Refinery), Moscow, 1961, p. 77.
714. U. S. P., Class 23-232, No. 3057693 (claimed 2nd September 1960); Ref. Zhur. Khim., 8I143P (1964).
715. A. N. Aleksandrov, S. L. Skop and I. L. Levina, "Metody Issledovaniya Produktov Neftepereabotki i Neftekhimicheskogo Sinteza" (Methods for Studying the Products of Petroleum Refining and Petrochemical Synthesis), Gostoptekhizdat, Leningrad, 1962, p. 141.

Mendeleev Institute of
Chemical Technology, Moscow.