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THE BRITISH SOCIETY OF RHEOLOGY

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RHEOLOGICAL CONGRESS, BERLIN, MAY 5th-8th, 1954

Members of the British Society of Rheology are invited to attend and give papers at the 4th Annual Congress of the German Rheological Society. Those wishing to do so should write to the Secretary of the G.R.S., Dr. H. UMSTÄTTER, Berlin-Dahlem, Unter den Eichen 86-87, without delay. P.F.

RHEOLOGY IN MECHANICAL ENGINEERING

It is proposed to hold a three-day meeting on this topic at the Mechanical Engineering Research Laboratory, D.S.I.R., East Kilbride, nr. Glasgow, from 10th to 12th June, 1954. Papers will be presented both by Divisions of the Laboratory and by invited speakers. Opportunities will be provided to visit the laboratories. The full details have not yet been settled and further information will be circulated later.

SUMMARIES OF PAPERS read at meetings of the Society

The Preparation of Pastes of Starch and Certain Gums for use in the Sizing of Textile Materials

E. H. JONES

(British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester)

Briefly, the purposes of sizing textile warps are to protect them from the destructive action of the loom, to impart to the cloth a specific feel and weight and to protect the warp and cloth against mildew attack. Tape sizing is a continuous process in which the warp is passed through a bath containing a hot sizing paste, mangled, and dried. It is important to be able to predetermine the percentage of sizing ingredients added to the warp. The chief characteristics of the sizing paste which, in ordinary practice, affect the percentage of added size are its viscosity, which largely determines the percentage of paste taken up, and the concentration of ingredients in the paste.

To cover all requirements many different types of ingredients are often included in the same mixing and these may be present in practically all the forms which liquids can assume. Thus adhesives such as starch are present chiefly as colloidal solutions, lubricants such as tallow are dispersed as emulsions, fillers such as china clay are present as suspensions, and deliquescent salts such as magnesium chloride dissolve to form true solutions. The preparation problem thus becomes one of effectively mixing these ingredients with the correct quantity of water to form a homogeneous paste which is stable in viscosity when boiled and stirred for long periods.

Instability is largely associated with the adhesive component which is generally starch. This is first mixed with cold water into a smooth cream which is then boiled for a period. When gelatinisation occurs between 60 and 70°C. the paste thickens up enormously but as the heating and boiling are continued the viscosity begins to fall. Some starches (e.g. sago and tapioca) reach a fairly stable viscosity after being boiled and stirred for an hour or so, but others (e.g. potato starch) are unstable for a much

longer cooking period. Adequate boiling time is essential for stability. Closed steam pipes and steam jackets are unsuitable for heating starch pastes because they become caked over with film: open steam is generally used.

Lubricants, such as tallow, should be added to the mixing after it has been gelatinised. Stirring and ebullition of the paste produce an emulsion, the stability of which is maintained by the high viscosity of the paste.

Clay should be mixed into a cream with water before adding it to the starch paste otherwise it is difficult to disperse.

Salts and other substances forming true solutions should be added after the starch has been gelatinised.

Locust bean flour gelatinises spontaneously in cold water and is most satisfactorily dispersed by first mixing it into a cream with methylated spirits. A sizing paste can also be prepared by sprinkling the powder slowly into vigorously agitated water.

To control the concentration of the mixing the moisture content of each ingredient should be allowed for and the volume of the mixing should be accurately adjusted at the end of the boiling period. Although most sizing pastes exhibit non-Newtonian flow properties, it is found in practice that simple viscometers can often be used to predict roughly how the pastes will behave at the sizing machine.

The difficulties of controlling such factors as viscosity and the take-up properties of the warp have led to the development by the B.C.I.R.A. of an automatic size regulator which operates on the concentration to compensate completely for all other variables. This development has, in turn, removed the necessity for stability in viscosity and has thus enabled simpler methods of size preparation to be introduced.

Paper read 25th September, 1953

The Physical Basis of Rheological Theories

L. R. G. TRELOAR

(The Royal Institution, London)

Rheological theories may be classified as either (a) phenomenological or (b) physical. A physical theory takes as its starting point certain structural elements, usually molecules, having definable properties, and attempts to deduce the properties of the combination. A phenomenological theory, on the other hand, is concerned only with formal relationships between observable, or potentially observable, phenomena.

Each type of theory has its value, and also its limitations.

Despite the analogy with spring-and-dashpot models, the relaxation time distribution theory is purely phenomenological. Its claim is that from a series of observations on a material it is possible to obtain a mathematical function which is capable of describing the results of any other rheological experiment which one may care to make.

Whether this claim is justified depends on whether the material satisfies the fundamental assumptions postulated in the theory. These assumptions are:

- (1) The deformation at any time is proportioned to the stress.
- (2) The effects of simultaneously applied stresses may be superposed.

Only if these conditions are satisfied is it possible to apply the theory. Even then there are a number of further difficulties which arise in its actual application; some of these will be considered.

Paper read 11th December, 1953

Theoretical Approaches in Rheology

G. W. SCOTT BLAIR

(The University, Reading)

In 1685 Newton published his famous law relating stress to velocity gradient, seven years after Hooke had explained his anagram "ceiinossttuu" and five years after Mariotte's independent discovery of the law of a spring. Maxwell (1868) and Kelvin

(1875) propounded prototypes for relaxation and for what we now call "retardation" phenomena corresponding to a viscous element and a spring in series and in parallel respectively. Maxwell well knew that his relaxation time, got by dividing the dashpot viscosity (η) by the spring stiffness (G), would be inadequate to describe the behaviour of systems showing complex elastic after-effects; and pointed out that for such materials, relaxation time would be a function of stress. Hopkinson (1878) and others explored power-law creep functions analogous to those used to account for "residual charges in a Leyden Jar."

Very soon summations (band spectra) and integrations (continuous spectra) of relaxation times were proposed, culminating in Wiechert's expression (1893) for a Gaussian distribution on a logarithmic time scale. Wiechert clearly distinguished two possible types of treatment for non-Maxwellian systems (1) η/G is not independent of stress and must be expressed as a function of it and (2) there are many Maxwellian relaxing units with differing relaxation times. It was some time before it was realized that, in relation to the second method, the principle of superposition, on which the various distribution functions depended, holds only for a limited range of real materials.

Schwedoff (1889) and Trouton (1906) were among the first to consider the flow-behaviour of systems neither Newtonian nor Hookean; yet Bingham is rightly credited with the first truly quantitative study of flow of complex materials. He explicitly divided the shear stress (τ) into two parts: that associated with elastic strains in the material (the yield-value) and that producing flow. For many suspensoid systems, the rate of shear ($\dot{\gamma}$) divided by the latter part of the stress gave an adequately constant "mobility," especially after Buckingham and (independently) Reiner had explained the reason for some apparent discrepancies. For emulsoid systems having no yield-value, however, Ostwald and de Waele's plot of $\log \tau$ vs $\log \dot{\gamma}$ gave good straight lines, though Scott Blair pointed out, as early as 1929, that a Bingham plot fitted many of Ostwald's data at least as closely.

In 1921 Nutting proposed a power-equation to relate stress, strain and time which was largely overlooked till it was revived by Scott Blair and Copen in 1939.

In 1946 Scott Blair proposed to describe treatments which "break down" the behaviour of materials into complex systems of linear prototype terms as "analytical" and those which treat the rheological phenomena as single but non-linear "wholes" as "integralist" (later improved to "integrative"). This classification corresponds closely to Wiecherts' distinction mentioned above.

In a sense, both systems are empirical, though molecular models can sometimes represent analytical equations but not integrative ones. Certain rather hastily conceived criticisms of the integrative approach on dimensional grounds were effectively refuted by Dingle (1949).

Nutting's equation and its modifications have been effectively used by so many authors (e.g. Broome & Bilmes, Buist & Seymour, Haward, Rigden, Scott Blair & Veinoglou, Shank, Straub, Wearmouth & Berenblut, etc.) that Scott Blair and his colleagues felt it worth while to try to develop some theoretical background. Nutting's equation was shown to represent the first terms of a double series derived by integration of a fractional differential equation describing behaviour as *intermediate* between that of the classical linear prototypes. The addition of one or at most two more of the terms of these series accounted for discrepancies from ordinary Nutting behaviour even for very complex materials which do not obey the superposition principle. Analogous "intermediate" expressions have been introduced in other fields, e.g. leaky dielectrics (Hartshorn, 1926) and the parachor (Telang, 1949).

The fractional differential equations have been shown to be interestingly linked with Boltzmann's equation (see Hermans, 1948); and Graham (1953) has proposed a Riemann-type fractional integral equation of which Scott Blair's fractional differential can be derived as a special case.

The use of non-linear distributions of linear relaxation times and especially Gross' introduction of the Mittag-Leffler function, suggests that a synthesis between the analytical and integrative approaches may be coming near. Since 1929, it has been the author's view that both methods are legitimate and perfectly "sound," but hitherto no connection between them has been apparent.

Paper read 11th December, 1953

Macroscopic Rheology

A. GRAHAM

(National Gas Turbine Research Establishment, Pyestock, Hants)

There are two main interests in rheology, the macroscopic behaviour and the microscopic details to which this behaviour is due. These correspond to the "field" and "particle" interests in science. The history of science shows that knowledge of the macroscopic laws is usually necessary before acceptable particle mechanisms can be formulated; alternatively, when the particle laws are discovered by direct experiment, their relation to the macroscopic laws is often difficult to establish.

These considerations point to the theoretical and practical need in rheology to attend to the macroscopic laws, and a case for the Nutting equation is presented. Experiment clearly indicates the possibility of several modes of deformation each obeying a Nutting law, so that the total deformation should be represented by a sum of Nutting terms. Such an expression has a very wide range of validity, and there is reason to believe that simple relationships may exist between the exponents of the different terms.

A plea is made for the systematic representation of experimental results in this manner.

Paper read 11th December, 1953

The Derivation of Nutting's Equation

P. FELTHAM

(Standard Telecommunication Laboratories, Enfield, Middlesex)

The power-law of stress relaxation under constant strain, $\sigma/\sigma_0 = (t/t_0)^{-m}$, and of transient flow under constant stress, as observed in many materials, can frequently be combined into a single expression, $\phi = \epsilon^{-1} \sigma^n t^k$, known as Nutting's Equation, where ϵ , σ and t are the strain, the stress and the time respectively, and ϕ , n , k and m ($=k/n$) are constants at a given temperature.

It is shown that the relation describing the stress relaxation can be derived on the assumption of the superposition of a spectrum of Maxwellian relaxation elements; the spectrum being approximately Gaussian on a logarithmic base, i.e.

$$\psi(z) = (b/\pi)^{1/2} \exp(-bz^2),$$

where $z = \ln(\tau/\tau^*)$, and τ^* the most frequent relaxation time in the distribution, over a wide range of τ .

The value of m derived from stress-relaxation experiments on Perspex at 80°C. was found to be 0.12, in good agreement with the value of 0.14 deduced from the relaxation-time spectrum $\psi(z)$ experimentally determined by Jenckel and Klein (Z. Naturforsch. 7a, 619, 1952). The arguments can be extended to retardation-time spectra.

The exponent n of the stress, in Nutting's Equation, is shown to result from an approximation by $(\sigma/\sigma_c)^n$ to $\sinh(\sigma/\sigma_c)$, where σ_c is a constant. The last functional relation is predicted for the stress-dependence of the rate of deformation of many materials by the Theory of Molecular Reaction Rates.

The relations between the interpretation of rheological data in terms of molecular theory or in terms of springs and dashpots (Maxwell elements), or finally in terms of single non-linear elements (Nutting's Equation) is thus clearly shown.

Paper read 11th December, 1953

BOOK REVIEWS

"Aesthetics and the Gestalt"

IAN RAWLINS

(Nelson, 1953)

It is now nearly ten years since Mr. Rawlins contributed his paper on "Rheology in the Fine Arts" to the first conference of the British Rheologists' Club in Oxford. His latest book shows that he has not allowed his interest in our science to wane. (He calls rheology "a very practical twilight subject": is this phrase borrowed from Dr. Houwink?).

"It is conceivable that art cannot be measured. Nevertheless there have been many attempts to do so . . ." and it is clear that in studying such attempts Mr. Rawlins is led to consider methods and theories essentially similar to those which have been applied in our attempted measurements of rheological craftsmanship.

Dr. Martin Johnson, of whose work Mr. Rawlins speaks in such glowing terms, once wrote: "If Einstein had widened his view to prevent the physical and mental sciences separating so disastrously, he would undoubtedly have been accused of importing philosophy into physics and paid the penalty of being ignored." Mr. Rawlins has taken a bolder course: it is to be hoped that rheologists, at any rate, will not ignore him, since he has much of interest to say to them.

Specifically rheological phenomena—thixotropy of paint, distortion of paintings, crazing (which the artist calls "crackle")—occupy but a small fraction of the book; but suggestions for a more fundamental approach to complex rheological problems abound. Can we "waive" some of our difficulties: let them "hover," while (following Husserl) we make a phenomenological approach to the results of our experiments?

Your reviewer was once accused of "witchdoctoring" for introducing the law of *Prägnanz* into rheology. Mr. Rawlins comes near to equating the artist's genius with his capacity to reduce the free energy of his composition to a minimum. How close is this analogy with thermodynamics? Is it fundamentally more than an analogy? We do not yet know.

The essays and book reviews collected in this volume have already been read by many of us in their original setting. The unique character of Mr. Rawlins' Reviews, especially in *Nature*, justifies the unusual procedure of reprinting such material, though not, perhaps, the inclusion of two reviews of the same work! Like all such "collected works," the book suffers from a good deal of repetition, yet rheologists would be well advised to acquire it as an introduction to the workings of the remarkable and highly original mind of a true friend of our "twilight" science. "Twilight" refers, of course, as well to dawn as to sunset, and I am sure that Mr. Rawlins has in mind its association with the birth of a new day.

G. W. SCOTT BLAIR

"Stress Waves in Solids"

H. KOLSKY

(Clarendon Press. pp. 206, price 25/-)

This addition to the Monographs on the Physics and Chemistry of Materials embraces a subject which has recently come to the fore in the study of the rheological properties of materials. The first part of the book deals in an elegantly concise manner with the propagation of elastic waves of various types in an infinite medium and in bars of finite length. The second part is mainly experimental. It includes a detailed account of the various methods of measuring the dynamic properties of materials, theories of internal friction in solids, the use of the Davies bar for measurements of mechanical properties of metals and plastics in the 10-microsecond region, and the properties of "plastic" waves and shock waves.

The lack of a coherent theory of visco-elastic properties shows up in the frequent

transitions between Voigt models, Maxwell models, "memory functions," and so on, in presenting the results of different workers. Despite this blemish (for which the author cannot be held responsible) the book succeeds in giving a clear and well-balanced picture of a rapidly developing subject to which the author has himself contributed in no small measure. His photographs of shock wave effects in transparent plastics are fascinating.

L. R. G. TRELOAR

Mixing of Thick Liquids, Pastes and Slurries

Mr. W. H. Bickle has prepared an annotated bibliography on this subject, containing 118 references. Those interested may obtain copies, and suggestions for additions or amendments would be welcomed. Please send enquiries to Mr. W. H. Bickle, D.S.I.R., 5 Lower Regent Street, London, S.W.1.

The paper presented by Mr. S. J. Cornford at the Symposium on 25th September has now been prepared in duplicated form under the title "Laboratory Studies in the Mixing of Wheat Flour Doughs." It is available on application to the Information Officer, Baking Industries Research Station, Chorleywood, Herts, at 3/6 per copy.

RHEOLOGY ABSTRACTS

2776. Elastic and strength properties of greases.

G. V. VINOGRADOV AND M. M. GVOZDEV. *Doklady Acad. Sci., U.S.S.R.*, 1953, **86** (2), 341.

Stress-strain curves were determined in a torsional coaxial-cylinder strain-recording elastometer at constant rate of increase of the shearing stress, on seven samples of greases made with oils of different viscosities (from 2.5 to 185 centipoise at 50°) thickened with 10 or 15% Li stearate, and solidol prepared from spindle oil thickened with 17.5% Ca soap from cotton oil. At small stresses, at 20°, strain and stress are proportional. At increasingly greater stresses, after-action sets in at increasingly earlier stages, and the growth of the strain finally outstrips the growth of the stress. Beyond the strength limit, viscous flow can proceed at shearing stresses lower than the limiting stress. The passage through the limit can be linked with irreversible structure changes as a result of which on repeated determinations the curves pass through lower stresses and end in lower strength limits. The sharpness of the transition, from elastic deformation to viscous flow, increases with the concentration of the soap and with decreasing viscosity of the oil, either from one oil to another or when the viscosity is decreased by a rise of the temperature. The sharper is that transition, the lower is the strain corresponding to the limiting shearing stress. With the temperature rising from -30° to +50°, τ_l , and the shearing modulus g_i for ideally elastic deformations (in solidol) fall rapidly only at low temperatures, and relatively slowly at higher temperatures where apparently the structure of the skeleton undergoes little change with the temperature. That, in particular, changes of the viscosity of the oil have little effect, follows from the fact that in a series of greases made with the same thickener and oils of viscosities varying by a factor of 365, the variations of τ_l and g_i at 20° were only by a factor of 1.5. Variations of the rate of stressing between 0.000632 and 2.518 g./sq. m. sec., i.e. by a factor of 3,840, in solidol at 20°, resulted in an increase of τ_l only by a factor of 2.5. This finding refutes the often asserted strong dependence of the strength limit on the velocity of deformation.

A.

2777. Some observations on the yield point of zinc.

H. L. WAIN. *Proc. Phys. Soc.*, 1952, **65B**, 886.

2778. A spherical obstacle in the flow of a viscous fluid through a tube.

S. WAKIYA. *J. Phys. Soc., Japan*, 1953, 8, 254-7.

The Poiseuille flow through a circular tube as affected by the presence of a fixed spherical obstacle with its centre on the axis of the tube is considered on the basis of the Stokes approximation. Expressions for the resultant force acting on the sphere and for the pressure difference which must be added to maintain the total flux through the tube at the value corresponding to the case of absence of the obstacle are obtained correctly to $(a/r_0)^5$, where a and r_0 are the radii of the sphere and the tube respectively. If terms of the order of $(a/r_0)^2$ can be neglected, the magnitude of the resistance is shown to be equal to that of a sphere moving with a constant velocity along the axis of a tube, which was first obtained by Ladenburg.

SCI. ABSTR.

2779. Internal friction and Young's modulus of cold-worked copper single crystals.

J. WEERTMAN AND J. S. KOEHLER. *J. Appl. Phys.*, 1953, 24, 624.

The internal friction and Young's modulus of single crystals of copper were measured as a function of strain amplitude after they were subjected to various amounts of cold work and different annealing treatments. It was found that the position of the peak in the internal friction $v.$ cold-work curve was dependent upon the strain amplitude of the measurement. No minimum in the Young's modulus $v.$ cold-work curve was found as contrasted with Lawson's result for polycrystalline copper. A minimum was found in the internal friction $v.$ annealing time curve, and a maximum was found in the corresponding Young's modulus curve. The results are semi-quantitatively explained using a dislocation model.

A.

2780. Effect of boron on the mechanical properties of low-alloy steels.

R. WILCOCK. *J.I.S.I.*, April, 1953.

2781. Flow of concentrated suspensions.

P. S. WILLIAMS. *J. Appl. Chem.*, 1953, 3 (3), 120-128.

Part I deals with general flow properties of concentrated suspensions. Part II describes work on flow of suspensions of glass spheres with coaxial cylinder viscometer in which torque measured by resistance strain gauges. Discusses method of preparation and particle size analysis of glass spheres. Results on various suspensions given. For volume concentration above 30% size distribution very much affects viscosity and for particles less than 1μ , the smaller the size the greater the thixotropy.

G.H.T.

2782. Electron-microscopic investigation of the surface of stretched pure aluminium.

I. H. WILSDORF AND D. KUHLMANN-WILSDORF. *Z. Angew. Phys.*, 1952, 4, 361.

Using a new preparation technique and tensile strains 0.5-64% it was found that a fine stepstructure covers the entire surface outside the slip bands.

2783. Dense random packing of unequal spheres.

M. E. WISE. *Phillips Res. Rep.*, 1952, 7 (5), 321.

2784. Temper-brittleness.

B. C. WOODFINE. *J.I.S.I.*, March, 1953.

2785. The vibrating-plate viscometer—an aid in slip-casting control.

J. G. WOODWARD. *Bull. Amer. ceram. Soc.*, 1952, 31, 389.

The development of the vibrating-plate viscometer makes it possible to observe the change in viscosity of a clay slip as it sets up in the mould. In this way some of the factors involved in slip-casting control can be studied. The technique is described and typical results obtained for low-fire artware slips are presented. (See abstract No. 2495).

B.C.R.A.

2786. **The viscosity of molten tin, lead, zinc, aluminium and some of their alloys.**

T. P. YAO AND V. KONDIC. *J. Inst. Met.*, 1952, **81**, 17.

2787. **Ductility transition and cold brittleness.**

T. YOKOBORI. *J. Phys. Soc. Japan*, 1953, **8**, 101-3.

2788. **Failure and fracture of metals from the standpoint of the stochastic theory.**

T. YOKOBORI. *J. Phys. Soc. Japan*, 1953, **8**, 104-6.

The phenomena of failure and fracture of metals were treated as a Markoff process or chain. In the fundamental types of failure and fracture, the physical meanings of transition probabilities were interpreted and they were found to correspond to the nucleation rate or reaction rate. The following fundamental features were given a unified interpretation: (1) the dependence of strength on stress velocity or deformation velocity and temperature; (2) the dependence of the time for creep fracture on stress and temperature; (3) many features in the endurance limit and the dependence of the number of repeated cycles for fatigue fracture on the stress range; (4) the size effect; (5) the fluctuation characteristics; (6) ductility transition phenomena. A.

2789. **Law of mechanical similarity for the deformation of different metals.**

G. P. ZAITSEV. *Zav. Lab.*, 1950, 599.

2790. **On the theory of deformation of rubber.**

G. M. BARTENEV. *Zh. tekhn. Fiz.* 1952, **22**, (7) 1154-65.

The two components of rubber deformation: (1) the Hooke's component, which in the normal state forms about 0.05% of the total deformation, but has to be taken into account at low temperatures, large deformations, etc., and (2) the highly elastic component previously incorrectly computed by the author [Abstr. 2087 (1951)], are derived theoretically and determined experimentally. From the comparison of data, conclusions are drawn concerning the structure of rubber and the assumptions and results of previous investigators. SCI. ABSTR.

2791. **Pigment flotation in paints.**

S. H. BELL. *J. Oil Col. Chem. Assoc.*, 1952, **35**, (386) 373.

Disturbances in the drying paint film ascribed to density differentials set up by loss of solvent from the surface, cause the film to break up into a system of vortices known as Bénard convection cells. The cellular condition has also been produced experimentally in smoke layers and may be seen in many natural phenomena, e.g. in cloud formation and in the hot gases on the sun's surface. Conditions affecting the cellular structure in the case of paint films are discussed. D.L.T.

2792. **Laminar flow in channels with porous walls.**

A. S. BERMAN. *J. Appl. Phys.*, 1953, **24**, 1232.

2793. **Degradation of polyisobutylene on shearing in solution.**

A. B. BESTUL & H. V. BELCHER. *J. Appl. Phys.*, 1953, **24**, 1011.

2794. **The energy stored in metal chips during orthogonal cutting.**

M. B. BEVER, E. R. MARSHALL & L. B. TICKNOR. *J. Appl. Phys.*, 1953, **24**, 1176.

2795. **The effect of pressure on the tensile properties of several metals and other materials.**

P. W. BRIDGMAN, *J. Appl. Phys.*, 1953, **24**, 560.

2796. **On the sliding of hard bodies on ice.**

S. S. BUDNEVICH AND B. V. DERYAGIN. *Zh. tekhn. Fiz.*, 1952, **22**, (12) 1967-80.

Apparatus is described for measuring load and speed dependence of coeff. of friction (μ) in the temperature range -150° to 0°C . for steel or wood sliders on ice.

μ rises approx. linearly from boundary value (~ 0.03) near 0°C . to dry value (~ 0.4) at -150°C . At fixed temperature near 0°C . μ increases to ~ 0.10 as the specific load is reduced to zero below 150 g/cm^2 . Results are explained if it is assumed that some of the asperities on the ice surface melt by frictional heating if they are greater than critical size. The temperature rise is deduced from the theory of Blok (1937). Water forms a boundary lubricating layer and μ obeys Amonton's law, so fluid lubrication is not achieved. Theory permits the prediction of temp. dependence (in range -150° to 0°C .) of μ for any load on a given ice surface, provided dependence has been measured at one load. μ decreases slightly as speed of sliding increases from zero but remains constant for speeds above 0.2 m/sec , in contradiction with theory which predicts a continuous fall of μ with increasing speed.

SCI. ABSTR.

2797. Objective methods for the determination of the mechanical properties of butter.

N. CHEKULAEV. *Molochnaya Prom.* 1953, 14, 32.

Describes a balance-type apparatus for measuring shear-resistance of butter and gives curves for this property against temperature for different seasons of the year and under varying cow rations.

G.W.S.B.

2798. The relationship between the Poisson coefficient and the plastic properties of substance.

I. I. CHERKASOV. *Zh. tekhn. Fiz.* 1952, 22, (11) 1834-7.

A comparison of the experimental data on the determination of the Poisson coefficient with the data on hardness and the relative decrease in the limit of the tensile strength of various substances shows that all the indices of ductility increase with an increase in the Poisson coefficient. For brittle and elastic materials such as glass or quenched steel the Poisson coefficient approaches the theoretical value of $\mu=0.25$. For soft and ductile materials such as lead or plasticine the Poisson coefficient approaches the value of $\mu=0.50$. A definite relationship between the Poisson coefficient and the characteristics of the ductility of substances is observed. The author develops approximate formulae for the ductility constant which may be expressed in terms of the plasticity β , which in turn is dependent on the Poisson coefficient. He shows by a number of concrete examples that the formulae are substantiated by experimental data. The best agreement is obtained for metals with regular crystalline lattices, and in general for isotropic substances.

SCI. ABSTR.

2799. The influence of the clay fraction on the engineering properties of soil, with some suggestions for future research.

E. K. CLARE. *Clay Min. Bull.*, 1947-52, 1, 30-34.

2800. Flow through uniformly tapped pipes.

C. CODEGONE. *Appl. Sci. Res.* 1953, A 4, 76.

In connection with a paper by B. G. Van der Hegge Zijnen (*Appl. Sci. Res.* 1952, A 3, 144) it is shown that for laminar flow in a pipe with a large number of orifices the pressure drop ($p_o - p_m$) is about half of the pressure drop for the same pipe without lateral orifices and with the whole rate of flow Q_o at the end.

P.G.M.

2801. Activation energy for viscous flow and short-range order.

G. J. DIENES. *J. Appl. Phys.*, 1953, 24, 779.

2802. Change of the basis for viscosity measurements.

SJ. VAN DIJK. *De Ingenieur*, 1953, 65, M 16.

The New Nat. Bur. Stand. value of the viscosity of water (1.0038 cS at 20°C .), determined by J. F. Swindells, J. R. Coe Jr. and T. B. Godfrey and reported in *J. Res. Natl. Bur. Standards* 1952, 48, RP 2279, and introduced July, 1953, will be accepted by other standardising organisations. Calibration factors of all A.S.T.M. and I.P. viscometers in use will decrease by 0.3% whereas this factor will be increased by 0.2% for all German (P.T.R.) viscometers in use.

P.G.M.

2803. Comment on the temperature dependence of the viscosity of liquids.

A. K. DOOLITTLE. *J. Appl. Phys.*, 1953, **24**, 1067.

See Abstract 2815.

2804. The measurement of dynamic strength of plastic materials.

F. X. EDER. *Z. angew. Phys.*, 1953, **5**, (1) 1-5.

Experiments in which Cu test-pieces were elongated at rates of strain up to 300 sec^{-1} are in good agreement with Kochendörfer's theory of the increase of tensile strength with rate of strain. The propagation of plastic waves along a test-piece is discussed, and the errors which can result from non-uniformity of stress along the length are demonstrated. These errors can be reduced by increasing the mass attached to the end of the specimen (to which the impulsive force is applied), and can be estimated by observing the permanent deformation of the test-piece after the experiment. SCI. ABSTR.

2805. The relaxation distribution function of polyisobutylene in the transition from rubber-like to glass-like behaviour.

J. D. FERRY, L. D. GRANDINE AND E. R. FITZGERALD. *J. Appl. Phys.*, 1953, **24**, 911.

2806. The plastic flow of iron and plain carbon steels above the A_3 -point.

P. FELTHAM. *Proc. Phys. Soc. B.*, 1953, **66**, 865.

2807. Determination of the drag on a cylinder at low Reynolds numbers.

R. K. FINN. *J. Appl. Phys.*, 1953, **24**, 771.

See also Abstract 2808.

2808. Erratum. Determination of the drag on a cylinder at low Reynolds numbers.

R. K. FINN. *J. Appl. Phys.*, 1953, **24**, 1050.

A correction is made in one equation (Abstract 2807).

S.T.

2809. Dynamic mechanical properties of polyisobutylene.

E. R. FITZGERALD, L. D. GRANDINE AND J. D. FERRY. *J. Appl. Phys.*, 1953, **24**, 650.

2810. Some properties of solutions of Navier's equations.

A. FORTIER AND J. KRAVTCHEKO. *Cahiers de Phys.*, No. 42, 64-75 (March, 1953).

Navier's equations are very briefly discussed, more especially in terms of a dissipation function, and solutions which should be intelligible to those not too familiar with modern analysis are derived and their physical significance pointed out. In particular, various extensions of the theorems of Bolyeff and of Korteweg, which should interest physicists and engineers are derived. Thus, e.g. in a steady Poiseuille flow of a viscous, incompressible, gravitating fluid through a cylindrical tube, for a given position of the tube, the distribution of velocities in any normal section is constant. The uniqueness (unicité) theorem stated by the authors leads to the conclusion that the velocity distribution across any normal section of the flow is independent of the inclination of the tube to the horizontal, provided the difference of pressure between the terminal sections is constant; this distribution, for a given inclination of the tube, is independent of the orientation of the section. SCI. ABSTR.

2811. The flow properties of cervical secretions in the cow as related to certain physiological conditions.

F. A. GLOVER AND G. W. SCOTT BLAIR. *J. Endocrin.*, 1953, **9**, 160.

A continuous record is made of the varying pressure required to extrude secretions from a capillary at a constant rate of 1 cm. per min. The volume of sample required is 0.006 ml. Equivalent viscosities range from 10 to 2,700 poises. The rate of variation of pressure with length of column is correlated with stages in the sexual cycle and in pregnancy, and with the occurrence of abortion and subfertility. F.A.G.

2812. **Elasto-plastic stress-optical effect in silver chloride single crystals.**
L. E. GOODMAN AND J. G. SUTHERLAND. *J. Appl. Phys.*, 1953, 24, 577.

2813. **The recovery of plywood after compression at elevated temperatures.**
P. U. A. GROSSMAN. *Aust. J. Appl. Sci.*, 1953, 4, 98.

The recovery of plywood panels of hoop pine, pressed in the oven-dry condition at temperatures between 160 and 200°C., was observed at room conditions and at the pressing temperature. The rate of delayed elastic recovery and the residual deformation were influenced by temperature during recovery. The decrease in residual deformation with increasing recovery temperature was slight, indicating that permanent deformation in compression short of cell-wall fracture is not due solely to the restraint in recovery produced by cooling. Heating immediately after removal of the stress caused greater total recovery than later heating. When no further recovery could be observed at room and at pressing temperatures, some specimens were subjected to temperatures 40°C. above the pressing temperatures and thermo-recovery was measured. A substantial increase in recovery was shown by specimens which were soaked in water and redried.
A.

2814. **Investigations on the plastic properties of high polymers.**
V. E. GUL' AND T. E. GELLER. *Koll. Zhur.*, 1953, 15, 95.

2815. **Further note on the temperature dependence of the viscosity of liquids.**
F. GUTMANN AND L. M. SIMMONS. *J. Appl. Phys.*, 1953, 24, 1067.
See Abstract 2803.

A discussion of the relative merits of two empirical equations, one proposed by Doolittle (Abstract 2131) and the other by Gutmann and Simmons (Abstract 2516), for predicting the viscosities of liquids over a wide range of temperature.
S.T.

2816. **Subharmonic oscillations in nonlinear systems.**
C. HAYASHI. *J. Appl. Phys.*, 1953, 24, 521.

2817. **Factors influencing the plastic deformation of timber and plywood in compression.**

H. G. HIGGINS. *Aust. J. Appl. Sci.*, 1953, 4, 84.

The relative effects of various factors on the plastic deformation of wood under compression perpendicular to the grain were determined. It is shown that there are substantial grounds for preferring plywood to solid timber specimens for this type of investigation, in so far, principally, as solid specimens are subject to the phenomenon of "glide" along the growth rings, which produces anomalous results. The concept of yield value is briefly examined and the advantages are discussed of taking the yield value as the pressure, or stress, at which appreciable residual deformation occurs, as determined from a series of independent tests at different loads, the load being kept constant during each test. In such tests, the duration of loading appears to be an important factor in residual deformation, but only at higher pressures, and it does not materially affect the yield value. The effect of time upon total deformation was also studied, and the general shape of the deformation-time curves suggests that they may be amenable to a rheological analysis suitable for systems of linear amorphous polymers. The type of adhesive used in the plywood specimen was found to have considerable influence on plastic deformation, as impregnation of the wood can greatly reduce its plasticity. With increasing moisture content (below fibre saturation) residual deformation increases, and yield value declines. The effect of species upon residual deformation appears to lie mainly in differences in density rather than in structure.
A.

2818. **The significance of clay-water relationships in ceramics.**
D. A. HOLDRIDGE AND F. MOORE. *Clay Min. Bull.*, 1953, 2, 26-33.

A summary. 24 references.

R.H.S.R.

2819. The Ferry reduction and the activation energy for viscous flow.

I. L. HOPKINS. *J. Appl. Phys.*, 1953, **24**, 1300.

The relationship proposed by Ferry and his co-workers for the effects of frequency and temperature on the dynamic properties of certain polymers is shown to lead to a method for calculating the activation energy of viscous flow from relaxation, creep, and dynamic test data, the results agreeing with those obtained in steady-state flow. The Ferry reduction explains, and is supported by, observed increases in dynamic modulus and viscosity with increasing temperature. A.

2820. The effect of intra-molecular bond strength on the onset of cavitation.

J. P. HORTON. *J. Acoust. Soc. Amer.*, 1953, **25**, 480-4. SCI.ABSTR. 5322(1953).

2821. Effect of biaxial orientation on the ultimate strength and crazing of linear polymers.

C. C. HSIAO AND J. A. SAUER. *J. Appl. Phys.*, 1953, **24**, 957.

2822. On the relation between dynamic viscosity and rigidity.

A. A. K. IBRAHIM. *J. Chem. Phys.*, 1953, **21**, 1422.

For a particular visco-elastic liquid it is shown that the dynamic viscosity η and the dynamic rigidity N as measured by a forced oscillation method, are related to the frequency of oscillation n by the relationship $N/\eta \propto n$ when n is below a critical value and $N/\eta \propto (n-c)$ when it is above. c is a constant. S.T.

2823. Studies on the deflocculation of clay minerals.

A. H. JOHANNESEN AND R. SCHNEIDER. *Tonind.-Ztg.*, 1952, **76**, 334-337.

The effect of concentration of deflocculent on slip casting properties of kaolins and micas is described. The viscosity of mica is unaffected by the presence of deflocculants. R.H.S.R.

2824. Pure gliding of metal crystals.

H. KANZAKI. *J. Appl. Phys.*, 1953, **24**, 811.

2825. Creep and recovery in metals.

A. J. KENNEDY. *Brit. J. Appl. Phys.*, 1953, **4** (8), 225.

2826. On the question of structure of metals.

V. E. KHOTKEVICH. *Zh. tekhn. Fiz.*, 1952, **22**, (3) 474-9.

Investigates the structures of Li, Na, Sn, In, Tl, Hg, Cd, Pb and Al submitted to plastic deformation at temperatures of liquid hydrogen and nitrogen. It is shown that under these conditions lithium shows a polymorphic transformation from a body-centred cubic modification to face-centred. The remaining metals maintain their crystal structure. SCI. ABSTR.

2827. The fundamental laws of flow of amorphous and crystalline materials.

A. KOCHENDORFER. Note in *Z. angew. Phys.*, 1953, **5**, (2) 69-80.

A comprehensive survey of the current theoretical explanations of viscous and plastic flow in terms of molecular or atomic rearrangements in the material. References. SCI. ABSTR.

2828. On plastic flow.

W. KOSSEL. Note in *Z. Naturforsch.*, 1953, **8a**, 211-12.

Plastic flow is considered as a type of crystalline rearrangement on the same footing as simple crystal growth. Material breaks away from a severely strained crystal lattice to join a new lattice formation with less potential energy. SCI. ABSTR.

2829. On the effect of crystalline structure on the yield point of a polycrystal.

P. I. KULESHOV. *Zh. tekhn. Fiz.*, 1952, **22**, (7) 1174-83.

A general method is presented for calculating the yield point of a polycrystalline substance from the properties of single crystals. Numerical integration is used to find the onset of yield in metals of the copper and iron type in the case of linear and two-dimensional stressed states, which is found to be related to the grain structure. With

fine homogeneous grains in complete disorder there may be some cases in which a difference in grain structure will not affect the value of the yield point. A curve is derived on the basis of shear stress theory and found to lie between the Saint Venant and von Mises curves and closer to the latter.

SCI. ABSTR.

2830. Some relations between the modulus of rigidity and the surface and sublimation energies.

G. C. KUCZYNSKI. *J. Appl. Phys.*, 1953, **24**, 1250.

2831. Dynamic compliance, dynamic modulus, and equivalent Voigt and Maxwell models for polyisobutylene.

H. LEADERMAN AND R. S. MARVIN. *J. Appl. Phys.*, 1935, **24**, 812.

2832. Wave propagation in finite rods of viscoelastic material.

E. H. LEE AND I. KANTER. *J. Appl. Phys.*, 1953, **24**, 1115.

2833. The rheological properties of clay.

H. H. MACEY. *Clay Min. Bull.*, 1947-52, **1**, 39-40.

2834. Viscosity and sedimentation of kaolin and bentonite in organic liquids.

E. W. J. MARDLES. *Clay Min. Bull.*, 1947-52, **1**, 41-43.

With clay suspensions even in dilute form the viscosity coefficient greatly exceeds 2.5, the Einstein coefficient, the greater the tendency to flocculation the greater being the deviation. When clays are dispersed in mixed liquids the properties (e.g. sp. viscosity and rigidity) usually differ considerably from the mean of those of the single liquids.

R.H.S.R.

2835. The influence of the dispersion medium and of surface-active substances on the plastic rigidity and structure of suspensions of the type of chocolate mixes.

V. É. MARKOVICH AND L. E. CHERNENKO. *Koll. Zhur.*, 1953, **15**, 204.

Measures a critical shearing stress and relates this to concentration of fat, lecithin and polyglycerides. (See abstr. No. 2252).

G.W.S.B.

2836. The gelation of montmorillonite.

M. B. McEWEN. *Clay Min. Bull.*, 1947-52, **1**, 177-178.

Optical and elastic studies on sols of Wyoming bentonite (fine fraction) lead to the conclusion that the gelation of very dilute (down to 0.05%) suspensions is due to the formation of a fibrillar network in which the plates are aggregated end-to-end in the form of flat, ribbon-like filaments.

R.H.S.R.

2837. Measurement of elastic constants at low temperatures by means of ultrasonic waves—Data for silicon and germanium single crystals and for fused silica.

H. J. MCSKIMIN. *J. Appl. Phys.*, 1953, **24**, 988.

2838. Epicentral displacement caused by elastic waves in an infinite slab.

A. G. MENCHER. *J. Appl. Phys.*, 1953, **24**, 1240.

2839. Tables for use in the measurement of interfacial tensions between liquids with small density differences.

O. S. MILLS. *Brit. J. Appl. Phys.*, 1953, **4**, (8) 247.

2840. Deduction of the maximum torsional stress in a shaft with notches.

S. MOMMA. *J. Appl. Phys.*, 1953, **24**, 959.

2841. Variation of the viscosity of ethyl chloride vapour with temperature.

M. EL NADI. *J. Phys. Chem.*, 1953, **57**, (6), 589-591.

The viscosity of ethyl chloride vapour is measured by the capillary tube method at temperatures well below the critical point. The applicability of the transpiration

formula was tested at each of these temperatures and found to hold quite well. Then the validity of Sutherland's model was examined for ethyl chloride vapour. A.

2842. On the mechanism of viscosity of polymer solutions.

G. NARSIMHAN. *J. sci. industr. Res.*, 1953, 12 B, 142-6.

An equation of the form $[\eta] = k \cdot m_p^{\frac{1}{2}}$, analogous to the one proposed by H. Mark (1948), relating the intrinsic viscosity of a linear polymer solution to the molecular weight of the polymer, has been derived. The equation is applicable only to linear polymers of low molecular weight in a state of extreme dilution. A.

2843. Determination of the surface stress by means of electro-plating.

H. OKUBO. *J. Appl. Phys.*, 1953, 24, 1130.

2844. Apparatus for measurement of electrical properties of colloidal suspensions in oils.

C. J. PENTHER AND A. BONDI. *J. Phys. Chem.*, 1953, 57, (5), 540-541.

A capacitor cell with rotating inner electrode and sensitive conductimeter are used for measurement of flocculation and deflocculation in non-aqueous systems. The speed of the electrode is controlled steplessly and held constant by a thyatron circuit. The motor load current is proportional to torque and is therefore a measure of viscosity. Conventional oscillator, bridge and null detector are used for dielectric constant and loss measurements over the range 20c./sec. to 100kc./sec. A.

2845. The rheology of margarine and compound cooking fat. I. Preliminary experiments and observations.

J. H. PRENTICE. *Brit. Food Mnfg. Res. Assoc. Ref. No. 37*, 1952. (released).

A study of such concepts as "spreadability," "workability" and "firmness" of fats, assessed by experts and others, in relation to data from mechanical tests. Instruments used include impact breaker (Izod principle), needle penetrometer, parallel plate impact and compression tests, "spreader" (imitating spreading on bread) and orifice viscometer. Principles of factor analysis for simplifying inter-test correlations are discussed and a preliminary analysis is quoted. Appendices on physics of impact penetrometer and steady compression of cylindrical test-piece. G.W.S.B.

2846. The effect of storing and blending on the firmness and spreadability of butter.

J. H. PRENTICE. *Proc. XIII Intern. Dairy Cong. (Hague)* 1953, 2, 723.

Studies rate of recovery of (false-body) consistency of butter following churning or blending. "Firmness" was measured in parallel plate plastometer and "spreadability" related to other rheol. tests (see Abstr. 2845). Firmness doubles after about 3 weeks resting. Effects of temp. are discussed. G.W.S.B.

2847. A quantitative study of the wear process.

E. RABINOWICZ. *Proc. Phys. Soc. B.* 1953, 66, 929.

It is well known that friction between solid bodies is accompanied by transfer of matter. In experiments with radioactive copper on mild steel the author studied the transfer of radioactivity by means of a photographic film which he placed on the friction track. The three "traces" of frictional contact which he publishes cast serious doubt on the qualitative interpretation of the black spots of irregular shape shown on the film strips. If his interpretation can be proved correct, the mass of the largest wear particles varies much less than does the applied load. R.S.

2848. Cold milk separation: the effects of pasteurization, separating procedure and product used for standardization, on properties of cream.

W. M. ROBERTS, L. F. BLANTON AND G. P. MARLEY. *Milk Plant Monthly*, 1953, 42, 19.

The "viscosity" (overall consistency) of cream is measured in a Borden Flowmeter (orifice viscometer). Separating at a low temp. (42°F.) gives higher viscosity cream than separating at high temp. (90°F.). Effects of various methods of cooling cream on its

consistency are discussed. Pasteurization of milk before separation does not damage whipping properties of cream. Modern "high-temp." pasteurization is in general satisfactory. G.W.S.B.

2849. A new method for continuous viscosity measurement. General theory of the ultra-viscoson.

W. ROTH AND S. R. RICH. *J. Appl. Phys.*, 1953, 24, 940.

2850. A theory of the linear viscoelastic properties of dilute solutions of coiling polymers.

P. E. ROUSE, JR., *J. Chem. Phys.*, 1953, 21, 1272.

The necessary co-ordination of the motions of different parts of a polymer molecule is made the basis of a theory of the linear viscoelastic properties of dilute solutions of coiling polymers. This is accomplished by use of the concept of the submolecule, a portion of polymer chain long enough for the separation of its ends to approximate a Gaussian probability distribution. The configuration of a submolecule is specified in terms of the vector which corresponds to its end-to-end separation. The configuration of a molecule which contains N submolecules is described by the corresponding set of N vectors.

The action of a velocity gradient disturbs the distribution of configurations of the polymer molecules away from its equilibrium form, storing free energy in the system. The co-ordinated thermal motions of the segments cause the configuration to drift toward their equilibrium distribution. The co-ordination is taken into account by the mathematical requirement that motions of the atom which joins two submolecules change the configurations of both submolecules. By means of an orthogonal transformation of co-ordinates, the co-ordination of all the motions of the parts of a molecule is resolved into a series of modes. Each mode is a characteristic relaxation time. The theory produces equations by means of which the relaxation times, the components of the complex viscosity, and the components of the complex rigidity can be calculated from the steady flow viscosities of the solution and the solvent, the molecular weight and concentration of the polymer, and the absolute temperature.

Limitations of the theory may arise from the exclusion from consideration of (1) very rapid relaxation processes involving segments shorter than the submolecule and (2) the obstruction of the motion of a segment by other segments with which it happens to be in contact. Another possible cause of disagreement between the theory and experimental data is the polydispersity of any actual polymer, this factor is important because the calculated relaxation times increase rapidly with increasing molecular weight. A.

2851. The flow double refraction and viscosity of concentrated solutions of high polymers.

B. SCHMIDLI. *Dissert. E.T.H. Zürich*, No. 2101, 84 pp. (1952).

Describes results of investigations on two polystyrenes in toluene, and three nitrocelluloses in butyl acetate, the polymers being characterized by the extrapolated viscosity values $(\eta_{sp}/c)_c \rightarrow 0$. In dilute solutions the molecules are probably orientated as a whole, while in concentrated solutions the orientation of chain segments of the long molecules seems to be the main phenomenon. The observation confirms the supposition that polystyrene molecules in solution are more coiled than the nitrocellulose molecules. SCI. ABSTR.

2852. A molecular theory of stress relaxation in polymeric media.

K. W. SCOTT AND R. S. STEIN. *J. Chem. Phys.*, 1953, 21, 1281.

The application of the kinetic theory of rubber elasticity to the description of the relaxation of cross-linked networks is only permissible in cases where the rate determining process is slow compared to the rate of diffusion of the polymer chains. Relaxation resulting from chemical reactions causing breaking of network cross-links and formation of new crosslinks is a process of this type. In this paper, a differential equation is proposed which describes the rate of relaxation in terms of the rates of the molecular processes. A simplified solution of this equation is given, and the consequences of the solution are discussed. A.

2853. Effects of rate of shear on inherent and intrinsic viscosities of polystyrene fractions.

L. J. SHARMAN, R. H. SONES AND L. H. CRAIG. *J. Appl. Phys.*, 1953, 24, 703.

2854. Subjective assessments of firmness: the use of a rating scale.

D. SHEPPARD. *Quart. J. Exper. Psychol.*, 1953, 5, 1.

Experiments consisted in comparing "firmness" of steel springs squeezed between fingers with objective stiffness of the springs. If a given sample is judged within a "soft" series, it tends to be given as firmer than if included in a series of firmer samples. Pressures actually exerted by subjects were measured and bore some relation to initial rating values but not to level of discrimination. Nor is discrimination related to capacity to reproduce pressures consistently. Effects of varying time intervals between judgments were also studied. (See Abstr. 2543).

G.W.S.B.

2855. Elastic and viscous properties of dilute solutions of polymethyl methacrylate in organic liquids.

B. A. TOMS AND D. J. STRAWBRIDGE. *Trans. Faraday Soc.*, 1953, 49, 1225.

2856. On the question of the theory of flow of visco-plastic materials.

M. P. VOLAROVICH AND A. M. GUTKIN. *Koll. Zhur.*, 1953, 15, 155. (Discussion).

A critical review of Tyabin's work (see abstr. No. 2098) pointing out irrelevancy of relating yield-strength to dead weight.

G.W.S.B.

2857. The effect of quebracho-extract on the thixotropy and viscosity of (ceramic) raw materials and bodies containing clay minerals.

T. WHITE. *Tonind.-Ztg.*, 1953, 77, 193-197.

The rheological data presented show that quebracho-tannin extract added to clay-containing suspensions reduce their viscosity, gel strength and thixotropy by increasing the degree of particle dispersion. The viscosity of cement slurries is similarly affected.

R.H.S.R.

2858. The sedimentation of dense suspensions of microscopic spheres.

B. W. WILSON. *Aust. J. Appl. Sci.*, 1953, 4, 274.

The velocity of sedimentation of non-uniform spheres relative to the velocity of a mean sphere at infinite dilution has been used to interpret viscous friction and surface forces in suspensions of microscopic particles in water. Within the limits of collective sedimentation, viscous forces are comparable with those acting on a sphere settling in a narrow cylinder over the range of volume concentration between 0.10 and 0.30 and with those acting in beds of spheres at higher concentrations.

Surface effects which play a secondary role are confined to forces between the spheres and there is little evidence of electro-viscosity for spheres as fine as 3.5μ . In very dense suspensions kinetic friction between the spheres leads to the formation of an unstable bed structure in the suspension.

A.

2859. The permeability of beds of microscopic spheres.

B. W. WILSON. *Aust. J. Appl. Sci.*, 1953, 4, 300.

The permeability to water of beds of packed and flocculated spheres $1-10\mu$ in diameter has been measured directly on thin membranes of sintered spheres. A simple mechanism of agglomeration is proposed to account for changes in porosity and permeability.

A.

2860. The effect of sodium hexametaphosphate in the washing process on the particle size distribution of washed kaolins.

F. ZAPP AND S. GOLLER. *Tonind.-Ztg.*, 1952, 76, 264-266.

German kaolins vary greatly in degree of thixotropy, thus the kaolin from Ehrenfeld is highly thixotropic and that from Hirschau hardly at all. No satisfactory explanation is given.

R.H.S.R.