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New Members

J. N. Counsell, 11 Sylvia Avenue, Westheath, Birmingham 31. Interests : Fats and foodstuffs generally.

K. Hill, The Yorkshire Copper Works Co. Ltd., P.O. Box 166, Pontefract Road, Stourton, near Leeds. Interests : Non-ferrous metals and thermoplastic materials for tubes.

H. G. Muller, Symbol Biscuits Ltd., Devonshire Road, Blackpool. Interests : Cereal products.

News of Members.

Dr. L. R. G. Treloar has been elected to the Board of the Institute of Physics.

We regret to announce the death of Mr. F. Taylor, a member since 1948.

Future Meetings of the Society.

Conference on Elastomers. This will be held at the British Rubber Producers' Research Association, Welwyn Garden City, on May 29th, 30th and 31st, 1957. Below is given a tentative list of papers to be given at the conference. An opportunity will probably be available to visit the Åkers Research Laboratory of I.C.I. at Welwyn and the I.C.I. Plastics Laboratory at Welwyn Garden City. The proceedings of the conference will be published in book form.

Dr. L. R. G. Treloar—The Present Status of the Theory of Large Elastic Deformations.

Mr. P. Thirion—Thermodynamics of Rubber in Extension : a Study of the Relation between Tension and Temperature at Equilibrium.

Dr. D. W. Saunders—The Photo-Elastic Properties of Rubber-Like Polymers.

Mr. A. G. Ward—A Note on the Elasticity of Gelatin Gels.

Dr. H. W. Greensmith—The Tearing of Rubber.

Mr. A. R. Payne—Temperature Frequency Relationships of Dielectrical and Mechanical Properties of Polymers.

Dr. A. S. L. Lodge—A Theory of Elastic Recovery in Concentrated Solutions of Elastomers.

Prof. G. Gee, Dr. G. Allen and Mr. B. E. Read—An Experimental Study of Stress Relaxation and Viscous Flow in Natural Rubber.

- Dr. J. Scanlan—A Network Theory for Stress-Relaxation and Set in Rubber.
 Mr. J. J. Benbow—The Recovery Behaviour of Polythene at High Strains.
 Dr. P. Clegg—Elastic Effects in the Extrusion of Polythene.
 Dr. E. L. Foster and Mr. H. Heap—High Temperature Tensometry and its Application to Amorphous Polyethylene Terephthalate.
 Dr. A. Charlesby, Miss J. Burrows and Mr. T. Bain—Filler Action on the Radiation Cure of Rubber.

The September Conference and Annual General Meeting will be held at Swansea. The subject proposed is "Rheology of Dispersed Systems."

The Third International Rheology Congress will be held in Germany in 1958. Further information will be given when available.

J. Pryce-Jones.

J. Pryce-Jones was an active member of the Society from the beginning until his death last year. He contributed papers on several occasions, shared in the numerous discussions of the "Club" and exhibited frequently before it several viscometers of his own design, his twin Couette viscometer being particularly interesting and important. With these instruments he studied the properties of dispersions and was the first to attach a definite meaning to the term "false body."

He was, I think, the first to give an account of the elastic effect now known as the Weissenberg effect (in fun he called it his Mae West effect), and he was certainly the first to demonstrate elastic recoil in certain honeys. Although his interest in rheology was of a general character his publications deal mainly with thixotropy, especially in connection with honey and it is indeed his very valuable honey work by which most people knew him. He collected honey samples from all over the world and his rheological methods for testing honeys have become of considerable practical importance.

The following are some of his publications on honey:

1936, *Bee World*. "Thixotropy and Elastic Recoil in Heather Honey.

1944, *Proc. Linnean Soc.* **155** pt. 2, 129. "Some Problems associated with Nectar Pollen and Honey."

1950 and 1952, *Bee World*. **55**, 2 and **33** (9) 147. "Stringiness in Honey and in Sugar Syrup."

1953. *The Rheology of Honey*. Chapter VI from *Foodstuffs, their plasticity, etc.*, edited by G. W. Scott-Blair.

This valuable rheological work constituted his hobby but his enthusiasm was extended to his industrial work at Reckitts on the properties of dispersions, familiar materials such as paints, oil emulsions, furniture creams, etc.

In 1934 Pryce-Jones designed an electro-magnetic thixotrometer by which he studied hysteresis and elastic recoil phenomena. In one type of rotary viscometer he constructed, the rate of shear and the length of torsion wire could be altered in three stages so that the effective lengths of wire were inversely in the same ratios as the three rates of revolution.

Using this instrument he was able to classify dispersions according to their apparent viscosity at different rates of shear.

Pryce-Jones distinguished between various classes of non-Newtonian flow of dispersions in his instruments. In one class, for example, he observed decreases in apparent viscosity with rate of shear which decreases were independent of time. This he regarded as the criterion of simple anomalous viscosity. In another class the viscosities, immediately after stirring, although practically independent of the rate of shear, increased when the dispersion was left to rest and equilibrium was again restored with further stirring;

this he considered was in accord with the definition of ideal thixotropy as originally formulated by Freundlich and Peterfi. In another class which was by far the most prevalent in materials such as paints, it was observed that anomalous viscosity was present after stirring had ceased and the viscosity rapidly increased on resting for a short while although the rate of increase did not continue with increasing intervals of rest. This behaviour he attributed to "false body" due to the partial dispersion of a flocculated gel under the influence of shear and the rapid re-formation of the gel on the removal of shear. In a study of over 500 paints after they had been aged over a period of several months he distinguished between four classes of flow behaviour. Some systems showed absence of thixotropy, a condition leading to hard settlement. Others showed slight thixotropy while with others there was marked thixotropy; some of the "false body" type gave settlements which could easily be redispersed.

He distinguished between the following five stages in dispersion:—anomalous viscosity, "false body," thixotropy, dilatancy and Newtonian flow. An account of these researches is given in the *Journal of the Oil and Colour Chemists' Association* for the years 1934, 1936 and 1943, in the *J. Sci. Instr.*, 1941 **18**, 39 and in the *Proc. Univ. of Durham Phil. Soc.*, 1948.

Looking through correspondence from Pryce-Jones of some ten years ago, I find we had several ideas in common. It is apparent that the behaviour of a dispersion is strongly influenced by flocculation, even though of an incipient character, the flocculation being in some way closely connected with the lack of wetting action. He demonstrated how the character of a dispersion could be remarkably changed by replacing a lyophilic film on the dispersed particle by a lyophobic one and vice versa.

In a joint meeting of the Society with the Newcastle-upon-Tyne section of the Society of Chemical Industry, October, 1947, Pryce-Jones spoke "On the Rheological State as a Criterion of Dispersion," when he enlarged on the view that the flow of a dispersion is fundamentally dependent on the dispersion coefficient of the medium. This dispersion coefficient or "dispersive power" is closely associated with the wettability of the dispersed phase by the medium and at a meeting of the Society, jointly with the Faraday Society, in the rooms of the Royal Society of Arts on the subject of "Dilatancy and Thixotropy," the discussion centred on means of determining wettability.

Pryce-Jones gave instances of suspensions altering their flow behaviour when a small quantity of an additive which affected wetting was introduced into the system and Prof. D. H. Bangham spoke on two properties of solid/liquid interfaces, namely, the heat of wetting and equilibrium contact angles, pointing out differences between these two criteria of wettability. During the past ten years the Society has devoted many sessions to the subject of dispersions particularly at the Washington Singer laboratories of the University of Exeter where special attention was given to the physics and chemistry of surfaces.

One important and interesting conclusion from these meetings is that the thixotropic and other rheological properties of a dispersion can apparently shed more light on the problem of the wettability of the dispersed solid by the liquid medium than do the measurements of contact angles, heats of immersion, rate of spreading, adhesion tensions, etc. and we are indebted to Pryce-Jones for his intuition derived from his wide experimental investigations. It is interesting to recall Lord Rayleigh's statement (collected researches) regarding equilibrium contact angles that "no such equilibrium and no such triangle is possible" and Sir Eric Rideal's conclusion that recorded contact angles are probably fictitious since they are measured so far away from the actual surface. Recent work by Hirst indicated that any value for wetting based on the Young-Dupre equation modified by Harkins does not lead to any useful practical results so in view of these uncertainties it is well worth while developing the rheological approach to the problem of determining the rate and degree of wettability of a solid by a liquid.

E. W. J. MARDLES.

RHEOLOGICAL CONTROL OF INDUSTRIAL PROCESSES

The Conference on the Rheological Control of Industrial Processes held at the Institute of Physics in London on December 7th, 1956, was attended by about eighty members and friends. It appeared from the discussion that rheological control in industry is at present exercised in two ways; (a) by withdrawing a sample of material from a process and subsequently measuring some rheological property of the sample, and (b) by continuously measuring a rheological characteristic of the material at some stage of the process by instruments installed permanently on the plant. This information is then used to control the process manually or automatically.

With both methods the property measured could either be a property like viscosity at a given rate of shear, or alternatively a complex property which may not be easily related to absolute terms but which is correlated with industrially important characteristics of the material being processed.

An additional summary of a paper presented at the conference is given below.

Continuous Viscosity Measurement using an Ultrasonic Viscometer,

T. RYBAK of Elliott Brothers (London) Ltd.

The basic Ultra-Viscoson System comprises an electronic computer, a sensing probe, and a connecting cable. The probe itself consists of a thin strip of magneto-strictive alloy which forms the end of the barrel. The computer induces short pulses of current in the coil located within the probe barrel thus setting the strip into longitudinal vibrations with a node at its centre, and antinodes at its end. The actual frequency of the vibrations is 28 kc/s and the maximum longitudinal movement of the strip at its tip is approximately $\frac{1}{2}$ micron. When the probe is immersed in a liquid the layers of the liquid slip back and forth over one another in a shearing motion at an ultrasonic frequency and thus produce a damping effect.

When the amplitude of the oscillation decays to 1/500th of the original value, the computer transmits another pulse to initiate another wave train. The repetition rate of these wave trains is about 50/second when the blade is in air, and approximately 5000/second when the blade is immersed in a fluid whose viscosity is equivalent to the maximum range of the computer.

The probes can be used for direct installation in pipe lines, kettles, etc., or laboratory glassware.

The computer is an electronic analogue computer comprising a variable frequency pulse generator, an A.C. amplifier, rectifier, an integrator, a D.C. amplifier, and an indicator. The standard computer has a range switch which allows selection of 0-50 or 0-500, 0-5,000 and 0-50,000 centipoises $\times$ density for full scale reading. Electrical and mechanical zero adjustment facilities are provided as well as calibration controls which allow the instrument to be calibrated with fluids of known viscosity. A variable output control is provided so that a full scale voltage of 0-50 mV can be obtained for operating potentiometric recorders and/or controllers. The instrument can be provided with an automatic temperature compensation unit.

Multiprobe systems are also available for any number of probes up to 6, having individual calibration and viscosity selection controls. This permits different probes in the system to be used with fluids of widely different viscosities.

Other features can be summed up as follows:—

1. Probe hermetically sealed.
2. Operating temperature: -190° to $+650^{\circ}\text{F}$.
3. Operating pressure up to 1000 p.s.i.
4. Standard range up to 50,000, special up to 500,000 centipoises $\times$ density.
5. Probe can be separated from the computer by up to a mile.

6. Accuracy : $\pm 2\%$ on Newtonian fluids up to 2,000 centipoises $\times$ density and $\pm 5\%$ above.
7. Reproducibility : $\pm 2\%$ on all ranges.
8. Response time : less than one second.
9. Continuous operation.
10. Probe manufactured in stainless steel for corrosion resistance.

The Ultra-Viscoson system has been used successfully in numerous scientific and industrial applications. Examples of industrial use include the control of the viscosity of adhesive coatings, of the viscosity of fuel oil at burner nozzles, of the colour shade of gravure inks by maintaining the viscosity of the printing ink at a constant value, and determination of polymerization end points in resin production. Due to its rapid response and convenience of inserting the probe in any part of a plant the Ultra-Viscoson is particularly useful for automatic processes incorporating closed loop control.

The standard instrument gives readings in centipoises $\times$ density.

With materials of non-Newtonian behaviour the Ultra-Viscoson is sensitive to both viscosity and shear rigidity. By including sensitivity to shear rigidity in the design of the instrument, the Ultra-Viscoson has been able to control the quality of many materials more accurately than was hitherto possible. The Ultra-Viscoson is affected by shear rigidity in large samples when it exceeds 10^6 dynes. cm^{-2} , but it is frequently able to measure lower values when used with small samples of materials.

SUMMARY OF PAPER

Read by Dr. G. F. Eveson of the University, Birmingham, at a joint meeting of the Society with the Hull Section of O.C.C.A., January, 1957.

An Investigation of the Rheological Properties of Stable Suspensions of Sub-sieve Size Spheres at Low Rates of Shear.

A rotational viscometer is used to investigate, at rates of shear between 0.05 and 1.10 sec^{-1} , the rheological properties of stable suspensions of nine sized fractions of spheres, eight of these fractions being in the sub-sieve size range. It is shown that non-Newtonian behaviour is associated with incomplete dispersion of the particles and that a lattice-work structure of flocculated particles forms within a non-Newtonian suspension when it is allowed to remain undisturbed. There is evidence that the degree of compaction and of continuity of this structure decreases, and that the time required for the structure to reform after shearing increases, as the degree of dispersion of the particles is increased. Controlled increase of the degree of dispersion enables a number of rheological states to be produced for a given concentration of solids, culminating in a Newtonian system of completely dispersed particles.

It is suggested that, for a given zeta potential, flocculation will occur if the average distance between sphere surfaces is less than a critical value. This critical distance decreases with increase in zeta potential and appears to be of major importance in the mechanism of flocculation. Results of attempts to evaluate the degree of dispersion of particles by measuring the electrical conductivity of the suspension are inconclusive. Methods are suggested for detecting the onset of flocculation and for investigating the mechanism of flocculation.

The relative viscosity of Newtonian stable suspensions of spheres is independent of mean particle diameter for spheres sized above about 15μ but, for finer particles, increases with decreasing mean diameter. There is no conclusive evidence that relative viscosity increases with decreasing size ratio.

RHEOLOGY ABSTRACTS

3429. Effect of Strain Rate on the Propagation of a Plastic Strain Pulse along a Lead Bar.

B. E. K. ALTER and C. W. CURTIS. *J. appl. Phys.*, 1956, 27, 1079.

By using a double pressure step technique, it was shown that the dispersion of pulses cannot be due solely to the nonlinearity of a time-independent stress-strain relation. On the other hand even a very simple model of a metal exhibiting a strain-rate effect serves to predict qualitatively all of the main features of the experimental observations. A.

3430. Effect of Pressure on Glass Structure.

O. L. ANDERSON, *J. appl. Phys.*, 1956, 27, 943.

The effect of pressure is to change the amount of skewness and therefore the average bond length which determines the density. Two kinds of persisting density changes are found. One is reversible and is called densification, and the other is irreversible and is called compaction. A.

3431. Potentialities of Viscosity Control.

W. BARKER, *Brit. Chem. Engng.*, 1956, 1, 16.

The metering-tube controls the viscosity of varnish. Liquid is supplied to the tube at a constant rate by a rotary pump; pressure taps on each end of the tube are connected to a pneumatic differential pressure transmitter, producing an air pressure which varies linearly with viscosity. The oil viscometer developed by Elliott Bros. (Lond.) Ltd. provides a hydraulic pressure output which bears a linear relationship to changes in viscosity. The principle is that the pressure drop across the capillary groove is directly proportional to the kinematic viscosity if the flow is constant; the flow through a sharp-edged orifice is only dependent on the upstream pressure head. A continuous sample is delivered at about 115 lb/in²/g. The downward spring thrust balances the upward force due to oil pressure under the plunger. The Norcross viscometer depends on measuring the time of fall of a plummet which is enclosed in a long tube fixed into the top of the processing vessel. The bottom of the tube must be immersed 12-14 in. in the material and the plummet completely submerged the total distance of its movement. The material being measured flows slowly through holes in the tube to give a representative sample. A motor-driven cam raises the plummet and releases it to fall through the material. The time required is recorded every 3 min. on a dial. The ultrasonic viscometer permits a full-scale reading of 50, 500, 5000, or 50,000 centipoise $\times$ g/c.c. A variable output control is provided so that a full-scale output up to 0-50 mV may be obtained for use with a standard electronic potentiometer record/controller. Full-scale accuracy of the system is $\pm 2\%$. A.

3432. Some Questions concerning the Surface Friction of Synthetic Rubbers.

G. M. BARTENEV, *Koll. Zh.*, 1956, 18 (5) 626 (Discussion).

Gives curves for static and dynamic friction against steel and glass and for frictional constants versus temperature. In some cases $\ln$ (frictional force) is linear with reciprocal temperatures.

Discusses power-law modifications of Amontons' law proposed by Deryagin and by Ratner (see Abstr. 3338). G.W.S.B.

3433. The Creep Properties of Paper.

J. P. BREZINSKI, *Tappi*, 1956, 39, 116.

The creep-time curve is in accord with the equation :

$$y/L_0 = Bt^a + C$$

where y is the total first creep. L_0 the initial length of the test piece, t the time, while a , B and C are constants. A.

3434. Kinematographic Study of Tensile Fracture in Polymers.

A. M. BUECHE and A. V. WHITE, *J. appl. Phys.*, 1956, **27**, 980.

High-speed motion pictures were taken of silicone rubber, irradiated polyethylene, Plexiglas II, and aluminium foil while they were being broken. Fractures started internally in some of the silicone samples but at the edges of all of the others. The velocities with which the cracks grew were compared with the results of the theories of Poncelet, Yoffe, Mott, and Roberts and Wells. Their prediction, that the velocities should be about one half those of transverse waves in the media, was found to represent the data for materials with moduli differing by five decades. After fracture, the ends of the rubber samples contracted with velocities approximately equal to the velocities of longitudinal waves in these samples. A.

3435. Retarded Deformations in Concrete.

Z. BYCHAWSKI, *Archivum Inzynierii Ladowej*, 1956, **2**, (1-2), 185. In Polish.

On the basis of experimental results the creep of concrete is discussed, and the theory of creep is used to determine the relaxation of stress in cables embedded in post-tensioned beams. The phenomenological part of the theory is based on simple rheological models. P.F.

3436. Dynamic Properties of Various Rubbers at High Frequencies.

J. R. CUNNINGHAM and D. G. IVEY, *J. appl. Phys.*, 1956, **27**, 967.

3437. The Temperature Variation of the Static and Dynamic Test Measurements of Vulcanized Rubber and other High Polymers.

R. ECKER, *Kautschuk U. Gummi*, 1956, **9**, 31.

The temperature range was from -60 to $+140^{\circ}\text{C}$. A.

3438. Relationships between the Surface Tension, Viscosity and Density of some three-component fusions of Refractory Oxides.

E. V. ERMOLAEVA, *Ogneupory*, 1955, **20**, 221.

Surface tension, density and viscosity of fusions in the systems $\text{MgO-Al}_2\text{O}_3\text{-SiO}_2$, $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2$, CaO-MgO-SiO_2 , and $\text{CaO-MgO-Al}_2\text{O}_3$ were investigated. The general conclusion is that the surface tension of 3-component fusions in equilibrium increases as one oxide replaces another in the order: SiO_2 , CaO , MgO , Al_2O_3 . The density of fusions increases with decreasing SiO_2 content. The viscosity changes with composition much more markedly than density and surface tension. The dependence of viscosity on the temperature and concentration along the monovariant curves is preserved very exactly, although in the systems investigated the viscosities are very different along different monovariant curves. A.

3439. Determination of the Rheological Properties of Clay Suspensions under Conditions of Steady Flow.

B. S. FILOMOV, *Colloid J., Voronezh*, 1954, **16**, 141.

In order to explain the form of the rectilinear portion of the viscometric curves obtained for clay suspensions, and the connection between the structural or plastic viscosity and the dynamic specific shearing-stress and the velocity gradient of shear, it is essential to give up the idea of the so-called "thixotropic," "vestigial" and other such structures, regarded as existing during stationary motion and progressively breaking down as the velocity of shear increases. The above phenomena can be explained from the experimental fact of the laminar structure of the moving suspension and the influence of the motion of the surrounding liquid on the micelles. The magnitude of the forces of resistance to motion is determined by factors other than the stability of the coagulation, thixotropic structure, and may be either greater or less than this. Viscometric

methods based on the measurement of rheological properties in the static condition, or under conditions of non-stationary shear, are inapplicable to the evaluation of these forces. The forces of resistance to motion in a current of clay suspension which has attained the laminar structure, whether viscous or plastic, depend on the maximum gradient of the velocity of shear to which the system has been subjected, and on the duration of this gradient. The values of τ_0 obtained with large gradients may be significantly greater, and those of η significantly less, than those obtained with small gradients. These magnitudes remain unchanged when the motion is continued with smaller shear gradients. The structure of viscometers for the measurement of the structural viscosity and the dynamic shearing-stress in the technical calculation of the motion of clay and similar suspensions, and the methods of their use, should conform to the following requirements: (1) the system when first investigated should be subjected to homogeneous stress for a period long enough to stabilize it under shear gradients corresponding to those arising in the instrument; (2) by the subsequent reduction of the velocity of shear without stopping the motion, pairs of figures for the speed of shear and the corresponding force of resistance can be obtained. A.

3440. The Creep of Cadmium Crystals at Liquid Helium Temperatures.

J. W. GLEN, *Phil. Mag. (Ser. 8)*, 1956, 1, 400.

Experiments on single crystals of cadmium at temperatures between 1.2° and 4.2°K have shown that measurable transient creep occurs, and that the amount of such creep does not fall off rapidly with decreasing temperature. It is suggested that this creep is due to the quantum mechanical tunnel effect, which allows dislocations to penetrate barriers to their motion that cannot be overcome by the action of the applied stress alone. A.

3441. Instrument for Measuring Workability of Clay-Water Systems.

H. H. GREGER and M. BERG, *J. Amer. Ceram. Soc.*, 1956, 39, 98.

A rotational viscometer has been developed that has proved satisfactory for determining the viscous flow properties of several clay-water systems in the complete range from fluid slips to thick pastes. Yield-point measurements also can be obtained with it by determining the torsion remaining after the clay has been sheared. A.

3442. Indentation Hardness of Diamond.

P. GRODZINSKI, *Nature*, 1956, 177, 1228.

A plot is made for average pressures and maximum pressures in various reported experiments on indentation hardness testing of diamond, using various diamond indenters. Average pressures with triangular and elongated pyramids are high, but with spheres and double cones relatively low. The observed differences are accounted for. In the one case there is a plastic flow at shear stress, in the other elastic deformation precedes fracture. A.

3443. Observations on the Theory of Plasticity.

E. GRUNER, *Ziegelindustrie*, 1955, 8, 881.

In solid/liquid systems, plasticity is said to be of three types: (1) True plasticity, as a result of a surface reaction between the solid and the liquid phase. It is "good" or "bad" according to the nature of the sorption. (2) Conditioned plasticity as a result of processes or admixtures which intensify or initiate surface reactions. Both can be produced by chemical activation of the crystal surface (e.g. oxy-chloride formation) by cation adsorption or by the adsorption of polar, hydrophilic colloids (e.g. humus). (3) Simulated plasticity, as a result of the insertion of solid particles of any size in highly viscous or adhesive liquids or gels. A.

3444. Definition and measurement of Instantaneous Viscosity.

R. GUY, *Silicates industr.*, 1956, 21, 69.

Relates to the measurement of the high-temperature properties of glass fibres of small diameter. The method was based on the study of the temperature at which a glass fibre, 8–10 μ dia. subjected for a given time (the shortest possible) to abrupt heating, breaks due to softening under a given load. This defines a point of instantaneous viscosity of the glass comparable with the points of viscosity obtained by the classical methods. Two fibres were studied: one that had been rapidly cooled and one that had been more slowly reheated. This method shows a significant lowering of the viscosity of glasses solidified abruptly, in the temperature range corresponding to $c. 10^{6.5}$ poises. The more abrupt the solidification the more marked the lowering of the viscosity. It reaches and exceeds 50°C. for the glasses solidified most abruptly, without the composition appearing to have an effect other than on the viscosity. The relaxation limit of the solidification state around $10^{6.5}$ poises required a time of several seconds. The higher the temperature of solidification of the glass, the higher the degree of network formation in the glass. A.

3445. An Investigation into the Variation of the Viscosity of a Suspension with its Concentration.

E. H. HARBARD, *Chem. & Ind.*, 1956, 22, 491.

The proposed relationship is based on the idea of the "free" liquid fraction of a suspension. A simpler correlation was found between the relative plastic viscosity of a suspension and its "free" liquid content; the equation appears to cover the whole range from the pure liquid to thick pastes, the main difficulties in measuring the viscosity of the very thick suspensions being the occurrence of thixotropy and the problems connected with the maintenance of high shear rates. A.

3446. The Flow of Polyvinylchloride under the effect of Strong Forces.

V. A. KARGIN and T. I. SOGOLOVA, *Dokl. Akad. Nauk SSSR.*, 1956, 108, 662.

Heat treatment of polyvinylchloride results in the formation of a net of crosslinks between chain molecules, as revealed by diminishing solubility and increase in work hardening which brings flow under constant stress to a standstill. The same material behaves in the process of rolling like a highly viscous fluid and rolled polyvinylchloride retains part of its solubility. It is concluded that the spontaneous formation of crosslinks is partly counteracted by the high stresses associated with the process of rolling so that existing links are broken. A.

3447. The Mechanical and Rheological Properties of Bitumen.

O. KIRSCHMER, *Bitumen*, 1956, 28, 86.

A survey of the work of Saal, van der Poel, Nijober, Prandtl, Seegers, Nüssel, Umstatter, Schültz-Grunow and others, A.

3448. The Dynamic-Elastic Behaviour of High Polymers.

J. KOPPELMANN, *Kolloid-Z.*, 1955, 144, 12.

3449. The Effective Viscosity of Suspensions of Spherical Particles.

G. J. KYNCH, *Proc. Roy. Soc. A.*, 1956, 237, 90.

A method has been devised for solving the hydrodynamic problem involving swarms of particles moving in an incompressible fluid, assuming that the inertia terms in the equation of motion can be neglected. The mathematical treatment involves the calculation of the potential due to point charges amongst a collection of earthed conducting spheres, coinciding with the particles. A.

3450. The Theory of Bending of a Statically Determinate Reinforced Concrete Beam.

J. LEMPICKI, *Archivum Inzynierii Ladowej*, 1956, 2, (3), 205. (In Polish). P.F.

3451. Viscosity of Clay Suspensions in the Presence of Polyanionic Flocculants.

T. L. MACKAY, I. B. CUTLER and M. E. WADSWORTH, *Bull. Amer. ceram. Soc.*, 1956, 35, 11.

Inorganic polyvalent ions have been employed as aids to flocculation of mineral suspensions for many years. Recent developments in the use of polyvalent organic electrolytes indicate superior properties of the organic materials compared to their inorganic predecessors. As part of an investigation of the properties of organic polyelectrolytes this paper describes the effect that various organic and inorganic electrolytes have on the viscosity of kaolinite suspension. Viscosities were determined at several concentrations of electrolytes and at different pH concentrations. Evidence is presented for the increased density of flocs formed with the aid of organic polyelectrolytes compared with inorganic electrolytes.

3452. A Study of the Elastic and Visco-Plastic Properties of Black Printing Inks.

T. N. MALOVA, *Koll. Zh.*, 1956, 18, (4) 438.

Relationships are established between behaviour in printing and rheological curves.
G.W.S.B.

3453. Dynamic Creep of Plastics.

J. MARIN and W. J. SCHUMAN, *S.P.E.J.*, 1955, 11, 18.

A theory is presented for predicting creep in the case of fluctuating stress based upon an assumed creep-stress-time relation for simple static tension. The condition of dynamic stress considered is that of a completely reversed axial stress superimposed on a static axial tensile stress. A.

3454. The Dynamic-Mechanical Properties of Kautschuk Mixtures.

S. DE MEIJ and G. J. VAN AMERONGEN, *Kautschu u Gummi.*, 1956, 9, 56.

3455. Experiments on the Investigation of the Fracture of NaCl Crystals.

N. M. MELANKHOLIN and V. R. REGEL', *Zh. ékspér. toer. Fiz.*, 1955, 29, 817

Development of cracks during the stretching of specimens of NaCl monocrystals was studied by the method of cinematography in polarized light. It was shown that the cracks spread intermittently. The development of the cracks is prevented by shearing bands which they have to cross. It is assumed that the propagation of the cracks is prevented by the regions of shearing bands in which compression stresses are present. The regions of shearing bands with stretching stresses apparently do not prevent their development. A.

3456. Theory of the Non-Newtonian Rheology of Raw Rubbers consisting of Supermolecular Rheological Units.

M. MOONEY, *J. appl. Phys.*, 1956, 27, 691.

A theory is developed on the postulate that raw rubbers, when subjected to continuous shear in the non-Newtonian region of flow, consist of microscopic rheological units which are semipermanent aggregates of many rubber molecules. The new theory leads to expressions for the number of temporary point attachments per unit area between two touching rheological units and for the mean life of these attachments. A.

3457. The Consistency of Ceramic Slips. A new Rotational Viscometer and some Preliminary Results.

F. MOORE and L. J. DAVIES, *Trans. Brit. Ceram. Soc.*, 1956, **55**, 313.

Ceramic slips can provide examples of a large number of rheological types, including plastic, pseudoplastic, dilatant, thixotropic, negatively thixotropic, and various combinations of these basic types. A satisfactory comparison of the flow properties of different slips can only be made if measurements are taken over a wide range of shearing conditions. A.

3458. Creep in Metal Crystals at very Low Temperatures.

N. F. MOTT, *Phil. Mag. (Ser. 8)*, 1956, **1**, 568.

A theory is given of creep in metallic single crystals at very low temperatures, which is based on the hypothesis that dislocations can pass through barriers, such as those provided by dislocations crossing the slip plane, owing to the quantum-mechanical tunnel effect. A detailed theory would depend on a knowledge of the atomic arrangements at the centre of a dislocation, which in this case does not exist, but a rough calculation shows that creep should be independent of temperature below about 10°K in cadmium. A.

3459. The Limit State Method of Dimensioning Steel Structures taking into consideration Shear Stresses and Deformations.

J. MUTERMILCH, E. OLSZEWSKI and M. LUBINSKI, *Archiwum Inżynierii Ladowej*, 1956, **2**, (1-2), 15. (In Polish.) P.F.

3460. The Internal Friction of Cold Worked Copper at Low Temperatures.

D. H. NIBLETT and J. WILKS, *Phil. Mag. (Ser. 8)*, 1956, **1**, 415.

The internal friction was measured by resonating the bars electrostatically in a transverse mode (~ 1100 c/s) and observing the decay of oscillations. Two peaks were revealed in the plot of internal friction v. temperature and they are considered to be of the type associated with a relaxation phenomena, such as the motion of a segment of a dislocation line. A.

3461. Application of the Laplace Transform to Problems of Torsion of Thin-Walled Tubes.

J. NOVINSKI, *Archiwum Mechaniki Stosowanej*, 1956, **8**, (1), 111. (In Polish.) P.F.

3462. Thick-Walled Elasto-Plastic Spherical Shell of Non-Homogeneous Material Subjected to Internal and External Pressure.

W. OLSZAK and W. URBANOVSKI, *Rozprawy Inżynierskie*, 1956, **4**, (1), 23. (In Polish.) P.F.

3463. Yield Stress of Clay-Water Systems.

A. PACKTER, *Nature*, 1956, **177**, 144.

The rheological properties of sols prepared from American, English and Mediterranean Na and Na-Ca montmorillonites, and kaolinites, under different experimental conditions were investigated. Yield stress was plotted in terms of the variation of specific viscosity. Heterocoagulation can be eliminated by heat treatment or by addition of certain anions that are strongly adsorbed on the positively charged edges of the clay platelets. Addition of electrolytes such as NaCl, CaCl₂ or AlCl₃ to presolvated Na montmorillonite sols leads to rapid coagulation beyond some specific minimum electrolyte concentration, and results in a changeover from the "house of cards" structure to an edge-to-edge association of clay platelets. Specific viscosity is reduced in the former systems owing to the fall in the value of intrinsic viscosity; but enhanced dissymmetry resulting in the latter system leads to a marked overall rise in both specific viscosity and yield-strength. Similar results have been obtained with suspensions of the non-swelling Ca montmorillonites and kaolins. A.

3464. The Rheology of Margarine and Compound Cooking Fat.

II. Instrumental and Subjective Measurements on Compound Fat.

J. H. PRENTICE, *Brit. Food Manuf. Ind. Res. Ass. Res. Rep.* 69, 1956 (released).

An extension of earlier co-operative work between the B.F.M.I.R.A. and the Nat. Inst. for Res. in Dairying (see Abstrs. 2845, 2846). Seven rheological instruments were used, two of which are new. Seven varieties of fat were tested at temps. 45–65°F. Flavour, firmness, spreadability and texture were assessed subjectively by a panel. Correlation coefficients were calculated between all the 136 pairs of 17 tests and factor-analysed. Some of the relationships were curvilinear and were improved by log. plotting. Five orthogonal factors were derived, of which the three most important were identified with consistency, structure (lack of false-body) and springiness (in order of importance).

Assessments of flavour and texture were mainly "specific," i.e. independent of the common factors and orthogonal to one another. Spreadability and firmness are highly correlated with one another and with data from the sectilometer and extrusion viscometer. Of the seven instruments described, these two give the highest reliability and reproducibility. The correlation between them is .94. G.W.S.B.

3465. Experimental Study of Elastic Creep in Metal Wires.

C. SĂLCEANU and M. ZAGĂNESCU, *C. R. Acad. Sci. (Paris)*, 1956, **242**, 2285.

The angle of twist is observed, as a function of time, in a wire recovering freely after being held at a constant torsional deformation. The characteristic creep function (defined so as to decrease from 1 to 0) is found to be a linear function of log (time) in Ag and Ni; the creep functions for Cu and Fe are represented graphically. A.

3466. Dependence of Flow-Curves and Viscous Properties of Bitumen on Temperature.

S. YA SHAL'YT and N. V. MIKHAĬLOV, *Koll. Zh.*, 1956, **18**, (5) 609.

For temperature range ~42–140°C, $-d \ln \eta/dT = K$ is constant. At higher and lower temperatures, K changes. η is independent of shear rate up to a critical value which depends on temperature. Above this rate, η falls steeply. At lower temperatures, (65–75°C), flow curves, clearly showing the Ostwald "Laminarast," are given. G.W.S.B.

3467. Studies on Clay-Water System. XV. Plastic Deformation of nearly dry Clay, and its relation to the Water Content.

Y. SHIRAKI and Y. FUKUURA, *J. ceram. Ass. Japan*, 1955, **36**, 527. (In Japanese).

A method for determining the strength and elasticity of clay bars is given. The moisture content at which a plastic body becomes elastic was determined. Both strength and elasticity of nearly dry clay are important for handling the clay body under working conditions. The theoretical considerations are also discussed for the flow of a nearly dry clay body. A.

3468. The Plasticity of Ceramic Bodies.

SOCIÉTÉ FRANÇAIS DE CÉRAMIQUE, *Industr. céram.*, 1955, No. 465, 141.

Known methods and apparatus for determining the relation between force and (1) deformation, (2) deformation rate or (3) rupture are reviewed. Norton's method was adopted for tests carried out on the plastic behaviour of 4 French kaolins as a function of the water content, method of preparation, etc., The behaviour of an earthenware body (composition given) was studied as a function of body preparation, period of storage of the body, shaping with and without vacuum, and moisture content. It is claimed that extrusion under vacuum of a freshly made body will give it the same plasticity that it has when prepared by filter pressing or by wetting and kneading. The effects of ageing and vacuum are complementary, so that there is little point in de-airing an aged body. In all cases the improvement is always greater in bodies with a low moisture content. A.