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RHEOLOGY OF DISPERSE SYSTEMS

7s.

RHEOLOGISTS from Holland, Germany, Israel, Canada and New Zealand were among nearly a hundred who met during September 19-21 to discuss the flow properties of dispersions at the Annual Conference of the British Society of Rheology, held this year in the University College of Swansea.

In his presidential address to the Society, under the title "Complicated Rheological Properties", Prof. J. G. Oldroyd developed the thesis that even the simplest dispersions cannot, from their very nature, exhibit anything like simple rheological behaviour. Any system in which one component has viscosity and another has some degree of elasticity of shape must show a combination of viscous and elastic effects when subjected to a variable shear stress; this must apply whether the system as a whole is solid or fluid. Precise calculations have been made of the type of the response to small variable shear stresses to be expected in disperse systems containing two components, at infinite dilution of one component in the other, in terms of arbitrary elastico-viscous or visco-elastic properties at small shear stresses assumed for the two components separately. Even a simple emulsion of one Newtonian liquid in another, the two liquids being immiscible with a constant interfacial tension between them—physically the simplest dispersion of all—is necessarily elastico-viscous and is characterized by a single relaxation time and a single retardation time in addition to a viscosity constant. The restoring force providing the elasticity of shape is in this case the interfacial tension.

Turning to the more general flow of a liquid dispersion with rates of strain not necessarily small, Prof. Oldroyd showed that the equations of state of any system which at small rates is elastico-viscous cannot possibly be linear in the stresses and velocity gradients. No equations in which product terms are entirely absent could possibly be physically significant as equations of state of general validity, since linear equations, of necessity, imply modes of behaviour dependent on the (physically irrelevant) relative motion of the material and the co-ordinate system one happens to be using. It follows that even the simplest liquid disperse systems must be expected to show cross-viscosity effects—in particular, normal stresses, different in different directions, are called

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into play by a steady simple shearing motion at a finite rate. Associated with these effects are the Weissenberg climbing effects, in a positive or negative sense, or the variation of the viscosity with the rate of shear in steady shearing flow, or both these features.

The idealized systems which the applied mathematician finds amenable to exact theoretical analysis are necessarily some of the most difficult in which to detect non-Newtonian behaviour experimentally, because of the small magnitude of the predicted departures from Newtonian flow at small concentrations of the disperse phase. Prof. Oldroyd submitted, however, that real suspensions and emulsions could scarcely be expected to be simpler in their rheological behaviour than the mathematician's idealized models, so that all the above-mentioned non-Newtonian effects should be looked for in real dispersions; there, they will not always be small. Some of the experimental papers which followed bore out this contention that real dispersions have, indeed, complicated rheological properties.

Recent careful experimental work on dilute suspensions of solid and liquid spheres in golden syrup and other liquids was described by Dr. S. G. Mason (Pulp and Paper Research Institute of Canada, and McGill University). The motion of individual suspended particles and the internal circulation in suspended droplets have been observed under the microscope at the same time as viscosity measurements were being made in a Couette instrument. Evidence for the existence of a visco-elastic film of emulsifier at the interfaces in an emulsion has been collected by Dr. Mason, W. Bartok and M. A. Nawab, from both viscosity and internal circulation measurements; the results are in good agreement with the theoretical formulæ of Einstein, Taylor and Oldroyd, and there is a clear gradation of the skin effects with concentration of emulsifier. A study has been made of the change of shape of droplets at finite rates of shear and of the formation of doublets—complications usually ignored in theoretical treatments.

Dr. R. L. Whitmore (University of Nottingham) directed attention to some quite unexpected effects in the flow of a suspension in a narrow tube. The average speed of travel of the suspended particles exceeds the average speed of travel of the suspension as a whole, whenever the radii of the typical particle and of the tube are comparable. There is a theoretical explanation of this, and decisive experimental confirmation, the volume concentration of the disperse component being slightly less in a tube than in two reservoirs connected by the tube. Such phenomena call for great caution when one is obtaining samples of a suspension, for example, by means of a

pipette ; and give rise to apparent wall-slip, since the apparent viscosities observed in capillary viscometers of different diameters are slightly different in consequence, and different from the viscosity of the suspension as observed in a Couette instrument.

Carefully graded sizes of 'Perspex' spheres (in the overall range of diameters 40-435 μ) suspended in a liquid of the same density have been used in a series of experiments described by Dr. G. F. Eveson (University of Birmingham). These experiments give some support to the rule that one can calculate the viscosity by a repeated application of Einstein's law, when two distinct, sharply sized fractions are present, the larger spheres being effectively suspended in a homogeneous liquid, rheologically equivalent to the finer particles in the pure liquid. The disturbing effect of particle interactions was apparent when the average distance between sphere surfaces was less than three-quarters of the mean diameter of the suspended spheres.

A descriptive theory of the flow of suspensions in terms of vorticity, energy and action was put forward by Dr. T. V. Starkey (Technical College of Monmouthshire). As one might expect from a largely dimensional argument, the results differed from accepted theory in respect of the numerical constants, for example, the specific viscosity of an idealized suspension is obtained as three-fifths of the correct Einstein value.

Disperse systems with the consistency of thick pastes were discussed by a number of other speakers. Dilatant and thixotropic pastes were demonstrated in films shown by Dr. A. Jobling (University of Cambridge) and J. E. Roberts (Ministry of Supply), the technique used being that of deforming samples by spreading them on a rubber sheet the change of shape of which can be carefully controlled. The appearance of periodic cracks and their subsequent disappearance on relaxation of the material by vibration are somewhat analogous to certain phenomena observed in metals. The Weissenberg effect in the negative sense can be observed in certain materials of this kind, as was also demonstrated in some pigment-plasticizer pastes by E. Bantoft (Imperial Chemical Industries, Leathercloth Division). In these, marked non-Newtonian flow was observed in shearing, possibly with a finite yield value. Thixotropy, dilatancy and the very marked elastic 'solid' response to suddenly applied stresses were observed, and explained in terms of the flocculation of particles. Somewhat similar results for pigment-oil suspensions of the printing-ink type were described by N. Casson (Imperial Chemical Industries, Dyestuffs Division).

Different viscosity measurements arising from non-Newtonian flow, as given by different commercial

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viscometers, were illustrated by the results of E. H. Steiner (British Food Manufacturers Research Association). In molten chocolate, a complex dispersion of cocoa particles, milk and other fats, liquid cocoa butter, sugar, etc., rheological properties are sensitive to fat content, size of particles, size distribution, heat treatment, temperature, and moisture content. Some starch-clay coating mixes, as described by R. S. Lenk (Bowaters Development and Research, Ltd.), are equally complicated, and sensitive particularly to the content of amylose. The yield values and apparent viscosities of lutings used for water-proofing screw-threads—for example, a dispersion of synthetic wax in polyisobutene of low molecular weight—have been measured by W. A. Dukes (Ministry of Supply) in the parallel-plate, torsional and cylinder plastometers, with results which are not easy to analyse.

A novel departure from the conventional dispersion was demonstrated by T. C. Daniels (University College of Swansea), who described experiments on the fall of metal spheres of different sizes and densities through fluidized beds of sand, ilmenite, and similar powders. Such a bed is not a single, physically well-defined piece of matter but consists of a 'framework' of dispersed particles with the continuous component (air) in appreciable linear motion relative to this framework. The usually neglected migration effects (sedimentation, creaming, etc.) are here of great importance. Anisotropy is to be expected because of the privileged direction of the air flow. Experimental results lead to an empirical law that the terminal velocity of fall of a sphere through the bed is a constant plus a term proportional to diameter squared and to a power (somewhat greater than unity) of the density difference. Such a clear departure from Stokes's law deserves the interest of theoreticians. The experimental work is to continue with an investigation of the viscosity appropriate to shearing between vertical cylinders.

Informal evening discussions in the recently opened men's hall of residence, Neuadd Gilbertson, included one at some length on the subject of rheological nomenclature, to which much thought had been given by the Dutch rheologists. A free exchange of widely divergent views, under the chairmanship of Dr. G. W. Scott Blair, brought into relief, if nothing else, the many different scientific disciplines—physics, biology, engineering, chemistry, mathematics—which are brought together in the membership of the British Society of Rheology for the study of deformation and flow.

THE BRITISH SOCIETY OF RHEOLOGY

Bulletin No. 53

December 1957

Price to non-members 7s.

The Form of the Bulletin.

In January, 1941, No. 1 Bulletin appeared. It was issued "gratis to members of the Club only"; at that time there were eighty-two members. In addition to the Abstracts 1 to 19 there were Club notes and an article by Dr. V. G. W. Harrison on Rheology in Industry. Bulletin No. 2 appeared in June, 1941, together with a translation by Dr. V. G. W. Harrison of Pochettino's paper on the Properties of Plastic Bodies (*Nuovo Cimento*, 1914, 8, 77). The present form of the Bulletin developed with Bulletin No. 8, December, 1944, which was the first to be printed, instead of by duplication on foolscap. This No. 8 issue gave a preliminary notice of the first Oxford Conference. The number of abstracts had reached 253. The membership was over 280. Since this time the Bulletin has been published regularly, usually quarterly.

Bulletin 30, March 1951, began with an editorial from Dr. V. G. W. Harrison, the Editor, who wrote, "This Bulletin sees the publication of our 2000th abstract. The Bulletin is also just over ten years old . . . surely this demands an Anniversary Edition, complete with colour plates and special articles. Unfortunately, there is neither money nor labour for such a venture, and we must remain content with trying to keep abreast of the abstracts in the same old humdrum way.

Looking back over the past ten years, I think it is true to say that more has been achieved than was thought likely or even possible in the first days of the British Rheologists, Club and the knowledge gives us hope for the future."

This Bulletin, No. 53, December 1957, is the last issue of the Bulletin in its present form. It was agreed at the A.G.M., Swansea, 1957, that in 1958 publication should begin of a new Journal, to be called Rheology Abstracts. This will correspond roughly to the second half of the present Bulletin, but there will be a number of new features. Rheology Abstracts will include a brief reference to all papers likely to be of interest or importance to Rheologists, and for this purpose an extended team of abstractors is being set up to scan each issue of the journals likely to contain rheological papers. The papers will be divided into groups, and subject indexes will be issued each year.

A second publication, the Bulletin, will be inserted in Rheology Abstracts, and will contain details of the Society's activities, summaries of papers to be given at meetings and symposia, and news of interest to rheologists.

Rheology Abstracts, by its comprehensiveness and ease of reference will be a small but, the committee hope, very useful addition to the ever-growing number of scientific periodicals. Its circulation is expected to rise above that of the present Bulletin.

Much preparatory work has been done. But there are many journals to cover; any member who regularly scans journals, especially the less accessible ones, and who is willing to report on papers of importance, is invited to get in touch with the Abstract Editor, Dr. J. H. C. Vernon, who will be very pleased to forward the necessary pro formas and instructions.

New Members.

Mr. K. Walters, 21 Fullers Row, Mount Pleasant, Swansea, Glam. Interests: Elastics, viscous liquids with "linear" differential equations of state.

Mr. J. Morris, 1 Gray Street, Loughborough. Interests: Plastic flow in metal deformation processes. Flow in sand-clay aggregate systems.

Mr. W. A. Dukes, DMXRD, ERDE, Waltham Abbey, Essex. Interests : Adhesives, lutings.

Mr. P. W. Harpham, 60 Bath Road, Maidenhead, Berks. Interests : Paints and emulsions

Dr. P. O. Andersson, Dr. Uristivas Våg Gl, Stockholm, Sweden.

Dr. R. K. Bullough, The British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22. Interests : Mathematical Theory of Polymers.

Mr. R. P. Reeves, 4 Redfern Avenue, Heathfield, Hounslow, Middx. Interests : Oils, fats and waxes and fatty materials. Emulsions, gels and systems encountered in cosmetic and pharmaceutical formulation. Plastics and high polymer systems.

Mr. P. Connor, The Grange, Drayton, Berks. Interests : The flow of slurries and anomalous liquids.

Mr. R. N. F. Pinfold, Plot 8, Beeby Road, Scraftoft, Leics. Interests : Thixotropic systems, Viscoelastic materials, Extrusion and capillary flow.

Dr. C. Van Heerden, c/o Bibliotheek Staatsmijnen, P.O. Box 18, Centraal Laboratorium, Geleen, The Netherlands. Interests : General interests.

Dr. A. E. Green, Department of Mathematics, Stephenson Building, King's College, Newcastle upon Tyne 2. Interests : Mathematical Theory of Elasticity. Non Linear Elasticity, Non Linear Viscous Elastic Liquids.

Annual General Meeting and Conference on Rheology of Disperse Systems.

This year the Annual General Meeting and Conference were held at the University of Swansea on September 19-21st. This venue proved eminently suitable, as the facilities available at the new Natural Sciences Building and the Hall of Residence are excellent for scientific conferences.

The Conference on the Rheology of Disperse Systems was attended by nearly a hundred people among whom we were glad to welcome, were many of our Dutch colleagues, as well as Professor Reiner from Israel, Dr. Mason from Canada and other overseas rheologists. Most of the members attending the Conference took advantage of the opportunity to visit the Abbey Steel Works and see the impressive operations involved in producing sheet steel by the hot rolling process. The papers were of considerable interest and included the Presidential address by Professor Oldroyd on Complicated Rheological Properties with special reference to disperse systems. The Proceedings of the Conference will be published in full by Pergamon Press and an account will appear in *Nature* (reprints will be sent to members).

British Society of Rheology. Accounts for Year Ending 30th June, 1957

1955-6	INCOME	£	s.	d.
£520	Balance on 1st July, 1956	558	0	2
224	Subscriptions (Members & Subscribers)	286	10	2
—	Casual sales of Bulletin	2	10	0
8	Interest on P.O.S.B.	9	2	4
£752		£856	2	8

1955-6	EXPENDITURE	£	s.	d.
£134	Printing and distributing Bulletin and Nature Reprints	209	12	4
—	Publicity	15	15	2
28	Committee and administrative expenses	41	11	2
—	Typewriter	25	13	0
32	Subsidy of Meetings	15	14	8
558	Balance on 30th June, 1957	547	16	4
£752		£856	2	8

Signed: DOUGLAS W. JOPLING,
Hon. Treasurer.

A. DE WAELE,
Hon. Auditor.

Third International Congress on Rheology

The Third International Congress will be held in Bad Oeynhausen, Germany, on September 23rd–30th, 1958. It is hoped to circulate full details to members shortly, but the German Society has requested that members wishing to present papers at this Congress should get in touch with

DR. W. MESKAT,

Deutsche Rheologen-Vereinigung e.V.,

Dormagen,

Bahnhofstrasse 9

as soon as possible. It would be appreciated if copies of such letters were also sent to the British Society Hon. Secretary, so that the Committee is aware of the likely British contribution to the Congress.

National Bureau of Standards Rheology Section

The chief research interests of the new group will be in the field of phenomenological relations between stress, strain and time in the non-linear region with emphasis on the rheology of various specific types of materials. The initial programme has three main items, namely:—

1. Viscosity standards and measurement of the viscosity of liquids.
2. Rheological equation of state including non-linear terms, and
3. Relation of rheological properties to structure.

With regard to viscosity measurements, efforts are being made to design a viscometer with which the viscosities of standard oils could be measured routinely without reference to any material standard.

The section is making initial experiments on the dynamic bulk modulus of rubber-sulphur systems with the objective of investigating the behaviour of the glass transition of this system as a function of static pressure, temperature, tune and composition.

News of Societies.

U.S.A. Society of Rheology. Volume 1. *Transactions of the Society of Rheology (U.S.A.)* has been published by Interscience Publishers, N.Y. This volume of 214 pages contains twelve papers presented at the 1956 Annual Meeting, The Bingham Medal presentation speech and the nomenclature committee's final report.

The annual fall meeting of the Society of Rheology was held in Princeton, N.J. on November 7th, 8th and 9th at the Textile Research Institute.

Nederlandse Reologische Vereniging. At a Conference held 4th October in Utrecht the following papers were read and discussed: "Rheology of Diluted Polymer Solutions," by Prof. Dr. J. J. Hermans (Rijksuniversiteit, Lieden), "A Network Theory of some Rheological Properties of Concentrated Polymer Solutions" by Dr. A. S. Lodge (The British Rayon Research Association, Manchester), and "The Flow of Inhomogeneous Materials and its Relations to Fatigue" by Prof. K. Weissenberg (Ernest Oppenheimer Laboratory, Cambridge).

Deutschen Rheologischen Vereinigung und der Deutschen Rheologischen Gesellschaft. The death of Dr.-Ing. Hans Umstätter on 21st July, 1957, has been announced.

At a Conference held 25th September in Bad Oeynhausen papers were read by Prof. Dr. F. H. Muller (Marlburg), Dr. K. Edelmann (Teltow-Seehof), Doz. Dr. H. Jung (Stuttgart), Doz. Dr. J. Schurz (Graz), Dr. K. Kirschke (Berlin-Dahlem), Dr. W. Weber (Braunschweig) and Drs. W. Meskat and W. Hoffmann (Leverkusen).

News of Members.

Dr. J. M. Alexander has been appointed Reader in Plasticity at the Imperial College of Science and Technology as from 1st October, 1957.

Dr. D. R. Oliver has moved to the Dept. of Chemical Engineering of the University of Birmingham.

Situations Vacant.

Chemistry Graduate with initiative and flair for rheological work required for industrial research in a new laboratory pleasantly located in the South of England. Industrial experience preferred but recent graduate with good Honours Degree would be considered carefully. Competitive salary paid to successful applicant. Pension Scheme. Please apply to the Secretary, British Society of Rheology for further details.

Engineer required for the research and development of specialised plastic film coating plant. Applicants should be of graduate standard, or members of professional institutes, with at least 5 years' experience in this or related field. Please reply giving full details of present status and salary to Personnel Department, E.M.I. Factories Limited, Hayes, Middlesex.

Course of ten lectures on Rheological Techniques, by R. W. Whorlow, at Battersea College of Technology. The course, suitable for physicists and chemists, will be held on Tuesdays, 6.30 to 8.30 p.m., commencing 21st January, 1958. Fee for the course: £1. Evaluation of stress-strain-time relations from measurements with capillary and rotation viscometers. Extension, compression and torsion methods for non-Hookean solids. Oscillatory stresses. Applications of linear viscoelastic theory to the correlation of stress relaxation and oscillatory stress measurements, and evaluation of relaxation time spectra.

RHEOLOGY ABSTRACTS

3617. Theory of Plastic Deformation of Metals.

N. S. AKULOV and P. P. GALENKO, *Dokl. Akad. Nauk SSSR*, 1955, **103**, No. 3,387.
English translation in: *Atomic Energy Res. Establ. (Harwell) Transl.* No. 672 (1956).

On the assumption that a crystal is composed of equal-volume blocks which behave as units in plastic deformation, equations for the area of the hysteresis loop on a twist-torque diagram for plastic shearing are deduced, which are found to fit experimental results satisfactorily. A.

3618. The Flow of Cohesionless Grains in Fluids.

R. A. BAGNOLD, *Phil. Trans. A*, 1956, **249**, 235.

A semi-empirical analysis is given of the state of stress, and the characteristics of the flow (laminar and turbulent) in a dispersion of solid grains in a fluid (wind or water) flowing over a gravity bed of similar grains. The drag on individual grains and the transport rate of fluid-driven grains are estimated. Quantitative deductions are based on earlier measurements of stresses in concentrated suspensions of grains in a liquid flowing between rotating coaxial drums. These are in reasonably good agreement with the available results of observation of the formation and disappearance of bed features, saltation, transport rates, etc. A.

3619. Variations in Tension of an Unwinding Thread.

K. H. V. BOOTH, *Brit. J. appl. Phys.*, 1957, **8**, 142.

The variations in tension occurring as a thread is pulled with uniform speed from a cylindrical spool are considered. Curves are given from which it is possible to estimate the variations in tension as the point of unwinding moves up the spool surface. A.

3620. Calculation of Compressibilities of High Polymers from the Energy of Interaction between Chain Groups.

W. BRANDT, *J. chem. Phys.*, 1957, **26**, 262.

A potential function for the interaction of long chain molecules in polymer lattices is formulated. The adopted model assumes polymeric substances to consist of imperfect assemblies of perfect chain crystals. Each chain is composed of evenly spaced dipolar dispersion force centres, with dipole orientations perpendicular to and alternating along the chain axes. The lattice energies of five linear polymers are calculated. A.

3621. Miscellaneous Effects of Pressure on Miscellaneous Substances.

P. W. BRIDGMAN, *Proc. Amer. Acad. Arts Sci.*, 1956, **84**, No. 1, 112

The following data are given: (1) electrical resistance of Y, Re, Tc up to 10^5 kg/cm² at room temperature and of Sr up to 200°C for 7×10^3 kg/cm²; (2) volume compression of Y, Re, Pb, fluorothene, hen's egg yolk and white; (3) shearing strengths of Y, Tc and tensile properties of Cr, Ge; (4) resistance changes during plastic extension under pressure for Cu, Fe. A.

3622. The Resolving Kernel of the Volterra Equation in the Case of the Generalised Creep Function.

Z. BYCHAWSKI, *Archivum Mechaniki Stosowanej*, 1957, **9** (2), 247.

Following Goursat's developments of the theory of Volterra integrals, the authors use a linear differential equation as the resolving kernel. They apply their method to the problem of creep, due to concrete shrinkage, of a straight cable prestressing a prismatic concrete member in the axial direction. P.F.

3623. Metallography of a Medium Carbon Steel subjected to Slow and Impact Compression.

J. D. CAMPBELL, J. DUBY and K. E. PUTTICK, *Phil. Mag.*, 1957, 2, 548.

Medium carbon steels subjected to slow and dynamic compression have been examined by optical and electron microscopy. In slow deformation, coarse slip in ferrite occurs in very narrow regions on corrugated surfaces; this behaviour appears to be related to the presence of an ageing precipitate. Coarse slip is absent in rapidly strained steel; the metal deforms by fine slip which occasionally forms deformation bands. Deformation twins were only observed on one specimen of which the microstructure was abnormal. A.

3624. On the Theory of Hydrodynamic Properties of Solutions of Macromolecular Chains.

R. CERF, *C.R. Acad. Sci. (Paris)* 1956, 245, 1875.

A general theory is obtained by introducing an internal viscosity into a model based on the concept of the submolecule. The coefficient of friction is now re-defined with respect to the normal coordinates of the molecule, and leads to a more rigorous theory with new applications for the case of flexible molecules. The theory is applied to flow birefringence and to non-Newtonian viscosity. A.

3625. On the Non-Newtonian Viscosity of Solutions of Macromolecular Chains.

R. CERF, *C.R. Acad. Sci. (Paris)*, 1957, 244, 456.

Equations for the dependence of the intrinsic viscosity $[\eta]$ on the flow gradient (G) are obtained. Two limiting cases are considered where the internal viscosity of the polymer is (a) large, and (b) small compared with the viscosity of the solvent. Case (a) approximates to that for rigid particles and an expression for $[\eta]/[\eta]_0$ as a function of $M[\eta]_0G$ is obtained. Flexible molecules approximate to case (b) and $[\eta]/[\eta]_0$ is a function of $M[\eta]_0G$. Analysis of experimental results for polyisoprene in benzene indicates that polyisoprene is a flexible molecule. A.

3626. Variation of Elastic Constants and Static Strains with Hydrostatic Pressure. A Method for Calculation from Ultrasonic Measurements.

R. K. COOK, *J. Acoust. Soc. Amer.*, 1957, 29, No. 4, 445-9.

An algorithm for separating out the effects due to variations in elastic constants from the effects due to static strains is presented and applied to cubic crystals and hexagonal crystals, these structures being of immediate interest to investigators concerned with the properties of metals. The results apply also to isotropic and transversely isotropic solids. The only measurements needed while the specimen is under hydrostatic pressure are resonant frequencies (or transit times). Also required are the size and density at zero pressure, or the elastic constants at zero pressure. A.

3627. The Asymmetry of the Stress Tensor and its Consequences.

Y. LE CORRE, *J. Phys. Radium*, 1956, 17, No. 11, 934.

It is supposed that the forces acting across any small surface drawn in an elastic solid do not have a simple resultant (i.e., that an associated couple must be taken into account), and that the usual stress tensor can in some sense then be replaced by an asymmetric tensor. Consequences are an increase in the number of elastic constants associated with each type of crystal symmetry, and different velocities of propagation of elastic waves in crystals. A.

3628. Summarized Proceedings of a Conference on the Electron Microscopy of Fibres—Leeds, January, 1956.

C. E. CHALLICE and J. SIKORSKI, *Brit. J. appl. Phys.*, 1957, 8, No. 1, 1, 21.

A conference on the electron microscopy of textile and other industrial fibres was held on 3rd and 4th Jan., 1956, in the Department of Textile Industries, University of

Leeds. The conference was organized by the Textile Physics Laboratory, under the auspices of The Institute of Physics. Seventeen of the eighteen papers are summarized. A.

3629. Creep of Concrete in Prestressed Beam Structures.

A. CHUDZIKIEWICZ, *Rozprawy Inżynierskie*, 1957, 5 (2), 229.

Theoretical aspects of creep in statically determinate and indeterminate prestressed structures are considered. Prestressing with grouted and plain cables are dealt with. P.F.

3630. The Effect of the Creep of Concrete on Composite Beam Structures.

A. CHUDZIKIEWICZ, *Rozprawy Inżynierskie*, 1957, 5 (2), 457.

3631. A Method of Measuring the Shear Modulus of Thin Xylonite Sheet.

J. CLARKSON, *Brit. J. appl. Phys.*, 1957, 8, No. 3, 103.

A torsion balance is described in which a common torque is applied to narrow strips of steel and xylonite connected end to end, and the twist of each specimen is measured. Knowing the shear modulus of steel, its twist gives a measure of the torque, and the shear modulus of the xylonite may then be calculated from its rotation. The measurements are easily made, and do not depend on frictional forces, nor are any forces applied to the specimens apart from the end forces producing the torque. These features are particularly important for thin xylonite. A.

3632. A Relation between Phase Velocity, Particle Velocity and Energy for Progressive Permanent Waves.

H. ERTEL, *S.B. Dtsch. Akad. Wiss. Berlin, Kl. Maths. Phys. Tech.*, 1956, No. 2, 5.

In the case of surface waves on a perfect fluid, the two velocities are such that $\vec{c} \cdot \vec{v} = E$, where E is the total energy per unit mass. The analogy with de Broglie waves is noted. A.

3633. Work-hardening in Face-centred Cubic Metals, with Special Reference to Polycrystalline Copper.

P. FELTHAM and J. D. MEAKIN, *Phil. Mag.*, 1957, 2, 105.

3634. On the Activation Energy of High-temperature Creep in Metals.

P. FELTHAM, *Phil. Mag.*, 1957, 2, 584.

3635. Dynamic Shear Properties of Some Rubber-like Materials.

W. P. FLETCHER and A. N. GENT, *Brit. J. appl. Phys.*, 1957, 8, No. 5, 194.

Measurements are described of the dynamic shear properties of a number of representative rubber-like materials, both vulcanized and unvulcanized, over a wide range of frequencies and temperatures. The major part of the transition from a rubber-like to a glass-like state has been investigated. Reduced values for the real component of the complex shear modulus and the ratio of the imaginary to the real part are presented, enabling the behaviour of the materials studied to be evaluated for other frequency and temperature conditions. A.

3636. Some Observations on the Nature of Fatigue Damage.

P. J. E. FORSYTH, *Phil. Mag.*, 1957, 2, 437.

Damage in an Al-Zn-Mg alloy occurs as persistent bands containing rows of holes, apparently in the form of tubes penetrating to different depths. Mechanical polishing reveals the holes, but not the bands. Electrolytic polishing reveals both, the bands appearing as grooves. No marked bands appear in pure aluminium or in heat-treated alloy. Probably therefore the holes are voids occurring along the slip planes, whereas the bands contain higher concentrations of solute atoms, which are electrolytically polished more rapidly than the matrix, thus producing grooves. A.

3637. Bounds for the Collapse Load of a Beam Compressed by Three Dies.
W. FREIBERGER, *Austral. J. Phys.*, 1956, **9**, No. 4, 419.

Deals with the problem of the plastic deformation of a beam under the action of three perfectly rough rigid dies, two dies applied to one side, one die to the other side of the beam, and single die being situated between the two others. It is treated as a problem of plane plastic flow. Discontinuous stress and velocity fields are assumed and upper and lower bounds for the pressure sufficient to cause pronounced plastic yielding determined by limit analysis. A.

3638. Microscopic Method of Studying Anomalous Viscosities.

U. GHOSH, *Sci. and Culture*, 1956, **22**, 172.

Flow of a glycerol solution containing graphite and an aqueous solution of carboxy methyl cellulose through a capillary tube of circular cross-section has been studied. The velocity distribution across the tube of the suspended particles has been observed by a microscope. A.

3639. Relationship Between Relaxation Time and Viscosity for Water.

E. H. GRANT, *J. chem. Phys.*, 1957, **26**, 1575.

The Debye relation connecting relaxation time, viscosity, molecular size, and absolute temperature appears to hold for water. The Debye equation was formulated on the basic assumption that each molecule can be considered as turning in a viscous continuum as it rotates in dielectric relaxation, and it is well known that this molecular picture is inapplicable to water. It is shown that a similar relationship can be deduced directly from equations based on the hydrogen bonded structure of the liquid. A.

3640. On Transition from Laminar to Turbulent Flow.

F. R. HAMA, J. D. LONG and J. C. HEGARTY, *J. appl. Phys.*, 1957, **28**, 388.

Water-tank observations of the flow phenomena associated with boundary-layer transition have revealed that a two-dimensional discrete vortex line, which is considered to be the consequence of an amplified perturbation wave, has a strong tendency, in shear flows, to form three-dimensional vortex loops with a marked transverse wavelength. The formation and development of the vortex loop is found to be the essential feature preceding the creation of a turbulent spot which takes place near the top of the vortex loop and near the outer edge of the boundary layer. This formation and development provides the guiding principle of laminar-to-turbulent transition in wakes and jets as well as in the boundary layer. A.

3641. Non-destructive Testing of Material with Magnetic Processes.

E. HANKE, *Wiss. Z. Hochsh. Elektrotech. Ilmenau.*, 1956, **2**, 89.

An exhaustive review based on the use of commercially available instruments ("Sigmaflux," "Förster-Sonde," "Ferrograph," "Koerzimeter," etc.), largely due to Förster. Processes for ferrous metals include magnetic-powder and acoustic testing methods for crack-detection, and coercive-force, permeability and remanance testing methods for structure determination, including anisotropy. For non-ferrous metals a wider range of methods is available, based on inductive, conductive and eddy-current principles. Some of these methods are usable also with ferrous specimens. Theories are given, together with the precautions to be taken and the corrections to be applied. A.

3642. The Elastic Properties of Dilute Aqueous Gels.

L. J. HASTEWELL and R. ROSCOE, *Brit. J. appl. Phys.*, 1956, **7**, 441.

The static rigidity of a gelatine gel was found to increase with temperature in accordance with the kinetic theory of elasticity for long-chain polymers, and a similar variation was found in the case of a betonite gel. This suggests that a loose chain structure is formed which is mechanically similar to that existing in a polymer gel. A.

3643. The Measurement of Surface Residual Stress by X-Rays.

G. A. HAWKES, *Brit. J. appl. Phys.*, 1957, **8**, No. 6, 229.

A multi-exposure, X-ray, back-reflection technique, with graphical solution for the evaluation of the level of residual macrostress in any particular surface direction in a polycrystalline material is described. This technique has, in particular, been applied to the stress analysis of aluminium alloys and high tensile steel components and specimens.

A.

3644. Some Applications of Physics to Wood.

R. F. S. HEARMON, *Brit. J. appl. Phys.*, 1957, **8**, 49.

A review is given of some of the more important physical properties of wood, particularly the hygroscopic, thermal, electrical and elastic properties. The vibration behaviour is also considered, with special reference to the effect of shear and rotatory inertia in flexural vibration, and to the connection between frequency of vibration and elastic stability.

A.

3645. On the Oscillating Cylinder Viscometer for Elastic Liquids. II.

ALI A. K. IBRAHIM, *J. Phys. Soc. Japan*, 1956, **11**, 1208.

The equation is given for the phase lag between the motion of the inner and outer cylinders when the latter is oscillated. It gives good agreement with the experimental results of Markovitz et al.

A.

3646. Plasticity (Elastic-plastic Deformations).

A. A. ILYUSHIN, *Rev Métall*, 1957, **54**, 320.

Book translated from the Russian by A. Popov. Includes problem of penetration of indenters.

A.

3647. The Elastic Deformation of Wood.

YU. M. IVANOV, *Zoll. Kh.*, 1957, **19** (3) 293.

Studies large deformations (5–10%) in swollen wood. Suggests that irreversible increase in high-elasticity at const. temp. results from mechanical activation of process of intra- and intermolecular bond-disruption of cellulose complex, in secondary cell walls.

G.W.S.B.

3648. A Tentative Explanation of the Weissenberg and Reiner Effects by Postulating the Existence of Gyroscopic Phenomena in Viscous Flow.

E. JABOTINSKY, *Bull. Res. Coun. Israel*, 1956, **6A**, No. 1, 65.

Gyroscopic effects in viscous flow are postulated resulting in the splitting of the flow into separate spinning portions. The spin of each portion is given for incompressible flow by the gyro-spin equation which is used to show that the Weissenberg-Reiner effects can be expected for values of $\Omega^2 rh$ satisfying a double inequality. The radial distribution of pressures is predicted.

A.

3649. A Tilting Stage Method for Three-dimensional Photoelastic Investigations.

H. T. JESSOP, *Brit. J. appl. Phys.*, 1957, **8**, 30.

A method of finding the directions of the principal axes of stress at any point of a "frozen" photoelastic model by the use of a simplified form of universal tilting stage is described. This results in more direct and more accurate measurement of the principal stress-differences at the point.

A.

3650. Thixotropy and Structural-mechanical Properties of Suspensions of "Askangel" and their dependence on the Composition of the Exchange Complex.

E. I. KABAKHIDZE, M. E. SHISHNIASHVILI and N. N. SERB-SERBINA, *Koll. Zh.*, 1957, **19** (3), 299.

Na askangels, unless electrolysed, are not thixotropic. Dialysed Ca and Al askangels are "kinetically unstable." Rheological characteristics are in agreement with electron microscope pictures (see Abstr. 3578).

G.W.S.B.

3651. Dynamic Mechanical Properties of Polyethylene and Polytetrafluoroethylene.

S. P. KABIN, *Zh. tekhn. Fiz.*, 1956, **26**, 2628.

The substances are studied using longitudinal vibrations at frequencies of 0.5, 1.0, 2.0, 3.5, 5.0 Mc/s at temperatures from -115°C to $+80^{\circ}\text{C}$ for polyethylene and from -65°C to $+20^{\circ}\text{C}$ for polytetrafluoroethylene. Mechanical and dielectric losses for crystalline and amorphous polymers may be accounted for by similar relaxation times and activation energies. A.

3652. The Nature of Persistent Slip Bands in Fatigued Copper.

D. S. KEMSLEY, *Phil. Mag.*, 1957, **2**, 131.

In rotating cantilever fatigue tests on annealed high-conductivity Cu, persistent slip bands are observed only when a specimen is electrolytically polished early in its fatigue life, and then only in the case of low-stress cycling. It is suggested that certain surface striations are subject to rapid attack during electrolytic polishing soon after their formation, so that grooves are formed which then give rise to stress concentration and hence to fatigue cracks. A.

3653. An Electromagnetic Vibrating Viscometer.

I. KIMURA and H. FUWA, *Bull. Electrotech. Lab. (Tokyo)*, 1956, **20**, 831.

Transducer has a vibrating plate or cylinder which is driven by a constant driving force. The mechanical impedance due to the retarding force against the motion of the plate or cylinder immersed in the liquid and corresponding to the viscoelasticity G and density ρ , is measured electromagnetically. Various types have been designed for operation within pipe lines or tanks. A.

3654. Investigations of the Rheological Properties of Mastic Asphalt, of the Development of Cracks in Mastic Asphalt Roofs, and of the Progressive Opening of the cracks.

J. M. KIRK, *Acta Polytechnica*, 1956, 193. Civil Engineering and Building Construction Series Vol. 3 No. 4.

The rheological properties of mastic asphalt bars have been determined at various temperatures. An equation has been deduced which allows calculation of the tensile stresses arising in mastic asphalt when cooled. Calculation shows that the cracks will open progressively when the mastic asphalt is exposed to variations of temperature and when the friction between the mastic asphalt and the foundation ranges within an interval, the limits of which are determined by the properties of the mastic asphalt and by the temperature. A.

3655. Influence of Heterogeneous State of Stress on the Mechanism of Plastic Deformation in Thallium and Caesium Halides.

M. V. KLASSEN-NEKLYUDOVA and A. A. URUSOVSKAYA, *Kristallografiya*, 1956, **1**, 410.

Plastic deformation takes place by the occurrence of faults under a combination of shear and tension corresponding to the existence of macro-bending moments; the crystallographic axis must also have a definite orientation relative to the deformation axis. Faults did not occur at any orientation under pure tension. A.

3656. The Derivation of the Minimal Principles of non-linear Elasticity Theory by means of a Canonical Transformation.

E. KOPPE, *Nachr. Akad. Wiss. Göttingen, Math.-Phys. Kl. IIa*, 1956, No. 12, 259.

Three general variational principles are obtained from the principle of virtual work, apparently valid without any restriction on the form of the relations between stresses and gradients of displacement. The mathematical form of the final result in each case is such that, for equilibrium, the sum of certain volume and surface integrals over the volume and surface of the undeformed body is stationary. A.

3657. Theory of Dilute Polymer Solutions.

R. KOYAMA, *J. chem. Phys.*, 1957, **27**, 234.

From the pearl necklace model for a chain polymer molecule in a solution, expressions for the mean intermolecular potential and the radial distribution function of polymer molecules are derived. The methods of Born and Green, are applied. The mean intermolecular potential depends on molecular weight and temperature. At critical temperature where the second virial coefficient vanishes, the mean intermolecular potential vanishes and the radial distribution function assumes the constant value which is equal to unity. Theoretical expressions for the second and third virial coefficients are also given.

A.

3658. Relationship Between the Fracture Ductility Transition and Strain Hardening Characteristics of a Low Carbon Steel.

J. M. KRAFFT, A. M. SULLIVAN and G. R. IRWIN, *J. appl. Phys.*, 1957, **28**, 379.

The strain-hardening is given by the index n in the equation $\sigma = \kappa \delta^n$ where σ and δ are true stresses and true strain and κ a constant. Values of n , of flow stress, and of the tangent modulus (derived from plastic propagation formula), each plotted against temperature, all yield curves of the same form. It is suggested that temperature-dependence of the brittle fracture of low carbon steels may be interpreted in terms of these strain hardening characteristics.

A.

3659. Application of the Variational Method to the Problem of Axisymmetric Rotational Flow of a Compressible Fluid.

B. KRAJEWSKI, *Archivum Mechaniki Stosowanej*, 1957, **9** (2) 211.

In considering flow through compressors or turbines the flow is assumed to be steady and axially symmetric. By the introduction of a stream function and a suitable change of variables it is shown that the flow problem can be reduced to one amenable to treatment by the variational method. It can then be further studied by known methods such as those of Ritz and Galerkin.

P.F.

3660. Dynamic Mechanical Properties of Polyhexene—1.

S. F. KURATH, E. PASSAGLIA and R. PARISER, *J. appl. Phys.*, 1957, **28**, 499.

A double electromagnetic transducer has been used to evaluate the complex shear modulus of polyhexene-1 from $+70^\circ\text{C}$ to -27.5°C in the 25 to 2500 c/s frequency range.

A.

3661. Bulk Viscosity of Certain Organic Liquids and its Temperature Variation.

T. M. LEDNEVA, *Vestnik Moskov. Univ.*, 1956, No. 2, 49.

The viscosity coefficients are derived from measurements of the absorption coefficient of ultrasonic waves over a wide range of temperatures and pressures. Tables and graphs of viscosity coefficient v. temperature are given for a number of paraffins, toluol and some alcohols. It is found that the formula put forward works well for alcohols over the experimental range.

A.

3662. Kinetics of Slow Fractures in Glass.

W. C. LEVENGOOD and W. H. JOHNSTON, *J. chem. Phys.*, 1957, **26**, 1184.

Fractures in plate glass, originating at a cutter mark, and progressing slowly parallel to the surface, were observed under controlled conditions. The rates of spread of such fractures, immediately after the glass is cut and for several hours afterward, were determined by viewing microscopically the movement of interference fringes produced in monochromatic light. Effects of external atmosphere, and of various included gases introduced during melting, are described. A theory of the kinetics of slow fracture rates is offered, which relates the fracture spreading rate to the molecular diameter and molecular weight of the internal gas involved.

A.

3663. The Effect of Thin Films of Gold on the Mechanical Properties of Cadmium Single Crystals.

F. R. LIPSETT and R. KING, *Proc. Phys. Soc. B*, 1957, **70**, Pt. 6, 608.

Thin films of oxides, hydroxides or metals have been shown to increase the stress at which plastic deformation starts by an amount which cannot be explained by the strength of the films themselves. Most experiments have been on creep, showing the effect of oxides and hydroxides. This paper records an investigation into the effect of thin films of gold on the stress-strain curves of cadmium crystals. The crystals were grown in an Andrade-Roscoe furnace and extended in a rigid frame machine with a Polanyi beam and photographic recording. The gold films were deposited by sputtering. It was found that thin gold films increased the stress at which plastic deformation started by about 6 g wt mm^{-2} . The increase was independent of film thickness for films of 1500–24,000 Å. The nature of the effect of the film upon the stress-strain curves depended upon the orientation of the crystals. A.

3664. Steady State Heat Transfer to Fully Developed Turbulent Flow in a Curved Channel.

A. W. MARRIS, *Canad. J. Phys.*, 1957, **35**, 410.

A vorticity transfer analogy theory of turbulent heat transfer is developed first for the case of fully developed turbulent flow under zero transverse pressure and temperature gradients such as that in the annulus between concentric cylinders rotating with different angular velocities or in a "free vortex." The mean flow is assumed to be two dimensional. The theory, which requires that the turbulence be statistically isotropic, yields a temperature distribution in agreement with experiment except in narrow regions immediately adjacent to the boundaries. An argument is given to show that the boundary layer thickness should be of the order of the reciprocal of the square root of the mean velocity, these boundaries are introduced, and Nusselt moduli are defined and their dependence on Reynolds and Prandtl numbers is investigated. The temperature distributions for the case of non-zero transverse temperature and pressure gradients, i.e. for the case of flow in a curved channel in which the fluid does not flow back into itself, are then obtained and the applicability of the simpler equations for zero transverse gradients to this case is investigated. A.

3665. Investigations of the Mechanical Properties of Plastic Dispersed Systems under Conditions of Uniaxial Tension and Compression.

E. P. MOSIKHIN and G. V. VINOGRADOV, *Koll. Zh.*, 1957, **19** (3), 311.

Samples of lubricating greases, when ruptured within the elastic range ($<0.1\%$), break along the planes of maximum shear-stress and show Lüder's lines. Plastic behaviour appears at higher strains. Tensile strength is twice shear strength. G.W.S.B.

3666. The Rheology of some Two-dimensional Disperse Systems.

J. G. OLDROYD, *Proc. Camb. Philos. Soc.*, 1957, **53**, Part 2, 514.

An investigation is made of the deformation and flow properties of two-dimensional disperse systems consisting of small circular patches of one component widely dispersed in a continuous component with different rheological properties.

Attention is restricted to small deformations (or small rates of deformation in the case of a fluid system) so that the equations of state are linear and the properties of each component can be characterized by two elastic moduli, or by two operators involving d/dt which take the place of moduli. Surface tension in each component and boundary tension between the components are taken into account, so that the theory can be applied to interfacial films at liquid-liquid or liquid-gas interfaces as well as to thicker sheets and films. General formulae are derived expressing the two modulus operators of a dispersed system in terms of those of the components, and their use is illustrated by means of examples. Author's Abstract.

3667. **Low-frequency Dynamic Modulus of an Acrylonitrile-butadiene Rubber.**
A. R. PAYNE, *J. appl. Phys.*, 1957, **28**, 378.

Low-frequency dynamic data for a vulcanized Buna-N rubber are analysed by the "method of reduced variables." The relation between complex compliance, frequency and temperature, is of the same form as for many other high polymers, and there is no evidence of a cross-linking structure affecting the mechanical properties sufficiently to invalidate the method of analysis. A.

3668. **An Application of the Diffusion Equation to Viscous Motion with a Free Surface.**

J. R. PHILIP, *Austral. J. Phys.*, 1956, **9**, No. 4, 570.

It is shown that the steady one-dimensional flow of a liquid over any plane surface in a gravitational field can be solved as a problem in diffusion. In the problem of surface irrigation it has previously been difficult to include the effect due to surface vegetation. In the present work it is suggested that the introduction of a height-variable permeability solves this problem. A.

3669. **Transient Fluid Motions in Saturated Porous Media.**

J. R. PHILIP, *Austral. J. Phys.*, 1957, **10**, 43.

The transition from rest to steady motion on the sudden application of a potential gradient to the fluid contained in a saturated porous medium is investigated. An approximate analysis gives the result that the time of the effective establishment of the steady motion is proportional to the permeability and inversely proportional to the kinematic viscosity. A.

3670. **Application of the Method of Brittle Lacquers in Studies of the Nature and Distribution of Deformations.**

J. T. PINDER, *Rozprawy Inżynierskie*, 1957, **5** (1), 35.

Results of a study with the resin method for indicating yield of metals are given. The method is said to be rapid and cheap in practice, and to give reliable results. The experimental data are compared with theoretically evaluated deformation patterns. P.F.

3671. **Some Regularities of Mechanical Properties in Specimens Obtained from Metallic Powders by Sintering. I.**

B. YA. PINES and N. I. SUKHININ, *Zh. tekhn. Fiz.*, 1956, **26**, 2076.

The basic metal being Cu, it was found that: (1) the tensile strength p in single-phase pressings fired for different times at the same temperature decreased linearly as porosity increased, (2) p depended also in the sintering temperature, (3) the slope of the p /porosity line was greater in Cu samples sintered at 1000°C than in those sintered at lower temperatures, and (4) the strength values extrapolated to zero porosity depended on the concentrations by volume σ and $1-\sigma$ according to the formula

$$p = p_1(1-\sigma)^2 + p_2\sigma^2 + 2p_{12}\sigma(1-\sigma) \quad A.$$

3672. **Some Regularities of Mechanical Properties in Specimens Obtained from Metallic Powders by Sintering. II.**

B. YA. PINES and A. F. SIRENKO, *Zh. tekhn. Fiz.*, 1956, **26**, 2378.

Powder pressings pre-fired at 1000°C were tested for tensile strength (p) in a H_2 atmosphere at temperatures up to 900°C, the ratio of the loading-rate extremes being 1/100. Linear relation between the logarithm of the loading rate and p was confirmed for specimens with the same porosity. When the specimens were of different porosity, the tests at high temperatures and constant loading rate showed that p fell linearly as the porosity increased. A.

3673. **Physical Properties and the Structure of Glass.**

E. PLUMAT, *Vetro e Silicati*, 1956, **1**, 19; *Verres et Réfract.*, 1957, **11**, 172 (Original in Italian). A.

3674. Turbulent Flow in the Gap Between Two Cylinders, the Inner of which Rotates.

J. POLÁŠEK, *Elektrotech. Obzor.*, 1957, **46**, 82.

The author gives a semi-empirical expression for the time average of the velocity of a viscous fluid between two concentric cylinders. The following assumptions are made : The inner cylinder rotates at a constant angular velocity, the flow between the cylinders is turbulent, the velocity in the axial direction is zero. Mean velocity profiles are determined for published examples and for turbine alternators. Calculated results are compared with experimental data. A.

3675. Carbon Tantalum Internal Friction Peak.

R. W. POWERS and M. V. DOYLE, *J. appl. Phys.*, 1957, **28**, 255.

The internal friction peak in tantalum arising from the diffusion of interstitial carbon has been located at 338°C for vibration frequencies of 0.55 c/s. The corresponding activation energy is 39.6 kcal. The identification of this peak is made difficult by its proximity to the nitrogen peak. However, the two can be distinguished by the lesser stability of the carbon peak with respect to ageing at 400°C and by a different dependence of peak height on solute concentration. A.

3676. Creep of Aluminium under Dynamic Load.

A. A. PREDVODITELEV and B. A. SMIRNOV, *Vestnik Moskov. Univ.*, 1956, No. 3, 51.

An apparatus is described in which the specimen can be given a heat treatment, studied at various temperatures, given a steady load and subjected to an additional load varying at 50 c/s. Studies with aluminium appear to show : (a) creep increases sharply under pulsed shock loading; (b) the curve of dynamic creep similar to that under constant load; (c) slip processes in the metal are intensified under dynamic load. A.

3677. Control of the Distribution of a Spray Projected to an Area.

D. J. RASBASH and G. W. V. STARK, *J. sci. Instrum.*, 1957, **34**, No. 2, 75.

Deals with the production of water sprays by nozzles which consist of a number of radially arranged pairs of jets, the two types considered being arranged to give two different spray angles. In each case it was found that the inclusion of an orifice plate immediately upstream of the jets produced a marked improvement in the spray distribution. A possible explanation is advanced and it is suggested that the use of different size orifices would be a method of spray control. A.

3678. Discussion on Friction of Synthetic Rubbers.

S. B. RATNER, G. M. BARTENEV and B. V. DERYAGIN, *Koll. Zh.*, 1957, **19** (3) 394, 397, 398.

Short contributions to the earlier discussions. The last author proposes a two-term modification of Amonton's law (see Abstrs. 3338, 3432, 3471, 3485). G.W.S.B.

3679. An Attempt to Establish the Theoretical Basis of the Moiré Method of Analysing Stress and Strain.

M. ROGOZIŃSKI, *Archiwum Mechaniki Stosowanej*, 1957, **9** (2), 191.

The use of superimposed ruled grids for determinations of stress and strain in surfaces on the basis of the optical patterns produced by the deformation of one of the two identical grids is discussed, and a theoretical basis for the use of such moiré patterns is advanced. P.F.

3680. Summarized Proceedings of a Symposium on Thin Films, Reading, September, 1956.

T. B. RYMER, *Brit. J. appl. Phys.*, 1957, **8**, 97.

The electronics Group of the Institute of Physics held an informal symposium on thin films at the University of Reading on 28th and 29th Sept., 1956. The papers presented are summarized in the report. A.

3681. Investigations of the Structural-mechanical Properties of Solutions of Ethyl Cellulose and the Effect of Oxidation on these Properties.

T. I. SAMSONOVA and L. V. IVANOVA-CHUMAKOVA, *Koll. Zh.*, 1957, **19** (3), 343.

Viscoelastic properties of 3–18½% ethyl cellulose in benzyl alcohol and dibutyl-phthalate differ from those of oxidized ethyl cellulose. The former produce a structure within two days which stands up to small stresses only. Data conform to earlier proposed relation which by elastic deformation and recovery may be characterized by a single constant. (see Abstrs. 3493, 3494). G.W.S.B.

3682. The Equations of Motion of an Incompressible Viscous Fluid in the Parallel System of Coordinates.

L. SANYAL, *Indian J. Phys.*, 1957, **31**, 6.

For a rigorous deduction of the equations of a three-dimensional boundary layer on a given surface, the Stokes-Navier equations of motion of an incompressible viscous fluid under no body forces have been transformed in the parallel system of coordinates. A.

3683. Crystallization Patterns of Sodium Chloride in Bovine (Uterine) Cervical Mucus as related to its consistency.

G. W. SCOTT BLAIR and F. A. GLOVER, *Nature*, 1957, **179**, 420.

Intensity of fern-like structures of NaCl crystals in mucus, which depends on balance of sex hormones, is highly correlated with overall consistency (emptying capillary viscometer) but unlike the latter, cannot readily be used to detect early pregnancy. G.W.S.B.

3684. Didactical Absolute Viscosimeter.

J. DE SMEDT and A. DE BOCK, *Amer. J. Phys.*, 1957, **25**, 152.

A didactical apparatus for the absolute measurement of small coefficients of viscosity (1 centipoise) with an accuracy of 1% is presented. A W-shaped piece rotates about a vertical axis at a variable distance from the walls of an identically shaped vessel, containing the liquid sample. A wire wound on a drum attached to the axis carries a mass, which accelerates the rotor when falling through a distance H in the time interval T . When completely unrolled the wire is rewound on the drum and the mass is lifted up to a smaller height H' in a shorter time T' . The determination of both distances and time intervals permits calculation of the coefficient of viscosity. A.

3685. Viscosity and Action.

T. V. STARKEY, *Brit. J. appl. Phys.*, 1956, **7**, 448.

For the laminar flow of a given volume of liquid through a tube the product of the energy dissipated and the time is a minimum. This condition requires a parabolic velocity distribution in laminar flow through tubes. It is also shown that the non-turbulent flow of a fluid showing shear dependence is not laminar, and that it resembles in many fundamental respects the turbulent flow of a Newtonian liquid. These results follow from the recognition of apparent viscosity as a direct measure of the action per unit volume associated with a given change in the configuration of the elements of which the fluid may be imagined to consist. A.

3686. Measurement of the Modulus of Rigidity of Nickel up to 1000°C.

C. SUSSE, *J. Phys. Radium*, 1956, **17**, 910.

The rigidity of a Ni specimen of high purity, annealed for an hour at 850°C, was observed at different temperatures by a dynamic method in which vibrations were transmitted to the specimen in a furnace by means of fine Ni and Pt wires. The plot of rigidity against decreasing temperature is slightly different from that against increasing temperature, and shows a sharp drop as the temperature falls through 355°C. A.

3687. Internal Friction and Critical Stress of Copper Alloys.

S. TAKAHASHI, *J. Phys. Soc. Japan*, 1956, **11**, 1253.

The effects of strain amplitude on the internal friction and the Young's modulus of polycrystalline specimens of copper alloys (Cu—Zn, Cu—Al, Cu—P) with various concentrations of solute atoms have been investigated. The results are : (1) The critical stress, up to where internal friction and Young's modulus are almost independent of strain amplitude, increases with concentration of solute atoms, showing good agreement with the theoretical stress obtained by Mott. (2) The strain-independent part of the internal friction decreases as a power function of concentration of solute atoms, although its numerical value depends largely on the pre-treatment. (3) The strain-dependent part of the internal friction and the fractional change of Young's modulus are represented by two parallel formulae, as in the theory of Nowick. But the factors of strain dependencies seem to increase with concentration of solute atoms. (4) Internal friction and Young's modulus are both almost independent of frequency in the range between 900 and 10,000 c/s at room temperatures. A.

3688. Hydrodynamics of Oscillating Discs in Viscous Fluids: Viscosities of Liquids He³ and He⁴.

R. D. TAYLOR and J. G. DASH, *Phys. Rev.*, 1957, **106**, No. 3, 398.

The viscosities of liquid He⁴ from the lambda-point to 4°K and of liquid He³ near the critical point and from 1.3°K to 2.15°K have been determined by the oscillating disk method. Detailed study of He⁴ near the lambda point shows a discontinuity in the temperature derivative of the viscosity and provides additional evidence that the He I—He II transition is of the second order. Considerations based upon the temperature dependence of the He⁴ viscosity above 2.5°K suggest that the zero-point kinetic energy plays an important role in determining the transport properties. The viscosity of liquid He³ rises as the temperature decreases, from a value of 18.7 micropoise at 3.35°K to 26.8 micropoise at 1.3°K. A simple empirical equation describes the He³ data over the entire temperature range. A.

3689. Some Considerations of the Magnetostrictive Composite Oscillator Method for the Measurement of Elastic Moduli.

N. B. TERRY, *Brit. J. appl. Phys.*, 1957, **8**, No. 7, 270.

The development of the composite oscillator method, using nickel transducers, to enable measurement of the rigidity moduli as well as the Young's moduli of small cylindrical specimens is described. The magnitude of the cementing errors for the different modes of excitation is examined both theoretically and experimentally. An analysis is given which shows the advantages, for the technique described, of resonating at the fundamental mode for specimens of relatively low characteristic acoustic impedance. A further consideration of errors due to cross-sectional mismatch between transducer and specimen is made and finally some measurements on coal specimens are given. A.

3690. Experimental Measurement of the Viscosity of a Stretched Liquid.

A. P. TOROPOV and A. I. KITOVA, *Zh. éksper. teor. Fiz.*, 1957, **32**, No. 2, 372.

Measurements were carried out by Stokes' method with C₆H₆. A cylindrical glass ampoule of 6 mm diameter was filled with C₆H₆ so as to leave a small air bubble, an Al-coated glass sphere (0.05–0.06 mm dia.) was put into the ampoule, after which C₆H₆ was frozen and the ampoule sealed and inserted into a frame fitted with two cross lines 100 mm apart and capable of placing the ampoule rapidly into a strictly vertical position. First the temperature of the complete dissolution of the air bubble and that of the appearance of discontinuity were determined for each of the three ampoules prepared, and then the times of falling (from one cross line to another) were determined for temperatures 0–3°C below the temperature of dissolution. Parallel measurements were made with

non-stretched C_6H_6 . The viscosity values showed that: (1) the viscosity of the stretched C_6H_6 can be measured with an accuracy of ± 0.03 millipoise and (2) contrary to Worthington's opinion (1893) this method is quite suitable for measuring the viscosity of stretched liquids. A.

3691. **On the Question of the Theory of the Flow of Plastic Dispersed Systems.**
N. V. TYABIN and G. V. VINOGRADOV, *Koll. Zh.*, 1957, 19 (3), 352.

An attempt to explain curved flow-curves for greases in capillary tubes by means of a complex series of "Bingham-terms" (but no appreciation of Buckingham-Reiner treatment). G.W.S.B.

3692. **The Effect of Basic Sols of Aluminium Oxychloride on the Structural-mechanical Properties of Suspensions of "Askangel."**
É. D. UZNADZE and M. E. SHISHNIASHVILI, *Koll. Zh.*, 1957, 19 (3), 368.

The conditions have been established for increasing the strength of the thixotropic structures in bentonite clays-askangels—by the use of basic aluminium oxychloride. A method of obtaining the aluminium oxychloride from freshly precipitated aluminium hydroxide has been described. The composition has been determined of the complex cation of that salt and it has been shown that the former contains 5 hydroxyl groups and that 6 water molecules are linked to a molecule of the latter.

Aluminium oxychloride is an effective structuralizing electrolyte, considerably increasing the strength of the reversible thixotropic structure, and can thus be used as an additive to suspensions employed in complicated cases of petroleum boring.

From electron diffraction diagrams it follows that the thixotropic structures appearing thereon are structural frameworks, consisting of larger sized aggregates (secondary formations) of askangel particles (see Abstr. 3578). A.

3693. **On the Structural Part of the Compressibility of Liquids.**
V. S. VENKATASUBRAMANIAN, *J. chem. Phys.*, 1957, 26, 965.

Frenkel postulated that the compressibility β_T of a liquid is the sum of the geometrical part (decrease of average intermolecular distance) and the structural part (alteration of intramolecular arrangement) i.e. $\beta_T = \beta_T^g + \beta_T^s$. It is shown that the structural part can be expressed in terms of the temperature coefficient of compressibility. A.

3694. **On a New Method of Applying Sinusoidal Fatigue Stresses at 87kc/s.**
G. VIDAL and F. GIRARD, *C.R. Acad. Sci. (Paris)*, 1956, 243, 1276.

A barium titanate crystal in the form of a tube is set in longitudinal resonance by an oscillator. A disk rests on one of the end of the tube and this is attached to the middle section of the cylindrical test specimen. The disk is pressed against the end face of the crystal tube by a rubber washer and by a clamp fixed to the middle section of the crystal. The test-piece is cut to a resonant length, oscillation being maintained by a pick-up. A.

3695. **Adhesion of High-polymers: 3, The Effect on adhesion to Cellophane of Size, Shape and Polarity of High Polymers.**
S. S. VOYUTSKIĭ, A. I. SHAPOVALOVA and A. P. PISARENKO, *Koll. Zh.*, 1957, 19 (3), 274.

Adhesion is greater the lower the M.W. and the less the number of side-chains and usually, the less the number of polar groups (see Abstrs. 3518, 3578). G.W.S.B.

3696. **Dislocation damping at High Temperatures.**
J. WEERTMAN, *J. appl. Phys.*, 1957, 28, No. 2, 193.

An unpinned dislocation damping model (based on the Mott-Nabarro solution hardening theory) was previously used to explain internal friction at room temperature

and is now extended into the high-temperature range. With the model it is possible to explain the high-temperature internal friction which has been observed in the kilocycle frequency range for measurements made at very low strain amplitudes. In addition, the damping due to dislocation climb is considered. A.

3697. Hydrodynamics of a Reacting and Relaxing Fluid.

W. W. WOOD and J. G. KIRKWOOD, *J. appl. Phys.*, 1957, **28**, 395.

General equations governing the hydrodynamic behaviour of an ideal compressible fluid in which chemical reactions and internal relaxations proceed are formulated. For one-dimensional flow, the equations are transformed to characteristic form, in which the "frozen" or high-frequency sound velocity plays a role analogous to the unambiguous sound velocity in the non-reactive case. A.