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SUMMARIES OF PAPERS read at meetings of the Society

The relation of certain properties of metals to their crystal structure

J. F. W. BISHOP

(Plasticity Division, Mechanical Engineering Research Laboratory,
East Kilbride, Glasgow)

The resolution into three classes, namely macroscopic, microscopic and atomic, of phenomena associated with metals is discussed, and certain mechanical properties are considered within the framework of this classification. In particular, the relevance of investigations at one of these levels to phenomena associated with a different level is examined. A brief summary of the salient features of three types of lattice structure commonly occurring in metal crystals is given and the mechanisms of deformation in such structures is discussed. The paper is then particularized to those lattice structures for which glide alone, i.e. relative sliding of atomic planes, is a sufficient mechanism for the imposition of an arbitrary strain. The Schmid critical shear-stress law is stated and examined in the light of the experimental evidence, and its application to conditions of simultaneous glide discussed. The nature of the yield surface in stress space for a single crystal is considered and its chief features commented upon. The maximum work principle of the Bishop-Hill theory of crystal distortion is given for single crystals and generalized to an aggregate. The application of this theory to three problems is then considered, namely to:

- (i) Yield under combined stress of an isotropic aggregate of face-centred cubic crystals
- (ii) Stress-strain relations
- (iii) Deformation textures

The predictions of these theoretical investigations are discussed in relation to the experimental evidence. The paper concludes with a comparison of the theoretical techniques applicable at the macroscopic and microscopic levels in metal plasticity.

*Paper read at Conference on "Rheology in Mechanical Engineering,"
10th June, 1954.*

Current problems and experiments on time-independent plastic deformation

H. LL. D. PUGH

(Plasticity Division, Mechanical Engineering Research Laboratory,
East Kilbride, Glasgow)

An account is given of the concepts underlying time-independent plastic deformation. Two classes of problems are considered; the first is concerned with the fundamental plastic properties of materials and the second with specific problems of plastic flow characterized by given boundary conditions.

Problems considered in the first class include yielding under combined stresses, stress strain relations, hardening and the effects of hydrostatic pressure. The mathematical theory of plasticity is briefly examined in the light of the experimental evidence

and the need for further work is indicated. A discussion is given of the incremental and total strain theories of plastic deformation and of the yield criteria.

The second class of problem is concerned with the application of the concepts of plasticity to specific problems, particularly those connected with technological processes. Although the equations governing plastic flow are well known, no general solution is yet available because of the practical difficulties in the mathematics. The simplification of the equations in the special cases of plane stress and plane strain are considered. Problems in this class may be resolved into steady state and yield point problems. The first group includes strip drawing, extrusion and machining under certain conditions and the second group indentation problems. In the examples quoted, theoretical and experimental results are compared for extrusion under plane strain conditions and for indentation with flat, smooth, rigid dies. The paper concludes with a reference to the physical mechanism of plastic deformation.

*Paper read at Conference on "Rheology in Mechanical Engineering,"
10th June, 1954.*

On the laws of stress relaxation and creep in solids

P. FELTHAM

(Standard Telecommunication Laboratories, Enfield, Middlesex)

The remarkable qualitative similarity in the response of solids of widely different structures to applied stresses, particularly in creep and relaxation, is ascribed to relaxation centres all of which, in a given solid, have approximately the same heat of activation but, on account of variations in their geometry—such as shape and size—have different configurational entropies of activation. A normal distribution of entropies of activation is shown to lead to a log-normal (Gaussian) spectrum of relaxation times of the type originally proposed by Wiechart (Ann. der Phys. und Chem., 1893, **50**, 335 and 546) on heuristic grounds.

Boltzmann's superposition principle and the relation between creep and relaxation derived by Zener (1948, Elasticity and Anelasticity of Metals, Ch. V) are used to show that this distribution yields a form of relaxation curve common to many solids, as well as the Andrade $t^{1/3}$ -creep law.

Experimental data, given in the literature, on the creep and relaxation in pure polycrystalline aluminium (Kê, 1947, Phys. Rev., **71**, 533), certain rubbers (Tobolsky and Stern, 1946, J. chem. Phys., **14**, 80) poly-methyl-methacrylate (Jenckel and Klein, 1952, Z. Naturf., **7a**, 619), ceramics (Macey, 1948, J. sci. Instrum., **25**, 251) are shown to be in good agreement with the theory.

The significance of Nutting's law of deformation is discussed, and it is shown that it represents an approximation to more general laws over ranges of the variables which, though restricted in each application, are nevertheless generally sufficiently wide to permit its use, or the use of the power laws of stress relaxation under constant strain and of creep under constant stress implied by it, in many practical applications for the presentation of rheological results.

*Paper read at Conference on "Rheology in Mechanical Engineering,"
10th June, 1954.*

An experimental approach to plane strain problems

F. ELLIS AND H. FORD

(Imperial College of Science and Technology, University of London)

Many problems in the technological forming of engineering materials are essentially problems in plane strain. Examples which spring to mind are strip rolling, sheet extrusion and sheet bending. It is shown in the literature that complete solution of such two-dimensional flow problems can be obtained if a slip-line field can be found which satisfies the boundary conditions in both stress and velocity. Slip-line fields have been proposed for various problems and in nearly all cases the field has been built up from relatively

simple geometrical elements such as the straight line, circular arc and involute. The slip-line field for cold rolling has so far defied solution. The present theory assumes it is a statically determinate problem. Experiments will be described in which a plane strain compression test is used to determine the yield stress/strain characteristic for strip material. This test uses parallel platens as the compressing tools, and the effect of the roll curvature in causing additional work-hardening will be discussed. Some findings regarding anisotropy and the Bauschinger effect will also be described.

A new experimental approach to the solution of the cold rolling problem is then described. The method however, is not confined to this particular process, but can be applied to many problems in plane plastic flow. The data required to plot the slip-line field is obtained from the measured distortion of a square network of lines engraved on a surface lying in the plane of flow. The specimens required for this particular investigation are in the form of strip with a width to thickness ratio of the order of 20 to 1. The technique has been developed using high-conductivity copper in strip form. A specimen is made by pressure welding two similar pieces of copper in such a way that a square network engraved on the edge of one of the pieces lies in a plane of flow and on the centre line of the specimen.

The method described in the paper fulfils the following conditions which must be complied with if quantitative results are to be obtained.

- (a) The network must lie in a plane strain field.
- (b) The method of joining the pieces forming a specimen must not distort the network.
- (c) The strength of the joint must be sufficient to withstand the stresses set up during the plastic deformation.
- (d) The welded joint must be capable of being parted after the deformation has been completed without damage to the deformed network.

The conversion of the data obtained from the measurements of the distorted network to a slip-line field is then considered.

*Paper read at Conference on "Rheology in Mechanical Engineering,"
11th June, 1954.*

Observations on energy dissipation during high-speed fatigue tests

N. WADSWORTH
(University of Bristol)

A number of observations have been made of the energy dissipated by polycrystalline copper specimens during high speed fatigue tests. The specimens were 3.8 mm in diameter and 2 cm long between the knobs used for gripping. The grain size was about 0.1 mm. Reversed tension-compression stresses between constant stress limits were used throughout. The frequency was about 1000 cycles per second (60,000 cycles per minute). The machine used for these tests was designed and built in the Physics Department of the University of Bristol. It has an electrically-maintained, mechanical-resonance system. The energy dissipated in the specimen can be deduced from the resonant properties of the mechanical system or from the heat produced in the specimen itself. The two methods agree to within the experimental error. The energy dissipated per cycle per cubic centimetre is equal to the area of the stress-strain hysteresis loop of the specimen and is related to its specific damping capacity.

If the specimen is fully annealed before testing, the energy dissipated per cycle is initially large and falls rapidly to a low value. As the test proceeds the rate of dissipation rises slowly and roughly linearly with time until the failure of the specimen. If the experiment is repeated at a slightly higher stress it is found that the steady rise occurs much more rapidly. The rate of rise is strongly correlated with the final life of the specimen the relation being $\text{life} \propto (\text{rate of rise})^{-1.3}$. This relation holds over a range of specimen life of 300 : 1. The energy dissipated per cycle is independent of both temperature and frequency over the small range of each investigated.

Some specimens were removed from the machine after part of their fatigue life and

annealed in vacuum. One hour at 600°C was sufficient to remove almost all the increase in rate of energy dissipation which had occurred during the previous stressing. On resuming the stressing the specimen behaved in a manner similar to a fresh one. The minimum value of rate of dissipation obtained after the initial hardening was completed was only slightly higher than that of a fresh specimen. The total fatigue life was however unaffected by an anneal of this type every 20% of the expected unannealed life.

Quite early in the test slip-bands formed and as the test proceeded these got thicker and more numerous. The number of slip-bands on the specimen was found to increase in a similar manner to the rate of energy dissipation in an unannealed specimen. It was found that the final crack started in one of these broad slip-bands and subsequently spread to neighbouring grains. If the rate of energy loss is a measure of the number and intensity of slip-bands this explains the observed correlation between the area of the hysteresis loop, or the rate of energy loss, and fatigue life. Since annealing can remove almost all the increase in area of the hysteresis loop without affecting the formation of the crack it is clear that this increase cannot be directly due to incipient cracks. The first crack, or the first irreversible process which eventually leads to the formation of a crack, must occur early during the fatigue test and certainly before 10% of the life of the specimen.

*Paper read at Conference on "Rheology in Mechanical Engineering,"
11th June, 1954.*

Some developments in the theory of viscosity

E. J. LE FEVRE

(Heat Division, Mechanical Engineering Research Laboratory,
East Kilbride, Glasgow)

Dimensional analysis is used to show how the viscosity of those fluids which satisfy the principle of corresponding states could be correlated in terms of reduced variables. The type of correlation deduced is used for the viscosity of gases and it is shown that with few exceptions the viscosity can be predicted within about five per cent if the three critical constants are known.

The relation between this and the kinetic theory is obtained. It is shown how the result found could have been deduced by combining the Lennard-Jones and Devonshire theory of the critical state with the calculations of Kihara and Kotani and others for the viscosity of gases having Lennard-Jones potentials.

It is shown that approximate asymptotic formulae for viscosities at very high or very low temperatures may be simply deduced from the potential of the intermolecular forces.

The Sutherland model is discussed and shown not to fit the facts. Qualitative reasons for the divergences observed in the cases of hydrogen and helium are indicated.

Liquids are also briefly considered.

*Paper read at Conference on "Rheology in Mechanical Engineering,"
12th June, 1954.*

Some fluid motion problems

W. J. ROBINSON

(Fluids Division, Mechanical Engineering Research Laboratory,
East Kilbride, Glasgow)

Many basic problems of fluid motion in the mechanical engineering and chemical engineering industries are amenable to investigations by models and examples of unsolved problems in industry are given where this technique might be usefully applied. By replacing gas for liquid in the model, or vice versa, considerable advantages are sometimes offered and examples of work in progress at M.E.R.L. are given where this device has been successfully adopted. Reluctance to employ models sometimes arises from the conflicting requirements of the laws of similitude and a plea is made for publication of more experimental data, so that rules can be evolved to assist in the "scaling up" of model performance.

Methods for estimating flow losses through pipes and the working passages of

machines such as pumps for handling water-solid mixtures, slurries and other non-Newtonian liquids, have not kept pace with requirements and reference is made to the general problem of pumping coal and to tests with which the Laboratory has been concerned in connection with the pumping of raw peat.

Higher ratings being adopted for ship propellers, concrete hydro-electric structures, hydraulic machinery and underwater weapons of war, have caused a marked increase in the incidence of cavitation and attention has been focussed for some years on the improvement of hydraulic design. There is a crying need for more knowledge of the physics of the process and the author discusses the problem of cavity collapse and noise, the influence of properties of the liquid itself and the presence of nuclei. A brief discussion is given of M.E.R.L. work in progress on cavitation damage and scale effect. Reference is also made to the influence of higher fluid speeds on noise and to gaps in the fundamental knowledge of the subject.

Much of the detailed evidence sought in fluid motion research requires measuring techniques specially developed to the task. A description is given of progress made at M.E.R.L. in the development of electronic and other equipment for the precision measurement of flow, pressure, torque and speed, and other special devices for measuring air content and pressure pulsations.

*Paper read at Conference on "Rheology in Mechanical Engineering,"
12th June, 1954.*

Retardation in paint and varnish media

A. J. ELLEMAN AND W. D. MAY

(Imperial Chemical Industries Ltd., Paints Division, Slough, Bucks)

The visco-elastic properties of paint and varnish films are discussed from the view point of retardation time distributions. By modifying Alfrey's method for obtaining the distribution from extension under constant load curves, a method of analysis has been developed by assuming the distribution to be Gaussian log-normal which can be characterised by three parameters. The three parameters are obtained by a master curve method without the need for tedious calculations or graphical differentiation.

This method is used to classify creep curves of paint and varnish films, and the effects of temperature, humidity, ageing and different filler concentrations on the three parameters are described.

Exposing the films to ultra-violet radiation is shown to change the distribution and a method of deriving the non-Gaussian long-normal distribution is described.

*Paper to be read at the Conference on "Viscoelasticity in Solids, Emulsions and Solutions"
(Imperial College), 17th September, 1954.*

Relaxation phenomena in organic glasses and high molecular weight materials

J. J. BENBOW AND H. KOLSKY

(Imperial Chemical Industries Limited, Butterwick Research Laboratories,
Welwyn, Herts)

When most high polymers are deformed mechanically they show only recoverable flow. This can be illustrated by birefringence measurements, where it is found that the optical anisotropy depends only on the value of the strain (Crawford and Kolsky, 1951, Proc. Phys. Soc. B, **64**, 119; Kolsky, 1952, Trans. Soc. Glass Tech., **36**, 56.) Materials of low molecular weight, on the other hand, can flow irreversibly and the present work is concerned with the mechanical behaviour of such low molecular organic materials in the glass-like state. In particular the dynamic shear properties of two such materials, 2'-hydroxy-2 : 4 : 4 : 6 : 5'-pentamethylflavan and glycerol sextol (cyclohexanol) phthalate, have been studied in detail at frequencies between 10^{-4} and 10^4 cycles per second (Benbow, 1954, Proc. Phys. Soc. B, **67**, 120.) In order to do this a number of different experimental techniques have been employed involving the use of both free and forced vibrations, and these are described (cf. Benbow, 1953, J. Sci. Instrum., **30**, 412.)

At the lower frequencies the logarithmic decrement of these materials is found to be

inversely proportional to the frequency, and this was found to hold over several decades of frequency. At the higher frequencies the logarithmic decrement decreases more slowly and appears to be approaching a constant value. In contrast with this the logarithmic decrement of high polymers varies comparatively little over extremely wide frequency ranges. The damping behaviour of these glasses in the lower frequency range is that expected from a single Maxwell element (one spring and a dashpot in series) and in this region a Newtonian viscosity and a Hookean elasticity can be assigned to these materials. The values of the viscosity are found to be in good agreement with those measured in a coaxial viscometer under equilibrium conditions. The approximate relaxation-time spectra of the glasses were also determined and it was found that they indicate the presence of a very narrow peak.

Thus at low frequencies these glasses behave like Maxwell bodies, whilst at higher frequencies their mechanical behaviour becomes similar to that of high polymers. The frequency range over which the behaviour is Maxwellian depends on the temperature and on the chemical association between the molecules. Thus materials which associate easily are Maxwellian only at the lowest frequencies, whilst those materials which have no possibility of chemical association are Maxwellian over a wider frequency range. This is reflected in the relaxation-time spectrum, which is broader for the more associated glasses. Extensive work by Van der Poel on pitches has shown that they too show similar behaviour with frequency (van der Poel, 1953, Proc. 2nd Int. Congress on Rheology, page 331.)

In addition to dynamic elasticity measurements some work (Crawford, 1953, Proc. Phys. Soc. B, 66, 953) has been done on the stress relaxation of these glasses by observing the manner in which the birefringence relaxes when flow is prevented. These results show that the stress relaxes exponentially, which is the behaviour expected from a simple Maxwell element.

Paper to be read at the Conference on "Viscoelasticity in Solids, Emulsions and Solutions"
(Imperial College), 17th September, 1954.

BOOK REVIEWS

Science and industry in the nineteenth century

J. D. BERNAL

(Routledge & Kegan Paul Ltd., 1953)

The reader who, on glancing upon the title, expects to find the detailed chronicles of the period of adolescence of modern science and technology would discover, on browsing among the pages, that he was mistaken. He is not, however, likely to find his reading disappointing. Of course history is there but, presented in the form of two major essays, it is rich, living history.

In the first essay Bernal chooses four principal fields of technical and scientific advance: Heat and Energy, Ferments and Microbes, Steel, and Light and Power to show, by their development, the reciprocal nature of the relation between science and technology, as human enterprises linked with current economic, political and cultural forces.

The second essay is a story—certain to move every scientist—of the discovery of Molecular Asymetry by Pasteur in the stormy year of 1848; of the antecedents out of which it grew, as well as of the consequences to which it gave rise. This is a timely essay, for it shows science in the service of human emancipation and, by implications, throws into relief its dehumanizing uses: the gap between the attainable and the attained.

These essays provide the key to an understanding of the nature of the historical paths along which science and industry developed, hand in hand. Such an understanding is no doubt the best starting point for an enquiry into what the future is likely to hold in science, in industry, in human relations, for to know where one is standing and how one got there is surely the best equipment for deciding on what to do next and how to do it.

While the chief merit of the book lies in the nowadays rare quality of inspiring

thought, it should also be said that the facts are well mastered and equally well presented; the reading is as pleasant as it is instructive. P.F.

Flow properties of disperse systems

Editor: J. J. HERMANS

North Holland Publishing Company, Amsterdam (1953)

xi + 445 p. £3 10s. 0d.

"Disperse systems" embrace a very wide range of materials and are governed by equally wide range of principles controlling their flow. Dilute solutions and suspensions of simply shaped particles form one boundary whilst such complex gels as wood might be considered to form another. In between are found smoke and other suspensions in air, foams, emulsions of various complexities, concentrated solutions and gels of all possible combinations of materials. Interest in the flow of these materials has, consequently, been of many different types too. Thus there is a fascinating field for applied mathematics in the behaviour of solutions and suspensions of particles in viscous fluids, another for the biological aspect of flow in living organisms, a third for the theoretical physical chemistry of macromolecules, and yet another for engineering studies of flow of slurries or of fluidised powder beds. The net result of this diversity of material and interest is that a great deal of basically related studies and literature has been published in very many types of journals and books not readily available to all who may need the knowledge. This book succeeds in bringing together these related findings and focuses attention on the essential unity, as well as the diversity existing within them.

The book consists of ten chapters. These deal with suspensions (R. Roscoe), emulsions (E. G. Richardson), gels (J. J. Hermans), dilute solutions of rigid particles (Ch. Sadron), dilute solutions of flexible molecules (J. J. Hermans), liquid sprays (E. G. Richardson), atomization of liquids (H. L. Green), foams (R. Matalon), smoke (H. L. Green) and powders (Mrs. B. S. Neumann). Subject and author indices complete the book.

The editor of a book covering such a wide scope and written by so many authorities has three main difficulties and dangers to contend with additional to the normal professional hazards of editors: the difficulty of knowing what to exclude, the monotony of repetition of the same theme by the different authors and the danger of disparity in the level of treatment accorded each section. Any judgement which may be passed on these three counts must, ultimately, be coloured by personal inclinations. Your reviewer's judgement is that the editor and authors have done well and deserve praise.

It was expected, for example, that the theoretical treatment of the infinitely dilute and more concentrated solutions would be given by more than one author as a statement of the problem affecting his particular section. This was in fact so. Where the editor and authors succeeded, however, was that this repetition was not monotonous, but was done from as many different points of view as there were discussions on it. Thus there is the brief dimensional treatment illustrated by empirical findings given by Roscoe, a thermodynamical approach followed by a physical chemistry interpretation in a later chapter by Hermans, and a hydrodynamical analysis by Sadron. The effect is that of reinforcement rather than of an overburden. Similarly the discussions on liquid break-up by Richardson and Green are complementary rather than repetitive.

Although there were many points of view, as just indicated, the method of discussion is uniformly clear, critical and well informed and documented. This picture of excellence is unfortunately marred by obvious misprints and mistakes. Thus, to take a few examples at random: on page 53, footnote (1), "mean rate of shear" should read "mean torque" or "mean pressure"; p. 54, 6th line, for "Tams" read "Toms"; p. 296, for "Fig. 4" read "Fig. 16" and on p. 341 the reference "Weissenberg [0000]" is more likely to be a case of forgetfulness to fill in the date than a genuine reference to Weissenberg's writings in the year of grace zero to four significant figures. These are slight and obvious mistakes which should be put right in the second edition.

Rheologists will find the book well worth its price and the effort to study it.

ALFRED H. NISSAN.

RHEOLOGY ABSTRACTS

2925. **Experiments in hydrodynamic lubrication using water as a lubricant.**
S. ABRAMOVITZ. *J. Appl. Phys.*, 1953, **24**, 1521.

A letter discussing experiments which have been carried out using a pivoted segmental thrust bearing with water as a lubricant. S.T.

2926. **Sedimentation from concentrated suspensions in relation to particle size.**

E. B. ALLISON AND P. MURRAY. *Brit. Ceram. Soc. Trans.*, 1953, **52** (4), 204-12.

Relations between the rate of sedimentation and the porosity and permeability of the sediment being examined are discussed. The process of settling of solid particles from concentrated suspensions is regarded as the upward flow of liquid through a porous bed. The KOZENY relation is applicable and hence specific surface values may be calculated from the sedimentation data. The results for samples of alumina, magnesia, and zinc oxide are compared with those obtained by other methods. Except for zinc oxide, the values calculated from sedimentation data are about 30 per cent lower than those obtained by the air permeability method. The high values obtained by the nitrogen-adsorption method for the lightly-burnt oxides are attributed to the presence of micro-fissures in the particles and do not occur with the strongly-ignited oxides. Specific gravity data confirm this view. B.S.A.

2927. **Investigations of clay by the Brabender cone penetrometer.**

I. A. AL'PEROVICH, P. I. BERENSHTEYN, AND G. S. BLOKH. *Glass & Ceramics*, Moscow, 1953, **10**, (8), 22.

A formula is given for calculating limiting shear stresses in clay in the plastic state and a formula for the determination of the yield value of clay at low moisture-content. Expts. have shown that the cone penetrometer is suitable for the determination of the consistency of clay (i.e. degree of wetness). The article also contains a method (and its theoretical basis) for the determination of the surface moisture-content and the surface moisture-gradient of green products necessary for the determination of the drying-schedule. The plastometer described is simple and gives reproducible results. B.C.R.A.

2928. **The flow of clay pastes.**

M. Y. BAKR AND A. ISKANDER, *Ceramics*, 1953, **5**, 274.

The flow curves of some Egyptian clays, prepared as slips of different pH values, were studied by means of Searle's co-axial cylinder viscometer. The pH value was varied by the addition of H_2SO_4 or NaOH. The pH of the slip is measured by means of a glass electrode pH electrometer. Both the yield-value and apparent viscosity of the slip (a red Aswan clay) are highly affected by its pH value. The mobility of the slip, as measured by the slope of the final straight portion of the curve, seems to be practically independent of the pH value. The yield value seems to be min. at the isoelectric pt. when the ionic atmosphere is very weak. On both sides of the isoelectric pt., the yield-value increases owing to the increase of the electric strength of the ionic atmosphere. Slips of clay in alcohol were prepared and their flow curves were compared with those of aqueous slips having the same proportions of clay to liquid. The pH values of both types of slip were adjusted to be equal. With the alcoholic slip, the apparent viscosity increases with the rate of shear. B.C.R.A.

2929. **Coagulation of solutions of sodium humate with sodium chloride.**

V. G. BEN'KOVSKIĬ AND S. S. SUKHAREV. *Kolloidnyi Zh.*, 1953, **15** (6) 404.

The process of coagulation is followed by viscosity measurements. G.W.S.B.

2930. Viscosity stability of latex paints.

D. A. BIXLER. *Ind. Eng. Chem.*, 1953, **45** (4), 739-42.

The effect of certain variables in protein (unhydrolysed soybean) usage on the viscosity of latex paints during storage is investigated. Concentration of ammonia in the dispersion, the temperature at which the dispersion is prepared, the protein concentration in the dispersion, and the order or mode of mixing do not affect the viscosity stability. Stable paints may be made containing up to about 2 per cent of protein; ammonia is the most satisfactory dispersant. Latex paints having viscosities over the entire desirable range were made with small amounts of protein. Some of the foregoing factors may alter the initial viscosities but not the stabilities of the finished paints. B.S.A.

2931. Sedimentation of pigments, its measurement, and its prevention.

C. BOLLER AND U. LICHTHARDT. *Farbe u. Lack.*, 1952, **58**, 441-3.

The amount of pigment in various strata of a paint, as well as the consistency of the sediments, is measurable. From B.S.A.

2932. The viscosity-temperature function.

A. V. BRANCKER. *The Industrial Chemist*, 1954, **30**, 112.

The numerous viscosity-temperature equations given in literature only apply in limited cases and fail as general solutions of the problem. An equation which is a modified exponential of the form $\eta/T = Ae^{B/T} + c$ is suggested as a practical, if laborious solution. E.W.J.M.

2933. Mixing of granular materials.

R. L. BROWN. *Research (Supplement)*, 1953, **6** (11), 57-85.

A statistical method of analysing data relating to mixes of granular materials is connected with Danckwert's theory. By introducing smaller volumes within the total volume of the mix, several scales of scrutiny can be considered and the quantitative estimation of mixing can thereby be facilitated. B.S.A.

2934. Some properties of vacuum-treated clay.

P. P. BUDNIKOV AND A. I. PEROVICH. *J. Applied Chem. U.S.S.R.*, 1952, **25**, 244-56.

When air is removed from a plastic clay by vacuum treatment (700 mm Hg below atmospheric) the plasticity rises and the thixotropy falls. This is ascribed to replacement of air adsorbed at the surface of the clay particles by water. The drying-rate curves of such clays before and after vacuum treatment, and the linear shrinkage during drying support this theory. Air in lean, non-plastic clays, is mostly mechanically entrained and not adsorbed, and the increase of plasticity in vacuum is due to a greater mobility of the liquid phase when micro-bubbles of air are removed. Whereas vacuum treatment considerably lowers the shrinkage of plastic clays on drying, it scarcely affects that of lean clays. B.S.A.

2935. The viscoelastic properties of plastics.

F. BUECHE. *J. Chem. Phys.*, 1954, **22**, 603.

A general method has been devised to predict the visco-elastic behaviour of plastics. A simplified model of the molecule is assumed and its general motion is treated by the method of normal co-ordinates. General equations have been developed such that when the manner of application of external forces to the molecule is known, the molecule's general behaviour may be found in a convenient and straightforward fashion. This method has been used to obtain theoretical curves for the viscoelastic behaviour of cross-linked polymers subjected to sinusoidal forces. Also, the similar problem for linear material has been solved together with the creep and stress relaxation problems. It is shown that the temperature-time superposition procedure of Ferry and Tobolsky has a firm theoretical basis. In general, the theoretical curves appear to agree with the limited experimental data available. The method is also applied to the case of dilute solutions and comparison is made with the result obtained by Rouse using a different approach. A.

2936. Thermal and elastic properties of α -keratin.

H. B. BULL. *J. Phys. Chem.*, 1954, **58** (2), 101-103.

The elastic coefficients of hair fibres indicate structural changes at about 5% and about 25% elongation. Minima and maxima in the volume of hair fibre and in the energy of activation for decay of stress are shown also. The polypeptide structure is considered in relation to these changes. G.E.B.

2937. Motion of small particles in skew shape suspended in a viscous liquid.

CHAN-MOU TCHEN. *J. Appl. Phys.*, 1954, **25**, 463.

The resistance experienced by a curved and elongated small particle is studied by the method of velocity perturbations. The fundamental equations determining the perturbations are derived from the equations of Oseen. The particle is curved in such a way that the axis of the particle is formed by an arc of circle. The opening angle may vary to exhibit various shapes from a straight ellipsoid to a closed ring. Results illustrate the circumstances under which manifests the co-operation between the different parts of the particle. Apart from this pure hydrodynamical interest, the problem has applications to long chain molecules in solution and to suspensions of swimming organisms. It demonstrates the effect of skew shape by taking for the chain molecule a model in the form of a variable-curved ellipsoid instead of a sphere or a cluster of spherical symmetry, as the co-ordination of the chain links, even in the case of free rotation, leads initially to configurations of variable skewness generally obscured under the averaging processes by current theories. A.

2938. Mechanism of creep deformation in high purity aluminium at high temperatures.

H. C. CHANG AND N. J. GRANT. *J. Inst. Met.*, 1954, **82**, 229.

2939. On the mechanism of grain growth in metals, with special reference to steel.

D. G. COLE, P. FELTHAM AND E. GILLAM. *Proc. Phys. Soc. B.*, 1954, **67**, 131.

The rate of grain growth in the initial stages of isothermal austenitizing has been studied by a thermal etching method in plain, eutectoid, carbon steel in the range 840-970°C. An equation relating the mean initial and instantaneous grain diameters, D_0 and D , to the austenitizing time t , of the form $D^2 - D_0^2 = Kt \exp(-H/kT)$ is developed on the assumption that the growth rate is controlled by interfacial tension at grain boundaries. An estimate of the constant K is made, and by the use of experimentally obtained values of D , D_0 and t the value of H is calculated to be 30 kcal/g atom, close to the activation energy estimated for grain-boundary self-diffusion and to that determined for the damping of low amplitude torsional oscillations. A.

2940. Variation of viscosity of gelatin sols with temperature.

R. J. CROOME. *J. Applied Chem.*, 1953, **3** (7), 330-4.

The variation of viscosity with temperature is investigated for sols of an isoelectric ossein gelatin and the Andrade-type equation $\nu = Ae^{K/T}$ is established (ν = kinematic viscosity, T = absolute temperature, K and A are constants). The constant A is a function of the weight-percentage concentration of gelatin in the sol. It is assumed theoretically that the hydration of the gelatin particles during soaking persists on dispersion, whilst the decrease in viscosity with rising temperature is mainly caused by a progressive loss of the absorbed water back to the free dispersion medium, thereby decreasing the weight of dispersed phase to weight of dispersion medium. Expression of the viscosity as a function of this ratio yields an equation representing variation of viscosity with concentration of gelatin. The reversibility of the viscosity-temperature relation may be due to the rupture and subsequent re-formation of hydrogen bonds set up between the water molecules and the lyophilic peptide groups in the gelatin particles. B.S.A.

2941. Theory of mixtures and mixing.

P. V. DANCKWERTS. *Research, Lond.*, 1953, 6 (9), 355-361.

The general theory of mixing substances, gases, solids and liquids, is reviewed briefly, with 18 references to general literature, a reference to two bibliographies, and some illustrations. It is suggested that such theory has been largely neglected in the past: the first requirement is for rational and quantitative methods for defining and measuring "goodness of mixing" applicable as widely as possible and avoiding purely arbitrary methods. A theory of the absolute efficiencies of mixing processes is also required, to discover how much energy is dissipated fruitlessly. Quick mixing means more energy; in practice a compromise must be sought between time and energy, though other factors may operate too. The idea of "scale of scrutiny" is introduced—this may vary over a very wide range. Fluctuations in a coarse-grained mix are considered: "fully randomized," and non-random but fully-dispersed conditions are differentiated. When the scale of scrutiny is great enough to include a very large number of particles of each component the mixture is termed "fine grained". "Composition at a point" and "spottiness" are referred to. Two distinct quantities are required to describe precisely an imperfect mix: scale, and intensity of segregation, or "unmixedness". The product of these two is important if samples taken at random are required to display not more than a given specified variation. The minimum work required for mixing—for positive mixtures of gases or miscible liquids; negative mixtures such as suspensions of solids in liquids; and central or static mixtures; scaling-up from models, and the significance of the Reynolds, Froude, and Schmidt numbers; power requirements; mechanisms of mixing; and back-mixing in continuous flow systems; are discussed theoretically. B.S.A.

2942. The physical processes involved in stress-reversal.

U. DEHLINGER. *Z. Metalk.*, 1953, 44 (5), 240-2.

From a review of the previously published experimental material concerning the effect of external conditions on fatigue resistance, especially straining, it is concluded that the cause of breakdown is non-thermal, and is to be sought in relaxation processes in crystals caused by frequently repeated slip. B.S.A.

2943. Coulomb friction, plasticity, and limit loads.

D. C. DRUCKER. *J. Appl. Mech.*, 1943, 21, 71.

No work can be extracted from an assemblage of elastic-plastic bodies in equilibrium and any equilibrium system of forces acting upon them, if either the attachment is complete or if all coefficients of friction are zero. However, if a coefficient of friction is finite, the bodies plus the forces can act thermodynamically as an engine. Theorems are developed to relate the limit loads with finite force of friction to the extreme cases of zero friction and of complete attachment, and also to the case where the frictional contacts are made by the medium of a cohesionless soil. R.S.

2944. Investigations of the kinetics of the production of shear strains in glycerol and in solutions of rosin in transformer oil.

I. A. DUMANSKIĬ AND L. V. KHAĬLENKO. *Kolloidnyi Zh.*, 1953, 15 (6), 426.

Using a Schwedoff rotation viscometer, authors give strain/time curves for a series of stresses. The authors claim that glycerol shows elasticity after some 4000 sec. straining, whereas rosin-oil mixtures do not. [sic!] G.W.S.B.

2945. Changes of damping capacity in quench-ageing aluminium-rich alloys.

K. M. ENTWISTLE. *J. Inst. Met.*, 1954, 82, 249.

2946. On the validity of Mott's theory of the Beta-flow in poly-crystals.

P. FELTHAM. *Phil. Mag., Ser. 7*, 1954, 45, 9.

A survey is given of the experimental evidence about the activation energy for transient creep. It is concluded that, if the Andrade equation is written in the form $\epsilon^3 = At$, the dependence of A on stress and temperature is governed by the same constants as for steady state creep. A.

2947. **The flow of clay suspensions in tubes.**

B. S. FILATOV. *Koll. Zhurn.*, 1945, 16, 65.

2948. **Determinations of rheological properties of clay suspensions under conditions of steady flow.**

B. S. FILATOV. *Koll. Zhurn.*, 1945, 16, 141.

Studies the flow of dilute clay suspensions through a number of capillaries, applying Bingham and Darcy equations. The resistance to flow in the latter, given by $2 PD/L\gamma v^2$ (where P is pressure difference, D is tube diameter, L is tube length, γ is density and v is velocity), falls linearly from Reynolds number 10 until turbulence starts at $\sim 3,000$.

The second paper discusses semi-quantitatively the anomalous flow of two dilute clay suspensions in a concentric cylinder viscometer under streamline conditions.

G.W.S.B.

2949. **Measurements of motor oil viscosity at 0°F.**

R. W. FOREMAN. *A.S.T.M. Bull.*, 1953, 191, 50-53.

Compares results from Stormer viscometer, capillary viscometer, and values obtained by extrapolation from ASTM standard viscosity-temperature charts.

G.H.T.

2950. **Crystallisation and the relaxation of stress in stretched natural rubber vulcanizates.**

A. N. GENT. *Trans. Faraday Soc.*, 1954, 50, 521.

2951. **Method of analysing flow of granular materials such as sand.**

J. GITTUS. *Nature*, Lond., 1953, 172, 364.

The flow of clay-bonded foundry sand is considered in terms of the energy e used to coagulate an initially dispersed unit mass of sand, and E the energy required to re-disperse or separate the grains again. The mathematical expression of flow is then based on the assumption that the energy needed to cause flow is used only in uniting and separating the grains.

B.C.R.A.

2952. **Network theory of the gel point and the "incestuous" polymerisation of diallyl phthalate.**

M. GORDON. *J. Chem. Phys.*, 1954, 22, 610.

The status of the gel point equation, advanced by Flory, Stockmayer, and Walling for polyfunctional reactions, is briefly discussed. Two complicating factors in the chain polymerisation of divinyl compounds, to which this equation has been applied, are reviewed: the admixture of a monovinyl compound of comparable reactivity, and the "incestuous" tendency for the two double bonds in a divinyl compound to enter the same polymerisation chain. Contrary to the treatment by Simpson and co-workers, these two factors are found to demand different theoretical approaches. The progress of polymerisation enriches the monomer mixture in the monovinyl compound, while the incestuous tendency remains constant. Kinetic derivations are given for the gel point condition in both cases. The gel point in the "incestuous" polymerization of diallyl phthalate is calculated to be at conversions 40% higher than estimated by Simpson and co-workers and much better agreement is thus achieved with their experimental measurements.

A simple network theory suffices to predict the gel point in two chain polymerisation reactions. Substantial delays of the gel point, predicted by Walling's theory of diffusion control in such reactions, are not encountered.

A.

2953. **On one type of motion of cylindrical bodies in visco-plastic disperse systems.**

N. A. GUKASOV. *Koll. Zhurn.*, 1954, 16, 10.

2954. The measurement of the consistence of Norwegian Whey-cheese.

G. HADLAND AND P. SOLBERG. *Proc. 13th Intern. Dairy Cong.*, 1953, 3, 1291.

Using Scott Blair's sphere-hardness tester, authors calculate correlation coefficients between fat and solid-not-fat content, subjectively assessed consistency and elastic and plastic components of hardness at various temperatures. Some of these are very high ($\sim .95$). Over 400 cheese were tested: cow, goat and mixtures. G.W.S.B.

2955. Variation of hardness of metals with grain size.

E. O. HALL. *Nature*, 1954, 173, 948.

A plot of hardness number against $d^{-\frac{1}{2}}$ where d is the grain diameter gave straight lines indicating that grains supporting a stress equal to or greater than the applied stress will have yielded. E.W.J.M.

2956. A general plasticity theory for clay.

J. BRINCH HANSEN. *Geotechnique*, 1952, 3 (4), 154-64.

For fully saturated clay with internal friction and cohesion the equations of a general plasticity theory have been developed, assuming a linear increase of the undrained shear strength with the depth, as well as a sinusoidal variation of this strength with the inclination of the failure plane. In this general case the "Rankine" solution has been investigated and applied to the earth-pressure problem. The result confirms the correctness of the usual procedure, which consists of adding or subtracting twice the shear strength, provided that this shear strength is taken as half the compression strength at the depth in question and for shear along the failure plane in question. The inclination of the failure planes is, however, $45^\circ \pm \frac{1}{2}\phi$ instead of 45° . In the special case of monogeneous, isotropic clay (with internal friction) a "Prandtl" type solution has been investigated and applied to the foundation pressure problem. Also in this case the result confirms the correctness of the usual formula with a factor $(2+\pi)$ on the shear strength, provided that this shear strength is taken as half the compression strengths. The rupture-figure, is, however, completely different from the ordinary Prandtl figure. A.

2957. Approximate analysis of structures in the presence of moderately large creep deformations.

N. J. HOFF. *Quart. Appl. Maths.*, 1954, 12, 25.

2958. A technical rotating viscometer without end effects.

Z. HORAK. *Strojirenstvi*, 1953, 3 (12), 928.

A motor driven recording viscometer of the concentric cylinder type is described. End effects are removed by specially shaped metal pieces fixed to the bottom and top of the cylinder containing the liquid and approaching closely to the bottom and top of the oscillating inner cylinder. P.F.

2959. The physical-chemical behaviour of oil-dispersible soap solutions. I. Sodium phenyl stearate in benzene.

J. G. HONIG AND C. R. SINGLETERRY. *J. Phys. Chem.*, 1954, 58 (3), 201-206.

The rheological behaviour of dilute solutions of sodium phenyl stearate in benzene is shown to be much affected by additions of small amounts of water or other polar substances. The possible changes in structure involved in the large changes of viscosity are considered. G.E.B.

2960. The dynamics of aerosols.

H. JARZYNA AND M. LUNC. *Archiwum Mech. Stosowanej*, Warsaw, 1953, 5, 311 (French Abstract).

2961. Electromagnetic velometry. II. Elimination of the effects of induced currents in explorations of the velocity distribution in axially symmetrical flow.

A. KOLIN AND F. REICHE. *J. Appl. Phys.*, 1954, 25, 409.

2962. **The mechanical and physical properties of a new carbamide moulding material.**

K. KONECNY. *Strojirenstvi*, 1953, 3 (11), 838.

Data on a recently developed urea-based resin suitable for a variety of mouldings, and capable of being coloured in almost any shade, are given. P.F.

2963. **Investigation of the elasto-plastic properties of printing dyes.**

L. A. KOZAROVITSKIĬ AND S. YA SHALYT. *Kolloidnyi Zh.*, 1953, 15 (6), 437.

Experiments with Veĭler-Rebinder cone viscometer suggest importance of thixotropy and elastico-plastic properties in general in relation to practical quality. G.W.S.B.

2964. **Influence of electrolytes on the viscosity of solutions of nitro-cellulose.**

P. V. KOZLOV, A. A. FREĬMAN, E. S. SHVAĬSHTĖIN AND L. K. LOKUTSEVSKAYA. *Koll. Zhurn.*, 1945, 16, 115.

2965. **Direct determination of the flow curves of non-Newtonian fluids. III Standardized treatment of viscometric data.**

I. M. KRIEGER AND S. H. MARON. *J. Appl. Phys.*, 1954, 25, 72. (See Abstract 2716)

A scheme is proposed for systematizing the handling of viscometric data through use of the variables apparent fluidity ϕ and shearing stress F . The rate of shear $g(F)$ is obtained from the relation: $g(F)/F = \phi_n[1 + \Delta(F)]$. Methods are presented for obtaining the correction term $\Delta(F)$ from capillary and concentric-cylinder viscometric data. Use of the proposed scheme is illustrated. A.

2966. **Approximations in linear viscoelasticity theory: delta function approximations.**

H. LEADERMAN. *J. Appl. Phys.*, 1954, 24, 294.

The relationships between certain approximations that have been proposed recently in connection with the linear viscoelastic behaviour of noncrosslinked amorphous polymers are discussed. The approximations reviewed here are applicable with slight modifications to other types of linear response, for example, di-electric behaviour. A.

2967. **Differential-integral equations of motion of a deformable fluid mass bounded by a surface subjected to stresses.**

J. LITWINISZYN. *Arch. Mech. Stosowanej, Warsaw*, 1953, 5, 15. (English Abstract).

2968. **Friction of an elastic solid.**

A. S. LODGE AND H. G. HOWELL. *Proc. Phys. Soc. B.*, 1954, 67, 89.

The simple case is considered of the area of contact of a surface asperity being determined by the yield value and the normal load. Reference is made to the ploughing of a comparatively soft material by a harder one under the combined action of shear and normal forces. The tension of a string round a cylinder is discussed in terms of the normal load, the size, number and elastic constants of the asperities. R.S.

2969. **The physical characteristics of butter produced by the alpha-process.**

J. LYONS AND M. J. O'SHEA. *Econ. Proc. Roy. Dublin Soc.*, 1953, 4, 65.

The conclusions are mainly qualitative. Butter made by "continuous" process is hard and brittle before working and soft and oily after re-working. G.W.S.B.

2970. **A compression testing instrument for use with pastes.**

P. MASON. *J. Sci. Instrum.*, 1953, 30 (11), 418-21.

An instrument of low frictional resistance is described in which small cylindrical specimens can be compressed by loads up to several kilograms. A.

2971. Fat separation of evaporated milks. I. Homogenization, separation and viscosity tests.

R. B. MAXCY AND H. H. SOMMER. *J. Dairy Sci.*, 1954, **37**, 60.

In order to apply Stokes' law to rise of fat particles, viscosities are determined with a modified Gardner Mobilometer. G.W.S.B.

2972. Temperature effects in a rotation viscometer.

C. C. MILL AND E. R. GATES. *Analyt. Chem.*, 1953, **25**, 1390.

In the early stages of work designed to study the rheology of printing-inks by means of a rotation viscometer, it was observed that even with simple oils the viscosity tended to decrease at higher shear rates. A thermo-couple inserted in the bob indicated a rise of temperature when the power input exceeded a critical value, and experiments were undertaken to determine the magnitude of the heating effect, the manner in which it affects the rheological data, and a simple method of correction. The data recorded in an experiment can be corrected simply if the temperature coefficient of viscosity and the equilibrium temperature of the bob are known, the method applying to pigmented systems as well as to simple oils. Use of the technique shows that part of the hysteresis loop previously reported with suspensions is due to temperature changes during the experiment.

B.C.R.A.

2973. On an indeterminate integral in Einstein's theory of the viscosity of a suspension.

M. MOONEY. *J. Appl. Phys.*, 1954, **25**, 406.

A letter discussing the significance of this integral.

S.T.

2974. Creep tests for plastics.

R. NITSCHÉ. *Schweiz. Archiv. angew. Wiss.*, 1953, **19** (5), 139-48.

The necessity of finding a suitable creep test for plastics, which would satisfy both the scientist and the manufacturer is indicated. In devising such a test, the following factors will have to be taken into consideration: the influence of the area of the plastics specimen subjected to test, the kind of plastics used, the type and magnitude of stress, the shape of the test specimen, the pre-treatment of the test specimen, the testing temperature and the testing time. Technique of measuring the creep is discussed. It is also indicated how the results should be evaluated. Reference is finally made to the standard specifications laid down by A.S.T.M.

B.S.A.

2975. A study of states of stress in inhomogeneous bodies.

J. NOWINSKI AND S. TURSKEI. *Arch. Mech. Stosowanej, Warsaw*, 1953, **5**, 397.

(English Abstract).

2976. Viscosity of industrial glasses in the interval between the softening and annealing temperatures.

M. V. OKHOTIN AND R. I. TSOI. *Glass & Ceramics, Moscow*, 1953, **10**, No. 6, 11.

Very brief. The viscosity of 23 industrial glasses was measured by the fibre method and calculated by means of a formula. Glass rods with a ball fused on to each end were used as specimens; the lower ball had a metal hook from which a load was hung to cause the extension. The total exptl. error was 4-8%. Comps. of the glasses and viscosities at various temps. are given.

B.C.R.A.

2977. Time dependent non-linear outflow of liquid as a rheological model.

W. OLSZAK AND J. LITWINISZYN. *Arch. Mech. Stosowanej Warsaw*, 1954, **5**, 557.

It is shown that conventional rheological models are inadequate for the representation of the rheological behaviour of even simple substances, particularly if this is non-linear. Satisfactory representations can be obtained by means of a hydraulic model in which fluid contained in a vessel of suitable shape flows from an orifice in the base. If the fluid is an ideal gas and the friction between the piston and the wall of the vessel is

taken into account, or if vaporization and condensation of the fluid are allowed for, complex rheological behaviour such as swelling and shrinkage can be represented. P.F.

2978. The necking of a tension specimen in plane plastic flow.

E. T. ONAT AND W. PRAGER. *J. Appl. Phys.*, 1954, **25**, 491.

A linearized version of the equations of plasticity is used to discuss the symmetrical necking of a tension specimen in plane plastic flow. The material is treated as perfectly plastic, and elastic strains are neglected. A.

2979. On the stability of fluid flows with spherical symmetry.

M. S. PLESSET. *J. Appl. Phys.*, 1954, **25**, 96.

The conditions for the stability or instability of the interface between two immiscible incompressible fluids in radial motion are deduced. The stability conditions derived by Taylor for the interface of two fluids in plane motion do not apply to spherical flows without significant modifications. A.

2980. Viscous flow through an elastic tube.

W. PRINS AND J. J. HERMANS. *Rec. trav. chim.*, 1953, **72**, 157.

The theory of the flow of fluids through elastic tubes is extended to Non-Newtonian flow. Experiments with a solution of sodium carboxymethylcellulose in water are in satisfactory agreement with theory. P.G.M.

2981. Poisson's ratio in stress relaxation.

B. M. REVINSKII AND V. G. LJOTSAU. *Izv. Ak. Nauk SSSR.*, 1953, (10), 1471.

In high purity aluminium and copper sheets, subject to constant longitudinal strains of the order of 0.1 at room temperature, an increase in Poisson's Ratio was observed to take place during stress relaxation, from an initial value of about $\frac{1}{4}$ to a final value of about $\frac{1}{2}$, attained after a few hundred hours. P.F.

2982. Brittle fracture of tars and bitumens.

P. J. RIGDEN AND A. R. LEE. *J. Applied Chem.*, 1953, **3** (2), 62-70.

As part of a study of the cracking and disintegration of bituminous road-surfacing materials, measurements were made of the tensile strength of tars and bitumens, of tars to which filler was added, and of tars after exposure to the action of weather. Measurements were also made of the Fraass brittle temperatures of the materials. Under conditions of test in which there is no flow, tars, pitches and bitumens have the same brittle tensile strength of about 6 kg. per sq. cm.; this value, which was obtained for materials tested in moulds that imposed lateral restraint, increases to about 30 kg. per sq. cm. when the specimen has no support at the position of fracture. Weathering of the materials has little effect on the brittle tensile strength, but the measured tensile strength increases considerably when the cross-sectional area of the test specimen is reduced. A mathematical analysis of the Fraass brittle test shows that it is an equi-viscous temperature test measuring the temperature at which the material has a viscosity of approximately 4×10^9 poises. Although the addition of filler to tar increases the brittle tensile strength, no significant change is produced in the Fraass brittle temperature because there is a corresponding increase in viscosity. The development of conditions for brittle fracture of the binder in a road surfacing depends primarily on the effects of temperature and of exposure to weather on the viscosity of the binder. B.S.A.

2983. The rheology of non-aqueous suspensions.

P. J. RIGDEN. *Road Research Tech. Paper No. 28* (H. M. Stationery Office, 1954).

It is shown that the way in which powder packs together largely determines its effect when added to bituminous liquid; the total volume and dimensions of the voids in the packed powder are its determining characteristics, and quantitative expressions are developed which show how the flow characteristics of the mixture are related to these properties. P.F.

2984. **On some simple methods for measuring intrinsic viscosities of dilute solutions of high polymers.**

E. S. ROSKIN. *Kolloidnyi Zh.*, 1953, 15 (6), 455.

2985. **On the theory of the bulge test.**

E. W. ROSS JR. AND W. PRAGER. *Quart. Appl. Maths.* 1954, 12, 86.

It is shown that the use of Tresca's yield condition and the associated flow rule leads to a simple theory for the bulge test for perfectly plastic or strain-hardening materials. The basic equation can be integrated in closed form even for finite deflections. A.

2986. **Propagation of longitudinal deformation waves in a prestressed rod of material exhibiting a strain-rate effect.**

R. J. RUBIN. *J. Appl. Phys.*, 1954, 25, 528.

We consider the longitudinal propagation of stresses above the yield stress in a material exhibiting a strain-rate effect. The system consists of a semi-infinite rod subjected to end impact. If the rod is prestressed above the yield point and if the impact stress is not too large, the equations of motion are linear. Integral representations of the solutions can be obtained by the method of Laplace transforms. It is shown in general that the strain-rate solutions approach asymptotically the solutions obtained by von Karman and Taylor in a treatment which neglects the strain-rate effect.

The propagation of the unloading wave is considered for the case in which the initial wave is a shock wave. The condition which defines the regions in the $x-t$ plane, where the loading and unloading equations apply, is given. It is shown that an unloading shock wave will be absorbed except for the case of a material which does not work-harden. In this case the complete solution of the unloading problem is obtained. A.

2987. **Turbulent processes as observed in boundary layer and pipe.**

G. B. SCHUBAUER. *J. Appl. Phys.*, 1954, 25, 188.

2988. **The subjective assessment of firmness: absolute standards with steel springs.**

G. W. SCOTT BLAIR. *Lab Practice*, 1954, 3, 2.

Continuing work started with Sheppard (see abstr. 2543) author studies learning and maintenance of absolute standards in recognition of steel springs by handling (without vision); also effects of successes on subsequent scores etc. The right-handed subject scored as highly with the left as with the right hand. Care must be taken to avoid prejudice for or against specific numbers in guessing samples presented. A.

2989. **Plastic deformation in beams under distributed dynamic loads.**

J. A. SEILER AND P. S. SYMONDS. *J. Appl. Phys.*, 1954, 25, 556.

2990. **One-dimensional consolidation of visco-elastic body.**

J. SHINODA. *J. Japan. Soc. Civ. Engrs.*, 1953, 38 (5), 180-3.

The secondary compression in the laboratory consolidation test of clay is due to its visco-elastic property. The one-dimensional consolidation equation is solved by the operational calculus, expressing the modulus of visco-elasticity by $E \frac{(p+B)(p+\delta)}{(p+a)(p+y)}$ where

E is the modulus of elasticity, p Heaviside's operator and a , B , y and δ are constants having the dimension (T^{-1}). The theory has a good agreement with experimental data continuing for about one month. Compressional visco-elastic constants are of the same order as shearing ones obtained from the torsional test. A.

2991. **Studies on the clay-water system. X. Effect of alkali and acid on viscosity of slip and pH-viscosity hysteresis.**

Y. SHIRAKI *J. ceram. Ass. Japan*, 1953, 61, 365, 411.

2992. **Dependence of viscosity of materials on the glassy state.**

M. P. SYMIN *Zh. prikl. Khim.*, Leningr, 1953, 26, 124.

2993. **A unique law for ideal incompressible flow with preserved pattern of finite separation.**

H. S. TAN. *Quart. Appl. Maths.*, 1954, 12, 49.

2994. **Creep and relaxation.**

H. UMSTATTER. *Schweiz. Archiv.*, 1953, 16 (6), 184-91.

The general rheology of materials exhibiting creep and relaxation phenomena under stress is discussed, with graphs and some mathematical treatment. Experimental equipment for investigating creep in stressed wires is illustrated and described: using the same technique as in a vibrating wire strain-gauge, and comparing the natural frequency of transverse vibration of the wire (which changes with creep) with that of a stabilized tuning-fork, provided with temperature control and automatic amplitude control by electronic means. The circuit diagram and some details of the latter arrangements are given. Comparison is made with the aid of a cathode ray tube. The author's summary states that materials of closely similar chemical composition may show different stress-strain relations, whilst others of distinct chemical character (such as cold asphalt and metals) may show similar behaviour: an analogous case is found in the viscous flow of liquids. Reference is made to the Maxwell relaxation theory; and it is stated that it has been shown that the elastic and plastic behaviour of materials depends above all on the period of mechanical stressing. A quantitative expression of relaxation phenomena has been sought.

B.S.A.

2995. **Movement of a concrete mix along a pipeline.**

V. M. VASILYEV. *Gidrotekhnicheskoe Stroitelstvo*, 1953, 22 (7), 25-6.

2996. **Movement of a concrete mix in a pipeline.**

V. M. VASILYEV. *Stroitel'naya Promuishlennost*, 1953, 31 (7), 42-4.

The view expressed by Abkseyev that the concrete mix in the pipeline moves as a hard undeformed "core" lubricated by the cement mortar, and the assumptions that the layers do not mix and are not displaced relatively to each other, do not appear to be confirmed by experimental data nor are they suitable as the basis of calculations of the resistance set up in concrete pipes. Experiments with pumped concrete and observations of the movement of the mix are described which lead to the following conclusions: Friction at the pipe wall depends only on the quality and quantity of the cement paste, while the energy necessary for moving the aggregate in the "core" moving through the pipe depends on the quantity of mortar in the mix and the grading, size and shape of the aggregate. The increase in density and strength of pumped concrete in the pipeline, mentioned in the literature, is to be attributed to the additional mixing of the concrete in the hopper and the valve system of the pump and in the pipeline, in which the cement is also re-ground. Obstructions in the pipeline arise fundamentally from friction between the concrete aggregate and the internal pipe surface. Friction is aggravated by loss of cement paste at joints in the pipeline. The conditions of movement of the concrete mix in the pipeline are a problem of immediate importance, the solution of which will facilitate the calculation of the loss of head and more rational determination of suitable concrete mixes for transport by pumping.

B.S.A.

2997. **The thermal conductivity of organic vapours. The relationship between thermal conductivity and viscosity, and the significance of the Eucken factor.**

R. G. VINES AND L. A. BENNETT. *J. Chem. Phys.*, 1954, 22, 360.

The thermal conductivities of a number of polar and nonpolar organic vapours have been determined. The relationship between thermal conductivity and viscosity is discussed.

S.T.

2998. **On the question of the theory of flow of visco-plastic media.**

(Observations on the reply of N. V. Tyabin to authors' criticisms).

M. P. VOLAROVICH AND A. M. GUTKIN. *Kolloidnyi Zh.*, 1953, 15 (6), 473.

The debate continues.

G.W.S.B.

2999. **Mechanical properties of films of dispersed high-polymers. VI. Connections between physico-mechanical properties of dispersed films and their structure.**

S. S. VOYUTSKIĖ AND B. V. SHTARKH. *Koll. Zhurn.*, 1954, 16, 89.

3000. **The rheological curve.**

A DE WAELE AND G. L. LEWIS. *Nature, Lond.*, 1953, 172, 298.

The authors found that, for non-Newtonian plastic bodies and for certain high-polymer sols, the geometrical characteristics of the stress/shear-rate relationship conform to a line, the curvature of which decreases with increasing velocity gradient: $d^2S/dv^2 = -(K) \exp(-T.v)$, where S is the applied shearing-stress, v the velocity gradient, and K and T are constants characteristic of the material. Some deductions are made from this equation. The degree of flocculation of a given material can be assessed by the value of the integrated area K/T^3 .

B.C.R.A.

3001. **Flow of slurries.**

J. R. VAN WAZER. *Rock Prod.*, 1953, 56 (12), 104-7.

Factors controlling the flow of cement slurries (normally plastic fluids) are discussed in relation to the beneficial addition of phosphates for deflocculating slurries of shale and limestone being fed to the kiln. Addition of about 0.15 per cent sodium tripolyphosphate to the slurry reduces the yield value (especially in slurries having small particle sizes, viz. 0.01-100 μ) and consequently improves milling and the settling of the larger particles from suspensions of fine ones. Concurrently with these improvements the flow changes from plastic to dilatant, and thus greatly increases the ease of pumping. The effect of the deflocculant is to cause the individual particles to repel each other and thus break up the agglomerates in which a large volume of water is entrapped. The exact chemical composition of the materials in the slurry strongly influences the amount and type of deflocculant needed; for example, should gypsum be inadvertently milled into cement shale, about 0.4 per cent of sodium tripolyphosphate will be needed to correct the effect.

B.S.A.

3002. **The relationship between the mechanical properties of Cheddar cheese and graders' judgments.**

W. G. WEARMOUTH AND M. BARON. *Dairy Ind.*, 1953, 18, 1094.

3003. **A further study of the relationship between the mechanical properties of Cheddar cheese and graders' judgments.**

W. G. WEARMOUTH. *Dairy Ind.*, 1954, 19, 213.

Authors describe the last half of a four-year experiment and draw general conclusions. Cheddar cheese shows more independent sources of variation (factors) than does Cheshire and the results of factor analysis were less clear. Hardness and elasticity ("springiness") were much less highly correlated for the latter than the former type of cheese and overall quality depends less on rheological and more on organoleptic qualities. Agreement between results from two different seasons in the same factory for Cheddar is reasonably good, but communalities are much lower than for Cheshire and 3-dimensional factor models are less effective. Comparatively large differences between factor loadings for two cheese types indicates that the same tests measure different "properties" when applied to different materials. (See Abstracts 1630, 1965).

G.W.S.B.

3004. **Viscosity measurements on full- and skim-milk at different temperatures.**
H. WEGENER. *Milchwissenschaft*, 1953, 8, 433.

The viscosities are measured in a Höppler (falling ball) viscometer and quoted to five decimal places in centipoise. A relation with density is also quoted with the same claim to accuracy. The temperature coefficient of viscosity between 10° and 40°C is measured, the relation between $\log \eta$ and $1/T$ being curvilinear and smooth for both types of milk.
G.W.S.B.

3005. **Delayed yield and strain rate and temperature dependence of yield point in iron.**

T. YOKOBORI. *J. Appl. Phys.*, 1954, 25, 593.

A unified explanation of delayed yield and of strain rate and temperature dependence of yield point in iron was attempted on the basis of the Cottrell locking theory, taking internal stress into account. The energy of a dislocation required to fit existing data is small by an order of magnitude compared with the value theoretically estimated by Mott and Nabarro. The distance, calculated from the value of internal stress, between dislocations assembled at a grain boundary is of a reasonable order of magnitude. It is suggested that the mechanism of yielding may change from Cottrell type to Mott-Nabarro or Frank-Read type when applied stress falls below some limiting value.
A.

3006. **Representation of a three dimensional state of stress by means of a triangle of stresses.**

W. ZAPALOWICZ. *Arch. Mech. Stosowanej*, Warsaw, 1953, 5, 641. (English Abstract).

3007. **Structure of Jellies IV. Influence of addition of various substances on the mechanical properties of jellies and solutions of gelatine.**

I. ZUBOV, Z. N. ZHURKINA AND V. A. KARGIN. *Koll. Zhurn.*, 1945, 16, 109.

Proceedings of the Second International Congress on Rheology, 1953

This book contains the 55 papers read and the subsequent discussions at the Congress held at Oxford from 26th to 31st July, 1953, together with a Foreword and the text of the Presidential Address by Sir Geoffrey Taylor, F.R.S. A brief description of the Exhibition of Rheological Apparatus and a note on the formation of the International Committee on Rheology are included.

The proceedings were edited by Dr. V. G. W. Harrison and are published by Butterworths Publications, Ltd., 88 Kingsway, London, W.C.2, price 60s. An American edition is published by Academic Press, 125 East 23rd St., New York, 10.

Viscoelastic Behaviour

A meeting is being planned at Kings' College, Newcastle, for April, 1955, to discuss "Viscoelastic Behaviour." Intending contributors are invited to communicate with the Secretary.