

Review

THE BRITISH SOCIETY OF RHEOLOGY

Michael White



(1952-53)

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THE BRITISH SOCIETY OF RHEOLOGY

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EDITORIAL

VALE!

This is the last Bulletin that I shall be editing. Decision to resign office now instead of at the end of 1953 is prompted by two considerations. First, as one gets older the number of duties that one is expected to undertake shows a steady increase and a stage is eventually reached when a certain amount of "load-shedding" is unavoidable. This stage has been reached. Secondly, it has always seemed to me undesirable that any Club or Society should have its affairs run by the same few individuals over a prolonged period. I have now held office of one sort or another in the Society for a total of ten years and it is surely high time that I withdrew. The best of us get tired and run out of ideas, and the vitality of any Society can only be ensured by the regular election of fresh officers and committee.

Looking back over these years I recall many happy and profitable meetings, and many useful contacts, some of which have developed into lasting friendships. The work involved, though at the time often irksome, is now seen to have been well worth while, and the progress made in these twelve years promises well for the future.

Rheology is at present a young science and accordingly it has only so far accumulated a mass of more or less disconnected experimental data with little underlying theory to knit the mass together. This need not worry us unduly, for it marks the first stage in any science: the observations of astronomy, now the most precise and formal of the sciences, once seemed equally chaotic and difficult to predict or relate. However, it will be necessary for a more academic approach to be made to many rheological problems if they are to reach a satisfactory solution. At present there is a marked tendency for Smith and Brown to make scores of uncontrolled measurements on Green & Co's Marmalade, using a homemade "consistometer" bearing no relation to any other instrument. The results are presented in arbitrary units strongly influenced by the design of the apparatus and the authors say in effect: "Isn't it funny?"—and leave it at that. Others discover alleged new phenomena of anomalous viscosity or elasticity to which they give long names but which prove, on more careful investigation, to be due to unsuspected instrumental errors or lack of proper control of variables. This sort of thing does not get one far. How can one build up an ordered body of knowledge if one cannot make valid comparison of the results of Brown and the results of Robinson for the same material? It would be more profitable to make a smaller number of observations on (when possible) known

systems, paying greater attention to the design of instruments, to identification and elimination or correction of instrumental errors and to the proper control of variables such as temperature. The ideal should be to make the results independent of the instrument used to obtain them, and to express them in such a way that the effects of time, rate of shear, temperature, stress, etc., acting independently or together, can be predicted. In most cases we are far from this ideal and even measurement of the viscosity of Newtonian liquids of moderately high viscosity gives us trouble. It is pleasing to note, however, that the Universities are now paying more attention to fundamental problems of the deformation and flow of matter and this cannot but be to the benefit of rheology.

I have never concealed my hope that the establishment of the various national rheological societies will help in some measure to strengthen bonds of friendship and co-operation between various countries. Though I am not yet old, I can remember two ghastly world wars which I think it fair to say brought none of their participants any good whatsoever—except in so far as they may have overthrown tyrannies that should never have been allowed to arise. It profits little to reflect on what prosperity might have been Europe's if they had not been. The stupidity of it all is evident from the way in which our gallant allies of one war become our hated and despised foes of the next; and when all the shouting and destruction is over we have still to sit round the conference table and attempt to solve our difficulties by reasoned argument and agreement. War is a great evil. It is steadily becoming more and more destructive, and less and less effective as an instrument for settling national differences. To avoid slaughter and wanton destruction of property is a duty not only enjoined by every great religion of which I have any knowledge but it is also seen now to be sound practical commonsense. The best antidote to war fever is the tolerance born of knowledge of one's fellow men and the more men of many nations can mix together and find common interests the less will be the likelihood of future wars. We hope that the Second International Congress of Rheology at Oxford in 1953 and the establishment of an International Association of Rheological Societies will contribute not only to the well-being of Rheology but also to world peace.

It is also my earnest hope that this Society will help keep alive that spirit of free and impartial enquiry, with open publication and discussion of results, to which the science of the past has owed its spectacular success. That freedom was won slowly and painfully, at the cost of men's lives; and it is to-day again menaced from two sides. On one side it is being fettered in the name of National Security. In the present deplorable state of the world, these chains may be unavoidable, but I am persuaded that in the long run they are thoroughly bad. Science has changed much since the days of Davy and Faraday and the change is, one fears, not for the better. On the other side we have the menace of political, racial and religious intolerance. From this we are never free. We had it in the middle ages over Galileo. We had it in the disgusting religious persecutions in this country during and after the Reformation. We had it in mild form in the Nineteenth Century battle over evolution. We had it in more terrifying guise in Nazi Germany—and unhappily present day examples are by no means hard to find. Of this we can be assured—that no "world-view" is, or is ever likely to be, uniquely, finally and absolutely correct; and the day when science is made subservient to any code of political or religious dogma whatsoever, that day sees signed the death warrant of science as we knew it.

And now nothing remains for me but to conclude with the words of the writer of the Second Book of the Maccabees: "If I have done well and as is fitting the story, it is that which I desired: but if slenderly or meanly, it is that which I could attain unto. And here shall be an end."

V. G. W. HARRISON.

MR. I. CAMERON: We much regret to record the death, on 2nd July, 1952, of Mr. I. Cameron, a member since October, 1940.

TWELFTH ANNUAL GENERAL MEETING

held at the Library, Connaught Hall, University of Southampton, on Friday,
26th September, 1952, 8-30 p.m.

PRESENT : about 30 members, the President being in the Chair.

MINUTES of the Eleventh Annual General Meeting, having been read by the Hon. Secretary, were signed as correct by the Chairman.

THE HONORARY SECRETARY REPORTED on the activities of the Society during the year 1951-1952, giving an outline of the five meetings held in that period. Mr. Leach moved the adoption of the report, which was accepted unanimously.

THE HONORARY TREASURER REPORTED that accounts were favourable and details had been circulated in Bulletin No. 35. Membership was 250. Owing to economies, three Bulletins were now issued yearly instead of four. £17 had been transferred to Second International Congress funds from the International Union of Rheology accounts, the approval of Dr. Signer having been obtained. There appeared to be no reason for increasing membership subscription from the present level of £1 *per annum*. Mr. Bessey congratulated Dr. Oldroyd and proposed acceptance of the report. The proposal was carried unanimously.

ELECTION OF OFFICERS FOR YEAR 1952-1953. The following Officers were elected :—

President : Mr. A. G. Ward.

Honorary Treasurer : Dr. J. G. Oldroyd.

Honorary Secretary : Mr. P. Feltham.

Honorary Editor : Mr. A. A. Milne (D.S.I.R. Mechanical Engineering Research Organisation, Lubrication Division, Thorntonhall, near Glasgow).

Northern Representative : Mr. L. Grunberg.

Midlands Representative : Mr. A. W. Richardson.

Honorary Auditor : Mr. A. De Waele.

Ordinary Members of Committee :

Dr. E. W. J. Mardles.

Mr. N. Wookey (52, Tavistock Road, Edgware, Middlesex).

Mr. E. B. Atkinson (310, Colchester Road, Ipswich).

Mr. D. W. Jopling (Research Laboratories, Kodak Ltd., Harrow, Middlesex).

INTERNATIONAL UNION. A statement was made by Dr. G. W. Scott Blair concerning the attitude of the Society to the international organization of rheology, a topic which would be dealt with on an international level during the Second International Congress in Oxford. After reporting his discussions with leading personalities in the various relevant organizations, he outlined the possible alternative courses open to the Society from the point of view of affiliation. In the discussion, Dr. Barkas said he thought a clear decision should be taken at the present meeting so as to define the attitude of the Society unequivocally. Mr. Feltham then moved that—

“In principle the British Society of Rheology considers the appropriate form of international organization of Rheology to be an International Association affiliated to the International Union of Pure and Applied Physics.”

The resolution was passed unanimously and was cabled to Dr. Ronald Frazer of the ICSU, who was at that moment at the meeting of the Executive Board in Amsterdam.

GREETINGS from Professor Ubbelohde were received on behalf of the German Society of Rheology, at that time meeting in Berlin, and a reply was sent to him by cable.

VOTES OF THANKS were expressed by the Meeting to members retiring from Committee, and to the Committee as a whole for the work done by them in 1951-1952.

The Meeting ended at 10.20 p.m.

SUMMARIES OF PAPERS read at meetings of the Society

The Plasticity and Elasticity of Gels

E. W. J. MARDLES

(Royal Aircraft Establishment, Farnborough, Hants.)

The subject of the plasticity and elasticity of gels is of importance in relation to the properties of materials used for aircraft, such as, for example, lubricants and hydraulic fluids at the low temperatures prevailing at high altitudes, plastics, synthetic rubbers, sealing compounds, etc. The problem of considering the plastic and elastic properties over a wide temperature range can be divided into two : (a) devising suitable methods and procedures of test and (b) interpreting the results in the light of flying experience. Results are presented by torsion methods, the use of the plate (edge on) and strip viscometer at constant rate of shear, and parallel plate viscometer for a variety of aeronautical materials. With organogels of soap or cellulose esters, etc. the elasticity is complicated by the persistence of strain after removal of stress so that the elasticity is Hookean only for small deformations and with short application of stress. The reversible sol to gel transition and its hysteresis can be followed completely by elasticity and viscosity measurements. The variation of the elastic constant with concentration, c , of colloid (weight/volume) over a limited range can be expressed by the empirical equation $E = kc^n$ where k and n are constants. Usually straight line graphs are obtained by plotting the logarithm of the elastic modulus and temperature over a range where melting and freezing effects are absent. In aeronautical science it is important to know the freezing and melting points of greases, etc. which must operate over the temperature range -80°C. to 250°C. and higher; the failure and success of various materials are indicated by graphs obtained by torsion and the plate methods. The stress-hardening of substances is often a desirable property; with thixotropic substances, such as a grease with a fibril structure, during impact stressing as occurs in gears the grease appears to harden almost in proportion to the rate of impact. Usually granular systems do not show this property to any appreciable extent.

Paper read at Southampton Conference, September, 1952.

Instruments for measuring Plasticity in the Rubber Industry

J. R. SCOTT

(Research Association of British Rubber Manufacturers,
105-7 Lansdowne Road, Croydon.)

Conversion of raw rubber into vulcanized products involves processes in which the material is plastic, and trouble-free operation of these processes depends on having the right plasticity. The material (unvulcanized rubber with or without fillers) on which plasticity tests therefore have to be made is highly viscous (effective viscosity 10^5 to 10^8 poises), flow being strongly non-Newtonian and temperature-dependent; there may be considerable thixotropy and reversible elastic deformation. Hence a full evaluation of the rheological behaviour is a complex operation, and simple factory control tests depend on the fact that with similar materials (e.g. repeat batches) the various rheological properties are closely correlated.

Industrial use of plasticity tests is limited to (i) checking uniformity of repeat batches, (ii) testing liability of rubber compositions to "scorching" or premature vulcanization, which is revealed by a marked stiffening. Prediction of processing behaviour of a new composition from laboratory tests is not yet possible. Plasticity tests used on rubber are of three main types :—

EXTRUSION. As there is some slip between the rubber and the walls of the nozzle, extrusion instruments do not measure true plasticity, though the results may correlate with behaviour in an extrusion machine and thus be a useful test of "extrudability."

ROTATION. It is essential here to avoid slip between the rubber and the confining surfaces, roughening these surfaces or applying hydrostatic pressure appears effective. Concentric cylinder instruments have been used for research purposes (Mooney, Hamm) but not for routine testing. Shearing the material between parallel discs, one fixed and one rotating, lends itself to a simpler construction and is the basis of the Mooney shearing-disc viscometer widely used for factory control. A modified form (shearing-cone) in which shear rate is uniform throughout the material has proved a valuable research tool. Indeed, the rotation principle furnishes the best research instrument for rubber, because a wide range of shear rates is possible and time (thixotropic) effects can be studied.

COMPRESSION. Compression between parallel plates is a widely used form of test; the plates may be either much larger than the specimen (Williams) or similar in size to the specimens, so that excess material is pressed out from between them (Van Rossem, Hoekstra, Defo). Flow is complex, the shear rate varying throughout the specimen and also with time of compression; fundamental constants can only be derived where rheological behaviour is simple, so that the test is very limited as a research tool. For routine factory control, the test is useful provided the materials tested do not show variable thixotropy. The compression principle makes possible a very rapid simple test, and the conditions giving rapidly with good discrimination have been worked out and embodied in a recent instrument (Wallace). Elastic recovery measurements are possible with all three types of instrument, but commonly are made only on compression instruments. The chief use is in detecting "scorching," because incipient vulcanization strongly increases recovery.

Paper read at Southampton Conference, September, 1952

The Revised Standard Method for Determining the Coefficient of Viscosity of Liquids based on the Viscosity Value of 1.0019 Centipoises for Water at 20°C.

E. W. J. MARDLES

(The Society's representative to the British Standards Viscosity Committee)

The standard method of determining the coefficient of viscosity of a liquid (British Standards Institution, American Society for Testing Materials and Institute of Petroleum) is being revised, the sole basis of the measurement being that of water at 20°C. taken as 1.0019 cp.* The new features of the measurement are (a) the introduction of a master U-tube viscometer with capillary length of 40 cm. of precision tubing 0.045 cm. diameter; (b) the specification of minimum flow times with the standard viscometers so that the kinetic energy correction is negligible and (c) the use of precision capillary tubing allowing accurate description of the standard viscometers. By a stepping up process from the time of flow of water in the master viscometer and the use of secondary standards the following precision is to be expected†

<i>Order of magnitude of viscosity cs.</i>	<i>Number of steps in calibration</i>	<i>Repeatability %</i>	<i>Reproducibility %</i>
1	1	0.14	0.25
10	2	0.16	0.4
100	3	0.2	0.5
500	4	0.3	0.7
1500	5	0.5	1.5

The use of the master viscometer, with water as standard, has reduced errors due to surface tension and inertia to a negligible amount while the use of the precision tubing allows of accurate dimensions so that the shear rate being the same for corresponding viscometers their use may be extended to liquids of non-Newtonian flow. With air pressure, say up to 10 cm Hg, the use of the viscometers can be extended to opaque liquids, tars, paints and other industrial and biological liquids.,

**Bull. Nat. Bur. Stand. (Wash.)* No. 36, Jan., 1952.

†*J. Inst. Petroleum* 1952, **38** (342), 428.

CORRESPONDENCE .

A matter of principle affecting the science of rheology is raised by the following sentence in the sheet notifying prospective members of the Second International Congress on Rheology about the scope of the discussions :

“ The Congress will cover the whole field of the study of the deformation and flow of matter, except such specialised subjects as have come to be regarded as branches of applied mechanics, e.g., the classical theory of elasticity, aerodynamics.”

This sentence appears to be inconsistent. The *whole field of deformation of matter* is to be covered *except for modes of expressing complex physical observations in a mathematical manner* allowing the experimenter to examine the internal consistencies of his results.

It seems relevant to ask “ Just what is rheology? ” The original definition of rheology as the theoretical and experimental study of deformation of all matter appears too general. As commonly practised rheology appears to deal with non-gaseous matter so that reframing its definition along these lines would exclude aerodynamics as appears to be required. The exclusion of solids to leave only the study of non-gaseous fluids greatly limits the field and was surely never intended. Some Americans restrict the study to plastic and visco-plastic flow under simple or complex loading as in Applied Mechanics Reviews. A generalised name for just these two topics appears unnecessary and restriction to them excludes the interests of many members of our British society.

Again, if we *are* dealing with non-gaseous matter then is membership of the society to be restricted to those interested in only “ simple ” loading such as uniaxial tension and compression and the simplest cases of shear? This would exclude the general classical mathematical elasticity but, even then, the generalised Hooke's law type of equations can come into the study of shear.

It appears that a more careful definition of the science of rheology is required so that our present and prospective members will know if their particular interest will appear in its turn in the formal activities of the society. Is the scope of the International Congress as organised by our British rheologists a “ straw in the wind ” to indicate our future national rheological activities? To avoid such topics as supersonic flow, etc. I suggest framing the definition to show that we deal with non-gaseous matter but certainly do not exclude the almost unexplored field on “ complex ” loading and the mathematical forms necessary to relate experiment and theory.

2nd October, 1952.

K. H. SWAINGER.

RHEOLOGY ABSTRACTS

2497. **Correlation of dynamic and static measurements on rubberlike materials.**

R. D. ANDREWS. *Ind. & Eng. Chem.* 1952, **44**, 707.

2498. **A characteristic type of instability in the large deflexions of elastic plates — I. Curved rectangular plates bent about one axis, II. Flat square plates bent about all edges.**

D. G. ASHWELL. *Proc. Roy. Soc. A.*, 1952, **214**, 98.

2499. **Mechanical strength of piezoelectric crystals.**

R. BECHMANN AND P. L. PARSONS. *Brit. J. Appl. Phys.* 1952, **13**, 147.

2500. **Viscosities of 0.25% to 90% GR-S rubber solutions.**

A. B. BESTUL, H. V. BELCHER, F. A. QUINN JR. AND C. B. BRYANT. *J. Phys. Chem.* 1952, **56** (4), 432.

Flow measurements are made at temperatures between 30° and 50°C. on solutions of GR-S rubbers in α -methylnaphthalene and in cetane with Bingham viscometers and with the McKee worker-consistometer over a wide range of concentrations and rates of shear. The data are examined in relation to the usual flow equations. The results show that as the concentration increases the solutions become increasingly non-Newtonian. G.E.B.

2501. **A determination of the frictional forces in a tidal current.**

K. F. BOWDEN AND L. A. FAIRBURN. *Proc. Roy. Soc. A*, 1952, **214**, 371.

2502. **The effect of the temperature of preparation on the mechanical properties and structure of gelatin films.**

E. BRADBURY AND C. MARTIN. *Proc. Roy. Soc. A*, 1952, **214**, 183.

2503. **On the energy equation for fluid-film lubrication.**

A. CHARNES, F. OSTERLE AND E. SAIBEL. *Proc. Roy. Soc. A*, 1952, **214**, 133.

2504. **Influence of the volume fractions of the phases on the deformation of ($\alpha + \beta$) brass.**

L. M. CLAREBROUGH AND G. R. PERGER. *Aust. J. Sci. Res. A*, 1952, **5**, 114.

The relative deformations of the phases were studied, after 20, 40, 60 and 80% reductions in area by wire drawing in duplex brasses of various compositions, using as a measure of the degree of deformation the temperature at which recrystallization began. In alloys containing more than about one-third by volume of the hard β phase, crystals of both phases deformed to the same extent, but in alloys containing 10 or 20% by volume of the β phase, the heavier deformation always occurred in the soft α phase. The mode of recrystallization of the phase varied with the degree of deformation and the volume proportion of the phases.

AUTHORS.

2505. **A study of some impacts between metal bodies by a piezoelectric method.**

A. W. CROOK. *RoProc. Roy. Soc. A*, 1952, **212**, 377.

2506. The viscosity and rigidity of gelatin in concentrated aqueous systems. I. Viscosity.

C. W. N. CUMPER AND A. E. ALEXANDER. *Aust. J. Sci. Res. A*, 1952, **5**, 146.

The viscosity of gelatin solutions at concentrations between 100 and 500 g/l has been studied as a function of pH, ionic strength and temperature. In these concentrated systems the predominant factor determining the viscosity appeared to be Coulombic forces between ionized groups on adjacent chains.

AUTHORS.

2507. The viscosity and rigidity of gelatin in concentrated aqueous systems. II. Rigidity.

C. W. N. CUMPER AND A. E. ALEXANDER. *Aust. J. Sci. Res. A*, 1952, **5**, 153.

2508. The effect of frequency on the behaviour of rubber under cyclical deformation.

D. M. DAVIES. *Brit. J. Appl. Phys.*, 1952, **3**, 285.

2509. Soil mechanics and plastic analysis or limit design.

D. C. DRUCKER AND W. PRAGER. *Quart. Appl. Maths*, 1952, **10**, 157.

2510. Temperature dependence of dynamic properties of elastomers; relaxation distributions.

J. D. FERRY, E. R. FITZGERALD, L. D. GRANDINE JR. AND M. L. WILLIAMS. *Ind. & Eng. Chem.*, 1952, **44**, 703.

2511. Apparatus for the measurement of the dynamic shear modulus and hysteresis of rubber at low frequencies.

W. P. FLETCHER AND A. N. GENT. *J. Sci. Instrum.*, 1952, **29**, 186.

2512. Experiments on the mechanics of rubber. II. The torsion, inflation and extension of a tube.

A. N. GENT AND R. S. RIVLIN. *Proc. Phys. Soc. Lond. B*, 1952, **65**, 487.

2513. Experiments on the mechanics of rubber. III. Small torsions of stretched prisms.

A. N. GENT AND R. S. RIVLIN. *Proc. Phys. Soc. Lond. B*, 1952, **65**, 645.

2514. Fluid bed flowmeter.

C. F. GERALD. *Ind. & Eng. Chem.*, 1952, **44**, 233.

2515. Measurement of the velocity distribution along a vertical line through a glacier.

J. A. F. GERRARD, M. F. PERUTZ AND A. ROCH. *Proc. Roy. Soc. A*, 1952, **213**, 546.

2516. The temperature dependence of the viscosity of liquids.

F. GUTMAN AND L. M. SIMMONS. *J. Appl. Phys.*, 1952, **23**, 977.

2517. On the meaning of the orientation-dependence of the strain-hardening curves for aluminium single crystals.

P. HAASEN AND G. LEIBFRIED. *Z. Phys.*, 1952, **131**, 538. *In German.*

The strain-hardening curves are dependent on orientation for very pure (99.99%) aluminium. This fact is discussed in terms of the shearing stresses across various crystallographic planes of the stressed crystal, and hindrance of slip on one plane by slip on others.

SCI. ABSTR.

2518. **Psychological and psychophysical studies of craftsmanship in dairying.**
R. HARPER. *Brit. J. Psychol.* Monogr. Suppl. No. 28, 1952.

A comprehensive summary of work on psychological aspects of programme on rheology of cheese and butter at (British) National Institute for Research in Dairying over several years.
G.W.S.B.

2519. **Some tests for hypotheses concerning tensile strength of cloth.**
J. HEMELRIJK. *Appl. Sci. Res. A*, 1952, 3, 211.

The strength may be tested by stretching a strip until it breaks and measuring the maximum tension which is attained during this process. The experiment may be performed in such a way that the time, necessary to attain the breaking point, has a pre-determined length. This is called the testing time and it appears that it influences the tensile strength. The present paper gives a number of statistical tests which enable certain properties of the relation between the two quantities mentioned to be investigated. The use of the tests is demonstrated by a numerical example.
AUTHOR.

2520. **Elastic and plastic properties of very small metal specimens.**
C. HERRING AND J. K. GALT. *Phys. Rev.*, 1952, 85, 1060.

Experiments on very fine Sn. "whiskers" (about 10^{-4} cm. diameter) show these to have an elastic and plastic behaviour not far different from that to be expected for a really perfect crystal. A permanent deformation, when the whisker becomes quite sharply bent at one point, is achieved only with strains of about 2 — 3%.
SCI. ABSTR.

2521. **Two viscometers for rapid measurements at definite shearing stresses.**
R. S. HIGGINBOTHAM AND J. J. BENBOW. *J. Sci. Instrum.*, 1952, 29, 221.

2522. **The elastic behaviour of a crystalline aggregate.**
R. HILL. *Proc. Phys. Soc. Lond. A*, 1952, 65, 349.

2523. **Some statistical mechanical models of elastic poly-electrolytes and proteins.**
T. L. HILL. *J. Chem. Phys.*, 1952, 20, 1259.

Three statistical mechanical models are developed for use in connexion with the problem of muscle action, and further applications of these models to certain other systems such as poly-electrolyte fibres or gels, fibrous proteins, and ion exchange resins are suggested.
S.T.

2524. **Plastic deformation features on cleavage surfaces of metal crystals.**
J. HOLDEN. *Phil. Mag.*, 1952, 43, 976.

2525. **The theory of an oscillating cylinder viscometer.**
A. A. K. IBRAHIM AND A. M. KABIEL. *J. Appl. Phys.*, 1952, 23, 754.

2526. **Viscosities of some lower aliphatic alcohols at constant volume.**
A. JOBLING AND A. S. C. LAWRENCE. *J. Chem. Phys.*, 1952, 20, 1296.

2527. **A method of studying the formation of cracks in a material subjected to stress.**
R. JONES. *Brit. J. Appl. Phys.*, 1952, 3, 229.

2528. **The creep of metals under interrupted stressing.**
A. J. KENNEDY. *Proc. Roy. Soc. A*, 1952, 213, 492.

2529. A numerical method for solving the flow equation for water in unsaturated materials.

A. KLUTE. *Soil Sci.*, 1952, **73**, 105.

An equation describing the flow of water in unsaturated porous materials was derived from Darcy's law and the equation of continuity. A numerical method of solution of this equation for semi-infinite horizontal systems of flow was described and applied to several examples. The phenomenon of a wetting front was shown to be indicated when the variation of the diffusivity with moisture content was considered. B.C.R.A.

2530. Problem of relaxation of mechanical stresses.

J. KUBÁT. *Naturwissenschaften*, 1952, **39**, 107. *In German.*

It is assumed that the equation $[d(df/dt)]/df = -k$ (f —stress, t —time, k —constant), showing the stress decrement, is an approximation only, and a form is suggested similar to Eyring's equation. The new equation can be transformed into $[d(df/dt)]/df = -ab + adf/dt$ and finally into $df/dt = C/(De^{abt} + 1)$. By studying stress relaxation in paper, the author observed that a decreased as the plastic deformation increased. SCI. ABSTR.

2531. Note on a sufficient condition for the stability of general plane parallel flows.

M. LESSEN. *Quart. Appl. Maths.*, 1952, **10**, 184.

2532. Frictional and elastic properties of high polymeric materials.

B. LINCOLN. *Brit. J. Appl. Phys.*, 1952, **3**, 260.

2533. Contribution on the measurement of plasticity.

M. LINSEIS. *Die Ziegelindustrie*, 1952, **5** (1), 7.

Describes empirical tests using the extrusion principle on a range of clays at different water contents. P.M.

2534. Temperature dependence of the viscosity of associated liquids.

T. A. LITOVITZ. *J. Chem. Phys.*, 1952, **20**, 1088.

By assuming that the activation energy for flow in associated liquids is proportional to the inverse square of the absolute temperature, an empirical expression for the viscosity is obtained, which fits the data well. An empirical expression for the activation energy of mixtures of associated liquids is also proposed. AUTHOR.

2535. Sedimentation behaviour of flexible chain molecules; polyisobutylene.

L. MANDELKERN, W. R. KRIGBAUM, H. A. SCHERAGA AND P. J. FLORY. *J. Chem. Phys.*, 1952, **20**, 1392.

The sedimentation constants at infinite dilution and the intrinsic viscosities of five fractions of polyisobutylene have been determined in cyclohexane. A theory to account for the observed behaviour is developed.

2536. A new method of measuring the modulus of elasticity—application to cement mortar and concrete.

A. MARGARIT. *Rev. Cienc. Apl.*, 1952, **6**, 28. *In Spanish.*

The apparatus described in Abstr. 2029 has now been further developed for measurements of the elasticity of cement mortar and concrete. The method depends on measuring the time taken to transfer energy from one pendulum to another via the specimen. In the present apparatus, the test-pieces are 140 cm long by 10 cm square or 10 cm by 8 cm. The specimen is attached to the machine in a vertical position, and, in order to calibrate the apparatus, tests have been made with beam specimens whose modulus of rupture has been determined in flexure. Various qualities of concrete were used and it was found that an approximately constant value was obtained by dividing the modulus of rupture by the time interval measured on the machine. It is now possible, therefore, to determine the modulus of other specimens by employing this constant and the measured time interval.

SCI. ABSTR.

2537. **Measurement of dynamic properties of rubber.**
R. S. MARVIN. *Ind. & Eng. Chem.*, 1952, **44**, 696.

2538. **Axially symmetric jet mixing of a compressible fluid.**
S. I. PAI. *Quart. Appl. Maths.*, 1952, **10**, 141.

2539. **The viscosity of suspensions of rigid spheres.**
R. ROSCOE. *Brit. J. Appl. Phys.*, 1952, **3**, 267.

2540. **Measurement of Young's modulus of metal bars by an electromagnetic method.**

J. SAVORNIN AND G. RENUCCI. *C. R. Acad. Sci. (Paris)*, 1952, **234**, 2045. *In French.*

The method applies equally to magnetic and non-magnetic rods. An alternating magnetic field near one end induces currents in the rod, which is supported centrally by a rubber ring, and hence gives rise to a repulsive force varying with twice the field frequency. The amplitude picked up by a telephone receiver loosely coupled to the other end has a sharp maximum at the resonant frequency of the rod, from which the modulus can be deduced. The method gave the value $(5.67 \pm 0.05) \times 10^{11}$ dyne cm⁻² for the Young's modulus of cadmium. SCI. ABSTR.

2541. **Time-temperature dependence of linear visco-elastic behaviour.**
F. SCHWARZL AND A. J. STAVERMAN. *J. Appl. Phys.*, 1952, **23**, 838.

2542. **Review of progress of dairy science : Physics.**

G. W. SCOTT BLAIR. *J. Dairy Res.*, 1952, **19**, 257.

Covers literature, mainly rheological, 1947-1951.

2543. **Subjective assessments of firmness: a comparison of methods using rubber cylinders and steel springs.**

D. SHEPPARD AND G. W. SCOTT BLAIR. *Quart. J. Exper. Psychol.*, 1952, **4**, 101.

2544. **The importance of psychophysical errors in subjective judgements of firmness of Cheshire cheese.**

D. SHEPPARD. *J. Dairy Res.*, 1952, **19**, 348.

2545. **A treatment of the viscosity of concentrated suspensions.**

R. SIMHA. *J. Appl. Phys.*, 1952, **23**, 1020.

2546. **Some viscous fluid flow problems — I. Jet emerging from a hole in a plane wall.**

H. B. SQUIRE. *Phil. Mag.*, 1952, **43**, 942.

2547. **Absolute viscosity of water at 20°C.**

J. F. SWINDELLS, J. R. COE JR. AND T. B. GODFREY. *J. Res. Nat. Bur. Stand. (Wash.)*, 1952, **48**, 1.

The determination was made by the method of capillary flow. The value found is 0.010019 poise as compared with the previously accepted value of 0.01005 poise. The estimated accuracy of the new determination is ± 0.000003 poise.

2548. **The mechanism of rolling friction.**

D. TABOR. *Phil. Mag.*, 1952, **43**, 1055.

2549. **Analysis of the swimming of long and narrow animals.**

G. TAYLOR. *Proc. Roy. Soc. A*, 1952, **214**, 158.

2550. An explanation of "Tachypyknosis."

R. N. THOMPSON. *J. Phys. Chem.*, 1952, **56** (6), 766.

The phenomenon in deflocculated kaolin suspensions previously designated by Von Wazer and Besmertnuk as "tachypyknosis" is shown to be simply a thixotropic effect. G.E.B.

2551. On plasticity in general.

U. VENTRIGLIA. *Ric. Sci.*, 1950, **20** (3), 310 abstracted in *Appl. Mech. Rev.*, 1952, **5**, 210.

Deals with a general expression for plasticity as the property of matter. Following Bingham in particular, the author presents a summary of the definitions relating to rheological properties of matter. He finds the criterion of characterizing the plasticity, in general sense, by the ratio f/η (f =yield stress, η =viscosity) insufficient to classify the solid bodies. He then proposes a new and more general expression, calling it "plasticity number," which contains the relation between the inelastic strain in the unity of time and the elastic strain :

$$N_p = [\tau^n / \eta - (\tau - f)^n] / (f/G)$$

where τ is the acting shear stress, η the coeff. of viscosity in general sense, or "pseudo-viscosity," f the yield stress, and G the modulus of rigidity of the body. For $n=1$ this expression becomes : $N_p = G/\eta$. Author shows that, in the case of a viscous liquid, this expression can be replaced with sufficient accuracy by the known relation f/η . B.C.R.A.

2552. The temperature-dependence of Poisson's ratio in metals.

F. VITOVEC. *Öst. Ingen.-Arch.*, 1952, **6**, 132. In German.

The temperature dependence of Poisson's ratio is computed from the modulus of elasticity and the compressibility. Sufficient experimental data exist for the temperature dependence of the modulus of elasticity. The temperature dependence of the compressibility is computed from the lattice energy. Poisson's ratio and the temperature gradient rises when the temperature is increasing. SCI. ABSTR.

2553. The elastic and viscous properties of alumino-silicate refractories.

B. A. WIECHULA AND A. L. ROBERTS. *Trans. Brit. Ceram. Soc.*, 1952, **51**, 173.

Commercial products covering the whole range of the alumino-silicate series were investigated. Changes in the mechanical properties at temperatures up to 1400°C. were examined by torsion methods and values of the modulus of rigidity, ultimate shear strength and the rates of "flow" were determined. B.C.R.A. (ABR.)

2554. The sedimentation of dilute suspensions of microscopic spheres in water.

B. W. WILSON. *Aust. J. Appl. Sci.*, 1952, **3**, 252.

A continuous photographic method has been used to show that Stoke's law applies to the sedimentation of very dilute aqueous suspensions of closely-sized microscopic spheres in the range 2.5 to 10 microns in diameter. Temperature uniformity was a more critical factor than in the usual methods of particle-size analysis by sedimentation. AUTHOR.

2555. Failure and fracture of metals as nucleation processes.

T. YOKOBORI. *J. Phys. Soc. Japan*, 1952, **7**, 44.

The discontinuous phenomena in plasticity of metals, such as the yielding, the state of ultimate strength and the brittle fracture, were regarded as a kind of Markoff process, and studied from the standpoint of nucleation theory. The fundamental features of these types of failures, namely (1) the relation between strength and deformation velocity or stress velocity, (2) the temperature dependence of strength, (3) the size effect, (4) the transition temperature from ductile to brittle failure, (5) the fluctuation characteristics of strength were uniformly interpreted. Theoretical criterions of failure and fracture of polycrystalline metals were also introduced. AUTHOR.

2556. Creep fracture of copper as nucleation process.

T. YOKOBORI. *J. Phys. Soc. Japan*, 1952, **7**, 48.

Creep fracture of Cu wire was regarded as a kind of Markoff process, and studied from the standpoint of nucleation theory. The theory indicates the power relation between stress and time for fracture which is in good accord with experiments. The dependence of time for fracture on the stress, the temperature and the length of specimen was experimentally obtained. The fluctuation characteristics accompanying these phenomena were also studied. These experiments were interpreted from the theory. AUTHOR.

2557. Modified method for viscosity measurement of small samples.

J. C. LILLARD. *Anal. Chem.*, 1952, **24** (6), 1042.

The rate of flow of a length of liquid in a tilted capillary tube is measured.

E.W.J.M.

2558. Viscosity of sodium salt of polyuronide hemicellulose from jute.

P. K. SAHA. *Nature*, 1952, **170**, 281.

2559. Photoelastic determination of boundary stresses.

W. SHELSON. *Nature*, 1952, **170**, 82.

2560. Miscibility of liquids influenced by rate of shear.

A. SILBERBERG AND W. KUHN. *Nature*, 1952, **170**, 450.

Stirring can affect the solubility and thereby the miscibility of phases, e.g. polystyrene and ethyl cellulose in benzene, equivalent to a change of 10°C. or a 1.15-fold dilution. E.W.J.M.

2561. Direct calculation of viscosities of liquids.

M. S. TELANG. *Nature*, 1952, **170**, 160.

2562. Elastoviscous properties of polyisobutylene—relation between stress relaxation modulus and dynamic modulus.

A. V. TOBOLSKY. *J. Amer. Chem. Soc.*, 1952, **74**, 3786.

An idealised distribution function for the complete elastoviscous behaviour is presented. An exact expression for the stress relaxation modulus as a function of time and temperature can be derived. E.W.J.M.