

BULLETIN



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Hon. Editor:

JOHN HARRIS,
Schools of Chemical Engineering
The University,
Bradford,
Yorks. U.K.



NOTICE TO INTENDING CONTRIBUTORS

The B.S.R. Bulletin is now available as a vehicle for several categories of communication by Members.

1. Technical papers (two copies required).
2. Descriptive papers of general interest.
3. Letters which may be either
 - (i) technical or
 - (ii) non-technical.

The technical papers will be refereed and so will technical letters but the latter only by one person. Descriptive and non-technical material will be published if it is of general interest.

In addition, project reports and computer information will be published.

It is hoped that B.S.R. members will find rapid publication sufficiently attractive to warrant submitting work.

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FOREWORD

The annual Autumn Conference of the B.S.R. promises to be a popular event with "Rheology in Industry" as the title and theme. It will be interesting to see whether the plastics industry with its considerable interest in the application of rheology will be the numerically strongest contributors. A notable feature in this respect is the concentration of papers on polymer processing at the B.S.R. conferences concerned with industrial applications and the dearth of contributions on the structural uses of polymeric materials.

Many of the older processing industries, particularly those dealing with metallic materials, are infrequent contributors to B.S.R. conferences although several of the basic processes are related to those of the plastics and rubber industries and are still the subject of current research. Perhaps at some future date a short conference on a common denominator such as "The extrusion of metals, plastics and rubbers" may provide a suitable theme, others of a similar type come readily to mind. The B.S.R. could possibly take the initiative in joining with a body such as the Institute of Metals; there has been little contact if any in the past, and the language of metallurgists is not unfamiliar to some rheologists.

As well as material forming processes, it is likely that there will be some contributions in the field of transport properties, that is unless the two or three other conferences to be held in the autumn on similar themes does not absorb all those available. In this we are assisted by a small but loyal band of members.

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MEASUREMENT OF SECOND NORMAL STRESS DIFFERENCES ON A RHEOGONIOMETER

C. W. Cowsley (Department of Chemical Engineering,
Pembroke Street, Cambridge)

The difficulty of obtaining measurements of the second normal stress differences in viscoelastic fluids undergoing steady shear is indicated by a recent paper from Ginn and Metzner (Trans. Soc. Rheol. 13 p. 429) who infer that current rheogoniometric techniques are unsatisfactory. A possible improvement to these techniques is suggested by the analysis of Marsh and Pearson (Rheologica Acta 7 p. 326). This can be used to show that for polynomial forms of N_1 and N_2 the total normal stress exerted on a cone and plate viscometer can be obtained analytically when the cone and plate are separated, and that each term of the polynomial makes its own additive contribution to the total thrust.

Examination of these predicted stresses shows that equal magnitudes of both functions will contribute unequally to the total observed thrust. Table 1 indicates the ratio of the N_2 contribution to that from N_1 at various values of separation, when N_1 and N_2 both vary according to various powers of the shear rate. The separation c is dimensionless, expressed as a proportion of the cone height, as shown in Fig. 1. The table clearly shows that if N_2 is to be measured in the presence of N_1 the measurements of total thrust most likely to yield information about N_2 will be taken from the $c = \infty$ (i.e. parallel plate) geometry. In this case N_1 and N_2 are reflected equally in the measurement.

The same analysis also yields the ratios of Table II if the cone angle is negative, corresponding to the geometry of a plate and hollow cone as in Fig. 2. As c approaches -1 the stress measured becomes wholly that due to N_2 , so that in practice much smaller corrections for N_1 will be needed. In addition, examination of the predicted stress levels shows in Table III that there is a small magnification of the effect of N_2 over the effect between parallel

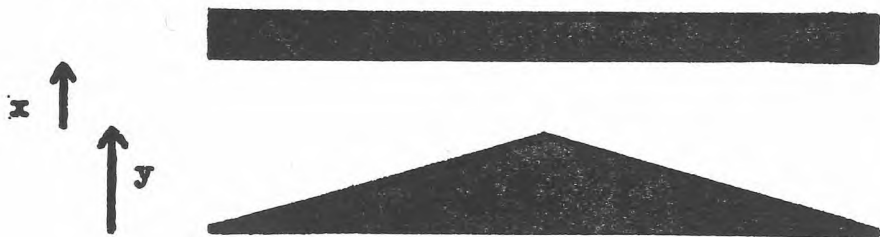


Fig. 1. $c = x/y$ (positive)

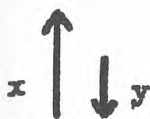


Fig. 2. $c = x/y$ (negative)

plates. The use of a hollow cone should therefore improve the accuracy with which N2 can be determined, and also reduce the level at which it can be detected. Experiments using such a cone are in progress.

TABLE I

Dimensionless gap c	Dependence of N1 and N2 on shear rate (s)				
	s	s^2	s^3	s^4	s^5
0	0	0	0	0	0
0.2	0.242	0.233	0.226	0.221	0.216
0.5	0.427	0.413	0.403	0.395	0.389
1.5	0.678	0.664	0.655	0.648	0.643
3	0.80	0.79	0.79	0.78	0.78
∞	1	1	1	1	1

Contribution to total thrust from N2 as a proportion of that from an N1 of equal magnitude but opposite sign—from the geometry of Fig. 1.

TABLE II

Dimensionless gap c	Dependence of N1 and N2 on shear rate (s)				
	s	s^2	s^3	s^4	s^5
-1.1	5.684	7.203	8.150	8.748	9.149
-1.2	3.681	4.298	4.688	4.945	5.121
-1.5	2.238	2.423	2.541	2.622	2.680
-2.0	1.669	1.744	1.793	1.827	1.851
-3.0	1.352	1.384	1.405	1.419	1.431
$-\infty$	1	1	1	1	1

Contribution to total thrust from N2 as a proportion of that from an N1 of equal magnitude but opposite sign—from the geometry of Fig. 2.

TABLE III

Dimensionless gap c	Dependence of N2 on shear rate (s)				
	s	s^2	s^3	s^4	s^5
-1.1	2.2	1.8	1.5	1.4	1.3
-1.2	1.9	1.6	1.5	1.4	1.3
-1.5	1.6	1.4	1.3	1.3	1.2

Contribution to total thrust from N2 as a proportion of that obtained from the same N2 between parallel plates at the same value of rim shear rate.

RHEOLOGY IN MEDICINE AND PHARMACY

A conference of the Society held on April 14th and 15th, 1970,
at the School of Pharmacy, University of London

Rheology is seen to infiltrate into many scientific activities, so much so, that it gives rise to some interesting secondary effects. One of the most valuable of these is the wide cross-section of membership of the Society and the healthy breakdown of information barriers between people who, in the normal course of events, would have no cause to converse and indeed would find communication difficult.

The problem of choosing a topic for each next rheological conference is certainly not the paucity of subject matter. The reverse is rather the case, where there is a definite danger of allowing too much time to elapse in a particular field and to be left in a situation where the harvest has already been gathered in before the meeting gets off the ground.

Although some aspects of haemorheology had been reviewed recently in London in 1968, the theme of rheological problems arising in general clinical medicine was clearly a useful focal point that had not been focussed on for at least twenty years. At the same time, it could be seen that pharmaceutical industry and hospital pharmacy were becoming increasingly aware of quality control, accelerated ageing and custom formulation to an extent where the pharmacological aspects of the drug packages were not sufficient. The hospital pharmacist trained in rheology would be in a good position to exploit the techniques of applied rheology and could take part in, perhaps even lead a team working on a pathological flow problem arising from a disorder in some body fluid.

With this background thinking in mind, it was encouraging, in the event, to see 130, comprising, Physicians, Pharmacists, Polymer Chemists, Mechanical Engineers, and Mathematicians attend the two-day meeting in April.

The original intention was to invite contributions from leading workers in the fields of body fluids and body tissues for the medical sessions on the first day. The second day would then be devoted to pharmaceutical formulations and interfacial rheological problems. This theme largely materialised, although suffering a little in balance. The planning time for a conference from inception to execution is extremely critical and must always be a compromise. If the meeting is planned two years in advance, one can have the world's experts and finish with a set of proceedings that are obsolete before they get into print. On the other hand, six months' grace is leaving things a little close for comfort.

Dr. Scott-Blair opened the conference by reminding us of the traditional roles of Medicine and Pharmacy and related these to the developing rheological trends. The morning session for the first day then continued with body fluid rheology.

One eternal unresolved problem in Medicine, is the *in vivo/in vitro* conflict of experimental performance and here rheology is no exception. Teams at both Leeds and Strathclyde have been studying the lubrication of human joints and the possibility, amongst other things, of preparing synthetic polymer solutions which could be formulated to replace natural synovial fluid. This involved trying to match both the viscous and elastic properties of the synthetic polymer solution and the natural hyaluronic acid-protein complex solution. Natural lubrication involved subtle effects between the articular cartilage and the natural fluid; it was not certain how well this could be simulated with the synthetics or how the depot requirements for the synthetic lubricants could be sustained. However, those concerned should be given every encouragement as they are certainly on the right tack.

Moving to saliva, a paper was presented from the School of Pharmacy, London, followed by some joint work on sputum from The Institute of Diseases of the Chest, Brompton, and St. Thomas's Hospital, London.

Most body fluids contain water-soluble polymers and it appears to be the nature of the dispersion of these polymers and their ability to take part in obscure sol-gel transformations that is most reflected in their rheology. Curiously, the viscoelasticity of saliva, a very easily accessible body fluid, was not already well documented, although it became abundantly clear, at the meeting, that structural rheology was important and if excessive could lead to poor drainage and perhaps be contributory to dental decay. Those mucolytic drugs that were active on sputum had a similar effect on saliva and the effect of natural mucolytic enzymes on saliva structure during simple storage was clearly indicated. Increased use of low amplitude oscillatory techniques on both sputum and saliva is to be welcomed, especially as these semi-solids and fluids are known to be extremely non-linear.

Histological staining techniques proved a useful complementary tool in the investigation of the breakdown of sputum gel during continuous viscometry performed at the Department of Anaesthesia, Liverpool. Those rheologists who are chemists by training often see rheology as one of the many helpful analytical techniques and in skilful hands it can be equally as rewarding, sometimes, as infra-red or gravimetric analysis.

Two papers then followed on the rheology of blood. The first, from the Haemophilia Research Centre, Oxford, described the development of a new capillary viscometer, in which the viscosity of whole blood could be examined repeatedly prior to the onset of coagulation. Complex, but extremely characteristic viscosity patterns were shown to occur and which seemed to show much promise in the correlation between the flow-age characteristics and specific blood diseases. Besides the haemophiliacs, those suffering from multiple sclerosis had characteristically abnormal blood viscosity patterns. The second paper, from the Department of Clinical Pathology, Taunton and

Somerset Hospital, also described the use of a novel capillary viscometer which was currently enjoying great popularity among paediatricians engaged in pathological studies.

The last five papers of the first day dealt with the rheology of body tissues. To start with the Leeds group presented a paper on mechanical techniques for measuring human joint stiffness. The "arthrographs" obtained were reminiscent of the polymer technologists' stress/strain hysteresis loops, obtained on tensile testing equipment and the authors showed an impressive slide indicating the increasing stiffness and hysteresis in the joints of subjects aged from two years to seventy-two years.

Next, the rupture strength of erythrocyte cell wall formed a nice contrast in an interesting paper from the Department of Microbiology at Cardiff. The red cells, in an aqueous saline suspension, were subjected to the critical shear stress produced in the vicinity of a wire vibrating at just ultrasonic frequencies. Some of the sonicated cells produced tube-like excrescences, and some of these burst and reformed to give haemoglobin-filled spheres. The application of this technique to cell metabolism studies had far reaching reverberations.

Finally, a contingent from the Bio-Engineering Group at Strathclyde held our attention right to the end of a hardworking day, with three valuable papers on skin rheology. The climax without a doubt was the skilful design, based on rheological considerations, of a cosmetic operation to remove a fair-sized cyst, resulting in an almost scarless heal.

During the luncheon breaks and after the day's business, a small display of demonstrations provided a conversation piece and a chance to meet colleagues working in similar fields. It was during one of these congregations that a clinician confided quietly to me that the best way to do the rheology of sputum was to build a mini-viscometer inside a bronchoscope. He had done just this and published it.

* * *

The Pharmacists had waited with great patience for the second day and put on an equally impressive performance. The professional boundary was crossed with assistance from an ally in Dentistry. Occasionally, one glimpses the sheer elegance of the professional rheologist at work, and certainly in the paper from the Department of Prosthetic Dentistry at the London Hospital, there was some very nice tailoring of formulation materials. This was to achieve the correct rheological response in the mouth of those unfortunate edentulous persons who find immediate rigidity intolerable.

At most rheology meetings we like to see battle done between the Theoreticians and the Experimentalists and this was no exception. For some time, experimental evidence had been accruing to the effect that liquid crystalline structures were to be found in many organic compounds and recently many pharmaceutical semi-solids were

shown to originate from hot fluids exhibiting optical microscopic evidence of liquid crystals. It is therefore timely that a theoretical paper should have been presented from the Department of Mathematics, Strathclyde, on a continuum theory of liquid crystals. One of the more sobering thoughts, emerging as a consequence of this work, was the distinct possibility that the geometry of the measuring instrument might influence the results in a way not expected by the Experimentalists.

The group from the Portsmouth School of Pharmacy presented some nice down-to-earth formulation rheology in a review paper and some curious ageing effects on similar systems were discussed in a contribution from the School of Pharmacy, London.

Next we were reminded of the subtle relationships between the psychological assessment of texture and rheology. In a paper from Unilever Research at Welwyn ideas which had originated in food texture studies were convincingly extrapolated to the pharmaceutical front. At a time when pharmaceuticals are becoming more competitive not only in their pharmacology but also in their physical characteristics the hint is well taken.

Finally, a session of surface rheological papers brought the two-day meeting to a close. Somehow surface and interfacial rheology is still a babe-in-arms, a sickly child that has never really left the cradle. It has undoubtedly got great potential, and one feels that in these days of molecular biology it could be of immense service to the enzymologist and the biochemist. However, the experimental difficulties are great and the rigorous theoretical treatments formidable. One thing is certain, it is very naïve to think that the rheology of two dimensions should be any easier than that of three. However, the closing papers from the Laboratory of Biochemistry, Ghent, Belgium, Unilever Research, Welwyn, and The School of Pharmacy, London, showed that the subject is by no means defunct, and who knows. . . .

The whole proceedings and the discussion of this conference are available from the archives of the Society recorded at $1\frac{7}{8}$ in./sec. on magnetic tape and publication is proceeding in *Rheologica Acta*.

B. WARBURTON.

PROGRAMME

Conference was opened by Dr. G. W. Scott-Blair

MORNING SESSION

Chairman: Dr. A. J. Palfrey.

Rheology of Synovial Fluid, with Reference to its Lubrication of Human Joints: D. Dowson, A. Unsworth, and V. Wright (Bio-engineering Group for the Study of Human Joints, University of Leeds).

Studies of the Nature and Significance of Macromolecular Complexes in the Rheology of Synovial Fluid from Normal and Diseased Human Joints: G. Nuki and J. Ferguson (Fibre Science Department, University of Strathclyde).

Rheological Simulation of Synovial Fluid by a Synthetic Macromolecular Solution: J. Ferguson and G. Nuki (Fibre Science Department, University of Strathclyde).

Study of the Effect of Mechanical Working on the Rheological Properties of some Potential Artificial Lubricants for Human Joints: M. A. M. A. Younes, P. S. Walker, D. Dowson and V. Wright (Bio-engineering Group for the Study of Human Joints, University of Leeds).

Rheological Properties of Saliva: S. S. Davis (Department of Pharmaceutics, School of Pharmacy, University of London).

AFTERNOON SESSION

Chairman: Professor R. M. Kenedi.

Rheological Properties of Sputum: Jennifer Sturgess*, A. J. Palfrey** and Lynne Reid* (*Department of Experimental Pathology, Institute of Diseases of the Chest, London, S.W.3) (**Department of Anatomy, St. Thomas's Hospital, London, S.E.1).

Histological Examination of Sputum during Rotoviscometry: M. H. Tekeres and I. C. Geddes (Department of Anaesthesia, University of Liverpool).

Discussion.

Rheological changes in the Nature of Human Blood prior to and during Coagulation: G. W. Scott-Blair and R. H. Matchett (Haemophilia Research Centre, Churchill Hospital, Oxford).

Viscosity of Human Blood Plasma: its Changes in Disease and on the Exhibition of Drugs: J. Harkness and R. B. Whittington (Department of Clinical Pathology, Taunton and Somerset Hospital, Musgrove Park, Taunton).

Rheological Characteristics of Human Joints with Particular Reference to the Knee: V. Wright, D. Dowson and R. Goddard (Bio-engineering Group for the Study of Human Joints, University of Leeds).

Hydrodynamic Disruption of Human Erythrocyte near a Transversely Oscillating Wire: A. R. Williams (Microbiology Department, University College of South Wales and Monmouthshire).

Dynamic Mechanical Testing of Living Skin: J. B. Finlay and I. A. Brown (Bio-Engineering Unit, University of Strathclyde).

Mechanical and Structural Characteristics of Connective Tissue: J. H. Evans and I. C. Clarke (Bio-Engineering Unit, University of Strathclyde).

Standing Cones and Lying Cones: H. L. Stark (Bio-Engineering Unit, University of Strathclyde).

**PHARMACY. Wednesday, April 15th—Rheology of Formulations
and Interfaces**

MORNING SESSION

Chairman: Dr. P. Sherman.

Rheology of Dental Materials: M. Braden (Department of Prosthetic Dentistry, London Hospital Medical College, London, E.1).

Continuum Theory of Liquid Crystals: F. M. Leslie (Department of Mathematics, University of Strathclyde).

Structure and Rheology of Emulsions stabilised by Mixed Emulsifiers: B. W. Barry (Department of Pharmaceutical Technology, School of Pharmacy, Portsmouth).

Rheological Changes occurring during the Storage of the System: Dodecyl Sulphate/1—Hexadecanol/Water: D. B. Mistry and B. Warburton (Department of Pharmaceutics, School of Pharmacy, University of London).

Rheology of White Soft Paraffin: B. W. Barry and A. J. Grace (Department of Pharmaceutical Technology, School of Pharmacy, Portsmouth).

AFTERNOON SESSION

Chairman: Professor E. Shotton.

Texture Profiling and the Evaluation of Pharmaceutical Products: P. Sherman (Unilever Research Laboratory, Colworth Welwyn).

Tensile Strength of Humidified Bulk Solids: T. M. Jones and T. Eaves (Department of Pharmacy, University of Nottingham).

A New Method for Studying the Rheological Properties of Gels: C. Roberts (Unilever Research Laboratory, Colworth Welwyn).

Surface Viscosity of Mixed Monolayers: P. Joos (Laboratory of Physical Biochemistry, State University of Ghent, Belgium).

A Versatile Surface Rheometer: E. Shotton, K. Wibberley, B. Warburton and P. L. Finlay (Department of Pharmaceutics, School of Pharmacy, University of London).

Rheological Properties of Two Dimensional Films: Mrs. Jean Boyd (Unilever Research Laboratory, Colworth Welwyn).

Rheological Properties of Thin Gelatine Surface Films: Serpil Kislalioglu, E. Shotton and B. Warburton (Department of Pharmaceutics, School of Pharmacy, University of London).

Copies of the *Proceedings* of the Conference will be available early in the autumn. If you would like to receive further details of this publication, please apply to:

B. Warburton, M.A., R.M.P., Conference Convenor,
Department of Pharmaceutics, The School of
Pharmacy, 29/39 Brunswick Square, London, W.C.1.

CONFERENCE REPORT

The Yield, Deformation and Fracture of Polymers Churchill College, Cambridge

March 31st–April 3rd, 1970

The Conference Chairman, Professor D. W. Saunders, echoed the feelings of many of those present when, at the end of the Conference, he remarked that Polymer Physics in Britain had “come of age.” Not, of course, that there have been no previous successful polymer physics meetings in this country, but several aspects of the present conference conspired to create a landmark in the development and recognition of this field of endeavour.

Firstly, the meeting was truly international, with delegates from East and West Europe, U.S.S.R. and a particularly strong representation from U.S.A. Secondly, unlike previous polymer meetings organised by voluntary groups, the Conference was officially sponsored by no less than seven representative bodies (the British Polymer Physics Group, British Society of Rheology, the Institution of the Rubber Industry, the I.P.P.S., the Materials Science Club, the Society of Chemical Industry and the Plastics Institute). Thirdly, both the subject matter and the attendance marked this out as a **physics** meeting. In the past the neglect of polymers by physicists has often meant that “polymer physics” has been co-extensive with polymer physical chemistry and has been practised by chemists rather than physicists. It was pointed out that, until halfway through the meeting, no reference had been made to chemical formulae—surely a unique occurrence in a polymer conference! If anything, it was the metallurgists who made their presence felt, emphasising yet more strongly the shift in interest, from origins to applications, so noticeable in recent years. Equally encouraging was the evident awareness on the part of the classical physicists involved of the importance of expressing theories and results in forms useful, ultimately, to the engineering designer.

This latter point deserves special mention because of the constant reference throughout the Conference to continuum (and in particular fracture) mechanics. Some eight of the twenty-six contributed papers used fracture mechanics to characterise and elucidate fracture phenomena as diverse as high speed crack propagation in glass-like plastics, fatigue failure in rubbers and “soft” plastics and the rupture of adhesive bonds. The advantages of this approach were enumerated as (i) its wide applicability, since it treats all solids as continuous media; (ii) its provision, as a consequence of (i), of a means of comparing fracture properties in different classes of materials as different as metals, rubbers and composites; (iii) its ability to produce quantitative insight into fracture **mechanisms**, so unifying the mechanical and

mechanistic aspects of the subject, and (iv) its statement of results in a form usable by the design engineer.

A further eight papers were concerned with bulk mechanics or homogeneous deformation in polymer solids. Two sophisticated papers were devoted to the characterisation of mechanical anisotropy at small strains. Polymeric materials have unique capabilities for anisotropy in their usable forms (e.g. in contrast to metal single crystals which are highly anisotropic but have few mechanical applications). Polymers are frequently produced in an anisotropic condition, either intentionally (e.g. fibres and films) or accidentally (e.g. injection mouldings). Their mechanical behaviour cannot therefore be predicted in terms of average elastic constants. The small-strain deformation of a uniaxially drawn material, for example, is governed by five independent elastic constants instead of two for the isotropic case. These constants and their dependence upon the strain level and also upon time have now been determined for low density polyethylene (the subject of the present papers) and, in part, for other polymers. The results carry implications, which are not fully understood as yet, in terms of the molecular and supramolecular mechanisms by which polymer solids respond to mechanical stress.

Mechanical behaviour at large strains is dominated, in plastics at least, by the phenomenon of yield, and this formed the subject for the opening session of the Conference. Two papers considered the effects of hydrostatic pressure and temperature on yield in glassy plastics. The purpose of superimposed pressure is, among other things, to enable us to differentiate between various continuum yield criteria such as the Tresca and von Mises theories. The results of various workers now lend strong support to a modified von Mises criterion, due to Sternstein and Onghin, namely that yield occurs when the octahedral shear stress τ_0 achieves a value given by

$$\tau_0 = a - b\sigma_m$$

where a and b are material parameters and σ_m is the mean normal stress. There is further evidence that the constant b is, like many other temperature-dependent mechanical properties in polymers, governed by the proximity of the experimental temperature to the glass transition temperature (or melting temperature in crystalline plastics).

What actually occurs, physically and on a molecular scale, when plastics yield is far from clear. In most materials yield is to some extent localised, but the nature of localisation varies from diffuse shear bands representing reasonably homogeneous deformation to the highly localised, crack-like discontinuities known as crazes. One study indicated that crazes (in polymethylmethacrylate) become narrower as temperature decreases but are still present as crack initiation sites well below the ductile-brittle transition temperature. The difference between cracks and crazes was beautifully illustrated by Kamobur in electron micrographs of sectioned material. The craze is filled with a

highly-voided sponge-like matrix of drawn polymer which under some circumstances is capable of transmitting load across the craze. This is in sharp contrast to the zero load-bearing ability of a crack and gives rise, among other things, to some of the anomalies observed in the mechanics of crack/craze propagation in active environments like solvents and their vapours.

At a molecular level, yield is still largely unexplained and no theory equivalent to that of dislocation multiplication in crystalline solids is yet available for polymeric glasses. One paper proposed that the basic molecular motion involved in yielding could be represented as a stress-induced cis-to-trans conformational transition, but a critical test of such a theory is still lacking. It was said by someone that we are still where the metallurgist stood before dislocations were discovered!

The papers and sessions not so far covered were concerned with mechanisms rather than mechanics. The paper just mentioned provides a logical bridge by which we pass to consider the remaining contributions.

One area causing considerable interest just now is that of molecular fracture under stress. Some very elegant work has been done in U.S.S.R. over a considerable number of years using the techniques of mass spectrometry, E.P.R. and infra-red spectroscopy and it was therefore fitting that Professor Zhurkov, of Leningrad, should be present to deliver a paper in this field. The concentration in stressed polymers of broken bonds (i.e. free radicals) measured by E.P.R. and of submicrocracks, measured by low angle X-ray scattering, correlate closely and indicate that the broken bonds are concentrated in the microcracks (10^{14} to 10^{16} per ml) rather than dispersed randomly. The role of molecular relaxations under stress in both the rates of production of broken chains and in molecular flow not involving fracture were discussed in other papers.

On a higher level of microstructural organisation, the role was considered of the crystalline phase in semi-crystalline polymers. The Conference organisers appeared to have deliberately minimised the number of contributions dealing with crystalline microstructure. This was probably wise, since this is a topic in its own right, but definitive work relating microstructure to deformation and fracture is scarce and extremely topical. The two papers which did lie in this field dealt respectively with the contribution of strain-induced crystallisation to strength in elastomers and with the roles of crystallographic slip, lamellar tilt and interlamellar slip in the deformation of oriented polyethylene. This general area is certain to attract increasing attention as techniques of low and wide-angle X-ray scattering and electron microscopy as applied to these complex microstructures are progressively mastered.

In conclusion an appreciative record should be made of the excellent work of the session chairmen who greatly enhanced the value of the research papers by the subject surveys with which each session commenced. The Conference was well organised and the Conference venue, Churchill College, Cambridge, proved to be a happy, almost perfect, choice.

E. H. ANDREWS,
Dept. of Materials,
Queen Mary College,
London, E.1.

NOTE: A copy of the collected reprints is available on loan from Dr. D. W. Hadley, J. J. Thomson Physical Laboratory, Whiteknights, Reading RG6 2AF.

PROGRAMME

YIELD SESSION

Chairman: Professor R. D. Andrews (Stevens Institute of Technology, New Jersey, U.S.A.).

The Effect of Hydrostatic Pressure on the Yield and Plastic Flow in Polymers: E. Baer, A Christiansen and S. V. Radcliffe (Case Western Reserve University, Cleveland, Ohio, U.S.A.).

The Pressure, Temperature and Strain Rate Dependence of Yield in Isotropic Polymethylmethacrylate: R. A. Duckett, S. Rabinowitz and I. M. Ward (University of Bristol).

A Yield Criterion for Isotropic Polymers: Shear Band Formation and the Effect of Structure on the Yield Behaviour: P. E. Bowden and J. A. Jukes (University of Cambridge).

Stress Field Criteria for Yielding and Crazing of Glassy Polymers and the Mechanism of Toughening in Rubber-Modified Systems: S. Sternstein, J. Paterno and L. Ongchin (Rensselaer Polytechnic Institute, New York).

The Nature of Glassy Polymers upon Yielding and their Approximation by States having the Structure but not the Thermal Energy of the Melt: R. E. Robertson (General Electric Company, Schenectady, New York).

FRACTURE SESSION

Chairman: Professor Thor L. Smith (I.B.M., San Jose, California, U.S.A.).

Fracture of Polymethylmethacrylate at Low Temperatures: P. Beardmore and T. L. Johnston (Ford Motor Company, Michigan, U.S.A.).

Deformation and Fracture of Polymethylmethacrylate at High Rates of Strain: J. C. Radon and N. P. Fitzpatrick (Imperial College, London).

Ductile Crack Growth in Polyethylene Terephthalate Films: P. I. Vincent (I.C.I. Plastics Division, Welwyn Garden City).

An Indirect Method to examine the damaging of Polymers during Tensile Tests: W. Retting (Badische Anilin and Soda-Fabrik, Ludwigshafen am Rhein).

Fatigue Failure in Plasticised PVC: R. N. F. Pinfold and J. R. Hall (Bostik Ltd., Leicester).

Fatigue Failure in Polyethylene—A Fracture Mechanic's Approach: E. H. Andrews and B. J. Walker (Queen Mary College, London).

Connection between the Destruction of Chain Molecules and the Formation of Submicroscopic Cracks in Stressed Polymers: S. N. Zhurkov et. al. (A.F. Ioffe Physico-Technical Institute, Leningrad, U.S.S.R.).

The Homogeneous Fracture Initiation in Polymers as Concluded from ESR Experiments and a consideration of the Micro-Morphology: H. H. Kausch (Batelle-Institut, Frankfurt).

CRAZING SESSION

Chairman: Dr. R. P. Kambour (General Electric Company, Schenectady, New York).

Transmission Electron Microscopy of Crazes reinforced with Solid Impregnants during the Microtomy Process: R. P. Kambour.

Crack and Craze Growth in Crystal Polystyrene—A Fracture Mechanic's Approach: G. P. Marshall, L. E. Culver and J. G. Williams (Imperial College, London).

Environmental Stress Cracking and Crazing of Polymethylmethacrylate in Alcohols: E. H. Andrews and L. Bevan (Queen Mary College, London).

Rubber-Toughening of Glassy Polymers—The Significance of the Secondary Mechanical Loss Peak: C. B. Bucknall and M. M. Hall (Cranfield Institute of Technology, Cranfield, Beds.).

DEFORMATION AND FRACTURE IN ELASTOMERS SESSION

Chairman: Dr. L. Mullins (Natural Rubber Producers' Research Association, Welwyn Garden City).

Adhesion between Viscoelastic Materials: A. N. Gent and M. Fujimori (University of Akron, U.S.A.).

The Viscoelastic and Frictional Behaviour of Tyres and the Deformation Characteristics of Road Surfaces: G. N. Lupton (Road Research Laboratory, Crowthorne, Berks.).

Application of Fracture Mechanics to Failure in Rubber Articles with Particular Reference to Groove Cracking in Tyres: G. J. Lake (Natural Rubber Producers' Research Association, Welwyn Garden City).

Some Factors Affecting the Strength of Strain-Crystallising Elastomers: J. F. Smith (Natural Rubber Producers' Research Association, Welwyn Garden City).

A New Relaxation Process in the Rubberlike State at Low Temperatures: G. M. Bartenev and A. M. Kucherski (Lenin State Teachers' Training University, Moscow, U.S.S.R.).

ANISOTROPY SESSION

Chairman: Professor L. R. G. Treloar (University of Manchester).

Mechanical Anisotropy of Cold Drawn Low Density Polyethylene: N. H. Ladizesky and I. M. Ward (University of Bristol).

The Complete Characterisation of the Non-Linear Creep Behaviour of Transversely Isotropic Low Density Polyethylene from Uniaxial and Shear Deformation Measurements: M. M. Hall, D. Clayton and M. W. Darlington (Cranfield Institute of Technology, Cranfield, Beds.).

The Effects of Applied Stress on Lamellae in Oriented Bulk Polyethylene, determined by Low and Wide-Angle X-Ray Diffraction: J. G. Rider and A. Cowking (University of Surrey).

Large Frozen-In Deformations and Internal Stresses in Glassy Polymers: Ir. L. C. E. Struik (Centraal Laboratorium T.N.O., Delft, Netherlands).

FRENCH RHEOLOGICAL TERMINOLOGY

The following is a free translation of the provisional definition printed in *Bull. Gpe. Franc. de Rhéol.*, No. 26, 1969.

81. *Rhéologie superficielle* (superficial or surface rheology).

The rheology of thin layers at the surface of a liquid or at the interface of two liquids (insoluble monomolecular layers, or soluble absorbed layers).

The expression *rhéologie bidimensionnelle* (two dimensional rheology) is sometimes used when one dimension of the system contains only a single molecule. In surface rheology only stresses and deformations in the plane of the layer are considered. When the layer is not planar one takes the plane tangent to each point.

Definitions of rheological coefficients are identical to those in three dimensions, but equations involving dimensions may differ; in particular for magnitudes defined as pressures or tensions, instead of force per unit of surface one has force per unit length: the dimensions of a surface pressure (π) or surface tension (γ) are MT^{-2} .

Module de compression superficielle (surface compressional modulus, area modulus). For an element of surface A:

$$\mathcal{H} = -A \left(\frac{\delta \pi}{\delta A} \right)_T$$

The index T indicates that compression takes place at constant temperature.

Elasticité de Gibbs (Gibbs' elasticity). For soluble adsorbed layers the area modulus coincides with the Gibbs' elasticity defined by:

$$E_G = A \left(\frac{\delta\gamma}{\delta A} \right)_T$$

Coefficient d'élasticité superficielle, module d'Young superficiel. (Coefficient of surface elasticity; surface Young's modulus):

$$E = L \left(\frac{\Delta F}{\Delta L} \right)$$

(Difficult to attain experimentally, and unique to compression.)

Rapport de Poisson superficiel (surface Poisson's ratio):

$$\nu = - \left(\frac{\Delta l}{l} \right) \left(\frac{L}{\Delta L} \right)$$

(Difficult to attain experimentally, and unique to compression.)

Viscosité superficielle dilatationnelle (area surface viscosity). Immediately following a rapid variation $\Delta\pi$ of surface pressure, the value of the expression:

$$\xi = A \left(\frac{dA}{dt} \right)_T^{-1} \Delta\pi$$

Viscosité superficielle de Marangoni (Marangoni surface viscosity). In the case of soluble adsorbed layers the area surface viscosity coincides with the Marangoni surface viscosity defined by:

$$\xi_M = A \left(\frac{dA}{dt} \right)_T^{-1} \Delta\gamma$$

Module de cisaillement superficiel, or, module de glissement superficiel, or module de Coulomb superficiel. (Surface shear modulus.)

For a shear stress σ_{xy} and the corresponding shear strain $2 \epsilon_{xy}$, in the plane xy tangential to the layer:

$$G = \frac{1}{2} \sigma_{xy} \epsilon_{xy}^{-1}$$

Viscosité superficielle de cisaillement (surface shear viscosity). For a shear rate $2 \dot{\epsilon}_{xy}$:

$$\eta = \frac{1}{2} \sigma_{xy} \dot{\epsilon}_{xy}^{-1}$$

The annual conference of Groupe Français de Rhéologie will be held in the latter part of September 1970. Offers of papers on the general topic of "Influence of temperature and pressure on rheological behaviour" should be sent to M. B. Persoz at 68 Boul, Saint-Michel, Paris 6 eme, France.

Translation by D. W. Hadley,
J. J. Thomson Physical Laboratory,
White Knights,
Reading RG6 2AF.

SOCIETY OF GLASS TECHNOLOGY

Grand Hotel, Eastbourne

May 27th–29th, 1970

SYMPOSIUM ON SCIENCE AND INDUSTRY

PROGRAMME

Wednesday, May 27th, 1970

Idea to Marketing. In the Chair: the President of the Society of Glass Technology—Mr. A. Garstang.

Introduction to the symposium by Professor R. W. Douglas.

Float glass: Mr. K. J. B. Earle (Pilkington Brothers Ltd.).

Lightweighting of glass containers: Mr. B. E. Moody (United Glass Ltd.).

Thursday, May 28th, 1970

Research and Technology. In the Chair: the President of the Glass Manufacturers' Federation—Mr. J. B. Livingston.

The University: Professor R. W. Douglas (Department of Glass Technology, Sheffield).

The Glass Industry: Dr. L. H. A. Pilkington (Pilkington Brothers Ltd.).

The Research Association: Dr. R. G. Newton (British Glass Industry Research Association).

General Discussion.

Research and Technology (continued). In the Chair: the Chairman of the British Glass Industry Research Association—Mr. W. E. C. Stuart.

The function of industrial research in corporate planning: Mr. E. W. Osmond (International Paint Co. Ltd.).

Contract research at the Arthur D. Little Research Institute: Dr. W. A. P. Black (Arthur D. Little Research Institute).

The application of industrial research: Dr. J. H. Chesters (British Steel Corporation).

Friday, May 29th, 1970

Industry in a Scientific Society. In the Chair: the immediate Past President of the Society of Glass Technology—Mr. L. E. Norton.

Needs research: Mr. B. Hart (Plessey B.T.R. Ltd.).

The future of the graduate in industry: Dr. S. L. Bragg (Rolls-Royce Ltd.).

The planning and control of scientific effort in industry: Mr. W. F. Spengler (United Glass Ltd.).

General Discussion.

Presidential Address.

ABSTRACTS

Mr. K. J. B. Earle

The two flat glass processes which existed in the 1950s are briefly examined in order to demonstrate the motivation to invent a new process.

The initial idea was described and also the way in which the idea was taken through the stages of small scale and pilot plant to first production plant. The way in which the project was managed is also discussed.

There is a film to show the process as it is today. The electrofloat process is quoted as an example of the potentialities for further development of the float concept.

The significance of the invention is examined in the context of its commercial and international implications as well as its technical merit.

Mr. B. E. Moody

Of the thousands of bottle designs in use today, some still seem to be close replicas of those made hundreds of years ago. Others have been re-designed many times in an apparently evolutionary trend, while a few really are revolutionary compared with their predecessors. Have scientific efforts played a major part in these changes, or is "lightweighting" just a convenient sales gimmick?

Successful lightweight designs are not at the present time produced by scientists working in back rooms, but their general work on better control of the glass forming process and better methods of surface strengthening has opened the door to a new range of possibilities. In the main, however, the scientist has to work in a team with his commercial colleagues, in order to evolve new products which are both technically feasible and commercially desirable.

As glassmaking becomes more a science and less of a craft, so the contribution made by the scientist will become relatively greater and perhaps some of the successful designs of the near future will be almost entirely the efforts of the back-room boys.

Professor R. W. Douglas

Education is one of the major industries in the country in terms of cost; quite rightly it is the focus of an enormous public debate. Undoubtedly education at university level is going through a period of rapid change. In an endeavour to deal very briefly with these pressures for change and the place of a university in the industrial scene three questions will be posed: what is a university?; what is university science?; what is technology?

These questions were answered both generally and in the specific context of the Department of Glass Technology and the glass industry, and the suggestion will be made that the area of contact between universities and industry needs recognising and defining; this area of contact although small is of vital importance, particularly for the future.

Dr. R. G. Newton

Other countries envy the British Network of Research Associations which serve two-thirds of British industry and form a communications bridge for the exchange of expertise between these many fields. Each R.A. provides an economical and efficient way of carrying out co-operative researches for the benefit of the whole industry but, in addition, there are some kinds of work which only an R.A. can carry out.

Examples were given of different ways in which R.A.s can increase the productivity of their industries, with particular emphasis on how B.G.I.R.A. helps the glass industry. The active participation of the industry is vital because each firm must ensure that it will obtain benefits appropriate to its own operations.

Mr. E. W. Osmond

Because in the past most directors of companies did not understand the research and development function of a company, research departments were not integrated into the overall planning of companies. The increasing rate of development and consequent great dependence of firms on technological innovation has emphasised the need for research and development programmes to be in line with company objectives.

There is, therefore, a requirement that: R. and D. should be profitable—means have to be developed for assessing and improving the effectiveness of research departments; R. and D. should be part of a corporate plan—policy making methods for the company have to be devised in which R. and D. will play an essential part, particularly in collaboration with the marketing function; R. and D. has to be managed efficiently—research is expensive and time consuming so management methods are required which will ensure that results are produced at the right time at the minimum cost without killing the spirit of innovation by bureaucratic organisation.

Dr. W. A. P. Black

The Arthur D. Little Research Institute is an independent British non-profit distributing organisation which undertakes research and development for industry and governments on a contract basis, aiming to assist companies whose R. and D. capacity is fully committed, to provide research skills outside the competence of a company, and to answer problems which require an independent objective approach

taken in strict confidence. Situated in two locations on the outskirts of Edinburgh A.D.L.R.I. provides the most modern facilities and equipment for scientific and technological investigations. Its staff has highly diversified academic training and industrial experience. It is a professional organisation whose sole objective is to help sponsors define and solve problems.

Since its establishment in 1956 the Institute has provided numerous industrial and government organisations throughout Europe and America with R. and D. facilities. These have ranged from short term investigations and feasibility studies, through product and process development to long-range scientific investigations. All research and development projects are conducted on a confidential basis and all patents resulting from such work are assigned to the sponsors.

Dr. J. H. Chesters

In his Presidential Address to the Iron and Steel Institute, the author suggested that there was little point in doing industrial research unless it was going to be applied. Further, that this final stage was dominated by the human factor. The problem is discussed under certain headings taken from an address by Augustus Kinzel of the Salk Institute, namely: they've never heard of it; they've heard of it, but they don't understand it; they understand it but they don't have the imagination of where to put it and how to use it; they have the imagination, can see where it can go, but reject it.

It is suggested that the main answer to the application problem will come from the movement of research men into production but that meantime the most vital factor is co-operation at an early stage between those doing research and those who it is expected will be called upon to apply it.

Mr. R. Hart

The selection of R. and D. projects on which to deploy relatively scarce resources is a well known problem. Possible solutions include playing a hunch or following the leader. Neither of these methods is very satisfactory in the telecommunications industry where, at the systems level, R. and D. phases can be comparatively long and expensive.

A preferred approach is to try and discover what the user of telecommunications needs and to direct R. and D. effort towards satisfying that need. Whilst this may appear to be a truism, its implementation requires a very positive effort. It was with this in mind that a mixed discipline team was established some years ago at Plessey B.T.R. Ltd. to carry out research into needs.

This paper described the objectives, methods and organisation of the "Needs Research" activity and in doing so will show the impact that telecommunications can have on society.

Dr. S. L. Bragg

Britain's university population in 1938 was about 50,000 and the comparatively few graduates who entered industry were usually introduced through research departments.

By 1980 there may be no less than 800,000 students undergoing full time higher education. But the amount of resource and effort we need to devote to research is still only a small fraction of that needed to develop, produce, and market novel systems: so how is this huge influx of recruits to be accommodated?

I believe that we must restructure our operations so that very many more jobs, from foreman to salesman, are attractive to, and worthy of, graduate power. Even the idea of a separate research department may be abandoned since every qualified individual will want the chance to apply some original thought to his particular job.

Mr. W. F. Spengler

The planning of scientific effort in industry cannot take place in a vacuum. It must fit with a company's business strategy and make a contribution to the achievement of the commercial objectives. To this end, the content of the programme and the ranking of the projects undertaken must reflect sound business judgement.

Essentially, this requires strong input by line managers in co-operation with their colleagues who direct the scientific activity. Top management must also accept the responsibility for the overall direction and control of this effort, as they do for other segments of the business. It is not something which can be left to the researchers alone. This does not mean that the research management should be told how to do their jobs, but rather what contribution is expected from them and when it is needed.

**The Netherlands Society of Rheology
The Rheology Group of the Netherlands Association
for the Advancement of the Knowledge of Materials**

**SYMPOSIUM: TRANSITIONS IN VISCOELASTIC MATERIALS
IN RELATION TO STRUCTURE**

Held at Leende (near Eindhoven—Netherlands)
in Hotel "De Schammert" on May 21st and 22nd, 1970
Secretariat: Stadhouderslaan 28, Postbox 9321, The Hague

PRELIMINARY PROGRAMME

(The papers were read in English)

Thursday, May 21st

Opening by Dr. C. A. F. Tunyman, President of the Netherlands Society of Rheology.

"General Introduction": Ir. J. Heyboer (Centraal Laboratorium T.N.O., Delft).

"The statistical interpretation of viscoelasticity": Dr. N. A. Brunt (West Terschelling).

"Pressure dependence of glass transition temperature in polymers": Prof. Dr. U. Bianchi (University of Genova).

"The isothermal compressibility of polyvinylacetate in the glass transition region": Drs. J. P. van Braam Houckgeest (Kon./Shell Laboratorium, Amsterdam).

"The temperature dependence of the volume retardation of polyvinylacetate": Dr. Th. Holleman (Kon./Shell Laboratorium, Amsterdam)

"Thermal activation relations": Dr. C. A. F. Tuynman, P. L. C. Jetten and L. M. W. Penders (Centraal Laboratorium D.S.M., Geleen).

Friday, May 22nd

"Melting behaviour in relation to morphological structure of polyethylene": Dr. A. J. Pennings and J. M. A. A. vander Mark (Centraal Laboratorium D.S.M., Geleen).

"The influence of sidegroup structure of the glass transition temperature of isomeric vinyl-ester polymers": Drs. H. van Hoorn (Kon./Shell Laboratorium, Amsterdam).

"The dynamic-mechanical glass-rubber transition of oriented sythetic fibres": Ir. S. J. van der Meer (A.K.Z.O., Arnhem).

"The mechanical and dilatometric glass transition of asphaltic bitumens": Ir. R. Jongepier (Kon./Shell Laboratorium, Amsterdam).

"Prediction of the glass transition temperature of polymers": Ir. H. G. Weyland (A.K.Z.O., Arnhem).

"Height of mechanical loss peaks and conformational energy": Ir. J. Heyboer (Centraal Laboratorium T.N.O., Delft).

Every lecture was followed by discussion.

"CHEMECA" 70
CHEMICAL ENGINEERING CONFERENCE
AUSTRALIA 1970

Melbourne August 18th-21st. Sydney August 24th-26th

Topics

1. Particle Mechanics: Including mineral processing, comminution, classification, froth flotation, agglomeration, dust and mist collection.
2. High Temperature Processes: Including pyro-metallurgy, glass and refractory manufacture.
3. Chemical Reaction Engineering: Including reaction systems, kinetics, electrochemical and hydrometallurgical processes, reactor performance, petrochemicals.
4. Biochemical and Biomedical Engineering: Including biological fermentation, biological leaching and extraction, food engineering, biomedical processes and devices.
5. Rheology and Mixing: Including engineering aspects of rheology and mixing of non-Newtonian fluids.
6. Diffusional Processes: Including heat, mass and energy transfer operations.
7. Process Dynamics and Control: Including computer control and optimisation.
8. Scientific Management: Decision making applied to the planning and use of resources; to R. and D.; to design; to process operation.

Addresses for communications:

General

The Secretary, Chemeca 70,
Australian Academy of Science,
Gordon St.,
Canberra City, A.C.T.,
Australia 2601.

Technical Programmes

Assoc. Prof. J. R. Norman,
Dept. of Chemical Engineering,
University of N.S.W.,
P.O. Box 1,
Kensington, N.S.W.,
Australia 2033.

SOCIETY OF GLASS TECHNOLOGY

Thornton, 20 Hallam Gate Road, Sheffield S10 5BT
England

Preliminary Notice

SOME ASPECTS OF THE PHYSICAL PROPERTIES OF GLASSES

A second meeting in the series of colloquia on the physics and chemistry of glasses will be held on January 6th and 7th, 1971, in the Advance Research Unit of James A. Jobling & Co. Ltd. at Brancepeth Castle, Co. Durham, by kind invitation of the company. It is hoped that accommodation will be available in one of the halls of residence of Durham University, about five miles away.

The topics to be considered are:

1. Strength.
2. Surface studies.
3. Viscosity, relaxation, and transformation range phenomena.

Research reports and short contributions, as well as more formal papers, will be accepted and titles should be submitted not later than August 3rd, 1970, to the Assistant Secretary at the address given at the head of this notice.

MATERIALS SCIENCE CLUB

Materials Forming Processes

Meeting at University College, Swansea, July 23rd/24th, 1970

The aim of the meeting is twofold. First, to report advances in forming methods for intractable materials like refractory metals and ceramics and novel methods for more familiar materials. Second, to strengthen contacts between academics and industrialists, between theories of process operations and practical problems and between people of different disciplines working on a variety of materials.

The speakers listed in the provisional programme all appear by invitation and form a strong nucleus for a stimulating meeting in this important field of Materials Science.

DR. J. P. BERRY,
Hon. Sec. Materials Science Club,
Rubber and Plastics Research Association,
Shawbury,
Shrewsbury,
Shropshire.

THE PHYSICS OF NON-CRYSTALLINE SOLIDS

Third International Conference

Monday, September 14th to Friday, September 18th, 1970
in the University of Sheffield, Sheffield, Yorkshire

The general areas of study to be discussed at the conference are:

1. The structure of inorganic and polymeric glasses.
2. Transformation range phenomenon and viscosity temperature relationships for supercooled liquids and glasses.
3. Relaxation effects and mechanical properties of glassy materials.

SPECIAL LECTURES INCLUDE:

Professor R. W. Douglas
University of Sheffield

Professor G. Gee
University of Manchester

Professor M. Goldstein
Yeshiva University
New York, U.S.A.

Professor N. March
University of Sheffield

Professor B. E. Warren
Massachusetts Institute of
Technology, U.S.A.

Professor S. F. Edwards
University of Manchester

Dr. A. J. Leadbetter
University of Bristol

Professor P. J. Bray
Brown University
Rhode Island, U.S.A.

Professor J. A. Prins
The Netherlands

Glassy Materials:
A General Survey
The Nature of the
Glass Transition
Relaxation Processes
in Glasses

Atomic Transport in
Simple Liquids
X-ray Structural
Determination
of Glasses

Theories of the Solid
State

Neutron Scattering in
Amorphous Solids

Magnetic Resonance
in Glasses

Low angle X-ray
Scattering in Glasses

SOCIAL PROGRAMME

The social programme will include a Civic Reception by the Lord Mayor of Sheffield and a visit to the Radio Telescope at Jodrell Bank. Ladies will be welcome and a programme of special events has been arranged for them.

ORGANISING COMMITTEE:

Chairman:

Professor R. W. Douglas

University of Sheffield

Secretary:

Mr. B. Ellis

University of Sheffield

Professor G. Allen

University of Manchester

Dr. I. G. Austin

University of Sheffield

Professor J. Lamb
Dr. A. J. Leadbetter
Professor N. March
Professor D. W. Saunders

University of Glasgow
University of Bristol
University of Sheffield
College of Aeronautics, Cranfield

COMBINED FEES

CLASS A £35

Conference Fee; accommodation in Earnshaw Hall, Monday night, 14th, to Thursday night, 17th; visit to Jodrell Bank; Conference Dinner and published proceedings to the Conference.

CLASS B £30

As Class A but **excluding** accommodation at Earnshaw Hall. A list of hotels will be sent on request.

CLASS C £21

For the ladies of Conference participants. As Class A but **excluding** Conference fee and published proceedings of the Conference, but including ladies' programme.

CLASS D £15

For the ladies of Conference participants. As Class A but **excluding** accommodation at Earnshaw Hall, Conference fee and published proceedings of the Conference but **including** ladies' programme.

NOTE: It is planned that the Conference will start at 10 a.m. on Monday, September 14th, those requiring accommodation for Sunday night, 13th, must book.

Enquiries and requests for booking forms should be addressed to:

Mr. B. Ellis,
Department of Glass Technology,
University of Sheffield,
Sheffield S10 2TZ.

THE FARADAY SOCIETY

A SPECIAL DISCUSSION ON THIN LIQUID FILMS AND BOUNDARY LAYERS

will be held at

CAMBRIDGE UNIVERSITY
on September 28th-30th, 1970

The discussions will be grouped around the following topics: equilibrium and non-equilibrium properties of thin films of surfactants and lipids, liquid layers near to solids and the lubrication and transport properties of boundary layers.

The sessions will bring together theoretical and experimental workers from both academic and industrial organisations, and will provide a forum for discussion of topics of joint interest to many scientists and engineers. The papers will include thermodynamic, kinetic, mechanical and spectroscopic studies of thin liquid films and boundary layers, and investigations of the significance of boundary layer properties for colloid phenomena, lubrication and the spreading and draining of liquids on solids.

Further particulars may be obtained from:

The Asst. Secretary, The Faraday Society,
c/o Dr. B. A. Pethica (Chairman of the Organising Committee),
Unilever Research Laboratory, Port Sunlight, Cheshire, England.
Telephone: 051 645 2000 Ext. 665.

NEWS FROM THE VICTORIAN BRANCH (AUST.)

SYMPOSIUM ON VISCOELASTIC LIQUIDS

held on **Wednesday, March 11th, 1970**

at CLUNIES ROSS HOUSE

Chairman: O. Delatycki.

Speaker	Title
P. Grossman	Fundamental principles of viscoelasticity.
H. P. Witt	Measurement of the fundamental properties of viscoelastic liquids.
Film	Rheological behaviour of fluids.
K. Hall	Viscoelasticity in practice.
Dinner	

Chairman: J. Stearne.

E. J. Dickenson	The viscoelastic behaviour of confined thin films of bitumen and other liquids in tension/compression.
D. Boger	Flow of viscoelastic liquids in pipe lines.

B.S.R. AUTUMN CONFERENCE

The Society has applied to hold its 1970 Autumn Conference at the Royal Military College of Science, Shrivenham, from September 7th to the 10th. The theme of the Conference will be "Rheology in Industry." Papers are invited for this Conference, and intending authors are asked to contact Dr. K. M. Beazley, 44 Brockstone Road, Boscoppa, St. Austell, Cornwall, as soon as possible. Titles and abstracts of such papers should be forwarded to the above address so as to reach it not later than May 1st, 1970, or as soon thereafter as possible.

JOURNALS COVERED FOR RHEOLOGY ABSTRACTS

JANUARY 1970

- | | |
|---------------------------------------|--|
| HAI 125 Advances in Polymer Sci. | KMB La Papeterie |
| CJSP 166 Appl. Mech. Revs. | JFH 76 Lubrication Eng. |
| FML 129 Arch. Rat. Mech. Anal. | KMB 88 Matl. Res. Stand.
(A.S.T.M.) |
| KMB Berichte Deutsch. Ker.
Ges. | KMB 90 Mod. Plastics |
| KMB 86 Brit. Plastics | KMB Nature |
| KMB Bull. Am. Ceram. Soc. | JFH 77 N.L.G.I. Spokesman |
| KMB Bull. Soc. Ceram. Franc. | KMB Paper Technol. |
| DWH 160 Cah. du Gpe. Franc.
Rheol. | CJSP 165 Phys. Fluids |
| JMS Can. J. Chem. Eng. | DWH 140 Proc. Am. Soc. Soil Sci. |
| DWH Can. J. Soil Sci. | FML 26 Proc. Camb. Phil. Soc. |
| KMB 135 Chem. Eng. | KMB Proc. Roy. Soc. |
| JRAP 132 Chem. Eng. Sci. | RR 170 Proc. Roy. Soc. Edin. |
| DWH Ind. Soc. Soil Sci. Bull. | JRAP 44A Poly. Eng. and Sci. |
| KMB 40 J. Am. Ceram. Soc. | FML 13 Quart. J. Appl. Maths. |
| PH 110 J. Appl. Chem. U.S.S.R. | KW 161 Quart. J. Mech. and
Appl. Maths. |
| DWH 128 J. Appl. Poly. Sci. | JFH 72 Rev. Inst. Franc. Petrole |
| MJG 89 J. Chem. Phys. | RR 63 Rev. Mod. Phys. |
| AE J. Biomech. | HAB 112 Rheol. Acta. |
| JMS J. Chem. Eng. Japan | RNFP 16 Rubber Chem. Tech. |
| KW 164 J. de Mechanique | RH 148 Russ. Chem. Rev. |
| KW 163 J. Fluid Mech. | RH 149 Russ. J. Phys. Chem. |
| GRS 141 J. Inst. Rub. Ind. | KMB Silicates Ind. |
| RR 169 J. Jap. Phys. Soc. | JRAP 44 Soc. Petrol Eng. J. |
| MJG 158 J. Pharmaceut. Sci. | DWH 42 Soil Sci. J. |
| MJG 159 J. Pharm. Pharmacol. | RH 150 Sov. Phys. Tech. Phys. |
| RR 69A J. Phys. A. | RH 151 Sov. Phys. Uspekhi |
| RR 69C J. Phys. C. | DWH 155 Sov. Soil Sci. |
| PH 14 J. Phys. Chem. | KMB Sverste Papperst. |
| HAI 19 J. Poly. Sci. A1, A2 | KMB T.A.P.P.I. |
| HAI 136 J. Poly. Sci. B | KMB 36 Trans. Brit. Ceram. Soc. |
| HAI 137 J. Poly. Sci. C | GRS 85 Trans. Plastic Inst. |
| RR 34 J. Sci. Inst. | CMF 168 Trans. Soc. Rheol.
(U.S.A.) |
| HAI 47 J. Soc. Dy. Col. | AE Ultrasonics |
| DWH 38 J. Soil Sci. | KW 162 Z.A.M.P. |
| DWH 49 Kolloid Zeits. | |
| KMB L'Industrie Ceramique | |

DIARY

1970

16-17 June. Conference—Polymers in High Performance Applications. Joint Soc. of Plast. Engrs. and Plast. Inst. at I.E.E., London.

17-24 June. Exhibition—Chemical Engineering—"ACHEMIA" 1970 at Frankfurt, Germany.

15-17 July. Conference—Testing Fibrous Composites for Mechanical Properties. The Meetings' Officer, The Inst. Phys., 47 Belgrave Square, London, S.W.1.

1-3 September. Conference—The Hydraulic Transport of Solids at Coventry. B.H.R.A. Cranfield, Beds.

29 September-1 October. Conference—Advances in Polymer Science and Technology No. 3. Chemistry of Liquid and Thermoplastic Co-polymers. Joint I.R.I., P.I., S.C.I., O.C.C.A. and S.D.C.

September. Conference—Furniture. Plast. Inst.

6-10 October. Exhibition and Conference—Inter. Science, Research and Technology Exhibition and Conference. Boardman Ltd., 8 Leicester Street, London, W.C.2.

13 and 14 October. Conference—Reinforced Plastics at Solihull. Plast. Inst.

20-22 October. Conference—7th Int. Reinforced Plastics Conference at Brighton. Brit. Plast. Fed.

November. Exhibition—Internat. Reinforced Plast. Exhib. (REPLEX) at Earls Court, London. Brintex Exhibitions Ltd., 3-4 Clements Inn, Strand, London, W.C.2.

9-13 November. Exhibition—Scottish Plastics, Packaging and Printing Exhibition at Glasgow.

19 and 20 November. Conference—Plastics in Furniture. Plastics Inst.

1971

4-6 January. Conference—Designing for Plastics; The Integrated Approach, at Cranfield. Plast. Inst.

2-4 February. Conference—Carbon Fibres, their Composites and Applications. Plast. Inst.

25-27 March. Conference—Exploitation of Polymer Research at Loughborough. Joint I.R.I., Plast. Inst.

March. Conference—Plastics in Fire: Building. Joint Plast. Inst./Agreement Board.

March. Conference—Plastics in Fire: Transport and Materials. Plast. Inst.

22 and 23 April. Conference—Industrial Conference at Leamington Spa. I.R.I.

15-18 May. Conference—International Rubber Conference at Brighton. I.R.I.

16-23 September. Exhibition—6th. International Plastics Trade Fair "K-71" at Dusseldorf.

LOST MEMBERS

The present whereabouts of the members listed below is unknown. Any information which will assist in tracing them will be gratefully received by the Membership Secretary:

Mr. B. Warburton,
Schools of Pharmacy,
Brunswick Square,
London.

Mr. P. Connor, 9 East Shrubbery, Redland, Bristol.

Dr. D. P. Earp, 35 Westfield Drive, Woodley, Reading, Berks.

Mr. B. Holdaway, c/o Bank of N.S.W., 47 Berkeley Square, London.

Dr. J. L. Maddock, 12 Addison Court, Maidenhead, Berks.

Mr. J. W. Sellars, "Pantiles," 6 Hazell Way, Stoke Poges, Bucks.

Mr. H. R. S. Tage, 16 Cae Rhadyn, Croesyceiio, Cwbran, Mon.

BRITISH SOCIETY OF RHEOLOGY

Computer Program Catalogue

Publication Abstract

1. Author
2. Establishment
- Tel. No.
3. Program Abstract
-
- Input Data
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- Output Data
4. Program date
-
5. Language
-
6. Computer requirements
-
7. Type of Input/Output
-
8. References
-
-
-
9. Related programs
-
10. Available for copy/data processing
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Return to: Dr. J. Harris,
Postgraduate School of Chemical
Engineering,
University of Bradford,
Bradford 7, U.K.

Additional blank abstract sheets are available as required from the above address.