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THE BRITISH SOCIETY OF RHEOLOGY

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THE BRITISH SOCIETY OF RHEOLOGY

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1991/92

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EDITORIAL

After another successful and informal Autumn Meeting we look forward to further growth in our activities and membership. We also welcome a new national society to the international community of rheology. Next year sees the International Congress quite close to home in Brussels. I hope many members are already making their plans to attend.

The inclusion of a short conference report by Adrian Merrington of Bradford University gives me the opportunity to remind members that the Society welcomes applications from research students for grants to help them attend conferences. Application should be made to the Secretary for consideration by Council.

In his report the Abstracts Editor makes the perfectly valid point that since many of the papers whose abstracts are published in *Rheology Abstracts* are written by members of the Society it seems sensible to abstract them direct. I therefore invite members to send a copy of papers they have published to him at the address inside the front cover of this Bulletin.

The centre of this issue contains a membership application form it may be detached without spoiling the page sequence, or photocopied. Please use it to encourage your colleagues to join the Society.

Copy date for next issue: December 15th.



THE FABRICATION OF AUXETIC POLYMERS: IMPLICATIONS AND APPLICATIONS

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When a material is stretched the normal expectation is that the material will become thinner in the direction perpendicular to the stretching direction. This expectation arises from the fact that all naturally occurring materials appear to exhibit this property. It is one of the fundamental mechanical properties of a material and is defined by the quantity known as Poisson's ratio. For an isotropic material Poisson's ratio, ν is defined by

$$\nu = -\frac{\epsilon_y}{\epsilon_x} \quad \dots (1)$$

where ϵ_x is tensile strain in the stretching direction while ϵ_y is the tensile strain perpendicular to this. Since most materials contract in the perpendicular direction the presence of a minus sign in the definition ensures that the ratio is positive. Conversely, a material with a negative Poisson's ratio is one that expands in all directions when pulled in only one, thus increasing its volume. Such materials may be described as auxetic materials (from the Greek, auxetos: that may be increased) to avoid the cumbersome phrase 'materials with negative Poisson's ratios.'

This article describes some of the consequences of this phenomenon, some applications of the materials and highlights the challenges which they pose to materials scientists, chemists and rheologists.

THE IMPORTANCE OF POISSON'S RATIO

Although it is generally believed that all materials have a positive ν it has been known for over a century that a negative ν is theoretically possible¹. In fact an isotropic material may have any value between $1/2$ and -1 . Typical values are nearly $1/2$ for rubber and nearly $1/3$ for steel. The upper limit represents a material that conserves its volume when stretched. So as it becomes longer it becomes thinner by an amount necessary to conserve its volume. For any value less than $1/2$ the material undergoes some increase in volume under deformation. Since most naturally occurring materials have $\nu \simeq 1/4$ - $1/3$ then they all undergo a small volume increase under deformation. Looked at in this way a negative ν just represents an unusually large increase in volume and does not involve any fundamental difference in deformation behaviour.

Having said this, however, auxetic materials are important for at least three reasons. Firstly, Poisson's ratio of a material is as important in defining its mechanical properties as, say, the tensile (or Young's) modulus. Both parameters must be measured to define the mechanical (in particular the elastic) behaviour of the material. Having said this it is surprising how often the value of ν is not measured, but assumed to be about $1/3$. Secondly, much emphasis has been put on increasing mechanical performance by improving Young's modulus. A classic example of this is in high performance fibres for composite materials, such as carbon fibres. However theoretical limits on stiffness for composite materials are being reached where maximum attainable values are restricted by the stiffness of the atomic bonds in highly ordered structures. There is, therefore, relatively little room available for further improvement in this area. By contrast, altering Poisson's ratio represents another way of improving mechanical performance and is, as yet, an unexploited way of doing so. Thirdly, because a material's Poisson's ratio is so fundamental to its performance, altering it may be used to improve a wide range of other mechanical properties.

Let us look at some examples where changing Poisson's ratio can produce a benefit. First consider the fundamental elastic constants of an isotropic material. In addition to Young's modulus and Poisson's ratio there are two other important properties — the bulk modulus, K , and shear modulus, G . For an isotropic material only two of these quantities need be measured as the other two are determined by them (see Figure 1).

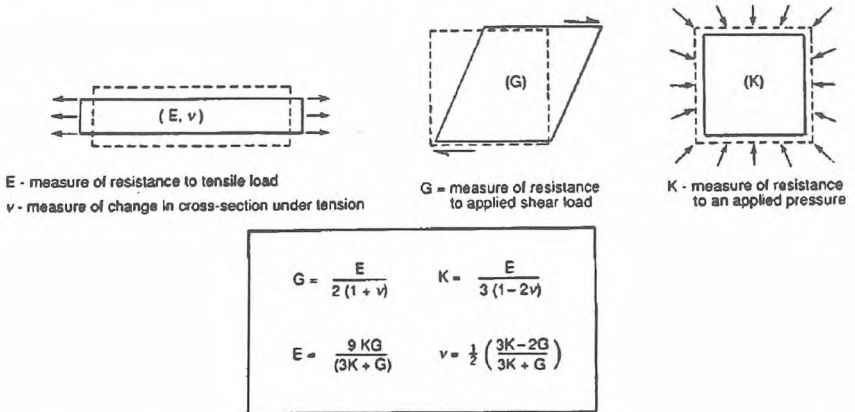


Fig. 1 The relationship between the fundamental elastic constants, the tensile or Young's modulus, E , the Poisson's ratio, ν , the bulk modulus, K , and the shear modulus, G , for an isotropic material.

Suppose that we have a material with a particular fixed value for its Young's modulus, E and that we are able to vary ν . How does this affect K and G ? If ν approaches $1/2$ the bulk modulus becomes very large. The immediate case of $\nu \approx 1/3$ that exists for most naturally occurring materials can be thought of as a compromise situation.

The important thing to note here is that for most man-made structures, that are formed from plates, shells and beams (for example buildings, vehicles, aircraft and ships) it is much more important to have a high shear modulus than a high bulk modulus. This represents one example where a large negative ν would produce a benefit, by increasing G at the expense of K . Other properties that can be improved with a large negative Poisson's ratio include indentation resistance, plane strain fracture toughness and shock and sound absorption properties.

FOAMS AND COMPOSITES

From a theoretical point of view, it can be seen that obtaining a negative Poisson's ratio is potentially very important. In 1982 this situation was further reinforced by the development of a theory for predicting the mechanical properties of conventional polymeric foams, in particular low density, open-cell foams². Contained within the mathematics of this theory was the prediction of a two-dimensional structure that would have a negative Poisson's ratio. This is illustrated in Figure 2. Figure 2 (a) shows a conventional hexagonal honeycomb which, when stretched, becomes thinner. By making cells of producing a negative Poisson's ratio the honeycomb re-entrant a negative Poisson's ratio is produced — see Figure 2b.

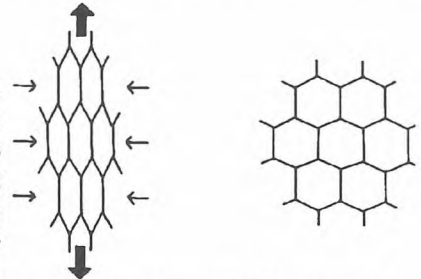


Fig. 2a A schematic diagram of a conventional hexagonal structure and how it deforms when stretched, producing a conventional positive Poisson's ratio.

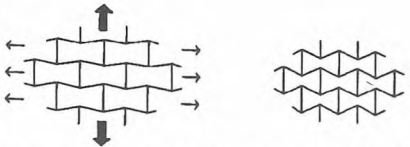


Fig. 2b A re-entrant honeycomb structure which, when stretched, becomes thinner, producing a negative Poisson's ratio.

In 1987 a conventional foam was converted into an auxetic foam; creating the three-dimensional equivalent of Figure 2 (b). This material was isotropic, had a Poisson's ratio of -0.7 and has since been shown to demonstrate some of the improvements, compared to a conventional foam, discussed above³. So, auxetic materials can be fabricated. However, foams have low densities and low mechanical

performance and a relatively restricted (although important) range of applications. If it were possible to improve the density and intrinsic stiffness the potential applications would be far more numerous.

One area in which some progress has been made, both by my group and in the United States, is in the field of long-fibre composite materials, such as carbon fibre-epoxies and glass fibre-polyesters. Laminates, i. e. stacked layers of reinforced composite, can be constructed that have a negative Poisson's ratio. In this case the effect is produced by ensuring the correct fibre orientations in each layer, which requires complex predictive design software. Significant benefits in performance have been shown and research is continuing in this area.

AUXETIC POLYMERS

However, this still does not represent an improvement in performance by modifying the material itself and this led us to two other promising areas of work. In 1988 my research group came across a commercially available form of expanded PTFE (polytetrafluoroethylene) with a large negative Poisson's ratio⁴⁻⁶. We were already working on auxetic composites and so were aware of the significance of this material. After careful examination we were able to determine the mechanism for a negative ν in this material and this was significantly different

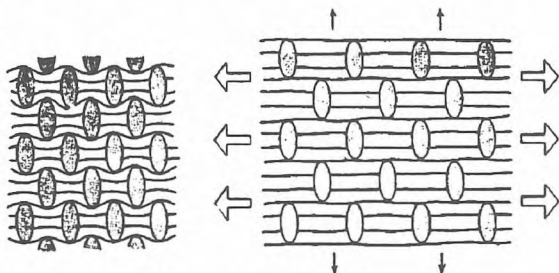


Fig. 3 Schematic of the polymeric microstructure to previous ones (see producing a negative Poisson's ratio. Typically the Figure 3). The material nodules and fibrils are about 20 microns long.

microstructure comprised an interconnecting network of nodules and fibrils. When the material is stretched the fibrils become taut and act to push the nodules apart, thus expanding the material. This material was found to be highly anisotropic and we have measured negative Poisson's ratios as large as -12!

Most importantly there was nothing in our investigations that suggested that the mechanism was unique to PTFE. Provided the same microstructure could be reproduced in other polymers a negative ν should result. Within a year of arriving at this conclusion we were able to reproduce the microstructure in polyethylene (see Figure 4) and measured a large negative Poisson's ratio. We are now pursuing this

work in order to fabricate a wide range of auxetic polymers. This involves an iterative process of molecular modelling to design novel molecules followed by chemical synthesis and testing. The fibrillar structure seen in these microstructures is important in determining the mechanical properties. This structure depends on the processing conditions and involves solving many interesting rheological problems to obtain the best microstructure. Therefore there are challenges to both chemists and rheologists here.

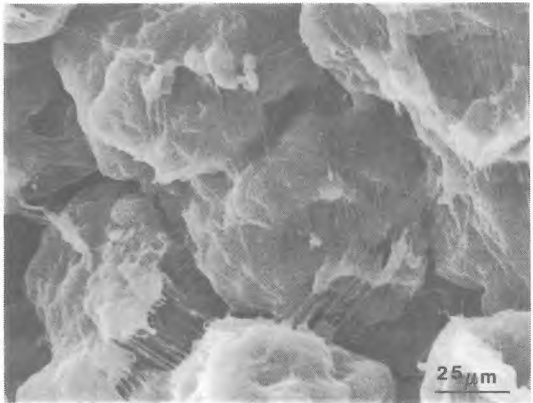


Fig. 4 A scanning electron micrograph of the microstructure fabricated in polyethylene that produces a negative ν .

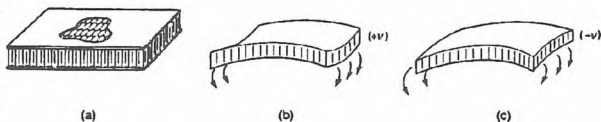
APPLICATIONS

The most obvious applications are those where the negative Poisson's ratio effect of transverse expansion when under tension, or conversely, transverse contraction under compression is directly applied. Fasteners and rivets that expand widthways when pulled is one such area; the rivet or fastener holds more tightly to the material and hence increases its holding capacity with load. A similar effect is also of importance in fibre reinforced composites. During the failure of a composite one important energy absorption mechanism is the process of fibre pull-out, where fibres that have failed are gradually pulled out of the matrix. The harder it is to pull out the fibre the better the composite. Much work has been done on improving composite strength and energy absorption by improving the strength of the interface between fibre and matrix by chemical surface changes, but the existence of a negative ν provides an alternative approach to the problem. As a fibre with a conventional positive ν is being pulled from the matrix it will contract, making adhesion with the matrix more difficult. If it has a negative ν the fibre will expand and grip the matrix more tightly, providing a mechanical aid to bonding.

Another direct application is in gaskets and seals. A conventional gasket tends to be squeezed out between, for example, the flanges of pipes. However a negative ν gasket will contract in on itself providing a tighter seal.

One application for the expanded PTFE described earlier is a vascular replacement. In this application it has been found to be particularly useful, firstly because its porous structure allows good adhesion to the surrounding tissue. Secondly, PTFE is inert and not toxic. Here the existence of a negative Poisson's ratio can also be of benefit. When a pulse of blood passes through an artery vein the vessel dilates locally. A thick walled tube made from a conventional material will become thinner as it expands. This will significantly alter the blood flow through the porous vessel and, in extreme cases, contribute to failure. A negative Poisson's ratio means that the tube wall actually thickens, preventing blood flow through the vessel wall and will act as a fail-safe mechanism against failure.

Another application which we have been actively researching is that of composite sandwich panels.⁷ Sandwich panels comprise stiff composite laminate skins of carbon or glass fibre reinforced plastic sandwiching a light, porous core material, which may be a foam or honeycomb material. Such panels are very stiff by virtue of their thickness, i. e. like a steel girder, with all the stress carried by the outer, stiff laminate layers. The core must have a reasonably high out-of-plane stiffness and should be as light as possible. Unfortunately such panels cannot be curved and this is a



direct result of the Fig. 5 A sandwich panel (a) comprising high stiffness composite laminate skins and a honeycomb core; (b) a conventional hexagonal honeycomb deforms to a saddle shape when it is flexed, whereas (c) a re-entrant material (Figure 5). honeycomb produces a dome-like double curvature when a thick flexing.

panel is curved downwards its natural tendency is to curve up in the transverse direction to form a saddle shape. A material with negative Poisson's ratio, however, will curve downwards in both directions producing a dome shape. Currently the only ways of using sandwich board panels in curved geometries is either by machining them — a costly process — or by forcing them into shape and damaging the core material. By using cores with a negative Poisson's ratio useful double curved sandwich panels, e. g. for domes, can be made. Obvious applications for these curved panels include aircraft bodies and wings and car doors and body panels.

CONCLUSION

In this article I have tried to show that auxetic polymers are not just of academic interest but have many useful applications. Clearly, much remains to be done and I hope that chemists and rheologists will be able to collaborate with materials scientists in producing new materials which can be fabricated.

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ANNUAL CONFERENCE 1991

ENGINEERING RHEOLOGY

The Autumn Meeting of the Society was held at the University of Bristol, September 9-11th, 1991. The forty-five delegates for the Conference assembled in brilliant sunshine at the University's Wills Hall, situated on the Downs above Bristol. The Conference, exhibition and accommodation were all located in the same modern building, with all of the delegates' rooms being fitted with showers. Luxury at last! The Refectory, bar and TV lounge were to be found in an old part of the Hall.

The Conference proceedings were opened after lunch by the President, Dr Cheng, followed by a review paper from Professor Barnes describing state-of-the-art in on-line and in-line process rheometry, followed by practical examples in chocolate manufacture from Dr Wells of Cadbury's, and descriptions of commercial instruments from Mr George of Porpoise Viscometers. After the tea break, Mr Rides of NPL described his work using an injection moulding machine to measure in-line shear viscosities for fibre-filled polyesters. Dr Shacklock of the robotics group at Bristol University discussed problems facing them in handling dough-like viscoelastic materials by robots. Sadly, a tour which had been planned around the Mechanical engineering Department for the Tuesday afternoon could not go ahead as the Group had been relocated and the equipment had not been re-commissioned, so we did not get to see the famous snooker-playing robot after all. Mr Rantanen of Polymer Laboratories reported his work on simultaneous rheological and dielectric measurements of curing resins. Finally for Monday, Dr Taylor of Courtaulds Research compared, with the aid of a unique rheometer, the viscous and elastic properties of silicone fluids and real spinning dopes at very high shear rates. A high-speed video recording showed some odd but reproducible elastic effects, as well as some distinct optical variations.

To start the Tuesday morning session, Professor Ferguson of Strathclyde University gave a presentation on on-line process control rheometry, with many practical observations. Dr Meeten of Schlumberger Research followed with a description of his pump-cup rheometer for studying oil well cements and slurries and drilling muds. Mr Carter, who had recently joined Polymer Laboratories, explained how a technique had been developed to enable the Strathclyde Rheometer to be used to measure reproducibly the curing properties of powder paints. To close the

first session, Dr Banfill of Liverpool University described his work on the rheology of fresh mortar, for which he had compared the results from two different viscometers.

The second session of Tuesday morning started with an enlightening talk from Mr Bonafont of Tarmac Industrial Products, who pleaded that any test which was adopted for bitumen should be meaningful. Dr Prentice of Nottingham Polytechnic continued on this theme by describing the widely-used Melt Flow Index test for plastics as a confidence trick, and using melt flow data from samples of the same MFI to demonstrate their evident rheological dissimilarities. Mrs Moules of Kruss UK described some surface rheology on synthetic saliva, and showed how the rheology varied as a function of concentration and pH, as well as of composition.

After lunch, the Society's Council met whilst delegates could examine the instruments on display in the exhibition area. Later in the afternoon, with the first of a double bill from the Warren Spring Laboratory, Miss Madhvi gave a paper on the role of rheology in understanding the behaviour of oils spilt at sea. This work, which is clearly of great environmental interest, is continuing, and Miss Madhvi stated the need to stimulate more research in this area. Dr Cheng, the Society's President, described how other rheological functions, especially the complex dynamic viscosity could be predicted from the measurement of flow curves, and Dr Cheng discussed the practical applications of such data. The afternoon session ended with Dr Moldenaers giving the Annual Award winning lecture, 'Intermittent Shear Flow in Liquid Polymers: Rheo-Optical Behaviour'. Since this has appeared elsewhere no more will be said here except that the work was fascinating and showed the author's patience and perseverance.

The Annual General Meeting of the Society took place immediately after the close of the formal sessions. As usual the meeting was good-natured and considering the clash of dates with conferences in Leeds and Capri, was relatively well attended. Dr Cheng displayed a gavel which had been presented to the Society by Professor Ferguson, and there was a display of gifts which had been received from other rheological societies. The Minutes of this A. G. M. will be published in a future edition of the Bulletin. The A. G. M. was followed by the Conference Dinner, which was held in the Hall's dining room (although I had tried to book the SS Great Britain, only to be told that the dining room there was being refurbished). The meal was enjoyed by all, and Dr Cheng completed the evening's proceedings by formally presenting Dr Moldenaers with her framed certificate and cash prize.

The first session on Wednesday morning was an experimental session, where three short papers were presented and active discussion encouraged. Dr Hudson of Strathclyde University described several techniques for measuring extensional viscosities, and some progress on reconciling the data from different techniques. Dr Jones of Plymouth Polytechnic presented rheological data obtained by several techniques on Standard Fluid A1, being the results of a round-robin international comparison of techniques. Mrs Moules described some measurements of some standard fluids, and particularly commonly available so-called gels. Mrs Moules showed that several of these products were not really gels at all. During the following lively discussion, one delegate conjured up, to roars of laughter, the concept of a Rheological Police Force carrying out dawn raids on supermarkets to test their gels!

After coffee, the final session of the conference started with Dr James of Plymouth Polytechnic presenting some theoretical and practical work on surface shear stress measurements in both Newtonian and non-Newtonian fluids. Dr Heyes of the University of Surrey, a previous Annual Award winner, reviewed some experimental correlation with computer simulation of particulate suspensions during shear flow. Mr Simpson of NEI International Combustion described his work on the flow behaviour of multi-phase slurries of various types of fuels, finishing with some impressive photographs of the different flame structures to be obtained with different materials. The last paper of the conference was given by Dr Hudson on the correlation of aerosol particle size with the steady shear properties of polymer solutions, and he showed that he had been able to relate the aerosol mass median diameters to the molecular characteristics of the polymer in solution.

The conference was a lively and entertaining mixture of theory and experiment, with a wide range of industries and materials represented. It was clear that there are many new rheological problems as well as unsolved old ones which will keep rheologists busy for many years yet to come. Many thanks are due to Nick Hudson for the lion's share of the organisation.

Roy Carter

FIRST ASME-JSME FLUIDS ENGINEERING CONFERENCE

The Fourth International Symposium on Liquid-Solid Flows was one of seventeen simultaneous sessions that collectively formed the First ASME-JSMAE Fluids Engineering Conference. This was held at the Portland Hilton Hotel in Oregon, U. S. A. from 23-27 June, 1991 where 440 papers were presented by and to 525 delegates from 25 nations; eight of whom where from Britain.

The programme lasted for four days with three sessions each day. These were subdivided into Modelling I-III, Experiments I-III, Computational I and Applications I-III.

There were two invited lectures which were both part of the modelling sessions. They were by Howard Brenner *et al.*, "Techniques for Analyzing the Behaviour of Concentrated Suspensions", and John Brady, "Modelling Particulate Flow by Stokesian Dynamic Simulation".

Some other modelling seminars of note were presented by Sangtae Kim and Yuris Fuentes, "Parallel Computational Strategies for N-Particle Stokes Flow Problems", and Kuniomi Asakura *et al.*, "Numerical Calculation of Velocity and Concentration Distributions and Pressure Loss of a Solid-Liquid Flow".

The experimental seminars were of practical investigations with fundamental background. Their number included Wolfgang Wiedenroth, "Experimental Study of Transition Velocity of Settling Slurries", Robert Powell and Lisa Walla, "Viscosity Measurement of Suspensions of Rod Mixtures" and our "Rheometric Experiments on Idealized Suspensions: Phase behaviour and Scaling Laws".

The number of Computational seminars were such that they occupied only one session. Dimitri Gidaspow, "Navier-Stokes Equation Model for Solid-Liquid Flows using Kinetic Theory", and H. Meng and C. W. M. Van der Geld, "Particle Trajectory Computations in Steady No-Uniform Liquid Flows" were presented in this session.

Karel Brada *et al.*, "Hydrodynamic Pump Performance for the Sand-Water Suspension Transport", T. Saito *et al.*, "Pressure Loss of Solid-Water Two-Phase Flow in Swaying Pipe", and David Wildman *et al.*, "Evaluation of Coal-Water Mixtures Prepared with Advanced Coal-Cleaning Products" were amongst the specialised application papers presented in the last three sessions.

With the meeting being staged jointly by the Japanese and American Societies of Mechanical Engineers, a fair impression of the activities carried out by two of the major players in the fields of

colloidal rheology research was evident. It was encouraging to see the strong similarities in the work performed by the many groups around the world.

I feel it was a shame that such a well organised and informative conference was attended by so few British delegates, especially as costs were not too excessive. The number of research students, who were not required to pay conference fees, was also quite low, at less than 10% of the total number of delegates. I hope that the next conference, to be held in Washington D. C. in June 1993 (with a first paper request appearing sometime in November 1991), will have a stronger British contingent.

Finally, I would like to thank the Society for a student travel grant, which enabled me to attend this conference, and recommend that other research students take the opportunity such grants offer.

ADRIAN MERRINGTON

FORMATION OF A LOCAL GROUP OF THE SOCIETY

With the approval of Council a North Midlands group based, at least initially, in Sheffield has been formed. Its objectives are to encourage contacts between Members of a more informal nature than is usually possible at large conferences and to promote cross-fertilisation of ideas between those working in different fields of rheology.

The first meeting was held on 11th September when a talk was given on the application of rheological methods in the control of concrete production; the next meeting will be held during the Christmas vacation, in the University of Sheffield, when Dr David Kirkwood will talk about the rheology of metal slurries.

Any member of the Society who would like to join the group is invited to contact Dr G. H. Tattersall, 174 Millhouses Lane, Sheffield S7 2HE (Tel. 0742-365144). Members from industry would be particularly welcome.

This international conference held at the University of Limerick in July 1991 drew particular attention to the processing characteristics of continuous fibre reinforced thermoplastic composites; the basic science underpinning many of the presentations had much wider implication. Held on the banks of the Shannon during the 300th anniversary of the signing of the Treaty of Limerick, which initiated the era of the Wild Geese, this meeting was attended by about sixty delegates from Europe and the United States as well as Eire and the United Kingdom. The warmth of Irish hospitality encouraged a frank exchange of views in a workshop atmosphere. As a measure of technical success, many delegates left with the intention of modifying their current research programmes in the light of the results presented at the conference. Although eighty percent of the papers were presented by academic groups there was a focus on industrial needs.

In an overview presentation, Cogswell (ICI) traced the experience of thermoplastic composites during processing in respect of the potential for chemical change, heat transfer, and shaping. He emphasised how these interacted with the microstructure of the material. The key activities of the material supply industry are the definition of matrix chemistry and the microstructure of the composite; those of the processor are the mechanics of shaping tempered by heat exchange and the control of exposure to air at high temperature.

Robroek (Delft) and Cogswell discussed the optimization of the viscosity of the matrix phase: high enough to give stable microstructure, low enough to achieve satisfactory self diffusion and forming. Empiricism suggests the range 100 to 1000 Ns/m² and, at this level, auto-adhesion takes place in about half a second. The auto-adhesion process is of particular significance in tape placement operations where only transitory exposure to heat is used.

The definition of the rheology of continuous and long fibre reinforced thermoplastics is a field of some contention. The ingredients, effectively inextensible but flexible fibres, and near Newtonian matrix resins, give rise to a wide range of complex responses. Pipes (Delaware) and Binding (Aberystwyth) characterised the extensional flow of discontinuous fibre systems at 60% and 25% respectively. Using contraction flows, Binding found satisfactory agreement with the theory of Batchelor as modified by Goddard provided that fibre length distribution, and how it is influenced by processing, is taken into account. In this latter area his results demonstrated the importance of preimpregnation processes so that the fibres are protected from attrition by self abrasion. Pipes

developed a simple working theory for the deformation of systems with high loadings of well collimated fibres. Concurring with the experimental results of Binding, he showed very little influence of fibre length on shear viscosity but a dependence on the square of the fibre aspect ratio for extensional viscosity. This produces up to eight orders of magnitude difference in the two viscosity functions and a new word for our lexicon — hyperanisotropy. Pipes speculated that, in such systems, any slight deviation from perfect alignment would produce a tendency for the material to shear. Since practical systems will inevitably contain some deviation from perfect collimation it is possible that such shearing will give rise to a domain flow.

Pipes, Groves (ICI), Wheeler (Aberystwyth) and Cogswell all noted the presence of apparent yield stress effects in these materials. The origin of these observations was the subject of intense speculation, although one school of thought posed the alternative hypothesis that, given the inevitable state of entanglement of the long inextensible fibres, the suprising result is that the materials flow at all! One result, which may reflect the presence of a domain structure, was the observation by Wheeler of an instability during small amplitude oscillatory shear transverse to the fibre axis. He found that groups of fibres "walked out" sideways on both sides, along the fibre direction. There was no obvious force field that could account for this secondary flow. Wheeler achieved his dramatic result with a room temperature model material based on carbon fibres impregnated with Golden Syrup.

Groves studied the oscillatory shear rheology of an amorphous thermoplastic composite over a wide temperature range where matrix response varied from rubbery to viscous. Using apparent Maxwell parameters to describe what appeared to be significantly non-linear results, he was able to normalise viscous flow behaviour in respect of the shear stress that the material experienced. The elastic response of the material proved to be less tractable.

The question "what is an allowable deformation?" was addressed by Gutowski (MIT) and Rogers (Nottingham). These studies were concerned with the geometry of the flow and potential singularities. Gutowski demonstrated the principle of mapping fibres onto surfaces in order to identify potential singularities such as cuts, folds and gaps. He emphasised that, in complex shapes, in-plane shear plays the dominant role and that it is often concentrated in localised regions. Rogers stressed the importance of interply slip in the resin rich layer between plies. The concept of allowable deformations was extended by Hull (Nottingham), who is seeking to define those flows which will not induce buckling in the fibres. Although extensible the fibres will crimp under compressive loading, that tendency is partially offset by

stress transfer to neighbouring fibres through the viscous matrix, but more important appears to be the ability for such destabilising compressive loads to be dissipated in shearing modes. The normal constraint supplied by the processing equipment clearly has a major role to play in defining the quality of any shaping process.

The issue of reorganisation of the fibres during processing was addressed, for continuous fibre systems, by Jones (Aberystwyth), Golden (Nottingham) and O'Bradaigh (Galway) and, for discontinuous systems, by Erheriene (Imperial) and Crochet (Louvain). The latter field is more advanced in terms of computer aided designs although the authors pointed out the limitations of those programmes, which were based on a considerable simplification of actual flow processes like injection moulding. One of the more surprising results, for short fibre systems, was that predictions of reorientation based on the original Jeffrey equation with only three fibres arrayed at 60° to each other were as good as the more sophisticated developments based thereon. With respect to the reorganisation of continuous fibre systems Jones studied the reorganisation of plies during normal compression. Plies at an angle to each other reorient to cross at right angles. That result may have surprised the experimentalists but it had been predicted some twenty years ago by Spencer. The observations of the power of the Jeffrey equation and the early work of Spencer emphasise the solid theoretical basis that is available to build on.

The influence of processing equipment on shaping and economic efficiency were described by M. Monaghan (Limerick), P. Monaghan (Galway), Devlin (Newcastle) and Robroek. P. Monaghan reviewed heat transfer in autoclaves. The importance of this scientific study to identify the key variables was demonstrated by the finding that long wave radiation, initially assumed to be insignificant, has a profound influence. As a result of his study the author expects to be able to design equipment where the heating and cooling cycle is reduced to about one quarter of their present levels. Heat exchange proved a limitation in the work on pultrusion described by Devlin. The main problem was getting heat into the material. Trying to overcome this by the use of very high temperature in the presence of air led to degradation. M. Monaghan studied the mechanical properties of "Upilex" diaphragm materials which control many forming processes for large area, double curvature structures. Robroek reported an unexplained antiplasticisation result induced in such materials by solvent leaching out of solution preimpregnated products. He also demonstrated the importance of rubber block design in rapid stamping processes; this design allows controlled pressurisation of the component that reduces wrinkling. Robroek also demonstrated ingenious techniques for controlling fibre orientation in

deep drawn structures. The art of processing is designing the interaction of the material with the machine.

Warping can occur as a result of anisotropic thermal expansion during solidification of mouldings. The study of this subject has now developed to include non-uniform solidification processes, heterogeneous anisotropy and complex geometry. Spencer (Nottingham) provided an analytic solution to this problem which complements the finite element studies used by Zahlan (ICI). Although not all the audience were able to follow the subtlety of the mathematics, the vital importance of verifying the more versatile finite element studies with absolute analytical solutions was warmly appreciated. This class of thermal effect seems well understood for thermoplastic composites. There appears to be an need for parallel studies for the field of resin transfer moulding; Martin (Dublin) described the very considerable problems caused by thermal and polymerisation shrinkage during his study of the moulding of artificial hip joints.

Such distortion causes a problem in achieving a satisfactory fit up of components at the stage of assembly. Such problems can, in part, be offset by the use of thick bond lines. Smiley (ICI) demonstrated methods of controlling bond line thickness by the addition of glass scrim within the resin layers. He found encouraging agreement between theory and practice.

Two presentations addressed the current trends in composite manufacturing in the aerospace industry. Kells (British Aerospace) and Whiting (Westland Engineering) pointed out how thermoplastic materials were liberating the processor from the tyranny of hand lay-up and autoclave processing. These new materials allow the adoption of high rate processing methods that have often been developed from metal working. Whiting stressed freedom from chemistry as another liberating theme. He demonstrated several structures produced in his laboratory which included the integration of different thermoplastic product forms to achieve effects beyond simple mechanical performance. Kells emphasised that success in the use of advanced materials depended on collaboration between end users, raw material suppliers and academe. Such collaboration was clearly evidenced by this meeting.

As well as the formal sessions, several posters were on display demonstrating active research in this field at the University of Limerick. Professor Mallon and his students were successful in ensuring the smooth running of the conference and Dr O'Bradaigh collated a full set of papers. A selection from the proceedings will be published in a special edition of *Composites Manufacturing*.

Neil Cogswell

ANNUAL AWARD 1991

During the Autumn Meeting held in Bristol in September 1991, the President presented the Society's Annual Award to Dr Paula Moldenaers.

DR PAULA MOLDENAERS

The 1991 Annual Award of the Society is made to Dr Paula Moldenaers in recognition of her paper entitled "Intermittent shear flow in Liquid Crystalline Polymers: Rheo-optical behaviour", which was presented to the Society at the Golden Jubilee Meeting in Edinburgh, September 1990.

The paper considers the influence of mechanical history on rheological transients during start up of steady shear flow. By careful and tenacious experimental study, Dr Moldenaers was able to establish a meaningful picture of the transients and to define that two independent relaxation processes were operating in the material. By combining mechanical and optical techniques, she was able to identify the scale at which these processes occur and so provide an insight into the morphology of the material. The paper is published in the *Proceedings of the Third European Rheology Conference* which was the alternative designation of the Golden Jubilee Meeting.

It is thought that this work will, in future, be recognised as a highly significant step forward both in the science of liquid crystals and in rheometric technique and analysis. In addition, it is considered that the structure and delivery of the lecture were outstanding.

Dr Moldenaers was born in Leuven, Belgium, in 1957. She is married to Herman van der Auweraer.

Dr Moldenaers graduated in chemical engineering from the Katholieke Universiteit Leuven in 1980. Her dissertation was on "Rheological characterisation of polymer solutions: use of the orthogonal superposition technique". She obtained her doctorate with the greatest distinction in 1987; the thesis was entitled "Rheological behaviour of lyotropic polymeric liquid crystals". After graduation, until 1986, she remained at the Chemical Engineering Department as Teaching Assistant. Since 1987, she has been Research Associate in the Laboratory of Applied Rheology in the same department. Her responsibility is for polymer research as well as teaching chemical engineering subjects.

Since her undergraduate days, Dr Moldenaers has worked closely with Professor Jan Mewis at Leuven. She has also travelled abroad

and has been exposed to the influence of other rheologists in Delaware and California, U. S. A., and in Japan.

Her curriculum vitae shows that since 1985 she has published more than thirty papers, given twenty five lectures at conferences and seminars, and made seven poster presentations. Most of her work concerns liquid crystalline polymers. She has also worked on suspension rheology (under an ICI-JRS Fellowship in 1986-87), developed methodology for measuring weak gels with syneresis, and undertaken rheological investigation of bone cement for cup fixation in total hip replacement.

Dr Moldenaers is the Secretary for the 11th International Congress to be held in Brussels, 17-21 August 1992.

The paper for which the Annual Award is being made is clearly only the tip of the iceberg of Dr Moldenaers' effort and achievement in rheology. On behalf of the Members of the Society, Council is pleased to make the 1991 Annual Award to Dr Moldenaers.



David Cheng presents the 1991 Annual Award to Paula Moldenaers at the Autumn Meeting in Bristol.

COMMENTARY ON 266TH COUNCIL MEETING

'Follow the elephant', they said, 'that'll get you there' and indeed it did. Your Council were meeting in Bristol, near the zoo (hence the elephant). This meeting was scheduled for a free period in the middle of the conference on 'Engineering Rheology' which was a mistake, especially as the conference organiser was a Council member and the next scheduled speaker in the conference was to be the President! This led to much rescheduling of the agenda with people coming and going. Have faith, however, for all business was eventually attended to, although Carole was having problems trying to take the minutes.

So what was the business of the day? Well before we've even started, Jim Ferguson, immediate past President, has popped in to present Council with a gavel. David tries it out to see if it conforms to BSR decibel norms.

And so to the minutes — has everybody read them? Should we have had them earlier so that we have no excuse for not having done what we were supposed to have done? But if we had them earlier, wouldn't we read them and then forget them before the next meeting? Tony suggests a compromise. Everybody agrees. The minutes are corrected — a few spelling mistakes in long Dutch names and the Treasurer wants a limit recorded for certain agreed expenditure (treasurers are always like that).

Matters arising — Tony worries about lack of response to Phil's request for guidance re structure of the Bulletin. Everybody reiterates their satisfaction with the status quo. Phil is happy. We discuss attempts to collaborate with the Society of Rheology in the United States. The President has made various suggestions to Professor Metzner, who has responded positively, but must discuss matters with his own Council first. Those advertisers again, they haven't paid up. A number of suggestions (some quite impractical) are made as to how to solve this problem. Carole has specific ideas which seem favourable. Advertising revenue is falling, so Phil must put on his salesman's hat soon. Lots of promotions recorded for BSR members. Rheology seems to be a good field to be in at present. We discuss a slightly embarrassing matter using terminology which would be out of place here. The matter is resolved. What about our nomination for the next President? Can we tell everybody that it's Ralph Oliver? Yes we can — at least I think

that's what they said! Good, that means 'puddings' are guaranteed for BSR Council lunches for the next two years.

It's nearly time for tea and we're still on the minutes. Panic. We can't miss tea. We move quickly on to the main agenda.

The President's business — a new brochure to be prepared, advertising the merits of the BSR, the Sheffield 'local' group to go ahead, a new U. S. S. R. Society of Rheology seeking admission to the ICR. The latter may be a bit short lived in the present circumstances, but the President agrees to send them appropriate warm greetings.

We discuss the proposed Third European School of Rheology to be held in Glasgow. Do they really intend to have four official languages? 'Well it will be 1992' says someone, but the Council are still sceptical. Nick chosen to represent BSR interests.

The President departs to give his paper . . . yet another chance for Tony to chair the meeting which now proceeds quite rapidly. The Treasurer predicts a net loss of BSR funds of £2k for next year, the Secretary to ask Dr Jones, Aberystwyth, to set up a committee to buy books for the Scott Blair Collection, and the Membership Secretary has seventeen new members for our approval. He also wants to know what to do with the old Apple IIe computer. Various unprintable suggestions offered.

There is little to say about the remaining items on the agenda that cannot wait until the next Council meeting and so the meeting is closed, just in time for the A. G. M. where we can go through everything again.

Peter Townsend

OFFICERS' REPORTS

This section contains the reports of the Officers of the Society presented to the A. G. M., held in Bristol on September 10th, 1991

PRESIDENT

Members will remember that our Society celebrated the Golden Jubilee last year in Edinburgh. I was both honoured and apprehensive of the responsibility to be your President and to take the Society into the second half of its century. Having worked for a year with your Council, I now feel much easier and I am very pleased to report that we have a wide range of activities underway.

One of the things that many members have remarked upon is the informal nature of our Society. This had been the hallmark of the Society in the early days of the British Rheologists' Club and it has continued in the intervening years. People wish very much that the informality should be preserved. Your Council notes this. But, as the range of our activities expands and also that the efficiency of the services to the membership should increase, Council needs to become more professional in doing things. However, this should not conflict with informality and we will do everything possible to maintain it. Of course, there is much that the membership can do also and I hope you will all contribute to this end.

One way would be for members to meet locally, in an informal atmosphere. Dr Geoff Tattersall has offered to organise the first of such meetings for members based around Sheffield. He has made approaches using the postal code and expects to have the initial meeting this month. If any other members wish to do the same for their locality, the Membership Secretary will be very pleased to supply the appropriate mailing labels.

As to our regular meetings, it was disappointing that the March meeting on Extensional Flows in Industry had to be cancelled. I am sure that there is a need for us to discuss the industrial application of extensional properties, as opposed to methods of measurement, and I hope we will organise a replacement in the future. We are now in the middle of our Annual Meeting and after that we have a full programme of meetings under planning for next spring and autumn, and for the year 1993. You will find details in the Diary section of the Bulletin.

There has been an increase in international activities. A Society of Rheology of the U. S. S. R. was formed in January this year; a message of congratulations is being sent. Our Annual Meetings for the coming

years will be held jointly with the French and the Netherlands Societies of Rheology. Council is in discussion with the Society of Rheology in America on ways to increase cooperation. Dr Chris Petrie is European Secretary responsible for the newsletter on European Rheological Activity. The Fourth European Conference will be held in Spain in 1994. I am your delegate to the International Committee of Rheology under whose aegis the 11th International Congress of Rheology will be held in Belgium next year.

You will find details of all these and other rheological meetings in the Bulletin. The Editor has endeavoured to make the Diary section as comprehensive and as far forward looking as possible, so that you can plan your business trips or even holidays abroad so as to attend ones of interest.

The Third European School of Rheology is being organised with the help of a grant from the European Community and the support of the British, Belgian, French and Spanish Societies of Rheology. Professor Jim Ferguson is the main coordinator and the School will be held 31 August to 11 September 1992 at the University of Strathclyde. Council would like to encourage rheologists and future rheologists to attend. Additional funding from industry will be welcome, either in sponsorship or in sending employees to study at the School. Industrial members are urged to approach their employers about this.

Returning to the domestic front, the catalogue of our Scott Blair Collection, which is housed at the University College of Wales Library in Aberystwyth, has been published in the Bulletin. We also have a legacy from Mrs Scott Blair to enable us to maintain and enhance the Collection. Your Council is considering ways in which we may do this and to make it more useful to members and other rheologists. Members' views will be very welcome. Please let me or any Council member know.

Council has also set up Working Groups charged with the feasibility study of two projects. The first is the preparation of a Handbook of Rheology, covering terms and concepts, under the chairmanship of Dr David Cheng. The second is concerned with transparency and openness in commercial rheometer operation and computer software, under Dr Howard Barnes. The Working Groups are to make recommendations to Council on detailed specifications and how to proceed by March 1992. Any member wishing to contribute to the work is asked to contact the respective chairman.

Council has decided not to make a Gold Medal Award this year. The Annual Award is made to Dr Paula Moldenaers, of the Katholieke Universiteit Leuven in Belgium, for her paper, "Intermittent shear flow in liquid crystalline polymers: rheo-optical behaviour", presented to the Golden Jubilee Meeting last year. A citation is published separately.

As you can see, there are a lot of activities underway which I hope meet with your approval. If there are any other things that you think Council should consider doing, please let us know.

I have not specifically mentioned the work of the Officers in detail. I will leave them to make their own reports. However, I would like to say that they are very dedicated and hard working; it is a pleasure working with them. This goes for the ordinary members of Council also. They regularly volunteer themselves when there are extra jobs to be done. We owe the vitality and success of our Society very much to all of them and I would like to thank them on your behalf.

David Cheng

ABSTRACTS EDITOR

The journal has had a successful year in terms of number of published abstracts. Volume 33 (1990) managed to cover some 1058 separate articles of rheological interest. I had projected that *Rheology Abstracts* would increase the number of published abstracts so that the journal would be of the order of 200pp./yr.. As it turned out, 1990 saw in the region of 400 pages, which led some members of Council to suggest that ways be found to improve the layout in order to save wasted blank space. If members support this view then please let me know; I have tried to retain readability as best I could but am willing to take advice from the readers, assuming of course that it is read! On this latter point, I have received a few enquiries during the year asking if copies of the full abstracted article are available. I regret that I can in no way entertain such requests as a matter of course. Please get in touch with the author directly, the full name and address is provided in the abstract.

I am again indebted to Pergamon Press for the continued support given in publishing the journal. You may be aware that in April this year Pergamon Press was sold to Elsevier Scientific Publishers but I was informed that this change of ownership would not lead to any major changes in the operation of Pergamon Press. The delays that are being currently experienced in the publication of the journal are solely due to the backlog of work, this was anticipated to have been cleared by the beginning of the year. Unfortunately it is taking longer than anticipated but my aim remains the same, to provide a comprehensive and up to date abstracting service to those with an interest in rheology. The burden for the success of this task still falls on those members who contribute to the journal. At present, there are some fifteen abstractors but more are needed. (Looking back over the years, successive editors have frequently pleaded with the membership to increase the number

of active abstractors, but it seems that this request is nearly always ignored. If you have any ideas about how one can gain and hold the enthusiasm of fellow rheologists to be abstractors, please let me know.) In addition to the scientific papers, book reviews are now in evidence and in the coming months abstracts of theses with a rheological input are to be included, these with the kind cooperation of University Microfilms International. This and other action will, I hope, increase the coverage of *Rheology Abstracts*.

Much of my time is spent scanning the literature base for articles that may have appeared in journals not covered by our abstractors. More often than not many that are found are papers authored by our own members. This raises an interesting and indeed alternative means of securing adequate coverage for *Rheology Abstracts*. Why not ask the members to send a copy of their most recently published paper to the Editor of *Rheology Abstracts*? This should provide in the region of 500 articles with minimal effort on my part. Also, members have the added publicity of their work to fellow rheologists worldwide.

To date, the journal abstracts both on a regular and irregular basis some 155 scientific journals, something that I think the Society should be most pleased about. Fellow abstractors, many thanks.

Geoff Brownsey

MEMBERSHIP SECRETARY

During the last year the membership records have been transferred from an old and increasingly unreliable Apple IIe to an Apple Macintosh L. C. During this transfer the data held on disc are being put in a common format and the records are being brought up to date. This time-consuming process is well on the way and there should be a fully updated set of records in about six months. The increase in the membership fee has also occasioned a significant amount of record keeping.

At the A. G. M. last year, my predecessor reported a total membership of 752 (527 from the U. K. and 225 overseas members). In the intervening year the following changes have occurred.

	U.K.	Overseas	Total
New Members	32	26	58
Resignations	13	6	19
Deaths	1	1	2

This produces an increase of 37 members.

Doug Hourston

THE BRITISH SOCIETY OF RHEOLOGY
REVENUE ACCOUNT FOR YEAR ENDED 30th JUNE 1991

	1991		1990	
	£	£	£	£
EXPENDITURE				
Council Expenses		2,173		3,631
Bulletin production costs		5,955		4,626
Expenditure by Officers:				
Secretary	679		117	
Treasurer	—		16	
Membership Secretary & circulation	<u>596</u>		<u>1,426</u>	
		1,275		1,559
Professional fees		192		176
Insurance		99		105
Awards		1,031		1,468
Miscellaneous		13		284
Conferences (see below)		4,217		—
Depreciation:				
Word processors		<u>1,451</u>		<u>905</u>
		16,406		12,754
EXCESS OF INCOME OVER EXPENDITURE	—	4,659		
		<u>16,406</u>		<u>17,413</u>
INCOME				
Annual subscriptions & entrance fees	2,505	1,967		
Publisher — Rheology Abstracts	2,009	3,490		
Advertising		5,728		2,850
Bulletin subscriptions		259		279
Sale of ties		16		53
Bank interest		3,034		2,928
Conferences (see below)		—		<u>5,846</u>
		13,551		17,413
EXCESS OF EXPENDITURE OVER INCOME	<u>2,855</u>	—		
		<u>16,406</u>		<u>17,413</u>
CONFERENCE ACCOUNT				
Surplus or (deficit) after expenses				
Liverpool		(845)		3,451
Lancaster		—		732
Warwick		(1,125)		1,663
Edinburgh		(2,197)		—
Glasgow		(50)		—
		<u>(4,217)</u>		<u>5,846</u>

BRITISH SOCIETY OF RHEOLOGY
BALANCE SHEET AS AT 30th JUNE 1991

	1991	1990
	£	£
FIXED ASSETS		
Word processors:		
At cost at 1st July 1990	3,618	618
Additions	<u>2,187</u>	<u>3,000</u>
	5,805	3,618
Depreciation to date	<u>(2,665)</u>	<u>(1,214)</u>
	3,140	2,404
CURRENT ASSETS		
Cash at bank:		
Premier Interest account	25,956	28,531
Deposit account	—	662
Current account	<u>874</u>	<u>5,121</u>
	26,830	34,314
Sundry debtors & prepaid expenses	<u>4,111</u>	<u>390</u>
	34,081	37,108
CURRENT LIABILITIES		
Sundry creditors	<u>(598)</u>	<u>(770)</u>
	33,483	36,338
SCOTT BLAIR LEGACY FUND ASSETS		
Premier Interest Account	<u>10,526</u>	<u>9,383</u>
	<u>44,009</u>	<u>45,721</u>
GENERAL FUND		
At 1st July 1990	36,338	31,679
Excess of expenditure over income in the year (1990: Income over expenditure)	<u>(2,855)</u>	<u>4,659</u>
	33,483	36,338
SCOTT BLAIR LEGACY FUND		
Balance at 1st July 1990	9,383	10,013
Bank interest	<u>1,143</u>	<u>1,370</u>
	10,526	11,383
Donations to UCW Library	<u>—</u>	<u>(2,000)</u>
	<u>10,526</u>	<u>9,363</u>
	<u>44,009</u>	<u>45,721</u>

Peter Anderson

RECENTLY PUBLISHED BOOKS

In answer to a recent query, the fact that a book is mentioned here does not necessarily mean that it has been acquired for the Scott Blair Collection at Aberystwyth. As ever, we welcome suggestions for acquisitions.

Principles of Polymer Engineering Rheology J. L. White, (Wiley, 1990), ISBN 0 471 85362 3 pp. 336 £45.00.

Describes how to experimentally determine and interpret the rheological behaviour of polymer melts and then analyse flow in processing operations. Develops the fundamentals of continuum mechanics and shows how to devise methods for measurement of rheological properties, formulation of 3-dimensional stress-strain relationships and analysis of flow in processing operations.

Properties of Polymers, Third edition, D. W. Krevlen, (Elsevier Science Publishers, 1990), ISBN 0 444 88160 3 pp. 875 \$337. 25/Dfl590. 00.

This is a handbook of polymer properties which also explains the fundamentals of these properties. It is in seven parts covering a general introduction, the basic thermophysical properties, properties of polymers in force fields, transport properties (including rheology), the thermal and chemical stability of polymers, the relationship between processing products and properties and finally, a series of tables of information.

Melt Rheology and its Role in Plastics Processing: Theory and Applications J. M. Dealy, K. F. Wissbrun, (Van Nostrand Reinhold Inc., 1990), ISBN 0 442 22099 5 (Hardback) pp. 688, £52. 00.

This volume is an introduction to polymer rheology as well as an analysis of the role of rheology in plastics processing. The relationship between rheological behaviour and molecular structure is emphasised. In addition, experimental methods for measuring rheological properties of melts are discussed. This book provides an understanding of nonlinear viscoelasticity and a description of the various experimental methods that can be used to study nonlinear behaviour. It also examines the role of polymer rheology in various processing operations, including extrusion, injection moulding, blow moulding, sheet casting and film blowing. Chapters on liquid crystals, birefringence, reactive systems and the use of rheometers as sensors for quality and process control are included.

NEWS OF OTHER SOCIETIES

THE SOCIETY OF RHEOLOGY

Here are some highlights from the recent activities of the Society of Rheology, Inc., culled from Rheology Bulletin 1991, volume 60 nos. 1 and 2. The Bulletin is published twice yearly.

The Annual Meeting held in October 1990 in Sante Fe attracted more than 170 papers and was attended by over 300 delegates. The 63rd Annual Meeting was to be held in Rochester, on the south shore of Lake Ontario, N. Y. in October 1991. In addition to receptions, the Bingham Banquet, a beer session and tours of local attractions, the technical sessions were planned as follows.

A. Molecular models of polymer liquids, covering experimental and theoretical work on diffusion, linear viscoelasticity and non-linear rheological properties.

B. The science and technology of electrorheological materials, covering measurements, models and continuum theories, as they relate to applications of ER fluids.

C. Polymer processing of homopolymers and polymer blends, dealing with viscoelastic flow in complex geometries, the relation between flow and morphology for polymer blends, and structure-property relationships.

D. General papers — complex systems.

E. General papers — viscoelasticity.

F. Viscoelastic properties of bulk polymers, including experimental and theoretical studies of amorphous and crystalline polymers.

G. Rheology of emulsions and dispersions, covering suspension rheology with particular emphasis on food and biological systems.

H. Networks and gelation, dealing with branched polymers, critical gels and crosslinked networks.

I. Rheology in composite processing, structure and properties, covering relationships between viscosity and cure, effective medium theories and moisture effects for short fibre reinforced composites, polymer composites and ceramic composites.

J. A workshop on sharkskin melt fracture intended to focus future work.

K. Coatings and coating processes.

L. Numerical simulation of viscoelastic flows.

Plenary lectures by Sir Sam Edwards on molecular models for polymer rheology, Louis J. Zapas, the 1991 Bingham Award Lecture entitled 'Sometimes nature is stranger than theories' and J. L. Kardos on technological barriers to the manufacture of reliable composites, were to be followed by over 170 submitted papers in four parallel sessions.

The Society normally arranges a meeting every Autumn, but there will not be one in 1992 because of the International Congress to be held in Brussels. Instead there will be a meeting in February 1993 in Santa Barbara and in October 1993 in Boston.

The 1991 Bingham Medal was awarded to Louis Zapas, for his extraordinary contributions to the field of rheology, especially in the development and experimental testing of what has now become known as the BKZ model, one of the earliest single-integral models of nonlinear viscoelastic behaviour based solidly on physical principles.

As a member Society of the American Institute of Physics, the Society has the benefit of administrative support from AIP for its 1087 members (September 1990). In addition AIP has now taken over publication of the *Journal of Rheology* from John Wiley, with Professor A. B. Metzner continuing as Editor. In the year to September 1990, 101 manuscripts had been submitted of which 54 had been accepted and 32 rejected outright. The time to publication was expected to be reduced to eight months by February 1991.

For more information on the Society of Rheology, contact the Secretary, A. M. Kraynik, Division 1511, Fluid and Thermal Sciences Department, Sandia National Laboratories, Albuquerque, New Mexico 87185-5800 U. S. A..

SOCIETY OF RHEOLOGY OF THE U. S. S. R.

At an extraordinary meeting of Soviet rheologists held on January 29th, 1991, it was agreed to establish this Society within the All-Union D. I. Mendeleev Chemical Society. With the aims of promoting rheology within the U. S. S. R. and cooperating with the International Committee on Rheology and Societies in other countries, membership is open to both individuals and organisations. Biennial symposia as well as conferences and workshops on specific topics are proposed. Professor V. Kulichikhin was elected President and E. Fremkin Secretary.

INTERNATIONAL COMMITTEE ON RHEOLOGY

The Secretary of the Committee is now Professor David James, Department of Mechanical Engineering, University of Toronto, 5 Kings College Road, Toronto, Ontario Canada M5S 1A4.

A SEAWATER RHEOLOGY GROUP

The sea is a dilute solution of polymeric and surface-active compounds. It is partially flocculated, and subject to widely varying amounts of turbulent and laminar shear, density-stratification, and biological activity. These variations act over a broad range of scales.

Processes such as gelation, adsorption, flocculation and sedimentation of this organic material largely determine or are determined by the rheological properties of whole seawater (here meaning the water with its dissolved, colloidal and suspended components). Through these processes, rheology may be controlling many of the physical, chemical and biological properties of seawater as well as life processes and interaction between organisms. Particular processes subject to rheological control may include: nutrient dynamics and microzones; ion, heat and gas exchange at surfaces; damping of turbulence and surface waves; vertical organic flux.

With the notable exception of some specialists working with turbid estuaries, marine scientists generally have no training in rheology, so they are unaware of the wide range of possible material properties of polymer solutions, organic aggregates, colloids and mucus, and they find it difficult to grasp the implications of these materials for the possible behaviour of seawater. Rheologists, on the other hand, are generally used to applying their knowledge to industrial processes and medicine, but have no experience in oceanography. Without this experience they cannot apply their knowledge of the physical properties of such materials to the scales present in the sea, which are generally extremely different from those both within mammals and in industrial processes.

To try to fill this yawning interdisciplinary hiatus, I am hoping to catalyse interaction between materials scientists, instrument manufacturers, marine and estuarine scientists, and funding bodies, initially as an informal interest group. I have already circulated a similar letter to rheologists at the Third European Rheology Conference, held in Edinburgh in September 1990, and met with extremely positive responses.

I hope that this group will lead to proposals for collaborative research between oceanographers and rheologists.

If you (or any of your colleagues) are interested in associating with the Seawater Rheology Interest Group, would you please send the following details to: Dr Ian Jenkinson, Agency for Consultation and Research in Oceanography, Lavergne, F-19320 LA ROCHE CANILLAC, France (TEL: +33 5529.1948; FAX: +33 5529.1982)

Name

Position

Institution/address

Research topics

Please attach a list of any publications of yours which are likely to be of interest to the Seawater Rheology Interest Group. If you have any comments or ideas about the proposed interest group, you are encouraged to attach these also.

MEMBERSHIP NEWS

The following applications for membership were approved at the Council Meeting, September 10, 1991.

Dr R. S. Bailey
Rheology Centre (F314),
ICI Advanced Materials,
Wilton Centre, Middlesbrough,
Cleveland
(fetsa BCD)

Mr A. M. Bellamy
Rheology Centre (F314),
ICI Advanced Materials,
Wilton Centre, Middlesbrough,
Cleveland
(fetsa BCD)

Prof. A. R. Davies
Dept. of Mathematics,
University College of Wales,
Aberystwyth, Dyfed,
Wales SY23 3BZ
(fetsa DJN)

Mr T. Dovey
Courtaulds Research,
101 Lockhurst Lane, Foleshill,
Coventry, CV6 5RS
(feta DG)

Miss I Funk
Buro Suddeuschland,
Reutlinger Strasse 56,
7300 Esslingen, Germany
(fetsa CDFGJKLM)

Dr L. B. Gilman
9305-B Munroe Road,
Charlotte, North Carolina,
28270-1488, U. S. A.
(feta BFGJLM)

Mr J. Greener
Dept. of Materials Technology,
Brunel University,
Kingston Lane, Uxbridge
Middlesex UB8 3PH
(feta CDGHI)

Dr A. M. Howe
Research Division, Kodak Ltd.,
Harrow
Middlesex HA1 4TY
(pesa DFG)

Mr A. L. Milton
Dept. of Mathematics,
University College of Wales,
Aberystwyth, Dyfed,
Wales SY23 3BZ
(fetsa GJ)

Dr P. Moldenaers
K. U. Leuven,
Chemical Engineering Dept.,
De Croylaan 46, B-3001,
Leuven
Belgium
(fetsa DFGO)

Dr L. Oldenhove
Colgate-Palmolive Research
& Development Inc.,
Avenue du Parc Industriel,
B-4041, Milmort,
Belgium
(pea FG)

Mr G. Oliver
Flour Milling & Baking
Research Association,
Rickmansworth Road,
Chorleywood, Herts,
WD3 5SH
(fetsa FGHL)

Dr S. Priel
Istituto de Chimica,
Applicata e Industriale,
Universita di Trieste,
Via Valerio 2, I-39127,
Trieste, Italy
(fetsa BGO)

Mr R. W. E. Roberts
Dept. of Mathematics,
University College of Wales,
Aberystwyth, Dyfed,
Wales SY23 3BZ
(fetsa B)

Mr S. Robinson
Cari-Med Ltd.,
Glebelands Centre,
Vincent Lane,
Dorking, Surrey
(fetsa ABCDEFGHIJKL)

Dr J. M. Steuten
DSM-Research,
Dept. of Polymer Evaluation
P.O.Box 18, 6160 MD Geleen
Netherlands
(fetsa BCDG)

Mr D. M. Stocks
Rheology Centre (F314),
ICI Advanced Materials,
Wilton Centre, Middlesbrough,
Cleveland
(fetsa BD)

The following have resigned: D. J. Hannant, C. S. Stuart, C. W. Nutt, T. Cochrane, D. P. Stait, R. E. Cohen, H. Markovitz.

Death: E. B. Babler died on 5th July, 1991.

Dr Dick Buscall, ICI, has been appointed Senior Company Research Associate.

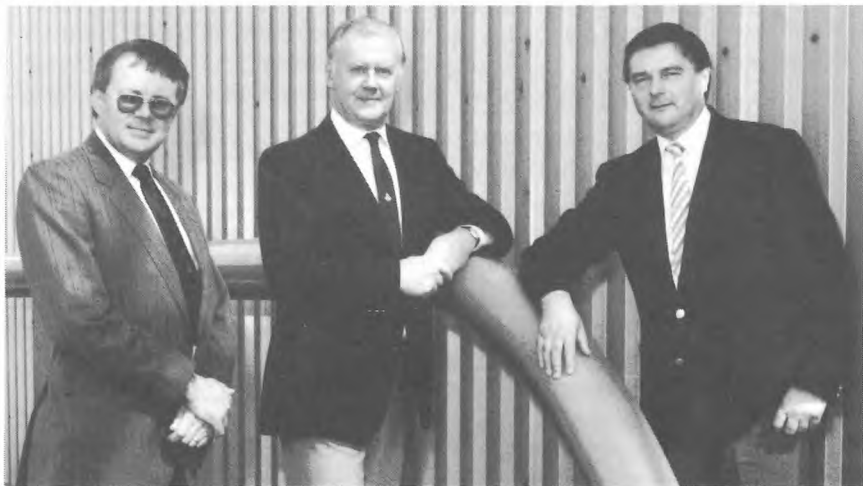
Dr Neville Waters, University of Liverpool, has been appointed Senior Lecturer.

Harry Schimanski is now an Industrial Rheology and Management Consultant, trading as Schimanski Scientific from 50 Cromwell Avenue, Thame, Oxfordshire, OX9 3TD, (Telephone & Fax 0844-260036).

M. J. B. Gough has moved from RARDE, Waltham Abbey to RARDE, Fort Halstead, Sevenoaks, Kent.

POLYMER LABORATORIES AND CARTER BAKER ENTERPRISES

Polymer Laboratories have announced that all product lines previously designed and manufactured by Carter Baker Enterprises Ltd. (CBE) are being incorporated into the range of materials testing and thermal analysis instruments offered by the company's Thermal Sciences Division. Both Mr Roy Carter and Dr Frank Baker have joined the technical team at Polymer Laboratories' Thermal Sciences Division in Loughborough, U. K.. They are both well known to members and have served on the Council, Roy having finished his term of office as Honorary Secretary in 1990. They may be contacted at: Polymer Laboratories Ltd., Thermal Sciences Division, The Technology Centre, Epinal Way, Loughborough LE11 0QE, U. K.. Tel: (0509) 233300 Fax: (0509) 234905.



Roy Carter (left), Professor Ray Wetton, Chairman of Polymer Laboratories and Frank Baker outside Polymer Laboratories' Thermal Sciences Division offices in Loughborough

COMPETITION

The response to the Competitions has so far not been very encouraging and in fact no entry has been received for Competition No. 4. We do not know whether Members are just not interested or whether they think that there will be so many entries that it is not worth trying; we should like to know. We cannot believe that the Society is bereft of gifted cartoonists so we repeat No. 4 as No. 5.

COMPETITION NO. 5

Draw a cartoon (black and white only) on a subject at least vaguely connected with rheology. The more amusing or witty the better. Entries to: Dr G. H. Tattersall, 174 Millhouses Lane, Sheffield S7 2HE. As usual, a BSR tie or £5.00 book token for the best. Closing Date December 15th, 1991.

EDITOR'S APOLOGIES

I am sorry that there were errors in Opus 91A, in the last issue. Line 3 of verse 4 should read "In series or in parallel" and line 4 of verse 6 should read "They found, considering an array,". In addition I omitted a complete verse, as follows:

Bingham entering the field
Proposed another constant, yield,
Power laws and exponential
And even fractional differential
Things were getting pretty tough
But some thought that was not enough

In Competition No. 2, Bulletin 34, (1), p. 31, one winning effort was by Ken Thomas of Sunbury-on-Thames, not as written. This prompted him to write as follows, having also not received the BSR tie which was his due:

It seems unintended pseudonymity
Is related to true anonymity:
Sounding kin to the hips
Gives this scribbler the pips,
And no tie to restore equanimity!

The other winner was Ian Evans of Sharnbrook, Beds.

CONFERENCE ANNOUNCEMENTS

RHEOLOGY OF GELS AND MICRO-STRUCTURED FLUIDS, AND
GENERAL RHEOLOGY

THE ANNUAL CONFERENCE OF THE BRITISH SOCIETY OF RHEOLOGY
at Selwyn College, University of Cambridge,
September 15-16th 1992

SECOND CALL FOR PAPERS

Offers of papers are invited for this conference. Papers addressing any aspect of rheology are acceptable. It is intended however to devote a number of sessions to the rheology of gels and structured fluids, and so submissions in these areas are especially welcome.

Speakers will be allocated 30 minutes in which to present their contribution, including discussion. The proceedings will not be published but it is intended that abstracts will be made available to participants. Titles and abstracts (ca. 250 words) should be sent to: Dr R. Buscall, ICI Corporate Colloid Science Group, P. O. Box 11, The Heath, Runcorn, Cheshire WA7 4QE. As soon as possible, and at the latest by 1st December 1991.

Potential attendees may like to know that the conference is being held immediately prior to a meeting in Cambridge on the subject of "Colloids in External Fields (flow, electrical, magnetic etc.)", organised by the Colloid & Interface Science Group of the Faraday Division of the Royal Society of Chemistry for September 17/18th. Further details of both meetings will appear in a later issue of the Bulletin.

FLUID DYNAMICS OF DRILLING AND COMPLETIONS

A one-day seminar will be held at the Institution of Mechanical Engineers on February 24th, 1992. Organised by the Energy and Thermofluid Mechanics Group it will review the state of knowledge concerning the flow of drilling fluids (mud) and cement during the drilling and completion phases of wellbore operations in the oil and gas industries. Invited speakers from industry and academe will report on the rheology of mud and cement, theoretical and laboratory modelling of mud flow in the drillstring-wellbore annulus and of cement in the casing-wellbore annulus, mud flow around the drill bit, the transport of cuttings away from the workface, gas-kick modelling, and the displacement of mud by cement. For further information contact: Professor M. P. Escudier, Department of Mechanical Engineering, University of Liverpool, P. O. Box 147, Liverpool L69 3BX.

THE EUROPEAN SCHOOL OF RHEOLOGY
AN E. E. C. COMETT COURSE
August 31st. - September 11th, 1992
THE UNIVERSITY OF STRATHCLYDE
GLASGOW, SCOTLAND

AIM OF THE SCHOOL

To provide a course leading to an advanced level of rheological knowledge for graduate students and staff from universities and colleges, and for industrial rheologists.

The course will be based on the assumption of no prior knowledge of the subject but will lead to current state-of-the-art knowledge on theoretical, experimental and industrial rheology.

LECTURERS

The course will be taught by acknowledged experts in the field from Europe.

PROGRAMME

Introduction to rheology: theory and practice of rheological measurement; rheological behaviour of non Newtonian fluids in shear and extension; the molecular basis for flow; industrial processes involving shear and extensional flows (such as fibre spinning, spraying, pumping, coating, extrusion etc.); numerical simulation; process control using rheology; specific fluids, including polymers, foods, suspensions and emulsions, biological fluids.

Demonstrations of rheological instruments will be arranged.

An essential feature of the Course will be seminars and tutorial sessions on specific topics.

LANGUAGES

English, French, German and Italian.

DIRECTOR OF THE COURSE

Professor J. Ferguson, Department of Pure and Applied Chemistry, University of Strathclyde, Cathedral Street, Glasgow G1 1XL, Scotland.

FEES

These will be minimal for students from academic institutions.

For more information contact the above.

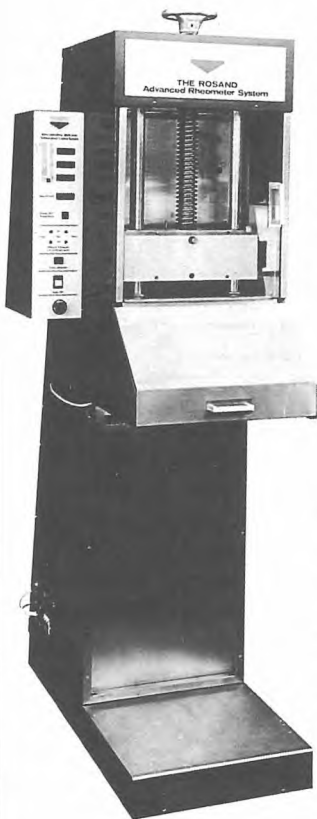
CONFERENCE DIARY

DATE	PLACE	DETAILS
17-22/11/91	Los Angeles, U. S. A.	Annual Meeting of the American Institute of Chemical Engineers: Fundamental Research in Fluid Mechanics, contact: James C. Hill (meeting coordinator), Chemical Engineering Dept. 231 Sweeney Hall, Iowa State University, Ames, IA 50011-2230, U. S. A.
4/12/91	Newcastle under Lyme U. K.	'Dispersants, Suspending and Stabilising agents', contact: British Association for Chemical Specialities, John Marshall House, 246-245 High Street, Sutton, Surrey SM1 1PA.
9/12/91	Swansea, U. K.	Inaugural meeting of the Institute of Non-Newtonian Fluid Mechanics, contact: Prof. P. Townsend, Dept. of Maths and Computer Science, University College Swansea, Swansea, SA2 8PP.
16-18/12/91	Southampton, U. K.	'The Conformations of flexible molecules in fluid phases', Faraday Symposium 27, contact: Mrs. Y. A. Fish, The Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN.
18-19/12/91	Reading, U. K.	'Emulsions', contact: Conference Secretariat, Society of Chemical Industry, 14/15 Belgrave Square, London SW 1X 8PS.
5-8/1/92	St. Augustine, Trinidad, West Indies.	'2nd Caribbean Conference on Fluid Dynamics' contact: Dr H. Ramkissoon, University of the West Indies, Dept. of Mathematics, St. Augustine, Republic of Trinidad and Tobago.
16-17/1/92	Tokyo, Japan.	Course on 'CAE in Polymer Processing', Society of Rheology, Japan, contact: Prof. Kunihiro Osaki, Institute for Chemical Research, Kyoto University, Uji, Kyoto 611, Japan.
2-5/2/92	Hutchison Island, Stuart, Florida, U. S. A.	'7th International Workshop on Numerical Methods in Non-Newtonian Flow', contact: Prof. D. G. Baird, Dept. of Chemical Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061-0211, U. S. A..
11-14/2/92	Paris, France.	'10th International Colloquium on Computing Methods in Applied Sciences and Engineering', INRIA, contact: INIRA-Rocquencourt, Domaine de Voluceau-Rocquencourt — BP 105, 78153 Le Chesnay Cedex, France.
26-28/2/92	New Orleans, U. S. A.	Water-borne, Higher Solids, and Powder Coatings Symposium, contact: Dr R. F. Storey, Dept. of Polymer Science, The University of Southern Mississippi, Southern Station Box 10076, Hattiesburg, MS 39406-0076, U. S. A..

- | | | |
|-------------|---------------------------------|---|
| 23-27/3/92 | Swansea, U. K.. | '8th International Conference on Finite Element Methods for Flow Problems', contact: FEMIF8 Conference Secretariat, Dr E. J. Probert, CDR, Innovation Centre, University College Swansea, Singleton Park, Swansea SA2 8PP, U. K.. |
| 6-10/4/92 | Barcelona, Spain. | '3rd International Conference on Computational Plasticity', contact: Eugenio Onate, COMPLAS III Secretariat, Centro Internacional de Metodos Numericos en Ingenieria, Modulo C1, Campus Norte UPC, Gran Capitan, s/n 08034 Barcelona, Spain. |
| 9/4/92 | London, U. K. | 'Rheology of Building Materials', contact: R. J. Mangabhai, TH Technology, Maple Cross House, Denham Way, Rickmansworth, Herts. |
| 5/92 | Tokyo, Japan. | '19th Annual Meeting' Society of Rheology, Japan, contact: Prof. Kunihiro Osaki, Institute for Chemical Research, Kyoto University, Uji, Kyoto 611, Japan. |
| 26-29/5/92 | Glasgow, U. K. | Residential Course: 'Theoretical, Experimental and Industrial Aspects of Rheology', contact: Dr N. E. Hudson, Dept. of Pure & Applied Chemistry, University of Strathclyde, Cathedral St., Glasgow G1 1XL. |
| 31/5-5/6/92 | Lake Garda, Italy. | 'Rheology, Processing and Properties of Polymeric Materials', contact: Prof. G. Marrucci, Naples, Italy. |
| 6-8/7/92 | Wollongong, N. S. W. Australia | 4th International Conference on Bulk Materials Storage, Handling and Transportation and 7th International Symposium on Freight Pipelines, contact: Prof. Peter Arnold, Dept. of Mechanical Engineering, The University of Wollongong, P. O. Box 1144, Wollongong, N. S. W. 2500, Australia. |
| 17-22/8/92 | Brussels Belgium | 9th International Congress on Rheology, contact: Dr P. Moldenaers, Chemical Engineering Department, Katholieke University Leuven, W. de Croylaan 46, B-3001 Leuven, Belgium. |
| 22-28/8/92 | Haifa, Israel. | '18th International Congress of Theoretical and Applied Mechanics', I. U. T. A. M., contact: Prof. A. Solan, Secretary ICTAM 1992, Faculty of Mechanical Engineering, Technion — Israel Institute of Technology, Haifa 32000, Israel. |
| 30/8-4/9/92 | San Diego, California U. S. A.. | 'NETWORKS 92-11th meeting of the Polymer Networks Group', contact: NETWORKS 92, c/o BIOSYM Technologies Inc., 10065 Barnes Canyon Road, San Diego, California 92121-2777, U. S. A.. |

31/8-11/9/92	Glasgow, U.K.	European School of Rheology, contact: Prof. J. Ferguson, Dept. of Pure & Applied Chemistry, University of Strathclyde, Cathedral St., Glasgow G1 1XL.
7-11/9/92	Brussels, Belgium.	'1st European Computational Fluid Dynamics Conference and 1st European Conference on Numerical Methods in Engineering', contact: Conference Secretariat, E. C. C. O., Rue Vilain XIII 17a, B-1050 Brussels, Belgium.
15-16/9/92	Selwyn College, Cambridge, U. K..	'Gels, microstructured fluids and general rheology', contact: Dr R. Buscall, ICI Corporate Colloid Science Group, P. O. Box 11, The Heath, Runcorn, Cheshire WA7 4QE.
17-18/9/92	Cambridge, U. K..	'Colloids in external fields', contact: The Royal Society of Chemistry, Burlington House, Piccadilly, London W1V 0BN.
10 or 11/92	Osaka, Japan	'40th Rheology Congress' Society of Rheology, Japan, contact: Prof. Kunihiro Osaki, Institute for Chemical Research, Kyoto University, Uji, Kyoto 611, Japan.
7-11/2/93	Santa Barbara, California, U. S. A..	'64th Annual Meeting', Society of Rheology, contact: Dr A. M. Kraynik, Division 1511, Sandia National Laboratories, Albuquerque, New Mexico 87185, U. S. A..
4/1993	To be announced	'Experimental rheometrical measurements', British Society of Rheology, Spring Meeting.
9/1993	Cambridge, U. K.	'Theoretical rheology', British Society of Rheology, Autumn Meeting.
17-21/10/93	Boston, Mass., U. S. A.	'65th Annual Meeting', Society of Rheology, contact: Dr A. M. Kraynik, Division 1511, Sandia National Laboratories, Albuquerque, New Mexico 87185, U. S. A..
1994	Spain	'4th European Conference on Rheology', contact: Prof. C. Gallegos, Departamento de Ingenieria Quimica, Universidad de Sevilla, Prof. García González, s/n (Edificio de Quimica), 41012 Sevilla, Spain.
1995	Caracas, Venezuela.	'3rd Caribbean Conference on Fluid Dynamics', contact: Dr H. Ramkissoon, University of the West Indies, Dept. of Mathematics, St. Augustine, Republic of Trinidad and Tobago.

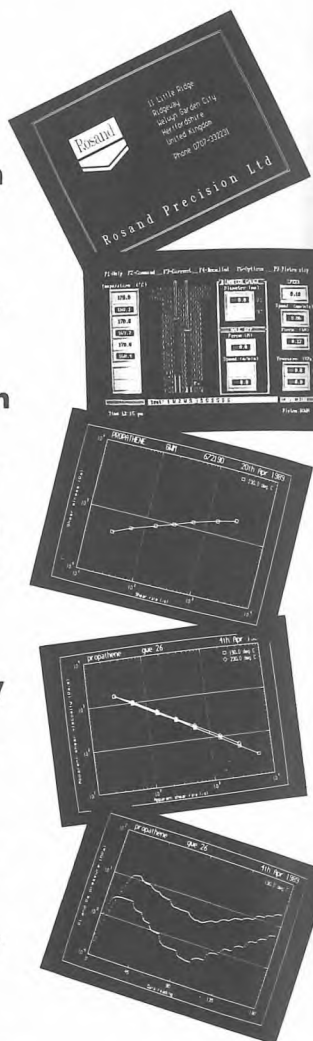
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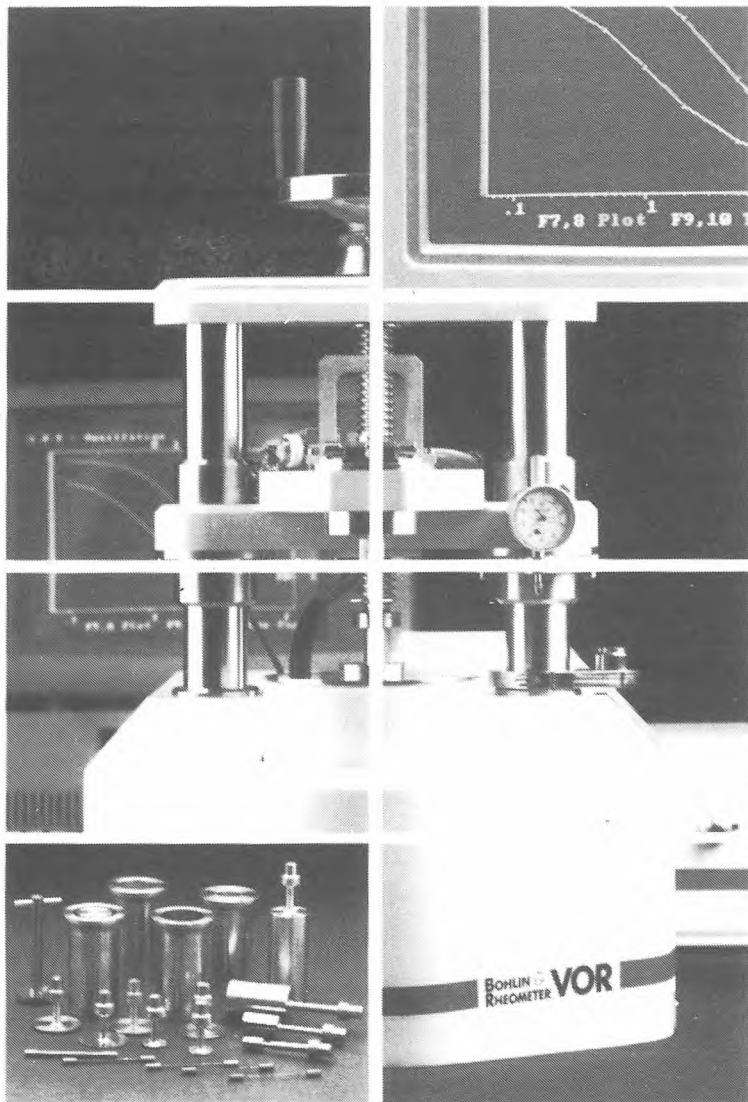
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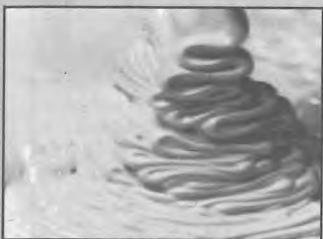
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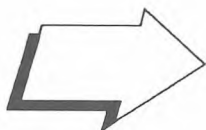
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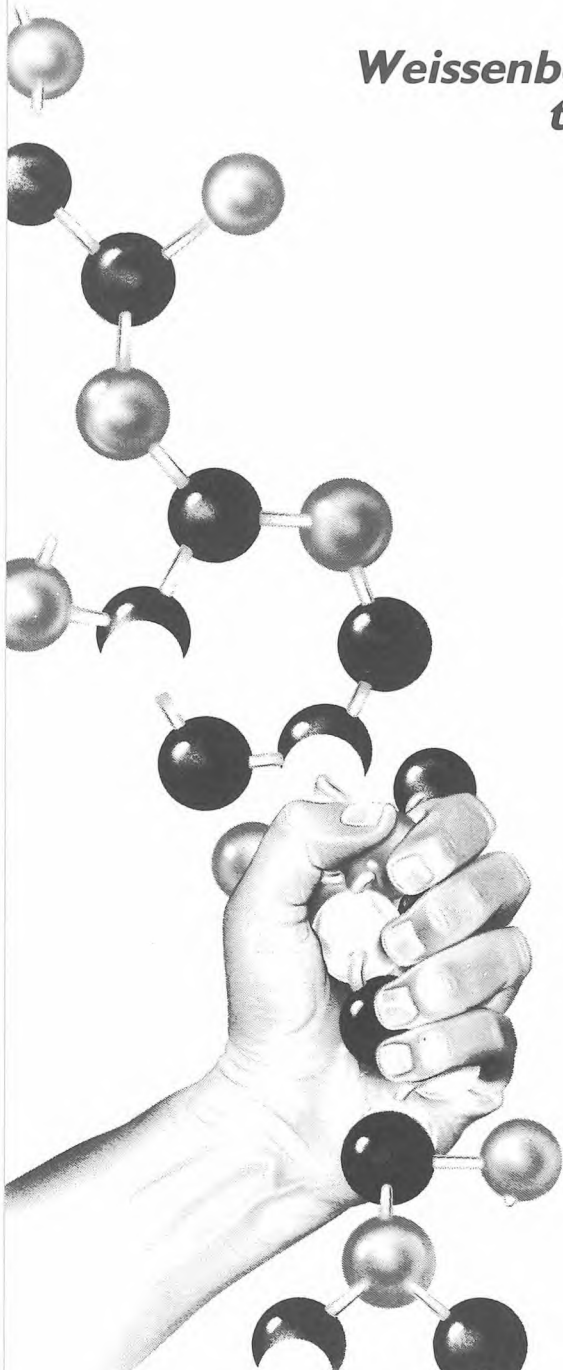
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A detailed illustration of a hand squeezing a long, flexible chain of spheres. The spheres are arranged in a zig-zag pattern, representing a polymer chain. The hand is shown from the side, with fingers and thumb applying pressure to the chain. The spheres are shaded to give them a three-dimensional appearance.

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