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THE BRITISH SOCIETY OF RHEOLOGY

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1992/93

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EDITORIAL

This issue includes brief biographical notes on Dr Ralph Oliver and Dr Gerry Meeten who became President and Council Member respectively at the A. G. M. in September and have already made their debuts at the December Council Meeting.

As already promised, this issue includes an article on food texture assessment, which is a subject area of interest to, but little studied by, rheologists. It would certainly have been of interest to Dr George Scott Blair, our co-founder, whose interests were firmly in psychorheology. No doubt, with the scale of computing power available now, and alluded to by Dr Kilcast in his article, Scott Blair would have made a considerable impact. (If only . . .). I aim to continue my policy of printing whenever possible a technical article in every issue and I hope that the results prove interesting to readers. However, there are many more topics of general interest which merit similar articles and I warmly invite readers to contact me with suggestions for topics of articles, and preferably give names of suitable authors or offer themselves.

Council had a preliminary discussion on an analysis of the results of our membership questionnaire which was circulated last year and briefly described in Bulletin 35 No 2. One of the matters which concerned us was the general lack of awareness of the financial support which the Society can offer. We are, frankly, worried that there have been no nominations for either of the two Studentships and that there is little call on our resources for Travel Grants. Both of these are the Society's main way of encouraging younger rheologists and I cannot believe that any research student would knowingly pass up the chance of £500 a year or the opportunity to attend a major conference. The terms of these grants are described in this issue.

On a related matter, this issue includes the audited accounts for the year 1991-92 which are held over from the last issue. Members will note that we have a healthy financial surplus, which is probably not unconnected with the comments made in the previous paragraph. We will be considering appropriate ways of using this surplus, but I warmly invite members to make constructive suggestions which are consistent with our charitable status.

Finally all members should have received a copy of the Membership List in December. We owe a debt of gratitude to Doug Hourston for his hard work in preparing such an excellent document and I am sure all members will join me in saying thank you.

Copy date for next issue March 15th 1993.

INSTRUMENTAL MEASUREMENT OF FOOD TEXTURE

Dr David Kilcast

Leatherhead Food Research Association

INTRODUCTION

Eating food should be a pleasurable experience. Our judgement of the eating quality of food can be influenced by many factors, such as advertising, pricing, nutritional image and the environment at consumption, but nonetheless sensory factors frequently dominate. The importance of appearance, odour and flavour has received much more attention than that of texture. This may be a result of our relatively poor understanding of the psychology of texture perception, which has only relatively recently appeared in the sensory literature, although an additional factor may be that the texture, unlike appearance, odour and flavour, is not an indication of spoilage. Good texture is, however, often associated with excellence in food preparation.

An additional reason for the relative lack of attention paid to texture may be the sheer complexity of texture perception. Initial expectation of textural characteristics can arise from appearance, for example the roughness/smoothness of skins from different apple cultivars. Tactile information from the fingers can also be important; this is used as a quality index when choosing fruits and vegetables. Another form of tactile information can result from the use of a knife, fork or spoon to portion the food — all these are sources of textural information even before the food enters the mouth. Once it is in the mouth, a complex series of changes occurs. During biting, the food experiences shearing and crushing motions, breaking it down into smaller pieces. Simultaneously, saliva is mixed with the food bolus, and temperature changes occur; the latter produce important structural and textural changes in many foods, for example frozen desserts and chocolate. The tongue and palate play an increasingly important role throughout this process, manipulating and crushing until the textural characteristics of the bolus make it suitable for swallowing. Even after swallowing, the characteristics of the residue in the mouth can be important, for example the unpleasant fatty mouth feel of some fat-containing foods, or the gritty residue from fibre-enriched foods.

CURRENT METHODS OF TEXTURE MEASUREMENT

SENSORY TEXTURE ASSESSMENT

Several schemes of assessment based on subjective methods using panels of people trained to assign descriptors and quantitative ratings of intensity have been developed, but whilst offering the most relevant picture of perceived texture they are labour-intensive and may require

extensive use of statistical analysis to draw conclusions. The practical difficulties posed by these subjective methods have resulted in the food industry's seeking simple and inexpensive objective measurements of texture.

INSTRUMENTAL TEXTURE MEASUREMENT

Instrumental methods can be classified into three main categories: empirical, imitative and fundamental.

Empirical Tests

Empirical tests often measure ill-defined variables that are indicated by practical experience to be related to some aspect of textural quality. Devices have been developed within different sectors of the industry that are appropriate to specific product types. Even for the same product type, different food manufacturers have even developed their own in-house devices. Fuller details of the devices described in this section can be found in Bourne (1982).

Examples of empirical tests are as follows:

Puncture or penetration devices measure either the force needed to push a probe into the food to a specific depth or the penetration distance achieved by application of a specific force. Typical uses are fruit, gels, fats and peas.

Shearing devices measure the force needed for one or more blades to shear through the food. The maximum force is often assumed to measure toughness, firmness or fibrousness. There are devices for meat, peas and for general purposes.

Compression devices measure the force needed to achieve a given compression or the compression achieved at a given force. Such devices have been used for bread and for fats.

In extrusion tests the food is forced through one or more orifices and maximum force, average force or work done over a specified time period is measured. The measured values are assumed to relate to firmness, toughness, consistency or spreadability, and are frequently used for measurements on fats.

Cutting devices use wires or blades (sometimes rotating) to cut through the food and measure the maximum force developed or the time needed to cut through a standard size of sample. Measurements are assumed to relate to fibrousness, firmness or hardness, and such devices have been used for biscuits.

Flow and mixing devices are used to give a measurement of viscosity or consistency of liquid and semi-liquid foods. They often measure the extent to which samples flow or spread under specific geometric conditions.

Although such empirical devices are often simple, inexpensive and portable, precision and reproducibility are generally poor and the measured parameters are poor measures of perceived texture. Extensive use is still made of them in industry, however, mainly for quality control purposes.

Imitative Methods

Imitative methods of measurement mimic the conditions to which the materials is subjected during eating. Developed from an early device in which a pair of human dentures were used to crush the food, the General Foods (GF) Texturometer uses a plunger which is driven through the arc of a circle into the food sample and the forces exerted as a function of time are recorded.

A schematic diagram of the GF Texturometer is shown in Fig. 1. As a result of the complex dynamics of the instrument, interpretation of the data was of a semi-empirical nature. The force-time output was analysed in terms of a number of measured parameters, and these were related to specific sensory attributes using a Texture Profile Method.

Although the GF Texturometer remains in use in North America and in Japan, the General Purpose Testing Machines such as those made by Instron, Lloyd and Stevens are most commonly used in the food industry. The instruments differ in their mechanical construction and in their data acquisition and data analysis capabilities, but in their normal configuration they have a number of important features in common. All have a crosshead containing a load cell, which is driven vertically at a range of constant speeds, and which can cycle over a fixed distance or load range. Probes can be attached to the crosshead for penetration, shearing or crushing the food, which can be held in a variety of cells. The load is recorded relative to time or to penetration/deformation distance, and displayed on a suitable recorder. Computer control of the instrument and computer analysis of the data are increasingly common.

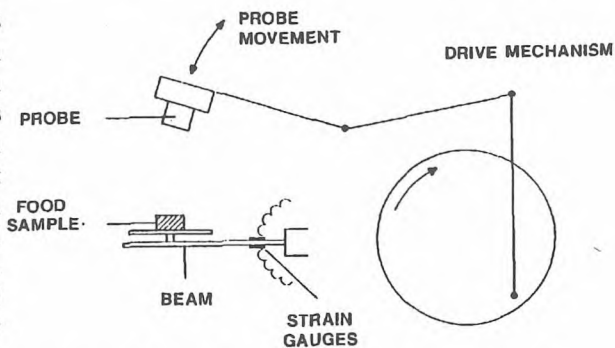


Fig. 1 Schematic diagram of the General Foods Texturometer (after Brennan *et al.*, 1975)

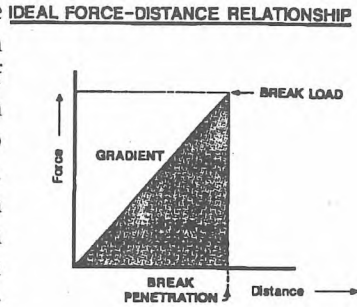
An idealised force-distance relationship is shown in Fig. 2, together with some interpretations that are commonly placed on the

measured parameters. It should be noted, however, that any interpretation should only be made via correlation of the instrumental parameters with quantified sensory attributes. This is too seldom the case in published literature. Force-time curves from real foods are in general considerably more complex than the above. Figure 3 shows data from a gelatin gel penetrated using a flat-ended cylindrical probe. Measurements of such curves require considerable care in both execution and interpretation. Work at Leatherhead has shown that, by exploitation of the photoelastic properties of gelatin, stress distributions associated with different penetration configurations can be visualised, assisting in understanding the test data.

A major advantage of such instruments is that flexibility of design allows them to be used for a wide range of foods. This is particularly useful for companies that are handling or manufacturing a varied product range. Load cells can be changed to give a high level of accuracy for a range from relatively soft foods to very hard foods. Probes and sample holders can easily be changed to accommodate measurements on different product types. An additional advantage is that such instruments can often be adapted for fundamental texture measurement.

Fundamental methods

Fundamental methods involve measuring well-defined physical properties of food, which, if measured properly, are independent of the method of measurement. The most common fundamental parameters are Young's modulus, shear modulus, bulk modulus and Poisson's ratio (for solids) and viscosity (for liquids). Fundamental parameters for solids can be measured on general-purpose testing machines, but such



POSSIBLE INTERPRETATIONS

GRADIENT	- FIRMNESS
BREAK LOAD	- STRENGTH/ HARDNESS
AREA	- WORK/ TOUGHNESS/ CHEWINESS
BREAK PENETRATION	- BRITTLENESS

Fig. 2 Idealised force-distance relationship

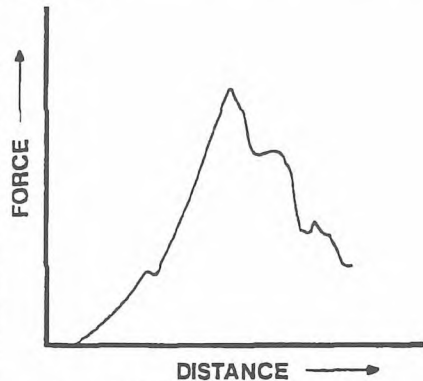


Fig. 3 Actual force-distance relationship: gelatin gel penetrated by a flat-ended cylindrical probe

measurements require a carefully designed experimental set-up and are consequently slow. In addition, foods are generally heterogeneous and do not exhibit simple elastic behaviour. Fundamental parameters can be measured on liquids using suitable instrumentation, for example the Weissenberg Rheogoniometer and the Carri-Med Rheometer. Again, however, liquid foods rarely exhibit simple viscosity behaviour.

Such fundamental measurements are valuable in investigating the physical properties of food, but are too complex for routine use and, in common with other instrumental measurements, rarely correlate well with perceived texture. Some reasons for this can be identified on examining some of the physiological factors associated with chewing.

PHYSIOLOGICAL ASPECTS OF CHEWING

Once food is bitten with the incisors or placed in the mouth, a complex series of events occurs. Firstly, the food may be positioned in an appropriate part of the mouth using tongue movement. Pressure from the tongue may press the food against the hard palate, giving information on the response of the food to such pressure and on the surface textural characteristics. Biting using the lateral sets of teeth occurs in two stages, the first of which occurs at low loads with a high rate of movement (up to 300 cm/min for whole meat) and the second at high loads with low speeds. The motion itself can be composed of complex combinations of vertical and horizontal movements, and can depend on the state of occlusion of the teeth (Boyar & Kilcast, 1986). These movements lead to the foods being subjected to a complex combination of compressive, shearing and tensile forces.

During this process, saliva is being introduced to the food, acting as a lubricant and helping in the formation of a bolus with the correct physical properties needed for swallowing. Foods eaten at temperatures higher than or lower than body temperature also undergo physical changes as thermal equilibration occurs. The fatty component of meat products, for example, can solidify and give a change to the mouthfeel characteristics. More importantly, chilled and frozen foods undergo changes leading to melting of any ice component and extensive structural breakdown; this can happen rapidly even in the absence of any chewing action.

It is clear that no realistically priced mechanical instrument can operate in such a way as to simulate this wide range of conditions. At best, an instrument can only simulate a first bite, and even then only with an oversimplified mechanical action. Moreover, few instruments can reach the high force application rate experienced in the mouth; most tests in the industry are operated at 3 cm/min. Since most solid foods are viscoelastic in nature, rate of force application is an important factor in measuring physical properties, but is rarely taken into account.

An elegant alternative approach to solving the problems of surrounding sensory assessments using people and objective measurements using instruments would be to make objective measurements on people during eating.

MONITORING HUMAN SUBJECTS

The sounds emitted when crushing crisp foods are potentially useful for objective assessment, and have been used for potato crisps and breakfast cereals but the approach is limited both to foods that emit sounds during chewing and also to a small number of textural attributes. Electromyography (EMG) which involves the measurement of electrical signals generated in muscles that are active during mastication, offers the potential for relating activity and food texture, but early attempts were restricted by the complexity of the data produced. (Boyar & Kilcast, 1986). The development of more sophisticated EMG equipment and computer systems, however, has permitted much deeper analysis of EMG data and its relationship to food texture. An added potential advantage of this technique is studying changes in food texture in the mouth throughout the whole chewing cycle. The remainder of this paper describes experiments carried out at the Leatherhead Food Research Association, reported in full in Eves, 1990.

TEXTURE MEASUREMENT BY ELECTROMYOGRAPHY

INSTRUMENTATION AND MEASUREMENT PROCEDURE

Electromyographic patterns were recorded using a Grass Polygraph (Model 7D). A schematic diagram is shown in Fig. 4. Although analysis of raw data using Fourier techniques is possible, computational demands are complex, and consequently analysis of integrated data only is described in this paper.

Surface electrodes were used to detect the electrical signals from the masseter muscle which is both close to the surface of the skin and is active during the chewing of solid foods. The skin on the cheek and earlobe were cleansed

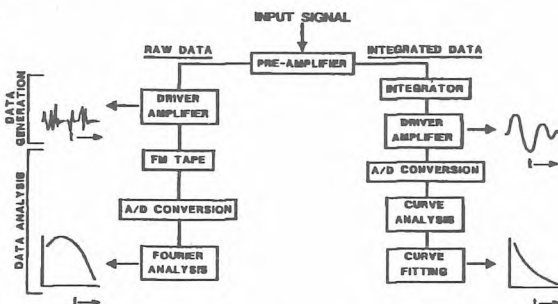


Fig. 4 Schematic diagram of electromyograph.

with 95% (V/V) ethanol to remove traces of dust and perspiration, which may interfere with the signal. A position was located on the cheek at the maximum point of inflection of the masseter muscle and two electrodes were located above and below this point in line with the muscle and approximately 0.5 cm apart. A third electrode was placed on the earlobe, a point of no muscular activity, which acted as an earth. Electrode cream, a conductive paste, was applied to the electrode surface in all cases.

Following connection of the terminal ends of the electrodes to the Polygraph, the subject was presented with the sample to chew. The data acquisition system was capable of recording information from up to three muscles simultaneously; however, the experiments described in this paper were carried out using a single masseter muscle, and consequently the subjects were asked to eat on the side of that muscle only. All samples were assessed in triplicate and all samples were of the same size and geometry. Data were recorded from the time the sample was put into the mouth to the time of swallowing.

The raw EMG signal and its integrated form were recorded together with a time signal (Fig. 5). The integrated wave was digitised and stored for subsequent analysis. A digitisation rate of 50 points per second was used, and from the data a number of curve parameters were calculated - peak height, pre-maximum gradient, post-maximum gradient and area under peak.

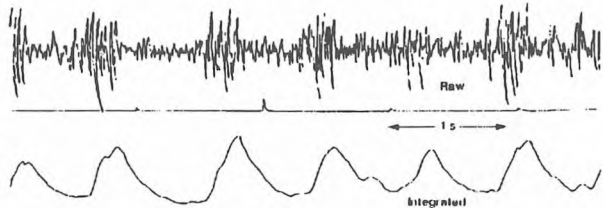


Fig. 5 EMG output signals.

Gradients and area were calculated from minima rather than baseline, and all parameters were adjusted in relation to a pre-recorded baseline. With the exception of the post-maximum gradient, the change of most EMG parameters with time can be described by either a falling exponential curve or by a rising straight line followed by a falling exponential curve. The following "broken stick" model was consequently fitted to peak height data:

$$\begin{aligned} y &= \{Ae^{-au} + Q(t-u)\} & \text{if } t < u \\ y &= Ae^{-at} & \text{if } t \geq u \end{aligned}$$

In this model, a straight line is fitted up to the time of the break point (u), and a falling exponential at longer times.

REPRODUCIBILITY STUDIES

The reproducibility of the method was studied both between subjects and between occasions. Of thirty subjects asked to chew fruit pastilles, the plots of peak height against time of twenty-six subjects could be described by the broken stick model. Two other subjects did not show the rising portion, and the remaining two showed a rising curve. As the peak height was shown in separate experiments to be directly related to biting force, this behaviour can be regarded as anomalous.

Experience of the technique has shown that the choice of subjects for EMG work is not critical provided they fit the broken stick model. Absence of the rising phase may be a result of aggressive biting behaviour - the upward phase is thought to be a consequence of either positioning the food before biting proper, or a tentative biting of foods that are unfamiliar or that are recognised as hard or chewy. Research has concentrated predominantly on the breakdown phase, but valuable information on oral manipulation may be contained in the upward phase.

In a separate experiment, five subjects were asked to eat toffee (three replicates) on three separate occasions. Integrated peak height was measured for each subject for each day and a broken stick model fitted.

Although differences were apparent in the initial phases of chewing, the breakdown rates of the samples over the three days remained the same. Overall amplitudes showed some variation, but this could be allowed for in various ways, for example by using a standard calibration material.

RELATIONSHIP WITH SENSORY DATA

Any non-subjective method of food texture assessment can be of practical value to the food industry only if the results of the data measured can be interpreted in subjective terms. Although the use of integrated peak height as a measure of biting force is of great value, it is clear that a considerable amount of additional textural information is contained within the EMG traces. A preliminary study was carried out in an attempt to relate the texture profile of three types of commercial confectionery gums to measured EMG parameters.

Profile analysis was carried out on three commercial fruit pastilles using the QDA method. A panel of twelve derived textural terms for the pastilles (jelly, tough, rubbery, chewy, moist and sticky) and scored their intensities in five replicate sessions. Eleven of the twelve panellists then chewed the pastilles in three replicate sessions whilst wired to the EMG. Initial attempts were made to find simple correlations between profile terms and EMG parameters. It was found, however, that each individual profile term showed high correlations

with several EMG terms and that these correlations could not be explained logically. Similarly, attempts to relate each profile term to linear combinations of EMG parameters using multiple linear regression required, typically, more than five EMG parameters to give a satisfactory fit. Such ambiguous relationships are of little practical value to the food industry, and consequently the EMG data were examined further using a multivariate statistical technique - canonical variates analysis (CVA).

Multivariate methods seek to examine patterns in data points by finding linear combinations of the original experimental variables that account for most of the variations in the data. CVA operates in a similar way, but defines groupings in the data by maximising the ratio of the variation between groups to the variation within groups. The first canonical variate is the direction that maximises this ratio; the second is the orthogonal direction that maximises the remaining ratio, and so on.

Figure 6 shows the CVA plot from analysis of EMG parameters for the three commercial fruit pastilles. Each point represents one subject, and the dotted lines represent the 95% confidence limits for each grouping. The plot separates the three pastilles into three non-overlapping groups, with most subjects falling within the 95% confidence limits. Since CVA is designed to maximise the separation between groups, a check was carried out on the risk that the groupings might be an artifact of the method. Nine identical samples of wine gums were chewed, and the EMG data treated as three different samples chewed in triplicate. The resultant CVA plots showed that no distinct groupings were found in the data, demonstrating clearly that CVA does not generate artificial groupings.

In a second set of experiments designed to examine further the use of the CVA method, profile and EMG analyses were carried out on a set of confectionery materials formulated and manufactured to give a controlled range of structures and textures. CVA plots from the profile and the EMG data were compared, but

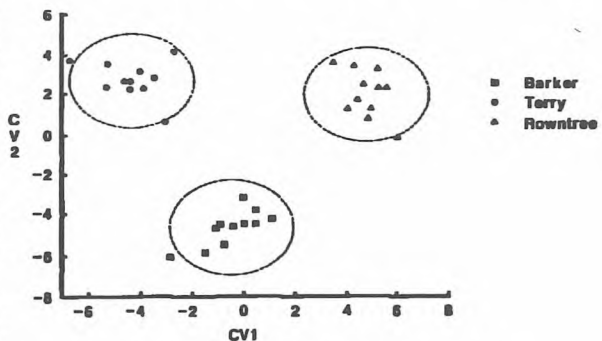


Fig. 6 CVA plots on EMG data measured on commercial pastilles

agreement was less good than expected, with different products being separated in each case. One reason for this difference may be that the profile data contain textural information on attributes that are associated with other perceptual paths, for example from tongue and palate manipulation. A second reason may be that sensory profile data is effectively time-averaged, and therefore temporal (time-intensity) data may be more appropriate for correlation purposes.

The use of CVA enables foods of different textural characteristics to be readily visualised in a low-dimensionality texture space. Although more work is needed to understand the potential and the limitations of EMG, this combination of methodologies is unique in adding another dimension to the measurement of texture. This gives the product developer a powerful tool in attempting to match the textural characteristics of foods and in identifying novel textures not represented in CVA texture space.

FUTURE DEVELOPMENTS IN TEXTURE MEASUREMENT

It is unlikely that the food industry will see any revolutionary developments in texture measurement in the near future. There will be a continuing demand for new empirical instruments for specific purposes; the author has recently been asked to develop a simple, hand-held instrument for measuring the texture of ratatouille. The industry will also increasingly need to rely on precision, general-purpose machines, particularly with increasing product diversification. Although substantial improvements have been made to such instruments, particularly in terms of computer control and analysis, these still remain too complex (and expensive) for routine quality control use in many companies. Simplification and cost reduction are, however, not generally compatible with the required versatility. One important requirement for further development in such instrumentation will be the capability to operate accurately at the high rates of force application prevailing in the mouth.

The industry is becoming increasingly aware that detailed texture assessment requires sensory methods. Relatively few companies, however, have the resources needed to operate trained profile panels. More companies may be able to operate free choice profiling procedures, with their minimal training requirements, but simplification of computer software needed to analyse the profile data is needed. Another sensory method that may have an important role is time-intensity (T-I) testing. T-I methods involve assessors recording the intensity of specific sensory attributes as a function of time (Wyeth & Kilcast, 1991). Such methods have the advantage of following textural change during chewing, and have been used to investigate melting foods such as ice cream. Work has been carried out at the

Leatherhead Food Research Association for examining flavour release from gels and from low-fat foods.

EMG also records, indirectly, textural change in the mouth. Most work to date has been associated with solid foods. Preliminary studies at Leatherhead have shown that information on viscous and semi-solid foods can be gathered from the group of muscles under the chin controlling tongue movement, although data acquisition is more difficult. This would also open up the possibility of monitoring the textural change of foods undergoing temperature-related phase changes, such as the melting of chocolate or frozen desserts, by monitoring both masseter and tongue muscle activity. At present EMG should be regarded as an important research tool, rather than as a quality control technique. Considerable simplification of equipment is feasible, but the need to rely on human subjects would limit its use as a routine quality control method.

With the exception of measurement of viscosity, there has been little progress in the development of on-line methods. One area in which future developments may be made is in the use of acoustic measurements. Research has been carried out into the use of sonic input methods for measuring the texture of biscuits, cheese curd and, more recently, soft gels. The last mentioned (Ring & Stainsby, 1985) is based on timing the passage of shear waves through soft gels, which form a difficult class of material for instrumental texture measurement. A simple instrument based on this principle, the Rank Pulse Shearometer, is commercially available, and this can also be used to measure gelation phenomena.

In conclusion, there are considerable challenges in the area of food texture assessment which will require cooperation between food scientists, physiologists and equipment manufacturer. I hope that rheologists can be persuaded to play a part.

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RHEOLOGY

TESTING

PL-TSR



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FLOW AND MICROSTRUCTURE OF DENSE SUSPENSIONS

Imagine a concrete and glass enclosed colony of human ants, where the individuals seem to be moving around at random, bent on their own errands, and you have a picture of the Boston Marriott and Westin Hotels complex during the Fall Meeting of the Materials Research Society (MRS). Over 4000 delegates attending over 20 symposia on a range of topics, including ceramics, composites, microelectronic materials, superconductors, fullerenes and metal processing, seemed to be continually moving up, down and around the four floors of the atrium outside the various meeting rooms, bars, cafes, exhibition halls and overflowing into the contiguous shopping mall, with its four storey concrete-sculptured waterfall. MRS staff told me that this meeting is always held in Boston and that the Spring Meeting somewhere on the west coast attracts about 2500 delegates. The Fall Meeting has grown steadily and is now almost too big for the facilities available. Even the book of abstracts was 650 pages, with about six abstracts per page.

The Flow and Microstructure of Dense Suspensions was Symposium M, one of the smaller ones, and generally had an audience of 30-50 people, but because of the all the counter-attractions this is a time averaged figure with people popping in and out. This latter behaviour was facilitated by the strict timekeeping imposed by the system and which required disciplined chairing of the sessions. The aim of the organisers was to bring research on fundamental behaviour of suspensions together with work on materials of practical significance like cement, ceramics, metal slurries and pastes. In so far as the people were there, the organisers achieved their aim, but how far there was a meeting of minds is more questionable.

The first session was concerned with fundamental aspects of dispersed suspensions and we heard papers on viscoelastic properties, crystallisation, lubrication forces, and interparticle forces in model systems, mainly of polymer latices. The second session dealt with flow and microstructure and papers reported experimental work on and theoretical modelling of coagulation processes, concentration dependence and suspension behaviour. Industrially important materials discussed in the rest of the sessions included clays, ceramics, polymer microgels, metal slurries, fibre-reinforced polymers, cement and concrete, and precursor materials for high-temperature superconductors. Finally, there was evening poster session at which presentations on rheometrical methods were on display. Overall, the meeting confirmed the view that in many fields of materials processing it is necessary to strike a balance between the most favourable rheology for the process and the optimum properties of the final product.

Nowhere was this shown more clearly than in the talk by McHugh on MDF cements. (People may remember MDF cements as the wonder materials developed by ICI in the early 1980s which showed that it is possible to produce a tough, strong manufacturing material from the normally brittle and weak cement. The technology was never taken up in this country and is now the subject of a multi-million dollar cooperative research programme in the United States, but that is another story.) McHugh's team showed that it is possible to produce an extrudable and mouldable material by high shear processing in a twin-roll mill, but that excessive processing actually degrades the material and reintroduces the very defects which the MDF process had so successfully eradicated.

The sessions were all conducted very efficiently with time for questions and discussion, but because of the scale of the meeting it was difficult to contrive those informal discussions which can so often prove such a valuable feature of conferences. New experiences for me were submitting the camera-ready manuscript of my paper at the start of the meeting and receiving some other manuscripts to referee and hand back to the organisers before departure. I think this is a good idea as it helps to maintain publishing standards and spreads the editorial load somewhat. It also means that speakers can include the up to date information, which they present verbally, in the written version. I look forward to seeing the proceedings in due course.

Phil Banfill

LETTER TO THE EDITOR

Azur, Israel

Dear Sir,

At the Cambridge Autumn Conference, several speakers considered the gel point, and defined it as the point at which the curves for G' and G'' crossover, whether this refers to temperature, time or other variable being studied.

I contend that this definition has no basis in the physics of what is happening as the material changes over to a gel. To me it seems merely a convenient way of determining something, although what it is I cannot guess. If we were to define the gel point as that at which the viscosity or G' rises very rapidly or G'' begins to fall rapidly, there would be some justification for it, although the location of such a point would be difficult, because obviously it would be diffuse.

Does anyone care to comment?

Yours faithfully
Z. Rigbi

The President of the British Society of Rheology 1992-1994 is Dr D. R. Oliver. Ralph obtained the degree of BSc in Physics and PhD in Mining at Birmingham University. In around 1953, the Professor of Mining (Stacey G. Ward) introduced him to the British Society of Rheology and he also met John Pryce-Jones and Alfred Nissan, two early pioneers in this field. He then spent three years working on guided weapons and a further year dealing with the manufacture of cellulose triacetate film at Bexford Ltd., in Essex.

Returning to Birmingham University in late 1957, he became a lecturer in Chemical Engineering, initially carrying out research on laminar flow heat transfer to polymer solutions. This led to a series of projects aimed at enhancing the rate of heat transfer to viscous liquids — using flattened tubes, coiled tubes, two phase (gas/liquid) flow, tubes fitted with inserts and heat exchangers with mechanically scraped surfaces. At the same time he maintained interest in work on suspensions of idealised spherical particles. He showed that the Segré-Silbergberg effect (the radial migration of spherical particles in suspension flow into an annular region) was caused by interplay between an outward-directed force related to particle rotation and an inward-directed force caused by proximity to the wall. It was possible to prevent the rotation of small spheres by drilling tiny holes in them! Another interesting problem studied was the increased rate of settling of suspended particles in tubes, caused by the *inclination* of the tube. This had first been observed by Boycott during tests on the settling of blood cells, and the effect is named after him. The work led to the testing of equipment suitable for carrying out inclined settling on a continuous basis, the experimental programme being carried out at the National Research Centre in Ottawa during the summer of 1963.

A visit to Brown University at Providence (Rhode Island) was made in the same year, coinciding with the Fourth International Congress on Rheology. Since then, Dr Oliver has attended all subsequent Congresses — Kyoto, Lyon, Gothenberg, Naples, Acapulco, Sydney and Brussels. The memorable visit to the far east included the fascination of the Japanese baths, which had originally been thought by some of the British to be too “naughty”, on account of the scanty clothing of the Japanese girls and the total lack of clothing of the men! However, the steam bath, gentle swim and wash (all over) by a personal attendant, followed by massage, manicure, pedicure, free drink and colour television (in 1968) for the sum of four pounds had some of the most unlikely delegates visiting the Daishogun twice!

A new research interest developed around 1964 was the jet thrust method of measuring elastic stresses in dilute polymer solutions (after Harris). This led to work on extensional flow, by allowing liquids to converge into an orifice or a contoured nozzle before emerging as a jet. It confirmed that solutions of polymers having a high molecular weight had exceptionally high extensional viscosities. An entirely new device known as the "triple jet" was used to show that some polymer solutions had stretching behaviour which was affected by their history; pre-shearing the fluid could often increase its extensional viscosity. Another novel system, aimed at lubrication problems, was the continuous-flow squeeze film apparatus, in which two discs were held parallel and close to each other. One disc, however, was pierced by over 15000 holes through which liquid could be forced, entering the region between the discs and flowing rapidly outward to the rim. This system simulated squeeze film flow, where the plates move towards each other, but had the advantage of having no moving parts. Other devices involving the rheology of lubricants were the external near-contact of lubricated rotating cylinders, and the case where lubricant is contained in the gap between two cylinders (as in a Couette viscometer) and the inner cylinder is then moved into an eccentric position. This produces a side-load on the cylinder and increases viscous drag; the arrangement is a model for a steadily-loaded journal bearing. If the inner cylinder is made to run eccentric on its own shaft (so that it "wobbles" when rotating) the system simulates an unsteadily loaded bearing such as those in the crank-shaft of a car engine. A commercial instrument based on this principle is being manufactured.

Ralph is a keen sportsman, having played tennis at Wimbledon five times during the period 1953-59 and becoming Captain of the Warwickshire tennis team and later President of the Warwickshire Lawn Tennis Association. He also plays squash and golf fairly frequently. Another strong interest is flying in various forms; he has designed and built two hang-gliders, one of which currently adorns the wall of his office at Birmingham University. He is married, with two daughters and two (very recent!) grand-children, a boy and a girl.

Ralph Oliver first joined the Council of the British Society of Rheology in 1972 and has held the positions of Treasurer and Abstracts Editor. He also edited the Proceedings of the Golden Jubilee meeting of the Society, held in Edinburgh in 1990. The theme of Rheology runs through most of his research work and he looks forward with anticipation to his short period as President of the Society.

DR G. H. MEETEN

Dr Gerry Meeten was elected to the Council at the A. G. M. in September 1992 and has given the following personal description.

Discerning B. S. R. members will have wondered why they have not noticed my rheological career over the last few decades. The reason is simple; there has been little to notice! An explanation, and my *c. v.*, follow.

After two years at the Caswell research labs of Plessey, I took a physics degree at the Sir John Cass College. By the second week of the first term I had been introduced to non-Newtonian fluids. I became fascinated by the complexity of humble materials. Our lecturer was not only a physicist but was (and remains) a man of great experimental skill, and my interest in rheometry grew when he emerged from the sub-basement, having resuscitated an old Couette rheometer. This had been made by Emil Hatschek, who in 1928 was a reader in colloid science at the college.

During my degree years, lasers and the other components of modern optics were becoming less uncommon, and physical optics became a growing interest. The fields of rheology, fluids and optics were combined when I studied flow birefringence in molecular fluids, as a postgraduate (1964-67) in the research group of Dr John Campion, who had revived the Hatschek rheometer three years before. (It is, incidentally, 120 years ago this year that James Clerk Maxwell discovered experimentally the phenomenon of flow birefringence, or streaming double refraction). This work gave me an abiding interest in the behaviour of particles inside fluids under shear. I stayed for some years in this research group with a City of London Polytechnic lectureship. In addition to their rheology, the optical, electromagnetic and ultrasonic properties of fluids and colloidal particles in suspensions were added to my interest. In this period I enjoyed a fruitful sabbatical at ICI plastics (Welwyn), applying optics to polymers in bulk and latex form. On my return to academia, applied science as an activity *per se* began to appeal, and my attention moved toward practical problems.

I am presently a Senior Research Scientist at Schlumberger Cambridge Research (SCR). Much of the work of this laboratory involves complex fluids; a mix of materials at a molecular, polymeric and a particulate level. All are required to flow at some stage in their service. A more detailed picture of rheology at SCR has been drawn in the article by Dr Geoff Maitland. (B. S. R. Bulletin, 33 (4), 1990, 78-88).

I intend to continue my relatively new involvement in Rheology, and to serve the B. S. R. as a member of Council.

TREASURER'S REPORT

The report of the Honorary Treasurer to the A. G. M. in September 1992 included the following statement of accounts

REVENUE ACCOUNT FOR THE YEAR ENDED JUNE 30TH, 1992

	1992	1991
£	£	£
EXPENDITURE		
Council expenses		
Bulletin production costs	4,834	2,173
Expenditure by Officers:	7,152	5,955
Secretary	90	679
Membership secretary and circulation	1,172	596
	<u>1,262</u>	<u>1,275</u>
Professional fees	228	192
Insurance	109	99
Awards	332	1,031
Miscellaneous	213	13
Conferences (see below)	—	4,217
Student grants	1,150	—
Bad and doubtful debts	1,100	—
Depreciation		
Word processors	<u>1,451</u>	<u>1,451</u>
	<u>17,831</u>	<u>16,406</u>
INCOME		
Annual subscriptions and entrance fees	6,230	2,505
Publisher — Rheology Abstracts	4,882	2,009
Advertising	3,060	5,728
Bulletin subscriptions	134	259
Sale of ties	67	16
Bank interest	2,591	3,034
Conferences (see below)	<u>1,428</u>	<u>—</u>
EXCESS OF INCOME OVER EXPENDITURE	<u>561</u>	<u>—</u>
EXCESS OF EXPENDITURE OVER INCOME	<u>—</u>	<u>(2,855)</u>
	<u>18,392</u>	<u>16,406</u>
CONFERENCES ACCOUNT		
Surplus or (deficit) after expenses		
Liverpool	219	(845)
Warwick	—	(1,125)
Edinburgh	(405)	(2,197)
Glasgow	—	(50)
Bristol	<u>1,614</u>	<u>—</u>
	1,428	(4,217)

BALANCE SHEET AS AT JUNE 30TH, 1992

	1992	1991
	£	£
FIXED ASSETS		
Word processors		
At cost at July 1st, 1991	5,805	3,618
Additions	<u>—</u>	<u>2,187</u>
	5,805	5,805
Depreciations to date	<u>(4,116)</u>	<u>(2,665)</u>
	1,689	3,140
CURRENT ASSETS		
Cash at bank:		
Premier Interest account	32,928	25,956
Current account	<u>1,425</u>	<u>847</u>
	34,353	26,830
Sundry debtors and prepaid expenses	<u>1,110</u>	<u>4,111</u>
	37,152	34,081
CURRENT LIABILITIES		
Sundry creditors	<u>3,108</u>	<u>598</u>
	<u>3,108</u>	<u>598</u>
	34,044	33,483
SCOTT BLAIR LEGACY FUND ASSETS		
Premier Interest account	11,287	10,526
	<u>45,331</u>	<u>44,009</u>
GENERAL FUND		
At July 1st, 1991	33,483	36,338
Excess of income over expenditure in the year (1991: shortfall)	<u>561</u>	<u>(2,855)</u>
	34,044	33,483
SCOTT BLAIR LEGACY FUND		
Balance at July 1st, 1991	10,526	9,383
Bank interest	<u>941</u>	<u>1,143</u>
	11,467	10,526
Expenses	<u>(180)</u>	<u>—</u>
	<u>11,287</u>	<u>10,526</u>
	<u>45,331</u>	<u>44,009</u>

COMMENTARY ON 271ST COUNCIL MEETING

It has now become an established tradition for the first meeting of a new Council to meet in a location close to the home of the new President, and to join him for dinner after the business has been concluded. Consequently, we all converged on the George Hotel in Solihull. The first problem to solve was finding a place in the Car Park — not that it was small, but all the locals going Christmas shopping had decided that this was the best place to park. On to registration in the hotel, where the next problem was to find one's room. With the opening of the nearby N. E. C. and the enlarging of the airport, this hotel, like many others in the area, had expanded rapidly — even the extensions had extensions. Finally, by following a trail of arrows from Reception, and only getting lost twice, your intrepid reporter managed to arrive at the correct meeting room with three minutes to spare.

The meeting opened with greetings to the new members of Council. Our new President, Ralph Oliver, formally introduced himself, and then greeted Gerry Meeten. Ralph then laid down his ground rules for covering the business of the meetings. Essentially, we are to conclude all matters in as close to three hours as we can, Officers' reports are to be distributed beforehand, and errors / omissions in the minutes are to be forwarded to the Secretary in advance. Apologies for absence were received, a Deputy Chairman was selected, and we moved on to the minutes of the last meeting, and the matters arising. There was a brief discussion about the International Congress in the year 2000; the Council are in favour of bidding to hold it in Britain. Further consideration was put on the back burner for the time being. Some further details have emerged as regards a dinner to celebrate the centenary of the birth of Karl Weissenberg, in June of this year. Carri-Med have offered to sponsor to the tune of £1000.

The President then gave his initial report. The joint meeting with the French Society in September at Cambridge was a great success, and they wished to continue the liaison with another conference. More about this later. Discussion then ensued about the insurance for the chain of office, which had become due. My notes then say that the Secretary made a *faux pas*, but I can't remember what it was. As the Treasurer was away on holiday in South Africa, his interim balance sheet was distributed, and some questions were minuted for his attention. The Secretary then reported that she had received some items from the Chinese Society, and duly handed them on to the Abstracts Editor. The Membership Secretary then handed out copies of

the new Membership List, which all members should have received by the time this Bulletin is published. Everyone thanked Doug for performing such an arduous task over the last two years.

The Bulletin Editor requested that councillors should actively solicit articles for the Bulletin, so that the diversity and quality of that publication can be maintained. The Abstracts Editor is still looking for abstractors, though his main contribution to the meeting was to further elaborate on the recent questionnaire in the Bulletin (issued with 34 (4) and reported in 35 (2)).

On to future Conferences, with Carole Moules first reporting on developments for the Spring meeting. Response to date has been slow, and it was decided to reduce the length. A new announcement and registration form is in this Bulletin, and anyone wishing to attend should contact Carole immediately. For the September meeting in Cambridge, there has been little response to date. Consideration was given to inviting distinguished speakers, and we all passed lists to Malcolm so that he can make suitable enquiries. Finally, a tentative date is set for a joint meeting with the French Society in France — September 1995!

The various working parties have not submitted anything to report, so we move on. The Council have invited Dr John Benbow to be the Society's Archivist, and there was some discussion of the job description. As most readers will know, John was our President from 1976 to 1978, the recipient of the Annual Award for 1989, and a long time member of the Society.

After a quick look at the Memoranda to see if there are any other actions to perform at this meeting, we move on to deciding where and when to meet over the coming year. A quick look at our watches shows that we have only just gone beyond the three hours, so it's off to the bar to meet John Benbow, and for the President to hand out his complimentary Buck's Fizz. One or two members had to leave for home, but most stayed for dinner. The hotel has a large dining room, which was filled with several parties having a Christmas meal. Crackers were pulled, and party hats donned. A good meal was had by all, and the watch word for the evening was 'tactile'.

The following morning, everyone dispersed after breakfast. Fortunately the weather was kinder than it had been two years prior to this, when the last Council first met at Welwyn (one member had taken forty-four hours to get home in the snow).

MEMBERSHIP NEWS

The following applications for membership were approved at the Council Meeting, Dec. 10th, 1992.

Mr J. P. Cornelisse,
Delft Hydraulics,
P. O. Box 177,
2600 MH Delft,
The Netherlands.
(pet GH)

Mr R. J. English,
Dept. of Colour Chemistry,
The University of Leeds,
Leeds
LS2 9JT.
(fea DFGO)

Mr W. I. Gouldston,
Dept. of Mechanical Engineering,
University of Liverpool,
P. O. Box 147,
Liverpool, L69 3BX.
(fesa DFGJ)

Mr J. Grimsey,
112 College Road,
Sittingbourne,
Kent,
ME10 1JG.

Mr M. Hawe,
Physical Measurements,
Laboratory, Allied Colloids,
Cleckheaton Rd., Low Moor,
Bradford BD12 0JZ.

Dr O. Kramer,
Department of Chemistry,
University of Copenhagen,
Universitetsparken 5,
DK-2100 Copenhagen,
Denmark.

(fesa CDFGHO)

(pea DFGO)

(fesa CDM)

Mr S. Lam,
Dept. of Physical Chemistry,
University of Bristol,
Cantock's Close,
Bristol.
(fes DGF)

Miss J. M. Lowe,
Physical Measurements,
Laboratory, Allied Colloids,
Cleckheaton Rd., Low Moor,
Bradford BD12 0JZ.
(feta EFGHO)

Dr N. Nemoto,
Institute for Chemical Research
Kyoto University,
Uji, Kyoto,
611, Japan.
(pes DM)

Mr J. P. Newbury,
Courtauld's Research & Technology,
P. O. Box 111,
Loakhurst Lane,
Coventry, CV6 5RS.
(fetsa CDEF)

Mr C. O'Donnell,
Dept. of Food Engineering,
University College Dublin,
Earlsfort Terrace, Dublin 2,
Ireland.
(petsa GHL)

Ms L. Ray,
Camtel Sciences,,
27 Alexander Road.
Stotfold, Hitchin,
Herts. SG5 4NA.

Dr S. Ren,
Dept. of Chemical Engineering,
University College of Swansea,
Swansea,
SA2 8PP.
(fea DFGJ)

Mr S. Sinha,
Particle Technology, Chemical
Engineering and Chemical
Technology, Imperial College,
London, SW7 2BY.
(fea GL)

Mr J. C. Winterwerp,
Delft Hydraulics,
P. O. Box 177,
2600 MH Delft,
The Netherlands.
(peta GH)

Professor I. M. Ward, director of the Interdisciplinary Research Centre in Polymer Science at the University of Leeds and past President of the B. S. R., has been awarded the Charles Vernon Boys Medal and Prize by the Institute of Physics for his contribution to the development and application of polymer physics.

EQUIPMENT FOR SALE

The Society has an Amstrad PCW8512 word processor and printer for disposal. Bought about six years ago for the use of the Secretary, it is in perfect working order but surplus to requirements. Offers to buy it should be made to the Secretary, Mrs Carole Moules at the address inside the front cover.

NEWS OF OTHER SOCIETIES

INTERNATIONAL COMMITTEE ON RHEOLOGY

While not strictly a rheological society, some information from the International Committee on Rheology has come into my hands. This committee operates mainly by correspondence but comes together every four years at each International Congress. The proceedings volumes of the XIth Congress contain the Secretary's reports for 1988 and 1992.

The worldwide membership of the twenty one member societies listed below is estimated at 5000 and a twenty second member, the Korean Society of Rheology, joined in 1992.

TABLE 1

MEMBER SOCIETIES OF THE INTERNATIONAL COMMITTEE ON RHEOLOGY
In the order founded (year), and approximate membership in 1992.

1. The Society of Rheology (USA) (1929)	1100
2. The British Society of Rheology (1940)	550
3. Nederlandse Reologische Vereniging (1950)	85
4. Deutsche Rheologische Gesellschaft (DRG) (1951)	300
5. Nordic (Swedish) Society of Rheology (1956)	80
6. Australian Society of Rheology (1959)	60
7. Arbeitsgruppe Rheologie Gesellschaft Österreichischer Chemiker (1959)	80
8. Groupe Français de Rhéologie (1964)	260
9. Rheology Group of the Czechoslovak Chemical Society (1968)	95
10. Societa Italiana de Reologia (1971)	120
11. The Society of Rheology, Japan (1973)	750
12. Belgian Group of Rheology (1974)	120
13. Sociedad Mexicana de Reologia (1975)	90
14. Israël Society of Rheology (1981)	60
15. Spanish Group of Rheology (1981)	70
16. Canadian Rheology Group/Groupe Canadien de Rhéologie (1982)	120
17. Association Argentina de Reologia (1983)	70
18. Indian Society of Rheology (1984)	60
19. Chinese Society of Rheology (1985)	300
20. Slovene Society of Rheology (1987)	50
21. Soviet Society of Rheology (1991)	150

As shown in Table 2 most Societies hold meetings yearly or more often and several produce technical publications. In addition there are many other international meetings and, statistically, there is a rheology meeting taking place somewhere in the world every week of the year. The Secretary, David M. James, concludes that rheology worldwide is strong and healthy.

Table 2

Summary of Activities of Member Nations

Country	National Meetings		Local Meetings		Newsletter issues/year	Technical Publications
	Frequency	Attendance	No/year	Attendance		
Argentina	annual	100	—	—	1	—
Australia	biennial	50	6	30	2-3	Abstracts (biennial)
Austria	annual	30	2-3	15	—	—
Belgium	annual	30	—	—	1-2	—
Canada	—	—	2	25	2	—
China	triennial	150	—	—	—	—
Czechoslovakia	triennial	50	3-4	25	—	Abstracts of Meetings
France	annual	70	2	20	3	<i>Les Cahiers de Rhéologie</i> (annual)
Germany	biennial	200	—	—	—	—
India	biannual	30	variable	—	2	—
Israël	biannual	30	occasional	40	—	—
Italy	—	—	2	50	2	—
Japan	biannual	100	12	50	4	<i>Nihon Reoroji Gakkaishi</i> (quarterly)
Mexico	annual	60	—	—	—	—
Netherlands	biannual	30	—	—	—	<i>Materialen</i> (monthly)
Slovenia	annual	40	—	—	—	Proc. of national meetings
Spain	annual	20	—	—	1	—
Sweden(Nordic)	annual	50	1	10	4	—
U. K.	biannual	75	4	10	4	<i>Rheology Abstracts</i> (quarterly)
U. S. A.	annual	300	—	—	2	<i>J. Rheology</i> 8 issues/year
U. S. S. R.	biennial	300	1	50	—	—

NORTH MIDLANDS GROUP

The 5th meeting was held in the University of Sheffield on Thursday January 7th, 1993 when Dr T. C. B. McLeish spoke about the Rheology of Entangled Polymers and gave an interesting account of reptation theory.

The next meeting will be held on Thursday May 6th in the University of Leeds when Professor I. M. Ward will talk about Creep Behaviour of orientated Polyethylenes and there will be a conducted tour of his laboratory. Pre-registration for this meeting is essential.

Although the meetings so far have been very successful, it is very disappointing that little interest has been shown by members in industry. The whole purpose of the Group is to encourage cross-fertilisation of ideas from one field of rheology to another and from academic work to industrial application. To this end, all talks are at a level that assumes no previous knowledge of the particular topic. It is hoped that more members will take part, especially some from industry.

If those from industry fail to join in activities of this nature they have no right to make any criticisms of the 'ivory tower' variety.

Contact Dr G. H. Tattersall, 174 Millhouses Lane, Sheffield S7 2HE (Tel. 0742-365144).

SCHOLARSHIPS AND GRANTS

SCOTT BLAIR SCHOLARSHIP AND SCOTT BLAIR BIORHEOLOGY SCHOLARSHIP

In memory of the work and example of Dr G. W. Scott Blair, the Society and Pergamon Press make available a series of scholarships to encourage excellence in research. The Scott Blair Scholarship of the Society is for research in any field of rheology while the Scott Blair Biorheology Scholarship, funded by Pergamon Press, but administered by the Society, is for research in biorheology. The aim is to enable the scholars to undertake activities which would not normally be possible without such a grant, such as a period of work at an overseas University. Both scholarships are available for award.

PhD students, or equivalent, who are completing their first year of research, and are members of the British Society of Rheology, may apply to become a Scott Blair Scholar. PhD students, or equivalent, who are completing their first year of research in the field of biorheology, and are members of the British Society of Rheology, may apply to become a Scott Blair Biorheology Scholar.

The scholarships will have a value of £500 per annum (or such

value as shall from time to time be decided by Council) to be used at the absolute discretion of the scholar. Subject to a satisfactory report from their supervisors, the scholarships will be renewable for a maximum of one more year. Thus they will usually be available during the second and third years of a normal PhD project.

In addition to the annual payment, Council will consider applications for additional funding to attend conferences. The scholars will be expected to present the results of their research at meetings of the Society, and to make occasional contributions to the Bulletin.

The Awardees of the Biorheology Scholarships will be expected to present the results of their research at meetings of the British Society of Rheology, and will be encouraged to publish them in the Journal "Biorheology" in accordance with its editorial policy.

The award of the Scholarships will be decided by Council who cannot enter into correspondence with unsuccessful applicants, and who reserve the right not to award a scholarship in any particular year.

Applications for the Scholarships should be sent to the Secretary of the British Society for Rheology as soon as possible. The application should be on no more than two sides of A4 paper and contain: personal details of the applicant, a description of the research, notes on any special uses envisaged for a proportion of the scholarship, and an endorsement from a person with supervisory responsibility for the research.

TRAVEL GRANTS FOR STUDENTS

The Society makes grants to students engaged in research in rheology to attend and present their work at meetings on rheology, both its own and those of other societies. Members of the Society, who are full-time students, may apply in writing to the Secretary to be considered for an award and that application should be supported by the student's supervisor. The application should give details of the proposed expenditure, the title and date of meeting and the title of the paper to be presented. They should be submitted in time for consideration at a Council meeting before the money is needed, i.e. by the beginning of March, June, September or December.

The amount and number of such awards will be at the discretion of Council.

CONFERENCE ANNOUNCEMENTS

EXPERIMENTAL RHEOMETRICAL MEASUREMENTS

A meeting to be held at the Manchester Conference Centre, UMIST,
Manchester, on March 31st-April 1st, 1993

This meeting is intended to place an emphasis on practical testing of industrial and biological materials. It aims to bring together product formulation chemists, quality control personnel, and production engineers, on the one hand, and research scientists, students and manufacturers of instruments, on the other. There will be an open session during the meeting for people to identify their application problems with feedback from an invited group of experts as well as the audience. A presentation of the preliminary findings of a study set up by the B. S. R. to look at the transparency of rheometer operation and software analysis will be made. A special feature will be the discussion of a round-robin exercise involving tests on sample material, which has been organised. The results will be discussed at this meeting, with representatives of manufacturers present. To register please complete the accompanying form.

Papers to be presented include the following:

Microbial Polysaccharides as a Coating Component, Jan-Eric P. Nordström
(Royal Inst. of Technology, Stockholm).

Practical Rheology for Polymer Production and Processing, Dr K.-H. Moos
(Göttfert GmbH., Buchen)

Bed Shear Stress Measurements on Elastico-Viscous Liquids, T. E. R. Jones
et al (Plymouth Polytechnic)

Dynamic Modelling of Electro-Viscous Liquids subjected to Non-Sinusoidal
Shear Stresses, T. E. R. Jones *et al* (Plymouth Polytechnic).

A Method of Estimating the Confidence Limits of Curve Fitting
Parameters, Dr D. C-H. Cheng (Letchworth).

Definitive Load Enhancement Effects by Polymer-Thickened Oils using the
Journal Bearing Simulator, Dr D. R. Oliver (Dept. of Chem. Eng., Univ.
of Birmingham)

Rheokinetic Analysis of Reactive Compounding in a Laboratory Mixer,
Dr B. Poltersdorf (Brabender, Duisburg).

Slippage during the study of the Rheological Behaviour of Paste Inks,
Dr T. Gregory & S. P. Mayers (Coates Lorilleux, St. Mary Cray)

The Rheology of Fresh Mortar, Dr P. F. G. Banfill (Dept. of Arch. &
Building Engineering, Univ. Liverpool)

BRITISH SOCIETY OF RHEOLOGY
Experimental Rheological Measurements
at Manchester Conference Centre, March 31st — April 1st, 1993

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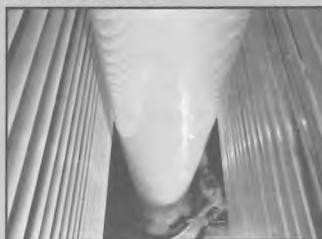
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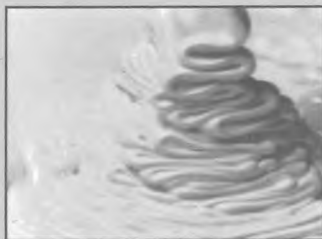
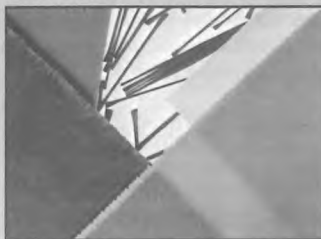
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RHEOLOGY OF PARTICULATE SYSTEMS

The Non-Newtonian Club is holding a joint meeting with the Institute of Chemical Engineers, on the Rheology of Particulate Systems on March 30th, 1993, at U.M.I.S.T., Manchester.

Provisional Programme

- 10. 00 Registration and Coffee
- 10. 30 Introductory Remarks, Professor H. Barnes (Unilever Research).
- 10. 35 Investigating the Flow Behaviour of High Concentration Coarse Solid-Liquid Mixtures, Dr D. L. O. Smith (Silsoe Research Inst.)
- 11. 10 The Behaviour of Particulate Suspensions in Chaotic Liquid Flow, Dr M. R. Mackley (University of Cambridge).
- 11. 45 Recent Advances in Suspension Rheology, Professor H. Barnes (Unilever Research).
- 12. 20 Normal Stress Differences in Concentrated Shear thickening Suspensions, Dr A. Jomha, Dr P. Reynolds (Courtaulds Coatings)
- 12. 55 LUNCH
- 14. 00 Shear-Induced Aggregation of Caboxylated Polymer Latices, Dr J. Husband, Mr P. McGenity (ECC International Ltd.).
- 14. 35 Particulate Rheology in Ceramic Pastes, Dr S. Blackburn (University of Birmingham).
- 15. 10 Rheology and structure of Cement-Based Systems, Dr P. F. G. Banfill (University of Liverpool).
- 15. 45 The Rheology of Solutions of Associating Polymers, Dr T. Annable, (ICI).
- 16. 20 Concluding Remarks and Tea.

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COST: £40 members, £45 non-members, £25 students, retired members.

I enclose a cheque made payable to "IChemE Particle Technology Subject Group" for £.....

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THEORETICAL AND GENERAL RHEOLOGY
 ROBINSON COLLEGE, UNIVERSITY OF CAMBRIDGE
 September 22nd-24th 1993
 A JOINT MEETING OF THE BRITISH AND DUTCH RHEOLOGY SOCIETIES

The meeting will cover recent advances in the rheology of fluids, pastes and particles, and both theoretical and experimental papers, relevant to current theory, are invited, and should be sent immediately to the address below.

Robinson College is the most recent addition to the Cambridge Colleges, and enjoys excellent conference facilities. The College offers accommodation of the highest standard and is set in beautiful grounds. There will be a programme for accompanying partners and a full range of social, musical and wine-tasting events should help to ensure that this will be a memorable meeting.

Please complete the form below and return to: Dr. M.R. Mackley, Department of Chemical Engineering, University of Cambridge, Pembroke Street, Cambridge, CB2 3RA. Tel.: 0223-334784. Fax: 0223-334796. E-Mail: MRM@CHENG.CAM.AC.UK

Please put me on the mailing list for the Theoretical Rheology Meeting

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I enclose abstracts for : (please tick)

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DAYTIME TELEPHONE

KARL WEISSENBERG CENTENARY LECTURE AND DINNER

This will be held on Thursday June 10th, 1993, at the Hilton International Hotel, Newbury. The Lecturer will be Professor A. S. Lodge, University of Wisconsin and the programme will start at 18. 30 followed by dinner at 19. 30 for 20. 00. The event will be sponsored by the British Society of Rheology and Carri-Med plc, manufacturers of the Weissenberg Rheogoniometer. Admission will be by ticket, obtainable by returning the form below. The Society has reserved a block of rooms for those attending. Please indicate your requirements on the form.

BRITISH SOCIETY OF RHEOLOGY KARL WEISSENBERG CENTENARY LECTURE AND DINNER June 10th, 1993

Please send me a ticket for the above event.
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I require overnight accommodation for the night of June 10th, please book me a

single/double room (delete as appropriate).

I understand that I will settle my own account for accommodation.

Price of Accommodation:

Single room and breakfast £70.00. Double room and breakfast £85.00.

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RHEOLOGY COURSE

THEORETICAL, EXPERIMENTAL AND INDUSTRIAL ASPECTS OF RHEOLOGY
JUNE 1ST TO 4TH, 1993

This Rheology Course, sponsored by Carri-Med Ltd., of Dorking, Surrey, will take place at the University of Strathclyde's Educational and Recreational Centre, Ross Priory, on Loch Lomond, Scotland. The course, which is residential, is intended to cover the basics of rheology, modern experimental techniques (including constant stress rheometry, rheogoniometry, elongational flow and industrial aspects of rheology) and lead to state-of-the-art concepts in flow, data acquisition and interpretation.

The lectures will be given by well known rheologists as follows Professor H. A. Barnes, Unilever plc, Professor J. Ferguson, University of Strathclyde, Mr. S. Goodyer, Carri-Med Limited, Dr. N. E. Hudson, University of Strathclyde, Professor T.E.R. Jones, University of Plymouth, Mr. S. Smith, Carri-Med Limited, Dr. A. Tanner, DEVRO Ltd, Professor K. Walters, U. C. W., Aberystwyth.

The cost of the course is £550.00. This includes the course fee, lecture notes, textbook, accommodation (full board) and transport to and from the centre of Glasgow. Accommodation at the Priory is limited and the overflow will be accommodated in a local hotel. All rooms have full facilities.

If you wish to enrol, please complete the attached form (photocopy acceptable) and return it to me. It should be emphasised that the numbers on the course will be limited, so please book as soon as possible to avoid disappointment.

To: Dr N. E. Hudson, Department of Pure and Applied Chemistry, University of Strathclyde, 295 Cathedral Street, Glasgow G1 1XL, Scotland.

I wish (a) more information (b) to attend the Rheology Course.
Please send details to:-

NAME (Mr, Mrs, Miss, Ms, Dr, etc)

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INTERNATIONAL SYMPOSIUM ON VISCOELASTIC FLUIDS
TO BE HELD IN TOBAGO (TRINIDAD AND TOBAGO, WEST INDIES)
JANUARY 4-7TH 1994

CALL FOR PAPERS

Papers are invited on extensional flow, constitutive equations from a phenomenological (and mathematical) point of view, and microstructural modelling (leading to constitutive equations). Other topics will be considered for inclusion in the programme. Abstracts should reach one of the two co-chairmen by March 31st, 1993.

The symposium is organised with the sponsorship of the Caribbean Congress of Fluid Dynamics, the British Society of Rheology, the International Union for Theoretical and Applied Mechanics and the Sociedad Mexicana de Reologia, the University of the West Indies and the University of Newcastle upon Tyne.

Invited speakers include L. G. Leal (U. S. A.), A. S. Lodge (U. S. A.), N. Phan-Thien (Australia) and K. Walters (U. K.).

CO-CHAIRMEN:

Dr H. Ramkissoon, Dept. of Mathematics, University of the West Indies, St. Augustine, Trinidad, W. I. Telex: 24520 UWI/WG. Tel.: +1-809-663-1559. Fax: +1-809-663-9684.

Dr C. J. S. Petrie, Dept. of Engineering Mathematics, University of Newcastle upon Tyne, Newcastle upon Tyne, NE1 7RU, U. K.. Telex: 53654 UNINIW G. Tel.: +44-91-222-6230. Fax: +44-91-222-0191. e-mail (Internet): Chris.Petrie @ Newcastle.ac.uk

ORGANISING COMMITTEE: Dr H. Ramkissoon (Chairman-Trinidad), Dr C. J. S. Petrie (Chairman-U. K.), Dr W. Mellows (Secretary/Treasurer-Trinidad), Professor D. D. Joseph (IUTAM), Professor B. Mena (Mexico).

It is hoped to attract rheologists in the forefront of international research and to have a meeting of a reasonably small size (no parallel sessions) in which informal discussions will be encouraged. Some rheologists from developing countries will be encouraged to attend.

Short abstracts of contributed papers and invited lectures will be available for participants and publication of the papers in a special issue of the *Journal of Non-Newtonian Fluid Mechanics* is planned following the Symposium.

CONFERENCE DIARY

DATE	PLACE	DETAILS
8-10/3/93	Karlsruhe Germany	'Annual Meeting', Deutsche Rheologische Gesellschaft, contact: Prof. Dr K.-H. Habig, Bundesanstalt für Materialprüfung, Unter den Eichen 87, D-1000, Berlin 45, Germany
31/1-2/4/93	Manchester. U. K.	'Experimental rheometrical measurements', contact: Mrs C. A. Moules, Camtel Sciences, 27 Alexandra Road, Stotfold, Hitchin, Herts., SG5 4NA
5-8/4/93	Manchester U. K.	'Ninth Annual Meeting', contact: Polymer Processing Society, 13400 A. David, St. Janvier de Mirabel, Québec, J0N 1L0, Canada.
20-22/4/93	Riga, Latvia	'8th International Conference on Mechanics of Composite Materials', contact: MCM-93, Institute of Polymer Mechanics, 23 Aizkraukles St., Riga 226006, Latvia.
12-15/5/93	Abbaye Royale de Fontevraud, France.	'Behaviour of Polymer Systems from Solution to Melt', contact: ARHEO Conference Secretary, Laboratoire de Rhéologie, IMG-BP53X, 38041 Grenoble Cédex, FRANCE. Fax: +33-76-82-51-64.
25-27/5/93	Nancy, France	'Rheology of Complex Fluids: Food Processing and Similar Applications', Euromech 301, contact: Prof. M. Lebouché, LEMTA-Université de Nancy 1, BP 160, F-54504 Vandoeuvre-lès Nancy Cédex, FRANCE.
26-28/5/93	Montreal, Quebec, Canada	'Recent Developments in Structured Continua III', contact: D. De Kee, Dept. of Chemical Engineering, University of Sherbrooke, Sherbrooke, Qué. J1K 2R1, Canada.
1/6-4/6/93	Ross Priory, U. K.	Short course 'Theoretical, Experimental and Industrial Aspects of Rheology', contact: Dr N. E. Hudson, Dept. of Pure and Applied Chemistry, University of Strathclyde, 245 Cathedral St., Glasgow G1 1XL Tel.: 041-552-5664 ext. 2162.
1-5/6/93	Perm, Russia.	'Influence of Microstructure on the Constitutive Equations of Solids' Euromech 303, contact: Prof. O. B. Naimark, Institute of the Mechanics of Continuous Media of the Russian Academy of Sciences, 1 Akad. Korolev Str., 614061 Perm, Russia.
8-14/6/93	Kiev, Ukraine	'Eighth International Conference on Fracture', contact: ICF8 Secretariat, Karpenko Physico-Mechanical Institute of the Ukrainian Academy of Sciences, 5 Naukova Str., LVIV 290601, UKRAINE.

Travel grants are available to help students attend any of these meetings.

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| 23-27/8/93 | Rhodos, Greece | 'The Mechanics of Swelling' Euromech 290, contact: Prof. T. K. Karalis, Democritus University of Thrace, 67100 Xanthi, GREECE. |
| 30/8-3/9/93 | Minneapolis, Minnesota, U. S. A. | 'Rheological Measurements: Applications to polymers, suspensions and processing', contact: Prof. Chris Macosko, Dept. of Chemical Engineering and Materials Science, University of Minnesota, 421 Washington Ave. S. E., Minneapolis, MN 55455, U. S. A. Tel.: 612-625-6606, Fax: 612-626-1686. |
| 15-17/9/93 | Reading U. K. | 'Physical aspects of polymer science', contact: Prof. D. C. Bassett, J. J. Thomson Physical Laboratory, University of Reading, P. O. Box 220, Reading RG6 2AF. |
| 22-24/9/93 | Cambridge, U. K. | 'Theoretical and General Rheology' contact: Dr M. R. Mackley, Dept. of Chemical Engineering, University of Cambridge, Pembroke St., Cambridge CB2 3RA. |
| 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.. |
| 4-7/1/94 | Tobago West Indies | 'International Symposium on Viscoelastic Fluids', contact: Dr H. Ramkissoon, University of the West Indies, Dept. of Mathematics, St. Augustine, Republic of Trinidad and Tobago. |
| 3-7/4/94 | Akron, Ohio U. S. A. | '10th Annual Meeting' Polymer Processing Society, contact: PPS Secretariat, 13400 A. David, St. Janvier de Mirabel, Québec, CANADA JON 1L0. Fax: +1-514-433-9041. |
| 4-9/9/94 | Seville Spain. | '4th European Conference on Rheology', contact: Prof. C. Gallegos, Departamento de Ingeniería Química, Universidad de Sevilla, (Edificio de Química), 41071 Sevilla, Spain. |
| 26-29/9/94 | Kyoto, Japan | 'First Asia-Oceanian Rheology Conference' Society of Rheology, Japan, contact: Professor Kunihiro Osaki, Institute for Chemical Research, Kyoto University, Uji, Kyoto 611, JAPAN Fax: +81-774-331247. |
| 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. |
| 18-23/8/96 | Québec City, Canada. | 'XIth International Congress on Rheology' Canadian Rheology Group/Groupe Canadien de Rhéologie contact: Prof. D. DeKee, Dept. of Chemical Engineering, University of Sherbrooke, Sherbrooke, Québec J1K 2R1. Canada. |

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