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THE BRITISH SOCIETY OF RHEOLOGY

# BULLETIN



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**1988/89**

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## EDITORIAL

I'm sure everybody who missed David Cheng's lecture 'The art of coarse rheology' presented at the 'Conundra Rheologica' meeting, will be pleased to read the written version presented in this issue. I have seen undergraduates attempt to fit curves to some pretty unusual data before but never an elephant!

It is pleasing to record the celebrations which took place in Wisconsin on the occasion of Bob Bird's 65th birthday. Bob is a real giant of the rheology world and I am one of those very many people who have benefited from working closely with him.

I would draw your attention to the words of the President who is campaigning for increased membership and new initiatives in the society. Also, the Council is urgently seeking nominations for the Scott Blair Biorheology scholarship.

*Peter Townsend*

**Peter Townsend**



THE ART OF COARSE RHEOLOGY  
=====

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Short Title:

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What Rheologists Really Do.

Keywords:

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Rheology, science, application, low-down, elephants.

WARNING:

=====

Do not let your boss read this paper or you may lose your job!

Rheology was defined in 1929 as the science of deformation and flow of matter [1]. This is a very wide-embracing definition and covers just about everything. It covers Boyle's law of 1661 and the Ideal Gas Law. It upsets the practitioners in branches of physics that are already well established, such as thermodynamics, hydrodynamics, aerodynamics, structural engineering and soil mechanics. They consider rheologists up-starts and think that nothing that the rheologists study is anything new.

An alternative definition is needed and this is: Rheology is what rheologists do. No one can object to this, but it does not tell anybody anything.

In this paper I will examine what the rheologists really get up to. I have some 25 years of active service in the field and after this time I think I should know what I am talking about. I will deal with the following topics one by one: (1) description of rheological behaviour, (2) measurement of rheological properties, (3) material science aspects of rheology, (4) applications of rheological data, and (5) some sociological aspects of rheology.

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Presented to the British Society of Rheology Annual Meeting "Conundra Rheologica", Dr G.W. Scott Blair Memorial Conference, Royal Holloway and Bedford New College, Egham Hill, Egham, Surrey, 7-9 September 1988.

## The Description of Rheological Behaviour

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At once we are faced with the problem that the simpler behaviour has already been studied by people like Newton and Einstein, and we are left with the more and more complicated behaviour to deal with. New terms have to be invented and they may not be generally accepted even if they have attained official status in a national or international standard glossary of terms. Some of these terms are: apparent vs true viscosity; pseudoplasticity vs shear thinning [2]; rheopexy vs negative thixotropy [2, 3]. Some people take these terms to be synonymous. But they cannot be exactly the same or there is no need for the separate words.

Not just terminologies but also concepts: Does the presence of normal stress always mean elastic property in a material? Does yield stress exist or not [4]? Do we need thixotropy to describe certain behaviour or does viscoelasticity cover all? Do suspensions, particularly very high concentration systems, have unique viscosities [5]? Can steady stretch rate extensional viscosity be measured or not [6]? What exactly is a Boger fluid? I can write (and have written, see references) short essays on each of them; some not all that short either!

Maybe some controversies are due to inexact or incomplete understanding, but maybe there is more to it than meets the eye.

I sometimes think that we use the term "thixotropy" in a special way. Where the molecular dynamics is known, we talk about viscoelasticity. We do not describe the time-dependent properties of suspensions arising from particle migration and phase separation as thixotropic. We seem to reserve thixotropy to describe materials where the exact physical and chemical bases of rheology are not understood in detail.

On the question of whether steady rate can be achieved or not in extensional viscosity measurement: maybe if it is difficult to reach equilibrium in a viscometer, it would also be difficult to attain steady state in practical flow situations. So how relevant is the steady rate viscosity value anyway?

We spend a lot of effort arguing about definitions when we should be arguing about facts. It is only when a new term is misunderstood, misquoted and misused, that a rheological phenomenon can be said to be established. This just adds to the richness of language.

I sometimes think that research in rheology is like the five blind men who want to discover the elephant (Fig. 1). After a lot of argument/theorising they decided to conduct an experiment and they rushed off to the zoo and started exploring. One blind man said: Ah, I know! The elephant is flat like a wall. Another said: No, no, it's like a thick rope. The third said: You are both

# 瞎子摸象



①幾個瞎子聚在一起閒聊，說著說著，話題轉到象的身上。

②我長這麼大，還不知道象長得是什麼樣子哩。



③我也是。



是呀！象到底是什麼樣子？



我……我也沒「見」過呀！



「哈！我知道了，象的形狀像一面牆。」



「可不！象的形狀像一條繩子。」



④五個人都有同感，於是一致決議：請人帶他們去「摸」象。

⑤有一天，這羣瞎子終於有個機會知道象是什麼樣子了。



只見他們興高采烈地靠近大象身邊，很專心地摸了起來。

「哈！我知道了，象的形狀像一根柱子。」



「你們都錯了，象的形狀像一條蛇。」



但他們各持己見，互不相讓，每個人都以為自己摸到的部分就是代表全部，以為自己的說法才是正確的，最後終於吵了起來。



們瞎子看不見東西，不知道象是個龐然大物，全身又有不同的部位，因此各自下了錯誤的結論；有時我們對一件事的瞭解不夠透徹，卻要自作主張，妄下結論，自然會發生很大的誤差，就好比是「瞎子摸象」一般。

Fig.1 Blind men discover the elephant

wrong, the elephant is like a floppy curtain. The fourth said: It's like a big column, and the fifth blind man said: It is like a snake. They cannot agree among themselves and they continued to argue with each other long after they left the zoo/conference hall.

#### The measurement of rheological properties

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To paraphrase a well-known classification, rheologists may be divided into those who build apparatuses that can hardly be operated (these are research people), and those who determine what can hardly be measured (these are industrial QC people).

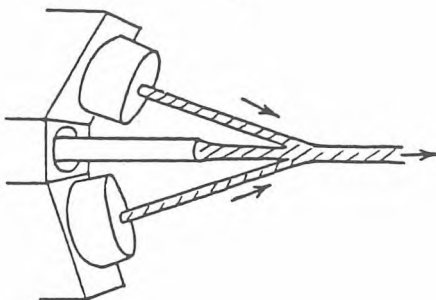
I would like to approach the discussion of rheological measurement with a historical perspective. There is, with rheology, as with any human endeavour, a bandwagon to be ridden. Before the science was made official in 1929, there was classical physics and in industry rheological measurements were carried out by Bill. He was the person to whom Scott Blair dedicated his book [1]. Bill would grab a handful from a bucket, squeeze the stuff in his fingers, sniff it, hold it to his ear, or chew on it. Then he looked wise and said "OK" or "Leave it for another ten minutes".

After 1929, rheology became a science in its own right. Through the 1930's and 40's, there was a lot of research interest in non-Newtonian viscosity, side by side with classical elasticity and plasticity. In industry, rheology was in the neolithic age but towards the end of the period QC people had begun to use Redwood and other flow cups and the MacMichael viscometer.

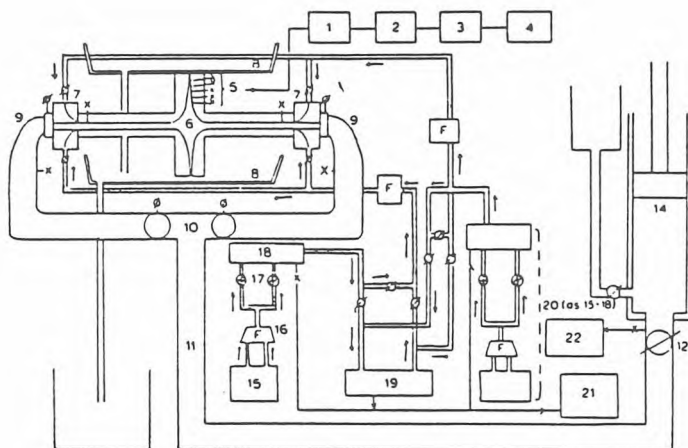
The research bandwagon gathered momentum in the 50's and 60's. Most research rheologists were busy with plotting shear stress vs shear rate flow curves and the measurement of normal stresses. Some worked on oscillatory and creep testing, but this required rather complicated rheogoniometers and mathematical skills for data interpretation that are beyond the run of the mill rheologists. Still commercial instruments now appeared in increasing numbers and by the 70's, everybody that was anybody was plotting flow curves almost as a routine.

Now as we approach the end of 1980's and into the 1990's, the research bandwagon is fully latched onto extensional viscosities, uniaxial, planar, uniform biaxial, multiaxial and all. All sorts of wonderful apparatus and machines have been devised. Such as:

The triple-jet (Fig. 2, [7]), where the central sample fluid jet is stretched by the two outer jets which have somehow been made to play on it. I marvel at how the idea was thought of in the first place, not to mention the skill and patience that must be needed to get the jets to cooperate.

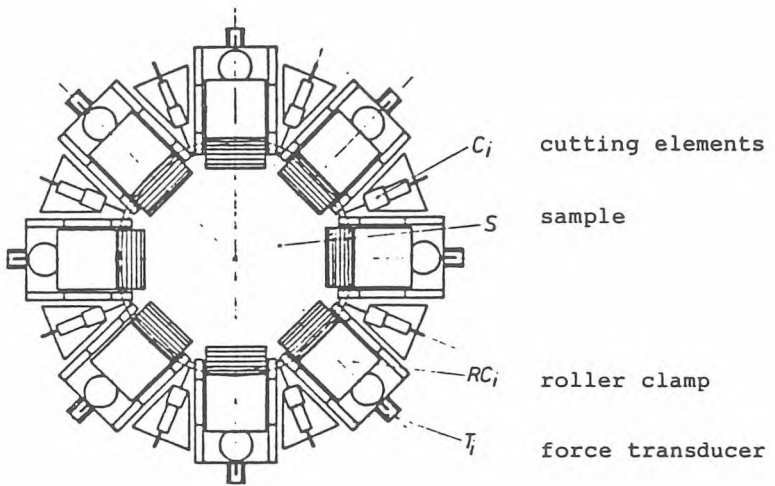


**Fig.2 Triple-jet method for extensional viscosity <7>**

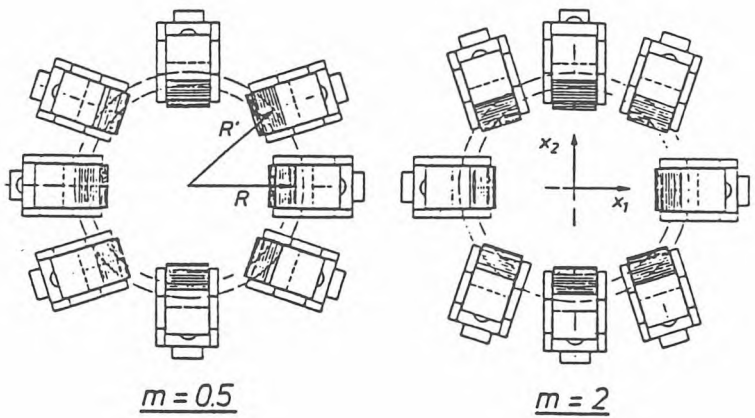


- |                                      |                                                                    |
|--------------------------------------|--------------------------------------------------------------------|
| 0 Valve                              | 11 Sample delivery pipe                                            |
| F Filter                             | 12 Main sample feed valve                                          |
|                                      | 13 Sample transfer valve                                           |
| 1 Multichannel pressure indicator    | 14 Actuator and sample reservoir                                   |
| 2 Data logger                        | 15 Lower lubricant reservoir                                       |
| 3 Apple microcomputer                | 16 Lubricant line filter                                           |
| 4 Printer                            | 17 Gear pumps                                                      |
| 5 Nozzle pressure transducers        | 18 Pressure reservoir and feedback path to gear pump control panel |
| 6 Rheometer test section             | 19 Mass flowmeter                                                  |
| 7 Inception boxes                    | 20 Upper lubricant delivery system (as 15-18)                      |
| 8 Waste collection trays             | 21 Upper and lower lubricant flowrate display                      |
| 9 Horns                              | 22 Actuator display and control panel                              |
| 10 T-piece and sample balance valves |                                                                    |

**Fig.3 Convergent flow extensional rheometer <8>**



**Fig.4 Biaxial extensional rheometer <9>**



**Fig.5 Mutiaxial extensional rheometer <10>**

The convergent flow extensional rheometer (Fig. 3, [8]) was commissioned in Aberystwyth. Just look at the peripherals surrounding the test section. It must be quite something for the Abers team to have coaxed the beast to play.

The third example is the biaxial rheometer developed by Meissner and his colleagues [9]. The sample sheet is stretched by being pulled with eight rollers (Fig. 4). The scissors are needed to cut the sample sheet to ensure uniform deformation. Just imagine the rollers whirling and the scissors snipping away all at the same time.

If the uniform biaxial extensional rheometer is complicated, just you see the latest multiaxial version (Fig. 5, [10]). Not only do the eight rollers rotate together and the eight pairs of scissors snip away, at the command of the computer, four of the pivotted rollers swing through an angle, to pull the sheet in a different direction.

As I said earlier: there are rheologists who design machines that it is a wonder that they work.

The other class of rheologists continue to struggle with materials that cannot be measured. They are slowly catching up with the research rheologists. By now, the 80's, the measurement of flow curves is decidedly old hat. The bandwagon that the QC people are trying desperately to hitch onto is creep and oscillatory testing. And anyone, who is anyone, will have one of the latest controlled-stress machines to use.

This is where we must acknowledge the role of the instrument manufacturers and their sales engineers in the advance of rheological measurement in industry. The research rheologists may develop wonderful apparatuses and train PhD students, but it is the manufacturers and the sales people who are the real driving force in pushing rheology into the wider world. With proprietary rheometers interfaced with microcomputers and a legion of peripherals, it is now kids' stuff. You do not need to have any O-levels to carry out rheological measurements.

It is so easy to run a test: just press the space bar and the run starts automatically. You can then go for lunch. Or, to justify the case of purchase (namely to increase productivity), you can go to the library instead. And come back later to find that you have forgotten to put the sample in the rheometer.

More and more industrial rheologists are buying these computerized instruments and manufacturers are having a grand time of it. It does not matter what is behind the monitor screens or in the rheometers - no user asks about that anyway; and even if an awkward so-and-so does so, a manufacturer can plead industrial secrecy - it does not matter how the machine works, as long as

the user can choose his or her own colour scheme, and graphs can be dumped and copied for reports. The data printout must include a yield value or two. (Oh, yes, I have seen a computer printout giving two yield stress values for one set of test data.)

An additional selling point is the games package. The next generation of software will also have to write the report for the user. You think this is far fetched? It is called desk-top publishing.

But the disadvantage with computerisation is data diarrhoea, leading to constipation of understanding. At the BSR Annual Conference in Canterbury in 1987, one speaker lamented that he had a clear picture of the significance of his research results when he composed the abstract of his paper. But he went and carried out more measurements before he went to Canterbury.



Before I leave the subject of rheological measurement, I will give you a hint about ensuring that nothing goes wrong with your rheometric tests. When you return after this meeting, you should nail up a horseshoe in your lab. Better still nail it to your rheometer. I was told that it works even if you do not believe in it.

#### Material Science Aspects of Rheology

-----

Rheologists also aim to understand the molecular and particulate nature of materials. It was Sir Cyril Hinshelwood, the chemist, who classified scientists (which includes rheologists) into those who explain what cannot be measured and those who measure what cannot be explained. To build a theoretical model and have it named after you is a way to gain immortality. It is also good for career development and many of us go in for that.

If you start off with one sphere, you can solve the Navier-Stokes equation for the motion of one body and derive the intrinsic viscosity of the suspension, the Einstein factor of 2.5. If you have one molecule, you can obtain the intrinsic viscosity for a polymer solution. If you have two bodies, you can develop inter-relationships. (If you are thinking of what I am thinking, you have a dirty mind.) In a high concentration system, interrelationships can multiply factorially (and you can have an orgy - oops! Sorry for the slip of tongue). Seriously, with high concentrations, you have to start considering phase-space distribution functions and statistical mechanics. This would make you more a thermodynamicist than a rheologist, and the subject is outside the scope of this lecture (meaning I do not understand it myself).

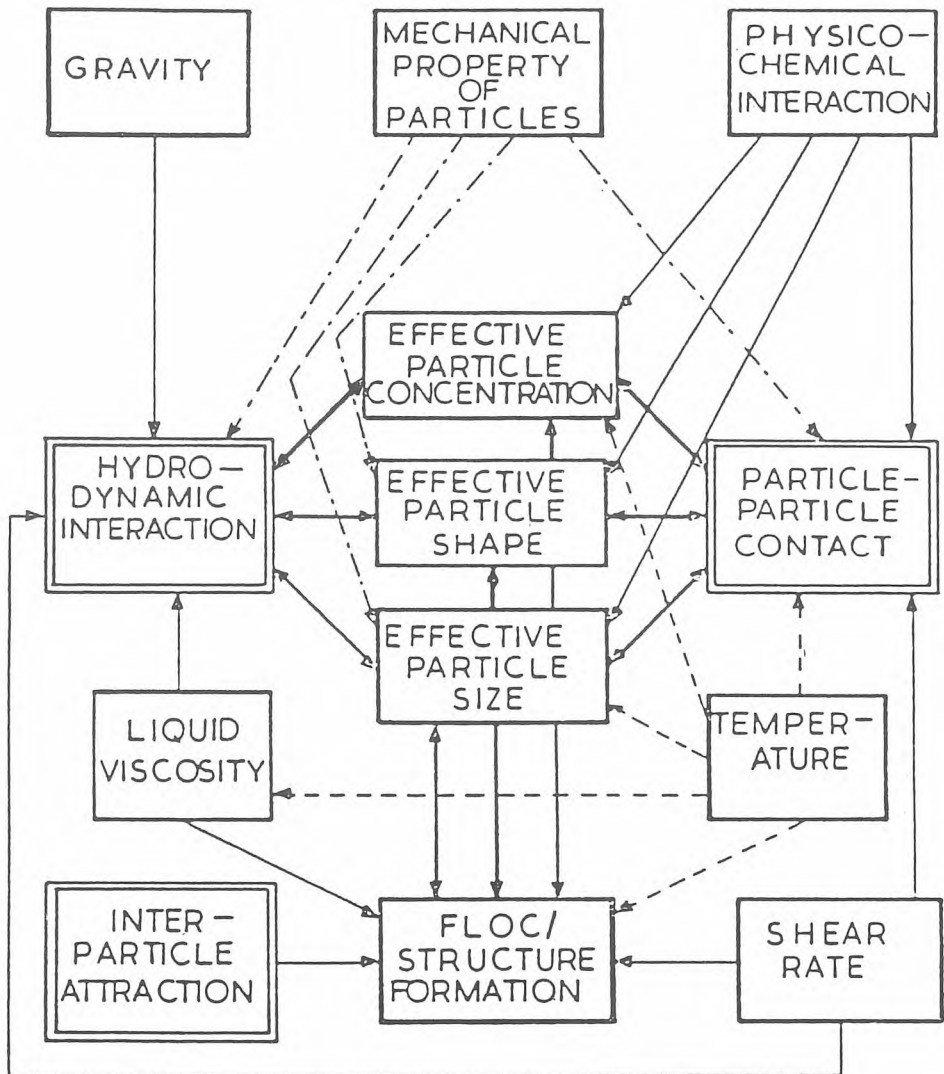
Apart from the Navier-Stokes equation, which covers hydrodynamic interaction, there are many other factors to take into account and this complicates theoretical modelling in a different way. For example, Table 1 lists some of the factors involved for polymer solutions and melts [11, 12].

I am more familiar with particulate systems or suspensions [13]. Fig. 6 shows the factors to be built into a thixotropic model of dispersions and examples of the development of models from first principles are by Casson [14] and the elastic floc model of Hunter et al. [15]. Fig. 7 shows the elastic floc, which is made up not just of particles, but of flocculi, flocs and floc aggregates. Table 2 lists the details of factors that account for viscous dissipation. It can be seen that this approach is very complicated.

Luckily, as Josiah Willard Gibbs (of Gibbs free energy fame) said: The whole is simpler than the parts. We do not have to worry about the details to build a model; a mean field theory or lumped parameter approach may be used.

Table 1. Factors involved in model building for polymer solutions and melts

- 
- (1) Molecular structure (topology)  
molecular weight
  - (2) Molecular configuration (size and shape)  
rigid or flexible molecules
  - (3) Excluded volume effect
  - (4) Polymer-solvent interaction
  - (5) Intramolecular forces  
Hookean or FENE tension
  - (6) Hydrodynamic interaction  
Rouse free draining or Zimm interaction
  - (7) Polymer-polymer interaction (concentration)  
encounter frequency, entanglement, reptation
  - (8) Brownian motion (temperature)
  - (9) Solvent viscosity or rheology
  - (10) Solvent velocity (shear or elongation)
-



**Fig.6 Interplay of factors affecting suspension viscosity <13>**

One such model was derived by Moore in 1959 (Table 3). All the complication is smoothed out into a simple structural parameter,  $\lambda$ , and two rate processes for structural break-down and build-up. The equation of state and the rate equation describe a thixotropic model and give a shear thinning flow curve.

In 1965, Cross went through a different argument and came up with another model (Table 4), again composed of an equation of state and a rate equation. But, if we change the notation:

$$L/L_0 = \lambda$$

$$\eta_0 = \eta_{\infty} + c \quad \eta_{\infty} = \eta_0$$

$$k_0 = a \quad k_1 = b$$

we see that the Cross model, with  $m = 1$ , is exactly identical with the Moore model. (Cross showed that  $k_2P/k_1L_0 = 1$ .)

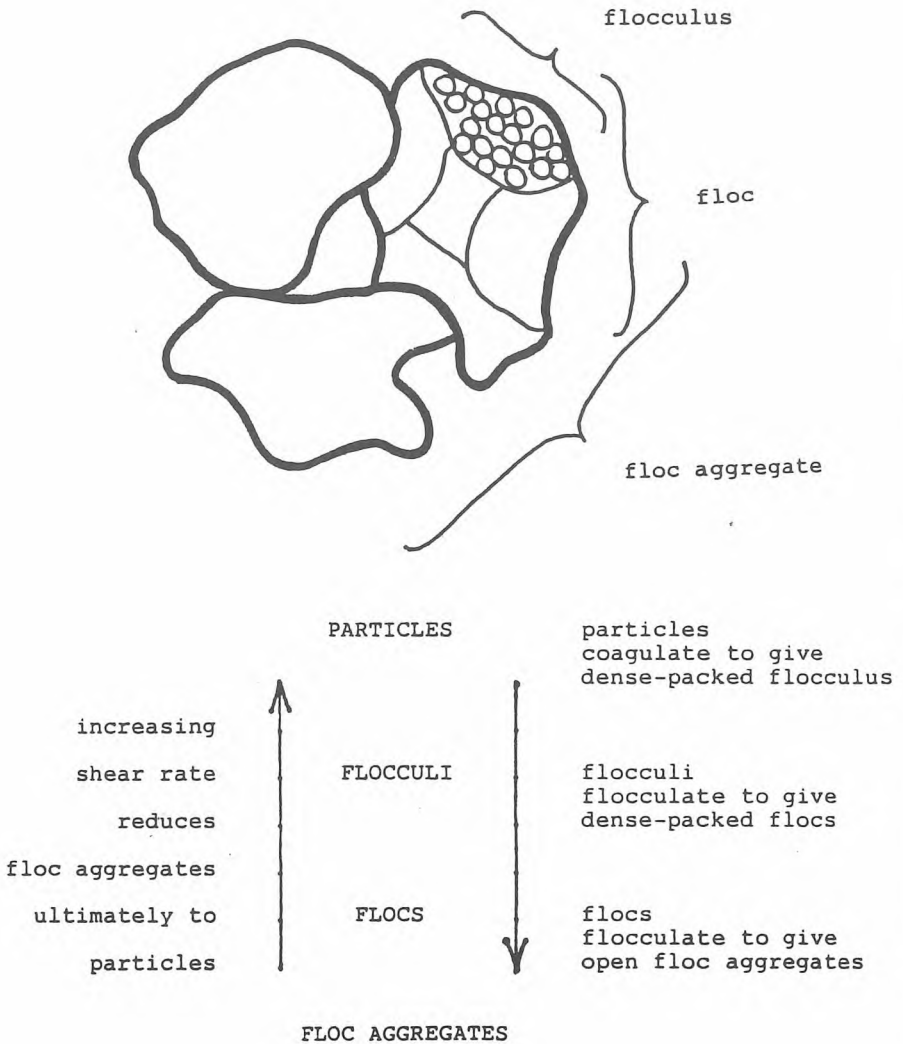
There are many other examples in the literature, where researchers described different molecular and particulate processes to come up with similar, but slightly different, models. In 1980, I counted 54 of them [13], but I have seen other new ones since then.

Now, it is generally accepted, that if a theoretical equation fits experimental data, the model is then held to be true for the material tested. But, if different models can give the same constitutive equation, how can we tell which model is correct?

On the other hand, it is useful to realise that with different

Table 2. Energy Dissipation in the Elastic Floc Suspension

- 
- (1) Viscous dissipation in "free" liquid -  
depends on floc concentration and floc shape
  - (2) Energy needed to
    - (i) break or make floc aggregates
    - (ii) break or make flocs
    - (iii) make flocculi -
 depends on flocculus/floc/floc aggregate geometry  
and potential energy at interfaces
  - (3) Dissipation within flocs -  
depends on bond stretching  
(potential energy at interfaces) and  
Stokes resistance due to particle movement in  
"immobilised" liquid
-



**Fig.7 Elastic floc model <15>**

incantations, one can conjure up the same constitutive equation. So, if you want to create a model of your own, it is best not to know the literature too well. Or you will loose the chance to be an independent discoverer and be credited with the [Tom-Dick-(Your Name)] model.

One problem with the proliferation of model equations is in the choice for data fitting. It is easy to try the usual equations, power law, Bingham, Herschel-Bulkley and Casson. The Cross equation is also gaining popularity recently. But invariably these do not fit the data. Which one of the 50-odd equations should one try next?

I have, elsewhere [13], suggested an algorithm whereby one can generate rheoretical (advanced typist mistake) models by cranking a handle. The idea is that the algorithm would generate a hierarchy of equations with increasing number of parameters. One

Table 3. Features of the Moore Model

- 
- (1) 'Structure composed of "links"
  - (2) Rheological behaviour governed by number of links
  - (3) Quantity (structural parameter) used to indicate state of build-up is defined as:

$$\lambda = \frac{\text{no. of links current}}{\text{no. of links in completely built-up state}}$$

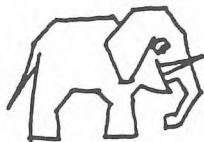
- (4) Complete breakdown:  $\lambda = 0$   
Complete build-up:  $\lambda = 1$
- (5) At each value of  $\lambda$ : viscosity is
 
$$\eta = \eta_{00} + c\lambda \quad \text{[Equation of state]}$$
- (6) Build up at rest: rate proportional to number of links remaining to be formed
- (7) Breakdown under shear: rate proportional to shear rate and to number of links present
- (8) Net rate:

$$\frac{d\lambda}{dt} = a(1-\lambda) - b\lambda\dot{\gamma} \quad \text{[Rate equation]}$$

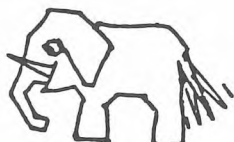

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would start with an equation with a small number of parameters and only resort to higher order equations if the simpler ones fail.

This approach follows the fact that the more parameters in an equation, the better the chance it has of fitting a set of



complex data. The French mathematician, Cauchy, is reputed to have said that given 6 parameters he would fit an elephant and with a 7th he would make it wag its tail. The Israeli rheologist, Silberberg commented that with any more parameters the elephant can be made to dance a samba.



berberg commented that with any more parameters the elephant can be made to dance a samba.

Table 4. Features of the Cross Model

- (1) Flocculation explains pseudoplastic flow
- (2) Flocculation consists of groups of linked particles in random kinked chains
- (3) Average number of links per chain at  $\dot{\gamma} : L$   
Average number of links per chain at  $\dot{\gamma} = 0 : L_0$   
Complete deflocculation as  $\dot{\gamma} \rightarrow \infty : L \rightarrow 0$
- (4) From Bueche's treatment of linear polymer:  
 $\eta$  proportional to number of segments/chain:

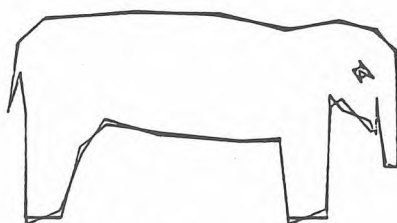
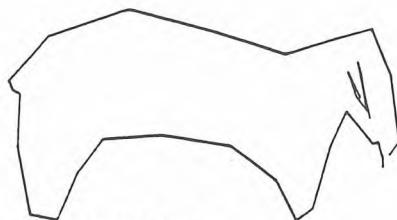
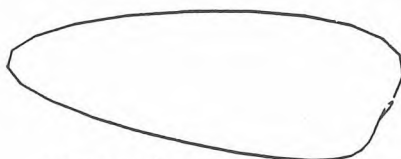
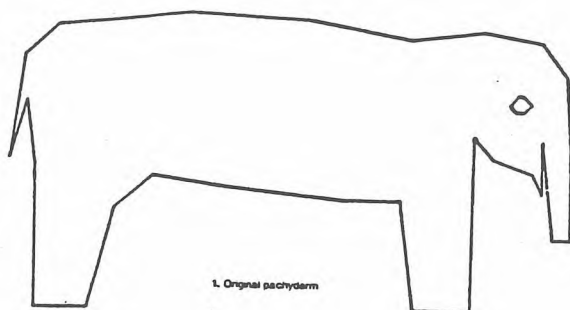
$$\eta = \eta_{\infty} + BL \quad \text{with } \eta = \eta_0 \text{ when } L = L_0$$

$$\frac{\eta - \eta_{\infty}}{\eta_0 - \eta_{\infty}} = \frac{L}{L_0} \quad [\text{Equation of state}]$$

- (5) Linkages formed by Brownian motion;  
rate constant:  $k_2$
- (6) Rupture rate constant:  $k_0 + k_1 \dot{\gamma}^m$
- (7) Net rate:

$$\frac{dL}{dt} = k_2 P - (k_0 + k_1 \dot{\gamma}^m) L \quad [\text{Rate equation}]$$

$P$  is total no. particles/unit vol., linked or not



**Fig.8 Least-squares fitting of an elephant**

This was put to the test by J Wei. He defined his elephant by 36 points in two-dimensions (Fig. 8) and operated on the x,y-coordinates of these points, using least-squares technique to fit Fourier sine series to the data. When he used a 5-constant equation, the reconstituted elephant is an egg. With 10

constants, the egg shows some development. With 20 constants, an embryo is formed. And it is only with 30 constants that a recognisable elephant is obtained.



Wei subsequently showed that a coordinate transformation of the elephant would give a different view, which reduces the number of parameters needed to fit the elephant by half.

#### Applications of Rheological Data

Rheological data are used for model testing. I do not know how general it is with different kinds of materials, but certainly with suspensions of spherical solids in a liquid, even a cursory survey would show that there is a surfeit of data. Rutgers in his 1962 survey quoted some 280 references [18]. It seems that given a theory, there is somewhere a set of data that will fit the model equation. And also, given a set of data, a theory can be readily devised to explain them. This makes for a theoretician's paradise.

Rheological data also find uses in a wide range of industrial applications. Companies go through alternate phases of looking to physics and chemistry to solve problems. When the management has faith in physics, rheologists would be engaged to work on product formulation, quality control and trouble shooting on the plant. The first thing a rheologist does is to measure the rheological property. Now, in order to do a proper job, you have to be something of a material scientist as well as a fluid mechanistic. The exact flow and deformation that the material undergoes in the plant and in end use has to be known in order that the relevant rheological properties can be measured. But the flow processes generally look complicated, and they are; they are also unknown. It becomes a matter of research to analyse them. You are not encouraged to carry out research of this kind, but you can get agreement to consult the experts. But all they do is to confirm the lack of knowledge and want you to fund a programme of research. In the end all you can do is to measure what your viscometer or rheometer can measure and hope that what you measure will correlate with the process behaviour of your materials and the quality of your products. This is finger-printing and maybe you will find the culprit.

At one time non-Newtonian viscosity was held to be the key to solve industrial problems and everyone measured flow curves. Then it was the turn of normal stresses. Now we look to dynamic viscoelastic properties, creep compliance and  $G'$  and  $G''$ , for salvation, as every rheometer sales engineer would be pleased to inform you. The research rheologists are working hard on extensional viscosity in case dynamic properties prove to be inadequate. You can be assured that affordable extensional viscometers are being developed by the manufacturers right now.

But as I look into this matter in detail, I begin to feel more and more that this may be an impossible task [19]. For example, the flow about a rotating sphere and the corresponding power consumption are given by the material constants (the Rivlin-Ericksen parameters) in certain combinations:  $\mu, \alpha_1, (2\alpha_1 + \alpha_2), (\beta_2 + \beta_3), (\gamma_3 + \gamma_4 + \gamma_5 + \gamma_6/2)$  and  $\gamma_6$  [20, 21]. These are exactly the combinations that appear in viscosity and normal stress coefficients, or can be derived from such data:

$$\begin{aligned}\eta &= \mu + 2(\beta_2 + \beta_3)\dot{\gamma}^2 \\ \psi_1 &= -2\alpha_1 - 4(\gamma_3 + \gamma_4 + \gamma_5)\dot{\gamma}^2 \\ \psi_2 &= (2\alpha_1 + \alpha_2) + 4(\gamma_3 + \gamma_4 + \gamma_5 + \gamma_6/2)\dot{\gamma}^2\end{aligned}$$

There is no need to measure extensional viscosity:

$$\eta_E = 3\mu + 3(\alpha_1 + \alpha_2)\dot{\gamma}_E + 9(\beta_1 + 2[\beta_2 + \beta_3])\dot{\gamma}_E^2 + 3(5[\gamma_1 + 2\gamma_2 + \gamma_3 + 2\gamma_4] + 6[\gamma_5 + \gamma_6 + \gamma_7 + \gamma_8])\dot{\gamma}_E^3$$

Everything seems alright then.

But, if we use the 6-constant Oldroyd model to determine the sedimentation of a small particle in a polymeric solution, the model parameters appear in certain combinations in the equation for drag coefficient [11, 22]:

$$\frac{F_d}{3\pi\eta_0 v_{sd}} = 1 - \frac{1}{2275} \left[ \frac{401}{11} - \frac{\lambda_2}{\lambda_1} - 39 \left( 1 - \frac{\lambda_2}{\lambda_1} \right) - 471 \left( \frac{\sigma_2 - \sigma_1}{\lambda_1^2} - 1 \right) \right] \frac{(2\lambda_1 v_s)^2}{(d)^2}$$

$$\text{where } \sigma_i = \lambda_i \mu_0 + (\lambda_1 - \frac{3}{2} \mu_0) \lambda_i \quad i=1,2$$

When we attempt to measure them in viscometers and rheometers, we find that the parameters appear in different combinations [11]:

$$\frac{\eta}{\eta_0} = \frac{1 + [\lambda_1 \lambda_2 + \mu_0 (\lambda_2 - 3v_2/2) - \lambda_1 (\lambda_2 - v_2)] \dot{\gamma}^2}{1 + [\lambda_1^2 + \mu_0 (\lambda_1 - 3v_1/2) - \lambda_1 (\lambda_1 - v_1)] \dot{\gamma}^2}$$

$$\frac{\psi_1}{2\eta_0\lambda_1} = \frac{\eta(\dot{\gamma})}{\eta_0} - \frac{\lambda_2}{\lambda_1}$$

$$\frac{\eta'}{\eta_0} = \frac{1 + \lambda_1\lambda_2\omega^2}{1 + (\lambda_1\omega)^2} \quad \frac{\eta''}{\eta_0} = \frac{(\lambda_1 - \lambda_2)\omega}{1 + (\lambda_1\omega)^2}$$

Measurement of the complex viscosities allows us to determine  $\eta_0$ ,  $\lambda_1$  and  $\lambda_2$  separately. But the other three parameters are horribly mixed up in shear viscosity, and the normal stress coefficient does not provide additional information.

What this means is that without a proper analysis of each flow situation, there is no general rule about which rheological property should be measured. The blanket advice is to measure everything, but this is a daunting task and not a practical proposition at most times. So, I see that industrial rheologists will continue to look for shortcuts, searching for just one rheological property as the key to solve their problems. But there are many rheological properties to cover .....

In another case, that of the viscosity of dense suspensions: at one time, I was thinking that they do not have an unique viscosity. I now know that the problem is that the result from a viscometer is a combination of viscosity property,  $\eta(c) = \eta_0 f(c)$ , and particle concentration profile changes in viscometers due to particle migration and phase separation,  $c = c(r)$  [23]. In tube viscometers, the flow rate and pressure are related by the equation:

$$V = \frac{P}{2\pi L R^2 \eta_0} \int_0^R \frac{r^3}{f(c(r))} dr$$

In coaxial cylinder viscometers, the speed and torque are related by:

$$\Omega = \frac{T}{2\pi h \eta_0} \int_{r_1}^{r_2} \frac{1}{f(c(r))} \frac{dr}{r^3}$$

We cannot easily unravel the two effects in viscometers and to recombine them to predict process behaviour, in which the geometry is different, without a lot of research.

I am wondering whether it is really profitable to measure rheological properties in viscometers and rheometers. I have therefore been suggesting the abandonment of viscometric and rheometric measurements and advocating the use of the engineering scale-up approach, or at least to use rheometers, where the geometry is suitable, as mimics of processes. I was trained as a chemical

engineer before I became a rheologist; maybe I am reverting to type.

What all this means is that there is no simple answer to rheological problems. There are a lot of different rheological properties to try out in the shortcut approach or several scales of experiments to do in the scale-up approach. There is a lot to do for rheologists yet.

#### Some Sociological Aspects of Rheology

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The rheologist writes up research results for publication, for the glory of your institution and to advance your career. Often your paper is not appreciated or not understood by the referees, supposedly one's peers, when you submit it to a regular scientific journal; especially if your paper really breaks new ground. There are many ways to circumvent this difficulty. You can get it published as an internal report of your laboratory. Or submit it to a conference for inclusion in the published proceedings, preferably one organised by a professional conference organiser rather than a learned society because the former is less fastidious about refereeing; or get yourself onto the organising committee. If all else fails, get one of the scientific publishers to start a new journal with you as editor-in-chief. Or publish it privately. Now-a-days, with the availability of desk-top publishing, this needs not be an expensive business. Some people have in fact found private publishing profitable. And practice at it might give one an alternative career, just in case.

Rheology is a growing field. With more and more PhDs coming out of graduate schools, the subject is beginning to be taught at the undergraduate level. But this supply does not meet the demand and with instrument manufacturers doing quite a bit of promotion to drum up interest, there will continue to be scope for post-experience, continuing education training courses and specialist topic seminars. Such courses used to be run by universities and polytechnics but they are now organised by research associations and contract research laboratories. The manufacturers themselves mount these courses and seminars also and lately, professional conference and course organisers have also moved in. Clearly the demand is substantial and there is profit to be made out of it.

Industry send staff to these courses and seminars to look for instant solutions to their problems. In the first instance, the participants will be quite content if they learn how to determine a nice flow curve, creep curve or others. But, once this becomes routine, they will then seriously consider what to do with the results in relating them to application problems. Some industrial rheologists are already at this stage and some are known to

attend these offerings one after the other, over many years, in search of the grail. But, here, as I have indicated earlier, there is no ready answer except that research is needed. This is good news for the research rheologists.

And so, between

- academic researchers inventing new rheological functions to measure and new apparatus to measure them,
- instrument manufacturers developing new rheometers and more and more sophisticated and faster software,
- industrialists looking for solutions to QC and other application problems,
- consultants interested in promoting technology transfer,
- teachers to teach rheology to undergraduates,
- students, to whom a career in rheology is highly recommended, and
- practising rheologists doing what they can about application,

the bandwagon rolls on. The grail is always almost in sight but never quite reached. There is clearly plenty to do in rheology and therefore for rheology as a career. Long may this continue to be the case.

P.S. The role of elephants in psychorheological studies was described by Scott Blair [1, p.218-219]. At the 10th International Congress on Rheology, Sydney, 1988, K. Osaki in discussing the tube model theory of Doi and Edwards stated that entanglement is like an elephant: if you cut and look at its trunk, it is like a tube.

#### Acknowledgement

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This paper is inspired by Michael Green, author of The Art of Coarse Acting/Golf/Rugby/Drinking/Sex/Office Life. Fig. 1 is modified from Sinorama, 1981, 6(3), 60-61. Fig. 8 is modified from J. Wei, Chemtech, 1975, 128-129 and the backview of the elephant from loc.cit., p.448. The Health and Safety Officer's office from State Service. J.W. Gibbs quote from J.G. Crowther, Famous American Men of Science (II), Harmondsworth, Mddx: Penguin Pelican Books, 1944, p.147.

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## BOB BIRD HONOURED

Question: What was the best kept secret in the rheological world during much of '88 and the first part of '89? Answer: The Academic Festival arranged at the University of Wisconsin on Friday, February 10th, to celebrate the 65th birthday of Professor R B Bird.

Up to a few days immediately prior to the festival, Professor Bird was blissfully ignorant of the feverish activity undertaken by Professor Arny Fredrickson and Professor Raffi Turian, amongst others, to contact his many old research students, postdoctoral researchers, coworkers and friends; and even when it began to dawn on him that something was up, he had no idea of the scale of the event. Over 60 attended a high-powered day of lectures at the Wisconsin Centre given by some of Professor Bird's coworkers, academic children (and one grandson). This was followed by a Banquet at the University of Wisconsin attended by over 150 coworkers, colleagues and friends. The food was good; the speeches (stretching over 2 hours) were interesting, sometimes humorous, sometimes sung, and always warm and appreciative of the massive impact Professor Bird has had on various aspects of life, especially his impact on chemical engineering in general and rheology in particular. There were visitors from all parts of North America, from Denmark, Australia and even Wales!

Amongst the many presentations was a superb framed version of Professor Bird's Academic Family Tree, a miniature copy of which is included with this report.

Professor Bird responded to the many tributes with characteristic humility and humour and we left Lowell Hall at 11.15pm to the cold night air of Madison with an internal glow generated from the realization that we had been part of a unique event arranged for a very special person. Diolch yn fawr, Bob Aderyn, mae'n ffrind i'ch cyfrif yn ffrind!

Ken Walters



# THE EAGLE'S NEST

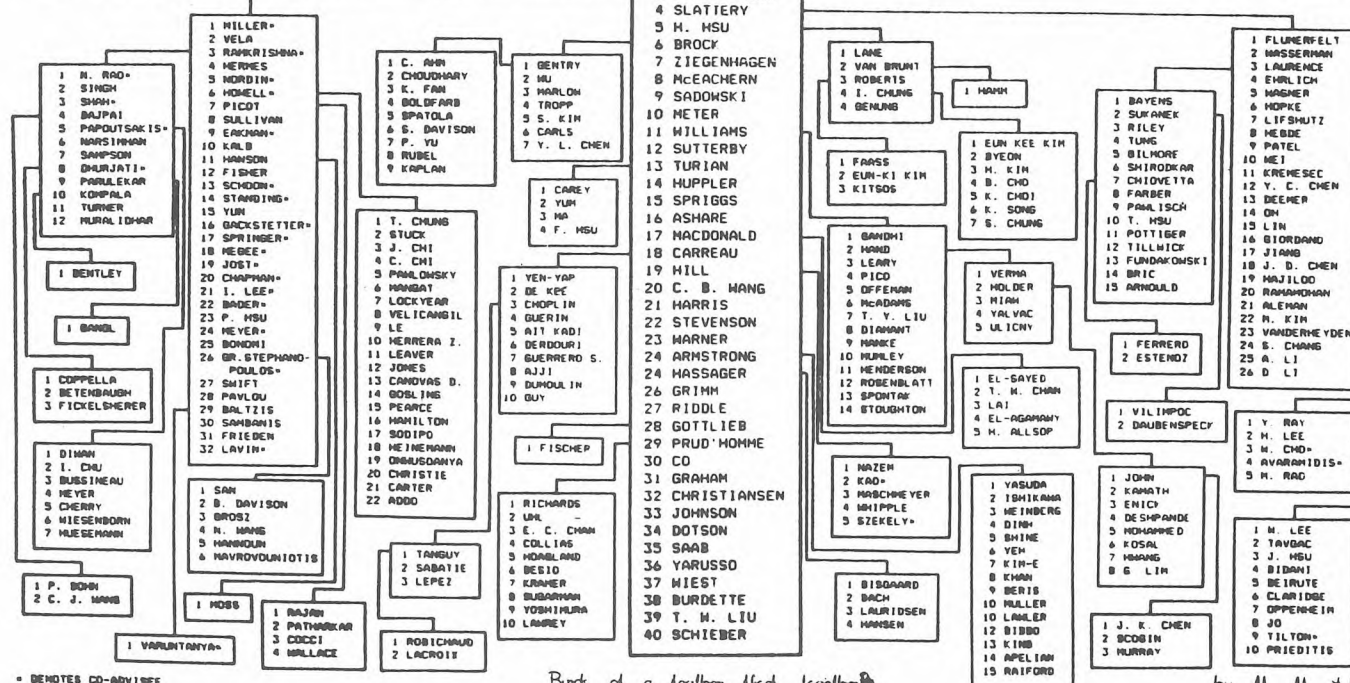
The Academic Family Tree of an Intellectual and Humanitarian Giant



AS OF JUNE, 1989

R. BYRON BIRD

一代宗師



\* DENOTES CO-ADVISEE

Back of a feather flock together.

by M. M. S. H.

# SUB ROSA

or

"If thou hast no name to be known by, let us call thee devil"

by G.H. Tattersall

I am pleased to be able to say that, throughout my career, I have never had a technical paper rejected for publication, or even seriously questioned, but that is not to say that I have not on occasions been quite irritated by the comments of anonymous referees. The irritation has arisen not so much from what they say, as from the fact that they are carefully protected from any riposte, and one feels they are accorded a respect by editors that many of them do not deserve.

It has always been my practice, and one I recommend to other authors, to reply to referees' comments in the perhaps forlorn hope that the editor will let them know exactly what I think. For example, on one occasion I wrote to say that I was grateful for the comments of Referee A which I had found helpful in improving my paper, but so far as Referee B was concerned, it was clear he knew nothing about the subject and that before he presumed to comment he would be well advised to read at least some of the relevant published work. I don't suppose that went any further than the editor's desk.

Now, I do not think I am going to suffer much harm from being shot at by people who shelter behind a concealing shield, but the effects on those who are younger and less confident (or arrogant) than I am may be quite devastating. Recently, a young research worker of my acquaintance received a referee's comment that began 'This is yet another paper on this topic .....'. Now, I happened to know that the only other paper that could be classified as being 'on this topic' was one that the young author had referred to in his own paper and was one that had failed to bring out the points of importance, so I was able to advise him accordingly. But just think of the effect such an irresponsible comment could have on one who was making his first submission for publication. Incidentally, after the paper was published a request was sent, at my instigation, to the guilty referee via the editor, for the evidence to support his statement; as I expected, he was not able to provide it.

Another recent example arose when a research worker included in the introductory paragraphs of his paper a proper statement about earlier relevant work and then added 'Unfortunately in one case (ref. given) the analysis of the data is faulty and the numerical information reported there has little value'. Although he very properly gave the reference, he did not give in the text the name of the author concerned. He was rewarded with a referee's comment that this was "a cheap shot" at this particular work.

I do not know whether the referee concerned had read the defective paper nor, if he had, whether he had understood it, but I have both read and understood it and can state categorically that the comment made about it was mild in the extreme; the use of much stronger condemnatory words would have been fully justified. The main point about this is that it raises the question as to whether we are not supposed to make other than sycophantic comments about previous work. Have we all been unwittingly absorbed into a mutual admiration society or are we supposed to be trying to get at the truth?

I think it probable that neither of the cases referred to above would have occurred if the referees had been required to subscribe their names to their comments. If it is argued that anonymity of referees is necessary because it allows them free rein to make honest comment without embarrassment, I reply that it also allows free rein for dishonest comment, for slapdash consideration, and for the exercise of a supercilious attitude.

I have always tried to follow the principle that if I have something to say, I do not say it unless I have the guts to put my name to what I say, and, in pursuance of that, when I referee a paper I give my name at the bottom of my sheet of comments. I do not know whether the editor passes it on in that form but in my view he should, and I should like to see a universal change in practice so that an author who is criticised, whether positively or negatively, is fully aware of the identity of the critic. Those who have not the courage to work under such a system should say so, and should decline to act as referee.

## NEW CHALLENGES --- NEW MEMBERS

As we approach the end of the eighties and come towards our Golden Jubilee year of 1990, it seems appropriate to take stock of the Society. It is, I am happy to report, in good heart. Our publications, the Bulletin and Rheology Abstracts, provide a valuable service to members with the latter being our main source of revenue. The conferences, often run in conjunction with other Societies, are well attended and acknowledged to be of a high scientific standard. New initiatives, particularly the Rheology Course being run by the Society at Birmingham University, indicate new ways of providing a service to members and non members alike. At a less advanced stage is the move to expand the highly successful European School of Rheology, possibly to make it an annual event using EEC funding from the Comet Scheme. The Society is actively supporting this effort.

It is worthwhile asking if there is more that can be done. Well, looking at the numbers in the BSR it is remarkable that they have remained virtually constant, at between 625 and 675, for the last fifteen years or so. All of us will be aware of the increasing interest in our subject, particularly in industry. Why then are the level for the membership numbers static? It may be that they represent a natural level for the U.K. with a dynamic equilibrium existing between those joining and those leaving. It certainly cannot be said that the membership fee is a barrier to those wishing to join. The annual subscription of £5/£6 must be the best buy of any scientific society. More likely is the simple explanation that many potential members are not aware of the advantages of membership. This is where all of us can help by making certain that our colleagues working in the subject are persuaded to join. Please give them the application form in this Bulletin and make sure they benefit their own careers by becoming members. We still have the second largest Rheology Society in the world, but only just. The Japanese group is almost as large. Our potential for growth is very great and should be fulfilled.

Looking towards 1990, the preparations for the Golden Jubilee Meeting are well advanced. We are honoured by being given the privilege of hosting, in conjunction with the above meeting, the Third Meeting of European Rheologists. Early indications are that attendance will be large, possibly in the region of 600. The scientific and social programmes will be wide ranging and varied. The venue, Edinburgh immediately after the Festival, is attractive. Please try to come to this very special Conference. There is a call for papers elsewhere in this Bulletin.

Finally, I would like to hear from you if you have any suggestions for developments in the Society. Your Council is very active and always anxious to consider how best to advance the interests of you the members.

**J Ferguson**  
(President)

# THE BRITISH SOCIETY OF RHEOLOGY

## APPLICATION FOR MEMBERSHIP



1) Full Name and Title .....

2) Degrees, Diplomas, etc. ....

3) Private Address .....

Tel. ....

4) Business Address .....

Tel. ....

5) Position Held .....

6) Interests (see over page).

7) I wish to apply for Membership of the British Society of Rheology and if elected I agree to abide by the rules and Constitution of the Society.

I understand that the Society's Journals will be supplied for my own personal use and I undertake not to pass them to a library. I should like my membership to date from ..... (Note ii). I enclose cheque/P.O./M.O. for ..... (Note iii)

Applicant's signature ..... Date .....

8) I ..... being a fully paid up Member of the Society recommend ..... for election to Membership.

Member's Signature ..... Date .....

### NOTES

i. This form when completed should be returned to the Honorary Membership Secretary:

**HARRY SCHIMANSKI  
CARRI-MED LTD.,  
GLEBELANDS CENTRE,  
VINCENT LANE, DORKING  
SURREY RH4 3YX**

ii. A person applying after 1st July in any year may choose to date his membership from the following 1st October. All other memberships will be dated from the preceding 1st October.

iii. The first subscription is due on election but it will reduce administrative work if each applicant will send it with his application together with the entrance fee of £1. If the application is rejected the money will of course be returned. The present annual subscription is ..... and is due on 1st October in each year.

P.T.O.

# CLASSIFICATION OF RHEOLOGICAL ACTIVITIES

It would be helpful to the Society for organising its meetings and publications so that they are of maximum benefit to members if you would complete the questionnaire below. Your replies will be entered in the published Membership List.

*Place ticks in appropriate boxes.*

1. Is most of your work of rheological concern? (f); or  
Does rheology enter into your work only occasionally? (p) ☐
2. Are your rheological interests mainly
  - (t) Theoretical ☐
  - or
  - (e) Experimental ☐
  - or
  - (ct) Theory and experiment ☐
3. Are your rheological interests mainly
  - (s) Pure science ☐
  - or
  - (a) Technology ☐
  - or
  - (sa) Pure and applied science ☐
4. Do you have a secondary interest in branches of rheology which you have not indicated in the list of major interests below?
 

|     |                          |
|-----|--------------------------|
| Yes | <input type="checkbox"/> |
| No  | <input type="checkbox"/> |
5. Which materials in the list below are of major concern to you?
 

|                                                               |                          |
|---------------------------------------------------------------|--------------------------|
| A Metals, alloys                                              | <input type="checkbox"/> |
| B Composites (e.g. fibre-reinforced resins)                   | <input type="checkbox"/> |
| C Solid polymers                                              | <input type="checkbox"/> |
| D Molten or dissolved polymers                                | <input type="checkbox"/> |
| E Natural fibrous materials (e.g. cotton, paper, wood, wool)  | <input type="checkbox"/> |
| F Liquid-liquid systems (e.g. emulsions)                      | <input type="checkbox"/> |
| G Liquid-solid systems (e.g. suspensions, slurries)           | <input type="checkbox"/> |
| H Particulate solids (e.g. granules, powders, fluidised beds) | <input type="checkbox"/> |
| I Glasses, ceramics                                           | <input type="checkbox"/> |
| J Oils, greases                                               | <input type="checkbox"/> |
| K Building and road materials                                 | <input type="checkbox"/> |
| L Foodstuffs                                                  | <input type="checkbox"/> |
| M Biological materials (e.g. blood, tissue)                   | <input type="checkbox"/> |
| N Theoretical materials                                       | <input type="checkbox"/> |
| O Other materials (please specify) .....                      | <input type="checkbox"/> |

## FOR OFFICE USE ONLY

|                    |                  |
|--------------------|------------------|
| Received .....     | Considered ..... |
| Acknowledged ..... | Decision .....   |
|                    | Informed .....   |

## Membership News

The following applications for Membership were approved at the Council Meeting on 9th December 1988.

Dr. R.J. Wright,  
Britoil plc.,  
301 St. Vincent Street,  
Glasgow.  
G2 5DD.

Mr. D. Holdsworth,  
Campden Food and Drink Research Association,  
Chipping Campden,  
Glos.,  
GL55 6LD.

Mr. M. Power,  
56 Sharples Avenue,  
Bolton,  
Lancs.  
BL1 7HF.

Mr. D. Subotic,  
University of Strathclyde,  
Dept. of P&A Chemistry,  
Tomas Graham Building,  
Glasgow.  
G32 0PG.

Mr. M. McGoldrick,  
Rheometrics GMBH.,  
Hahnstr. 70,  
6000 Frankfurt,  
West Germany

Dr. H.M. Meeten,  
Schlumberger Cambridge Research,  
P.O. Box 153,  
Cambridge,  
CB3 0HG.

Mr. H.P. Ronningsen,  
Statoil,  
P. Box 300,  
4001 Stavanger,  
Norway.

Dr. G.K. Rennie,  
Unilever Research Laboratory,  
Port Sunlight,  
Mcrseyside.

Dr. Alderman,  
Schumberger Cambridge Research,  
P.O. Box 153,  
Cambridge,  
CB3 0HG.

Mr. D.R. Gershkoff,  
TRRL  
Old Workingham Rd.  
Crowthorne,  
RG11 6AV.

Mr. P. Jenness,  
Laportc Organics plc.,  
Moorfield Road,  
Widnes,  
Cheshire.

Mr. D.M. Thompson,  
3M UK PLC.,  
Gorseinon Road,  
Penllergaer,  
Swansea.

Mr. M.J. Alison,  
RTI,  
120-122 Woodgrange Road,  
Forest Gate,  
London.  
E7 0EW.

The following person was elected to membership in December 1987 but was omitted from the Bulletin at that time:

Angela Maria Brighenti,  
Product Development Department,  
ITAP S/A - Divisao Rigos,  
An Torres de Oliveira 330,  
CEP 05347,  
Sao Paulo,  
Brazil.

## **Deaths**

I regret that Mr. Peter Merriman, an Honorary Member, has died.

Mrs Scott-Blair also died in November.

## **Resignations**

A resignation was received from Mr. Alan Lawton.

## THE SCOTT BLAIR BIORHEOLOGY SCHOLARSHIP 1989

In memory of the work and example of Dr. G.W. Scott Blair, Pergamon Press will sponsor a scholarship to encourage excellence in research in biorheology, and to enable the recipient to undertake research activities which would not normally be possible without such a grant, such as a period of work at an overseas University. The scholarship will be administered by the Council of the British Society of Rheology.

PhD students, or equivalent, who are completing their first year of research in the field of biorheology may apply to become a Scott Blair Biorheology Scholarship Awardee.

The scholarship will have a value of £500 per annum to be used at the absolute discretion of the Awardee. Subject to a satisfactory report from his supervisors, the scholarship will be renewable for a maximum of one more year. Thus it 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 funding to attend conferences. The Awardees 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 scholarship 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 1989 Scott Blair Biorheology Scholarship should be sent to the secretary of the British Society of 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.

## **Joint British-Portuguese-Spanish Rheology Meeting**

A further example of increasing collaboration within the European community of rheologists is a joint meeting that is presently being planned with Spanish and Portuguese groups on the subject of Molecular Structure and Rheology of Synthetic and Biological Polymers. Besides the more traditional aspects of theoretical and experimental polymer rheology the organizers will also welcome rheological contributions from haemorheologists. At this stage the intention is to hold a three day conference in Lisbon possibly in November of this year with some fifteen or more members from each society participating. It is hoped that funds will be available to provide some assistance with travel and subsistence costs for participants from the U.K.. Should any member of the Society be interested in taking part in this conference, it would be helpful if they could contact in the near future either:

**Prof. Frank Leslie, Mathematics Department, Strathclyde University,  
Livingstone Tower, Richmod Street, Glasgow G1 1XH,**

or

**Stephen Aldhouse, BP Chemicals Ltd., RD Department, PO Box 21,  
Bo'ness Road, Grangemouth, Stirlingshire, FK3 9XH.**

**The British Society of Rheology's Annual Conference 1989**

## **'Rheology of Food, Pharmaceuticals and Biological Materials'**

**with a session on 'General Rheology'**

The society's annual conference will be held at the University of Warwick on September 12th to 15th, 1989. A reservation form, with prices, is provided below, and completed forms with cheques made payable to the 'British Society of Rheology' should be sent to:

**Roy Carter, PO Box 2, Stansted, ESSEX CM24 8JG (Tel 0279-816779, Telex 93-12-10-22-87 CB G, Fax 0279-816702).**

The full programme for the conference will be published in the next issue of this bulletin. There is still room to squeeze in a couple of extra papers, but please let Roy Carter have a title and abstract of about 200 words as soon as possible.

Papers offered so far include:

M.L. Green, R.J. Marshall and K.R. Langley, *"Structure and mechanical properties of model composite foods"*

P. Sherman, *"Viscoelastic properties of emulsions as influenced by interfacial reactions between proteins and glycerides"*

I. Macdougall, *"Blood Viscosity and red cell deformability studies in haemodialysis patients during treatment of renal anaemia with recombinant erythropoietin"*

R. Parker, A-L Ollett, R. Lat-Fook and A.C. Smith, *"The rheology of food 'melts' and its application to extrusion processing"*

Dr. F. Van Voorst Vader, *"The redispersibility of flocculated W/O emulsions"*

Dr. D.W. De Bruijne, *"The rheological properties of bread dough and their relation to baking properties"*

Drs. H. Luyten and T. Van Vliet, *"Influence of a filler on the rheological and fracture properties of food materials"*

Zoon, De Cindio and Van Vliet, *"Interrelation between the dynamic moduli and the relaxation modulus of rennet-induced skimmilk gels"*

Lapasin, Priol and Esposito, *"Rheological behaviour of scleroglucan aqueous systems in the solution and gel domains"*

Wetton, Marsh and Foster, *"Dynamic mechanical spectroscopy of food and biology materials"*

H.R. Kerr, *"The ups and downs of baking bread"*

H.R. Kerr, *"The surface shear rheological properties of hyaluronic acid solutions - metal ion effects"*

A.J. Shah, *"Expansion, colour and textural properties of extrusion-cooked fish/corn grit mixtures"*

R.A. Speers, T.D. Durance and M.A. Tung, *"Flow behaviour of commercial brewing yeast suspensions"*

D. C-H Cheng, *"Viscosity measurement on an orange juice"*

J.R. Mitchell, *"Developments in biopolymer gel rheology"*

A.J. Rosenthal *et al*, *"Preliminary investigations into the replacement of sugar in cake batters"*

A.A. Collyer *et al*, *"Injection moulding of confectionery materials"*

J.J. Benbow, *"New Aspects of die design for paste extrusion"*

C.A. Moules and B. Warburton, *"The surface rheology of aqueous solutions of gum acacia senegal in the presence of various second component"*.

The conference sessions will be held in the physics block at the University of Warwick, and accommodation is available on the campus.

The conference dinner will take the form of a mediaeval banquet in Warwick Castle. The cost of this dinner and transport to and from Warwick Castle is included in the registration fee for the conference.

The University of Warwick is located on the southern side of Coventry, in the heart of England. Access is easy by road (M1, M6 and M5), by rail, and by air (Birmingham International Airport being a Taxi-Ride away).

## Registration Form

Name: (Mr/Mrs/Miss/Dr/Prof).....

Application: .....

Address: .....

.....

..... POST CODE: .....

Telephone ..... Telex ..... Fax .....

Conference fees: (Please tick appropriate box)

Non-Member      £ 150.00 Per Person

Member          £ 140.00 Per Person

Students         £ 130.00 Per Person

Fee includes registration, conference abstracts, accommodation and meals from Tuesday evening to Friday lunchtime inclusive.

Please send completed forms with cheques in full payment to:

**R.E. Carter,**  
**British Society of Rheology,**  
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Receipts will be issued for all payments.

## **SECOND CALL FOR PAPERS**

### **INTERNATIONAL CONFERENCE ON THE RHEOLOGY OF FRESH CEMENT AND CONCRETE**

**University of Liverpool, 26-29th March 1990**

The conference will be concerned with the rheology and related matters of all materials based on inorganic cement: e.g. fresh concretes, mortars, cement pastes, grouts, oils, well slurries and special products. Offers of papers have already been received from eight countries.

Further papers are invited in the following subject areas:

- (a) Fundamental studies, Theoretical or Experimental
- (b) Relationships between rheological properties and composition, hydration reactions, microstructure, processing techniques etc.
- (c) Instruments and methods for testing rheology whether for research or industrial control
- (d) Technological applications such as site trials and quality control through rheology.

A poster session will also be held.

Titles and abstracts of about 250 words should be sent by 30th June 1989 to:

**Dr. P.F.G. Banfill**

**School of Architecture and Building Engineering**

**University of Liverpool,**

**P.O.Box 147,**

**LIVERPOOL,**

**L69 3BX**

**Tel: 051-794-2619**

The registration fee, including accommodation, meals, a cultural event and, hopefully, a copy of the proceedings will be around £ 150.

# International Conference on Rheology of Fresh Cement and Concrete

University of Liverpool, 26-29th, March 1990

Surname .....(BLOCK LETTERS  
THROUGHOUT PLEASE)

Title: (Prof, Dr, Mr, Ms, etc).....

Business position: .....

Organisation: .....

Address: .....

.....

Telephone No: (in full) .....

Telex: .....Fax: .....

☐ I am interested in attending as a participant

☐ I expect to present a paper and enclose an abstract entitled .....

.....

☐ I expect to present a poster and enclose an abstract entitled .....

.....

Please return to: Dr P.F.G.Banfill  
School of Architecture and Building Engineering,  
University of Liverpool,  
P.O. Box 147,  
LIVERPOOL L69 3BX

Tel: 051-794-2619  
Telex: 627095 UNILPL G  
Fax: 051-708-6502

SECOND CALL FOR PAPERS

**GOLDEN JUBILEE MEETING AND  
THIRD EUROPEAN CONFERENCE**

**Edinburgh 3-7th September 1990**

The estimated cost for this meeting is £160 (£140 before February 15th 1990) with a reduction of £30 for students. Papers will be published in camera-ready form. Offers of papers in the form of a title and 250 word summary should be sent to

**Dr. C.J.S. Petrie  
Department of Engineering Mathematics  
University of Newcastle-upon-Tyne  
NEWCASTLE-UPON-TYNE  
NE1 7RU**

***Deadline for offers: December 1st 1989***

# NINTH INTERNATIONAL HEAT TRANSFER CONFERENCE

Jerusalem, Israel, 19-24 August 1990

## ABOUT THE CONFERENCE

The International Heat Transfer Conferences are held every four years with the purpose of bringing together the international heat transfer community. The conference will cover both fundamental and applied topics in heat transfer.

The format of the Conference will be arranged with the major elements being: general papers presented in poster sessions, keynote papers by invited speakers, panel sessions on special subjects, film and video sessions, equipment and book exhibitions, and social and tour activities.

## CALL FOR GENERAL PAPERS

The purpose of general papers is to report original, unpublished findings in heat transfer. All general papers will be reviewed under the direction of the International Science Committee. Accepted papers will be required on author-prepared mats in English only, and will be published in the Proceedings of the Conference. Authors are required to present their papers in poster sessions personally.

Submissions are welcome by authors from any country. Authors wishing to present a general paper (or film-video materials) should submit three copies of a preliminary abstract, typewritten in English. These should reach the appropriate member of the International Science Committee as listed, by June 01, 1989. Authors of abstracts considered appropriate for further evaluation will be informed by July 1, 1989 and will be provided with mats and instructions for the preparation of the complete manuscripts. These must be submitted for review in mat format by October 01, 1989 to the appropriate member of the International Science Committee, together with a final abstract of about 200 words. Final submission date following review is February 01, 1990.

There will be approximately 450 general papers, all presented in poster sessions organized under specific topics. Twenty-eight keynote speakers have been scheduled.

### Members of the International Science Committee:

Israel - G. Hetsroni, Chairman  
Canada - S.Y. Ahmad  
F.R. Germany - E. Hahne  
France - M. Cornbarnous  
India - M.V. Krishnamurthy  
Italy - M. Cumo  
Japan - S. Kotake

The Netherlands - C.J. Hoogendoorn  
P.R. China - B.X. Wang  
U.K. - G.F. Hewitt  
U.S.A. - L.S. Fletcher  
U.S.S.R. - M.S. Styrikovich  
Yugoslavia - M. Majcen

\*\*\*\*\*

If you are uncertain where to submit your abstract, contact: Y. Zvirin, Secretary, IHTC 9, Faculty of Mechanical Engr., Technion, I.I.T., Haifa 32000, ISRAEL - before May 01, 1989.

## THE RHEOLOGY OF POLYMER LATICES

A one-day meeting on this topic will be held in the Society of Chemical Industry's lecture theatre at 14/15 Belgrave Square, London on Wednesday, 13th December, 1989. This will be a joint meeting with the Macro Group (UK) Ltd.

For further details please contact:

Dr. D.J. Hourston,  
Department of Chemistry,  
University of Lancaster,  
LANCASTER,  
Lancs.,  
LA1 4YA.

Tel. (0524) 65201 Ext. 4061

(This will change to  
Ext. 3386  
during April/May).

Telex. 65111 Lancul G.

Fax. 0524 63806.

*Subsequent issues of this Bulletin will also contain information on this conference.*

## Polymers in Motion

14th December 1989  
Cambridge University



A day-conference concerned with dynamical aspects of polymeric liquids and solids. An opportunity to review recent advances in basic principles as well as applications.

**Venue:**

Department of Chemical Engineering and Emmanuel College.

**Structure of Meeting:**

In the morning session it is proposed that invited speakers would cover basic topics, i.e.:

Molecular motion in the liquid state; slow dynamics, reptation.

Molecular motion in the solid state; fast dynamics, local modes.

In addition speakers would review current applications in the field of melt rheology, diffusion and fracture.

In the afternoon session it is intended to hold a structured discussion for which short contributions are invited. These may be in the form of open questions or reports.

Accommodation would be available at Emmanuel College for the nights preceeding and following the conference for those requiring it.

Conference Organisers: Dr. M.R. Mackley (Chemical Engineering)

Dr. T.C.B. McLeish (Cavendish Laboratory)

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If you would like to be on the conference mailing list please return this slip to :

Dr. M.R. Mackley, Department of Chemical Engineering, New Museums Site, Pembroke St.,  
CAMBRIDGE, CB2 3RA.

Name:

Organisation:

Address:

I would be interested in raising/reporting on the following topic for discussion:

## CONFERENCE DIARY

| Date                | Place                           | Details                                                                                                                                                                                                                                               |
|---------------------|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 18-23/6/89          | Nancy,<br>France                | '7th International Congress of Biorheology'<br>contact: Lorraine Congres, Symposium<br>INSERM, Palais des Congres,<br>1, rue de Grand Rabbin Haguenauer,<br>54000 Nancy, France.                                                                      |
| 19-21/6/89          | Princeton, N.J.                 | 'Polymer blends and alloys'                                                                                                                                                                                                                           |
| 11-13/9/89          | Princeton, N.J.                 | 'Mixing of rubber and plastics'                                                                                                                                                                                                                       |
| 16-18/10/89         | Williamsburg,<br>Virginia, USA. | 'Reactive extrusion'<br>contact: William C Nissen, Polymer<br>Processing Institute, Castle Point, Hoboken,<br>New Jersey, USA.                                                                                                                        |
| 25-28/6/89          | Munich<br>W.Germany             | 'Biofluid mechanics and biorheology in large<br>blood vessels'<br>contact: Prof. Dieter Liepsch, Eisenhower<br>Medical Center, 39000 Bob Hope Drive,<br>Rancho Mirage, California, USA.                                                               |
| 19-24/8/90          | Jerusalem<br>Israel.            | 'Ninth International Heat Transfer Conference'<br>contact: Y Zvirin, 9, Faculty Mech. Eng.<br>Technion, IIT, Haifa 32000, Israel.                                                                                                                     |
| 29/8/89 -<br>1/9/89 | Glasgow<br>U.K.                 | 'Bifurcation phenomena in solids'<br>Euromech 252: contact Professor R.W. Ogden<br>Dept. of Mathematics, University of Glasgow,<br>Glasgow G12 8QW, Scotland, U.K.                                                                                    |
| 4-8/9/89            | Clermont-<br>Ferrand,<br>France | 'Powders and Grains'<br>International conference on micromechanics<br>of granular media: contact R. Gourves,<br>C.U.S.T., Laboratoire de Genie Civil,<br>Universite Blaise Pascal de Clermont-Ferrand<br>II, Rue des Meuniers, 63170 Aubiere, France. |
| 12-15/9/89          | Warwick<br>U.K.                 | 'Rheology of food, pharmaceutical and<br>biological materials' British Society of<br>Rheology: contact R. Carter, Carter Baker<br>Enterprises, P.O.Box 2, Stansted, Essex<br>CM24 8JG, U.K.                                                           |
| Sept. 1989          | Krakow,<br>Poland               | 'Applications of continuum damage mechanics'<br>Euromech 251: contact Professor M.<br>Chranowski, Politechnika Krakowska, ul.<br>Warszawska 24, 31-155 Krakow, Poland.                                                                                |

|                       |                                    |                                                                                                                                                                                                                                                                             |
|-----------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5-8/9/89              | Metz<br>France                     | '9th Congres Français de Mécanique'<br>contact: Secrétariat du Congrès Français de<br>Mécanique, Faculté des Sciences, Ile de Saulcy,<br>57045 Metz Cedex, France.                                                                                                          |
| Oct. 1989             | Hamburg,<br>Germany.<br>(B.R.D.)   | 'The time-dependent behaviour of ice'<br>Euromech 258: contact<br>Professor O. Mahrenholz, Technische<br>Universitat Hamburg-Harburg, Eissendorfer<br>Strasse 38, 2100 Hamburg 90, German<br>Federal Republic.                                                              |
| 21-26/10/89           | Montreal,<br>Canada.               | 'First Inter-American Conference on<br>Rheology' and '61st Annual Meeting, Society<br>of Rheology' and 'First Annual Meeting of the<br>Canadian Rheology Group': contact<br>Dr. L.A. Utracki, NRCC/IMRI, 75 boul. de<br>Mortagne, Boucherville, Quebec, Canada,<br>J4B 6Y4. |
| 31/10/89 -<br>2/11/89 | Paderborn,<br>Germany.<br>(B.R.D.) | 'Thermal effects in fracture of multiphase<br>materials' Euromech 255: contact<br>Professor Dr. K.P. Hermann, Laboratorium<br>fur Technische Mechanik, Paderborn<br>University, Pohlweg 47-49, 4790 Paderborn,<br>German Federal Republic.                                  |
| 21-23/11/89           | Paris<br>France                    | '24th annual meeting of Groupe Français de<br>Rheologie'<br>contact: Prof. B.Launay, Departement de<br>l'Aliment, ENSIA, 1 avenue des Olympiades,<br>91305 Massy, France.                                                                                                   |
| 13/12/89              | London<br>U.K.                     | 'The rheology of polymer latices'<br>contact: Dr D.J.Hourston, Dept. of Chemistry,<br>University of Lancaster, Lancaster, Lancs.                                                                                                                                            |
| 14/12/89              | Cambridge<br>U.K                   | 'Polymers in motion'<br>contact: Dr M.R.Mackley, Chemical Eng.,<br>New Museums Site, Pembroke St.,<br>Cambridge, CB2 3RA.                                                                                                                                                   |
| 3/90                  | Liverpool,<br>U.K.                 | 'Rheology of fresh cement and concrete'<br>contact: Dr P.F.G.Banfill, School of<br>Architecture and Building Engineering,<br>University of Liverpool, P.O.Box 147,<br>Liverpool L69 3BX, U.K.                                                                               |

- |            |                                       |                                                                                                                                                                                                                                                         |
|------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 24-26/7/90 | Cambridge<br>U.K.                     | 'Polymer Blends'<br>contact: Dr D.J.Hourston, Dept. of Chemistry,<br>University of Lancaster, Bailrigg, Lancaster,<br>Lancashire LA1 4YA, U.K.                                                                                                          |
| 3-7/9/90   | Edinburgh,<br>Scotland, U.K.          | 'Third Conference of European Rheologists'<br>and 'Golden Jubilee Meeting' British Society<br>of Rheology' contact Dr. C.J.S. Petrie,<br>Dept. of Engineering Mathematics, University<br>of Newcastle upon Tyne, Newcastle upon<br>Tyne, NE1 7 RU, U.K. |
| Oct. 1990  | Albuquerque,<br>New Mexico,<br>U.S.A. | '62nd Annual Meeting'<br>Society of Rheology: contact secretary<br>(Professor D.G. Baird, Polymer Materials and<br>Interfaces Laboratory, Virginia Polytechnic<br>Institute and State University, Blacksburg,<br>Virginia 24061-6496, U.S.A.            |

**PROCEEDINGS OF  
X INTERNATIONAL CONGRESS ON RHEOLOGY**

Sydney, Australia  
August 1988

Copies of the Proceedings may be obtained by writing to me at the address below. Cost, including air lifted mailing, is US\$96 or \$120 Aust. Please send Purchase Orders or cheques to

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University of Sydney  
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Australia.

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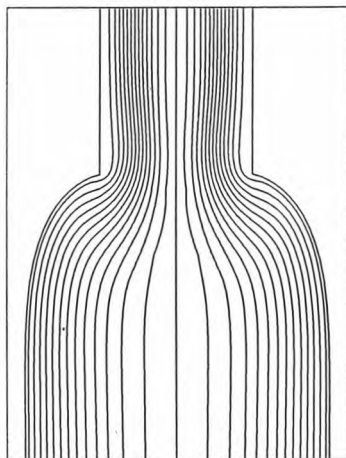
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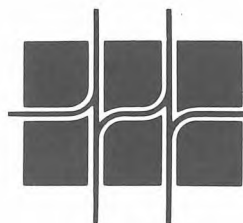


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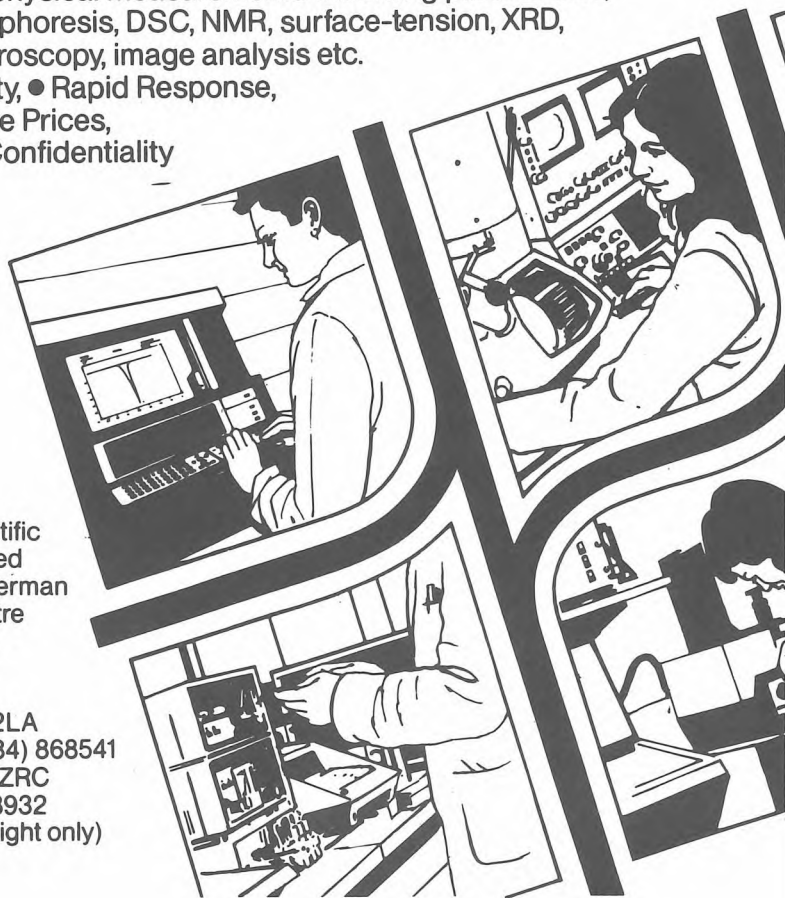
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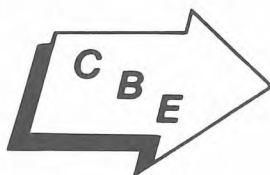
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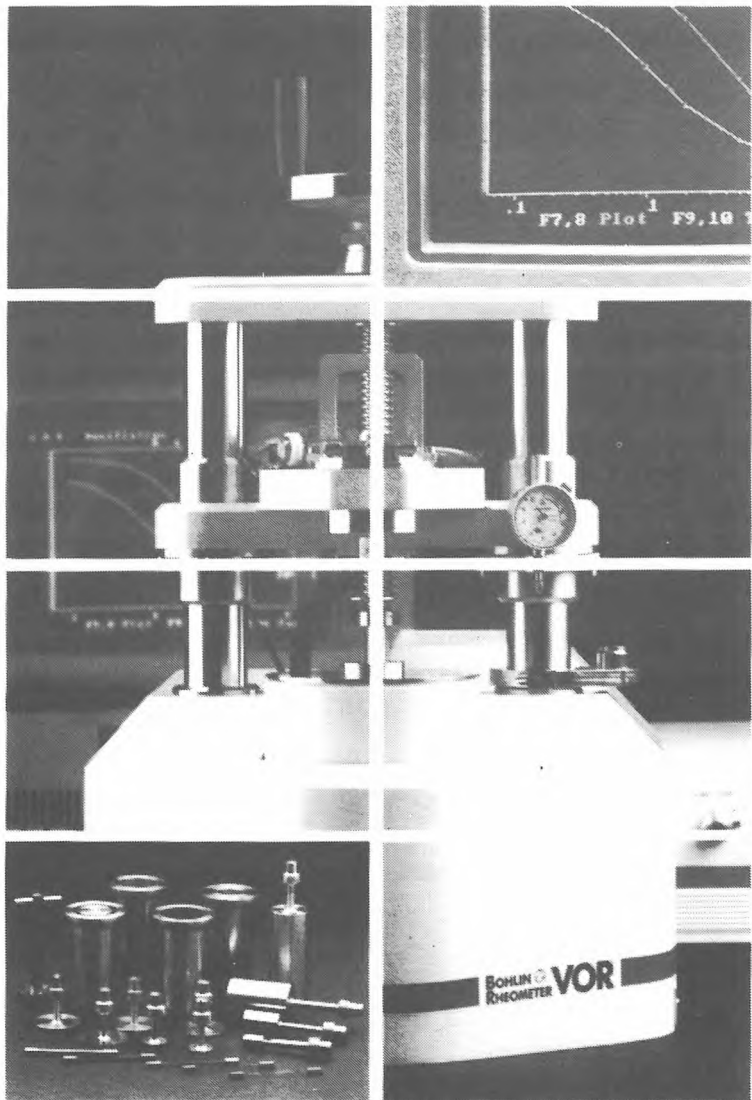
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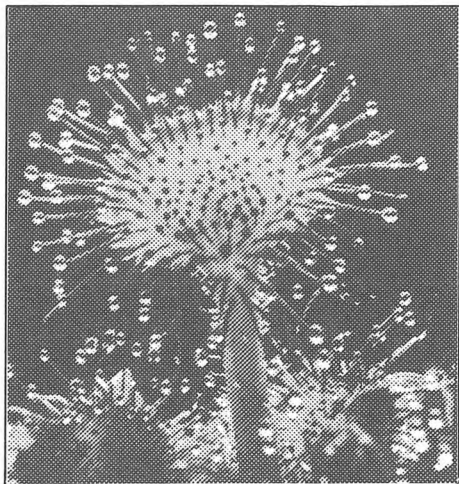
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Englefield Green, Surrey TW20 0  
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# Rheometrics

# Rheology - a matter of survival for the Sun Dew



The Sun Dew is an attractive plant which secretes drops of glistening sticky liquid from its tentacles to attract and trap insects. The rheology of the drops is essential to the Sun Dew's survival. Their structure allows the drops to flow and trap the insect whilst having the strength and elasticity to hold the potential meal despite its struggles.

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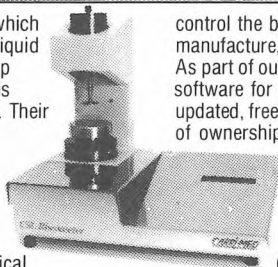
This computer-controlled instrument uses the techniques of flow, creep and oscillation to undertake a wide range of rheological measurements. These measurements can be used to predict and

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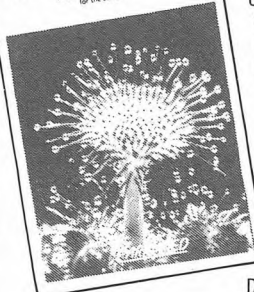
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