

# BULLETIN



## BRITISH SOCIETY OF RHEOLOGY

1980, Vol. 23, No. 1

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*Hon. Editor:*

Dr. C. R. DIMOND,

Department of Building Science

University of Sheffield,

Sheffield S10 2TN.



## FOREWORD

At the start of the new decade it is worth looking forward to possible improvements and innovations in the rheological field and also to take a look at the expectations and predictions as we entered the 70s.

John Harris, the then editor of the Bulletin, considered the widespread introduction of supersonic and super-sized aircraft with the possibility that some unsuspected and perhaps unpleasant rheological properties of the construction materials may be revealed. Certainly the super-sized aircraft have become a common sight in the skies but the supersonic commercial aircraft has not, for various reasons, been the success envisaged. As far as the technical problems are concerned perhaps a member working in that area would like to contribute an article to the Bulletin.

What do the 80s hold for rheologists? In this the decade of the microprocessor I assume that materials processing and handling techniques will become automated by use of the chip, viscometers will become more sophisticated and programmable and data analysis will be taken care of by a variety of even smaller black boxes. As somebody who does not understand electronics I hope we don't lose sight of our objectives and spend more time satisfying ourselves with the electronics than testing the material.

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MR. F. N. COGSWELL, I.C.I. Ltd., Plastic Division, Welwyn Garden City.

MR. M. CAMINA, Paint Research Association, Teddington, Middlesex.

## GOLDEN JUBILEE MEETING—BOSTON

### Letter to Conference from Dr. G. W. Scott-Blair

Grist Cottage  
Mill Lane  
Iffley  
Oxford  
Oxford 777462  
25 May 1979

The President  
Jubilee Congress of the Society of Rheology

Dear Mr. President,

I am sending to you and the Congress my best greetings. I was in the Chair at a session of the Inaugural Congress in Washington in December 1929 at which the term "Rheology" was officially accepted and the Society of Rheology was founded.

I practised Rheology until my sight failed a few years ago. I am now old and seldom leave Oxford but I continued to co-edit "Bio-rheology" until the end of 1978. Now that I cannot keep up at all with the literature I have had to reluctantly retire.

I only wish I could be with you at your Jubilee Congress, I send you all my very best wishes and am asking the representatives of the British Society to give you this note of Greetings on my behalf.

With all best wishes,

GEORGE W. SCOTT-BLAIR

### CONFERENCE REPORT

The Americans are justifiably proud that rheology as an organised science started with the formation of their Society of Rheology in 1929. To celebrate the event they organised what was undoubtedly the largest meeting on rheology ever held, excepting, of course, the International Congresses. Of the 14 Societies in the world, the Presidents of 12 were able to attend, including Dr. Mervyn Jones our own President. In fact it was to all intents and purposes an international meeting in its own right.

To match such a splendid occasion the Copley Plaza Hotel, Boston, Mass., was the venue. There is not a great deal one can say about the Copley Plaza Hotel except that it is totally unlike any American hotel this writer has ever been in. Built some 70 years ago the decor seemed to be rich Edwardian. Much to the management's credit it has been kept that way.

The format of the meeting was that five parallel sessions started each day at 8.15 a.m. and continued with a break for lunch until about

5 p.m. Anyone wishing a cup of coffee or to visit the Instrument Exhibition had to be prepared to miss a lecture. The main session topics were polymer processing, solutions, melts, extensional flows, composites, multiphase systems, drag reduction, tribology, food and biorheology. There were also sessions devoted to general topics, theory and lectures from Bingham Medallists and distinguished guests. As you will see this is a pretty comprehensive list. It must be said however that by far the greatest concentration was on the field of polymers (either solid, solution or in the melt). This perhaps represents a divergence between European and American rheology. In the former, suspension rheology would be expected to be more prominent.

The series of lectures given by Bingham Medallists was unique in that it provided one with an opportunity to hear from some of the great names in rheology who have been honoured by this Society.

Many of these were retrospective and reflective. Philippoff for example talked on "Some Ideas about the Future Needs of Rheology", while Alfrey discussed the thixotropy of benonite and heather honey. If one of these was to be selected as outstanding it would be A. S. Lodge's lecture on normal stress differences in unidirectional shear flow. R. B. Bird of the University of Wisconsin, also a Bingham Medallist, described fifty years of research relating macromolecular motions to the rheology of macromolecular liquids. It was significant that he followed a summary of the importance of papers by Rouse, Zimm, Green and Tobolsky and others with the recent paper by Doi and Edwards. This last paper was mentioned very frequently throughout the conference. One was left with the impression that those working on the theory of macromolecular rheology have seized on this particular work as representing the way forward for which they have been looking.

The sessions on polymer processing and melts involving a total of 31 papers in all, overlapped as might be expected in their subject areas. It was notable however that there was considerable emphasis on the blow moulding process as shown by Dealy's paper on the swell and sag of extrudate from an annular die. There seemed also to be considerable interest in the strain history of molten polymers and its effect on their processing. Cogswell with a paper on the experience of polymer melts during processing and White who lectured on flow pattern in melts both dealt with this aspect of the subject.

In the section on polymer solutions, the theme of the effect of macromolecular shape on the rheological properties recurred frequently. Mervyn Jones of Aberystwyth for example discussed the effect of molecular shape taking the "Xanthan Gum" molecule as his example.

It was in the Extension sessions that the British contingent made its greatest contribution. Papers by Oliver, Ferguson, Petrie and Cogswell together with a paper by Aldhouse in the Processing session and one

by Hinch in the Drag Reduction session emphasised the advances currently being made here in the study of elongational flow. It must be admitted however that if a prize for virtuoso performance had been awarded it would have gone to Meissner for his description and film of a new rheometer for measurement of biaxial extensions.

The 12 papers dealing with composites formed one of the few sessions in which the rheology of solid systems was dealt with. The overlying theme in this area, judging by the papers, seems to be the role played by fibre matrix interaction. No such single theme could be detected in the multiphase system sessions where the papers ranged from such topics as the large-scale rheology problem involved in the disposal of red mud discussed by Boger of Monash University to a paper on the motion of a deformable drop in Couette flow by Chan.

The 15 papers in the Drag Reduction sessions produced some surprisingly practical topics. Sellin from the University of Bristol showed some fascinating results on the effect of dosing sewers with drag reducing agents. Apparently at times of overload sewer capacities can be increased by up to 70%.

In the Biorheology sessions there was perhaps predictably great concentration on haemorheology, some 17 out of 19 papers being on this subject. This was in a way rather disappointing, as there are many more interesting, rheologically that is, fluids which could have been discussed. However, each of the sessions did reflect the interest of the organiser. The Food sessions were in fact much more varied both in topic and in treatment. Papers ranged from rheology of gells to the visco elastic properties of proteins with Mitchell and Sherman from the U.K. contributing notable work.

The Tribology session was one of the smaller in the Conference with only nine papers. The first of these was a summary lecture by John Hutton of Shell. If a theme could be detected in such a small number of papers it seemed to be the importance of high strain rate rheology.

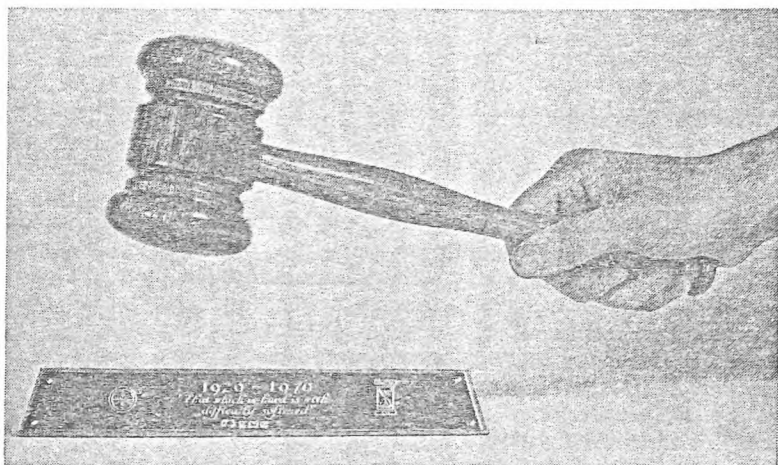
The Conference banquet held in the Hotel's ballroom was a splendid affair. All the Presidents of the various Societies were presented, with Mervyn Jones being kept to the last. He then presented the Society with a most attractive gavel from the British Society and our Australian branch.

Summing up a Conference of this sort is very difficult. The five parallel sessions meant that it was obviously impossible to attend more than 20 per cent of the papers. The organisation was, however, excellent and one could well believe the statement that two years had been spent organising it.

J. FERGUSON

## Memento presented by the British Society of Rheology

The British Society of Rheology together with a special contribution from the Australian Branch presented the Society of Rheology with a carved wooden gavel to mark the occasion of the Golden Jubilee. The two photographs below show the inscribed plates; the quotation "that which is hard is with difficulty softened" being taken from the works of Plutarch — our thanks to Dr. Ralph Oliver for organising its manufacture, and Mr. Tom Davenport for suggesting the inscription.



# VIIIth INTERNATIONAL CONGRESS ON RHEOLOGY

## NAPLES 1 - 6 SEPTEMBER 1980

### Travel Grants for Students

It is the policy of the British Society of Rheology to assist students engaged in research in rheology to attend major international conferences. Members of the Society, who are full-time students, may apply in writing to the Secretary to be considered for an award and applications should be endorsed by the student's supervisor. The value of the award will be in the region of £50 and applications should be sent to the Secretary by the 20 March 1980.

### Travel Arrangements

A special group travel scheme on regular scheduled flights is again being arranged for members attending the above Congress by EXPRESS BOYD LIMITED, 4/5 Bonhill Street, London EC2A 4BX (Tel. No. 01-628 6060 — Tours Department), in conjunction with the British Society of Rheology. Members will recall that Express Boyd Limited made similar arrangements for the 7th International Congress in Gothenburg.

### GROUP TOUR

#### Sunday 31 August 1980

Alitalia Flight AZ 291

|                           |                   |
|---------------------------|-------------------|
| London (Heathrow) Airport | depart 11.10 hrs. |
| Naples Airport            | arrive 15.55 hrs. |

On arrival you will be transferred to your hotel in Naples, where you will stay for seven nights.

#### Sunday 7 September 1980

Transfer from your hotel to the Airport for —  
Alitalia Flight AZ 290

|                           |                   |
|---------------------------|-------------------|
| Naples Airport            | depart 16.35 hrs. |
| London (Heathrow) Airport | arrive 19.20 hrs. |

### COST PER PERSON

**£276.00 per person**

The above price includes economy class air travel as described and seven-night ground package to the value of Lire 250,000 which will be offered by the Organising Committee. This is their current estimate for a ground package consisting of first-class hotel accommodation (twin-bedded rooms with bath) and breakfast daily for seven nights; transfers from Airport to hotel on arrival and vice versa on departure; and daily transfers between hotel and Engineering School. The cost with single room accommodation is likely to be higher, but there will be lower-cost

packages available with accommodation in second and third-category hotels. Pro-rata adjustments to the Sterling price quoted will be made dependent on the cost of the package chosen.

## **GENERAL INFORMATION**

### **CONGRESS VENUE**

The Conference will take place at the Engineering School in Naples which is approximately five minutes from the town centre.

### **BOOKING PROCEDURE**

In order to reserve a place on the group tour, please complete and detach the booking form below and send this with a photostat copy of your Registration Form to us, and a copy of the accommodation confirmation when you receive it. We will take over the booking and make the necessary accommodation payments to the Organisers. If you have not received your Registration Form from Italy by the end of February, please contact Express Boyd Limited for a separate copy.

### **PRICES**

Prices quoted are subject to availability of services at time of booking, and are based on currently prevailing rates for commodities and exchange. In the event of these altering, the appropriate adjustment will be made to your final account approximately eight weeks prior to departure, when payment is due. The tour is subject to a minimum of fifteen participants.

### **INSURANCE**

It is strongly recommended that you arrange comprehensive insurance against loss of money and baggage, personal accident and medical expenses, before travelling. Please tick the appropriate space on the booking form if details are required.

### **CONNECTING FLIGHTS**

Connecting flights from and to provincial U.K. airports can be arranged on written request.

### **PASSPORT AND HEALTH REQUIREMENTS**

All travellers will require a valid passport for travel to Italy. Holders of British passports issued in the U.K. will not require a visa; other nationals are advised to check with Express Boyd Limited to see whether visas are required. No health certificates are required for British passport holders travelling from the U.K.

## BOOKING FORM

Please complete, detach, and return to EXPRESS BOYD LIMITED,  
4/5 BONHILL STREET, LONDON EC2A 4BX, to arrive no later  
than **5 MAY 1980**.

Re: **8th International Congress on Rheology**  
**Naples — 1/6 September 1980**

1. Please book ..... place(s) on the Group Tour to Naples.
2. I enclose a photocopy of my Registration Form which I have sent to Italy, and will forward a copy of the confirmation of accommodation when I receive it.
3. Insurance details are/are not\* required.  
(\* please delete as applicable)

I/We enclose a deposit of £15.00 per person to secure reservation(s).

NAME .....

ADDRESS .....

.....

.....

TELEPHONE No. ....

SIGNATURE .....

NAME(S) OF ACCOMPANY PERSON(S):

.....

.....

.....

DATE .....



# RHEOLOGY, FOOD SCIENCE AND THE FOOD INDUSTRY

C. A. STREET, B.A., B.Sc., C.Chem., F.R.I.C.

Product Research Manager

Rowntree Mackintosh Limited

Food Manufacture covers a very wide range of activities and hence significant analogies can be found between this and almost any other industry. Similarly, examples of most rheological phenomena and types of measurement can be observed in the food processing field. It is likely, therefore, that most of the specific rheological problems associated with food manufacture will be discussed in other articles of this series.

Food rheology can be considered on two entirely different planes, one concerned with current usage and the other with the long-term interests of the industry. Having thought long and hard about the type of food science needed for future developments and the role of rheology in it, I am critical of the former and dream of the successful evolution of the latter. Hence, I propose to outline some uses of rheology in food systems today, particularly emphasising the limitations in respect of foreseeable needs.

Rheology is used in all the expected areas of the food industry such as raw material control, process control, product evaluation and relating material behaviour to machinery design. In the short-term many of these applications serve a useful purpose. On the other hand for the industry to develop new products, embark on automated processing or use the limited resources effectively, the whole food science philosophy must be reconsidered. Hopefully, my criticisms of current practices will point towards a systematic approach to using information for the furtherance of the food manufacturers aims and at the same time benefiting the consumer.

## Raw Material Control

Simple viscosity measurements are carried out on vegetable oils. These are effectively 'newtonian' and hence the method used is of no great relevance. It is useful in terms of metering and hence may well be a sensible measurement to make. Viscosity measurements may contribute considerably to the understanding of the behaviour of complex systems in which the oil forms the continuous phase. We have some rheological relations connecting the viscosity of the continuous phase to that of the dispersion but these are effectively empirical and not predictable directly from the properties of the dispersed entities. We are seldom able to predict the effect of mixing two oils unless we have tried similar mixtures before.

Gelatin is usually tested by dissolving in water, allowing to set under standard conditions and measuring the load required to depress

a plunger a fixed distance. If a test of this type gives the desired answer we assume that it is satisfactory. It does not tell us if it is right for the wrong reason, and hence not suitable for the different situation in which it will be used. A wide range of tests involving this and other principles, such as extrusion or torsional resistance, have been and are used for testing gelling agents. There is probably a different recognised test for each gelling substance. If gelatin is measured in Bloom units and agar in Kobe units, what is the value of a 50:50 mixture in a milk dessert at a different concentration measured with an Instron?

Rheology in the control of starch usually involves a flow cup to measure the viscosity of a paste produced either by dissolving in alkali or gelatinising in hot water. Not only is a variable pressure head, dependent on flow rate, being used for a non-newtonian fluid, but the texture of any resultant product relies on gel rigidity for its eating quality. I await the day when a non-gelling waxy maize starch derivative meets the specification for an acid modified normal starch.

All these tests reflect characteristics of the molecules or particles constituting the raw material and their tendency to interact. They do not characterise the materials in terms that allow us to directly consider the effects of processing or the structure of the resultant product.

### **Process Control**

Liquid chocolate manufacture is controlled by viscosity measurement with a view to assessing suitability for the user. For historic reasons each factory uses a different method and may involve ball fall, capillary flow or rotational shear principles. Any deviation from specification is corrected by fat addition or, very occasionally, increased emulsifier. Laboratory tests use concentric cylinder viscometers according to the IOCC (International Office for Cocoa and Chocolate) specification. The IOCC recommend use of the Casson equation for data interpretation although I am pleased to note that our York factory has continued to use the Bingham model.

It is necessary to use a flow model to interpret flow data, the choice being dependent on the application. A process control value is effectively useless unless it indicates the action required when the observed value is outside the specified range. Since there are at least four independent methods of reducing a high viscosity in chocolate, the correct action can only be predicted if we have a minimum of four control parameters. Both Bingham and Casson models only give two, ball fall and flow cup, usually only one. We are probably better off relying on Joe's judgement, based on accumulated experience, until research can provide a good answer, than depending on unreliable empiricism. A good rheological model will directly relate stress and strain in terms of material composition and hence to what we put in and subsequent changes during the process. Our simple measurements may be useful

in aiding Joe's judgement but an in-line device should decide what action to take and trigger its implementation or the benefits are lost.

### **Product Evaluation**

A vast range of methods, instruments and models have been applied to this problem. Favourite instruments include the Instron and the General Foods Texturometer. There is a considerable doubt as to what most of these instruments measure in rheological terms and although many attempts to correlate them with mouthfeel have been made, correlation with internal structure has been almost entirely ignored. Internal structure is the product description potentially predictable from the nature of the raw materials. Rheology, properly applied, manifests that structure and relates to the sensations in the mouth.

A cone penetrometer applied to cheese spread measures a combination of rigidity, bulk modulus, viscosity, surface tension, etc. If we change the spread we probably alter the combination of these parameters as the time dependence of response to constant load changes.

When we bite or cut an apple with a knife, using a controlled force, we effectively measure the turgor pressure of the cells and the break stress of the cell walls. A small contribution may result from deformation of the neighbouring cells. A second bite assesses a similar structure but with a different geometry. The relation between structure and mechanical behaviour in this example is relatively simple and may correlate with initial sensory response to the sample. Further chewing breaks down more structure and the mass is diluted with saliva. At the end of chewing a mass of cells and cell debris in a liquid is swallowed. Is the nature of that mass related in a simple manner to the result of our cutting test? Comparing gelatin and starch-based pastilles, with apparently identical first bite character, suggests the answer is no. Sensory assessment involves the integrated pattern of sensations throughout the chewing period. Flavour, a diffusion phenomenon, should also be included.

Although a single point measurement may be adequate to define the relation between product structure and consumer assessment for control purposes, it is rather risky to assume this without studying the relationship. It is even more unreliable when such tests are used, without fundamental understanding, for assessing the viability of development projects.

### **Material Behaviour and Machinery Design**

If, as is often the case, we wish to pump material along a pipe, an understanding of flow behaviour is required to aid the engineer in designing the equipment. For liquid chocolate we can use the Casson or Bingham models, quantified from experimental data, in a pipe flow equation and calculate pressure drops, etc. At five tons per hour both

equations give answers of the same order, the Bingham form giving the simplest equations. If we wish to drain semi-solid chocolate from a fondant after enrobing, the flow rate will be low and neither model satisfactory.

(I am intrigued as to why the Casson equation was ever applied to chocolate. Fat coated sugar particles are unlikely to aggregate by predominantly electrostatic forces and the slightly better fit to concentric cylinder data is a purely coincidental effect. The only evidence in its favour to my knowledge is a marginally higher correlation coefficient when applied to raw data, which appears to arise from ignoring the complication of outer cylinder stress being less than the yield stress when the Bingham model is used.)

During the last 100 years considerable resources have been expended on trying to drastically increase the rate of gum drop drying. Fick's second law was published in 1855 and easily shows the exercise to be futile. It also indicates possible alternative technologies. The difficulties of these potential routes can be evaluated, at least qualitatively, using chemical and rheological knowledge. As a result we need not try out equipment/process ideas without a reasonable probability of success.

Pipe flow involves pressure and drying is an example of mass transfer. Energy transfer is another rheological phenomenon of great importance in food processing. For example we wish to obtain sterilisation temperatures at the centre of a can without overheating and hence damaging the contents near the wall.

Mass or energy injection and force application as functions of time and position are the only activities of which the engineer's hardware is capable. The pattern required is that which brings the correct molecules together under suitable conditions to develop the desired reactions. Looked at in this way we can visualise food science as a branch of chemistry in which rheology provides the essential link between the changes required in the material and the hardware needed to achieve them.

## **Food Science and Rheology**

Food processing, like chemical manufacture, involves selecting ingredients, subjecting them to appropriate treatment and obtaining the desired product. Chemistry has developed to a stage where we can translate chemical ingredients to a form of mathematical description or at least a model form such as a molecular configuration in which certain characteristic features appear. All ingredients are describable in the same terms. Either quantitatively or qualitatively the interactions between species can be evaluated and the conditions to obtain a particular product model predicted. The product model can be transformed to a chemical product. Alternatively, a desired product can be converted to its model form and an ingredient/treatment com-

bination sought to match it. In this way only practical tests with a high chance of success need be carried out. The food processor needs the same type of theoretical capability to increase the flexibility of his operations and adapt to changing circumstances.

The first stumbling block is the inability to describe all materials in the same model form. The second is the limited information relating product to its model, whether based on internal structure as in the case of chemistry, or the related descriptions based on bulk behaviour or sensory assessment. We are a little better off in terms of relating material model to product model because analogy to chemistry often applies. There is, clearly, a tremendous challenge in formulating a quantitative, multidisciplinary science of this type.

Rheology may have a part to play in developing material/structure relationships, particularly in gel formation and crystallisation type reactions involving random time dependent processes. When temperature, pressure, movement, etc., requirements within the mass to be processed are defined, rheological techniques and ideas will be needed to relate the conditions to the hardware producing them and hence the design of equipment. Finally, rheology has an important role in relating product internal structure to the sensory evaluation which ultimately defines the success of the product.

Food is essential to all of us from a nutritive viewpoint. It also gives us much pleasure and this enjoyment depends on the manufacturer being able to provide a wide range of texture and flavour sensations on a reproducible basis. He should have the flexibility to do this whatever the economic and social pressures applied. To this end we need a predictive food science involving the integration of chemistry, rheology, engineering and mathematical modelling. Most of all the need is for new ideas with wide-ranging implications to develop a broad general approach. The same argument can probably be applied to other industries and much of the work could prove to be common ground. Can we rise to the challenge?

## **RHEOGONIOMETRY COURSE . . . REMINDER**

**14 to 16 May 1980**

As advertised in the previous Bulletin (No. 4, page 97) this course which is concerned with rotational rheometry and is aimed at users and potential users of the Weissenberg Rheogoniometer and similar instruments is to be held at the University of Strathclyde's Staff Educational and Recreational Centre, Ross Priory, on the banks of Loch Lomond.

The course fee is £80 including full board and further information can be obtained by contacting Dr. J. Ferguson, Department of Fibre Science and Textile Technology, University of Strathclyde, Glasgow G1 1XW, using the application form supplied in the previous issue.

## PERSONAL NOTE

DR. HOWARD A. BARNES

My interest in rheology began in my first summer vacation job while studying Physics at Aberystwyth. I worked in the Physics Department of the National Institute for Research in Dairying at Shinfield, near Reading, with Dr. Hywell Thomas, on a blood viscometer. At that time Dr. George Scott-Blair was in charge of the department and lots of well known rheologists passed through my little room into his office — Marcus Reiner, A. L. Copley and others. Listening to G.S.-B. explaining the rheology of milk, cheese and butter was quite an inspiration!

Returning to Aberystwyth I found that there was an active rheology research group in the Applied Mathematics Department under Dr. (now Professor) Ken Walters. After finishing my degree in physics and a year's post-graduate diploma course in electronics I transferred to the Applied Mathematics Department to work on flow of viscoelastic liquids in curved pipes, sponsored by NEL.

After completing my Ph.D. and a year's post-doctoral study I came to Unilever Research Port Sunlight as a rheologist. Since that time I have worked on a variety of liquids and soft solids. My contribution to Professor Walters' forthcoming book on the industrial applications of rheometry summarises my experience here.

During the next 12 months I hope to be engaged in a general review of the problems industry encounters with non Newtonian dispersions, through a Chemical Society Industrial Fellowship. I hope to visit many of the members of the Society to discuss the theoretical and practical problems they have with dispersions and also to assess the theoretical contribution being made by academics.

## THE PRONY SERIES EXPANSION

ZVI RIGBI

Department of Chemical Engineering  
Technion-Israel Institute of Technology  
Haifa, Israel

A number of authors, including the writer, have attempted to expand an observed relaxation curve into a series of discrete relaxation functions with increasing relaxation times. This is called a Prony series. Many of these authors, again including the writer have cited as authority for such a series, written as

$$D = D_0 + \sum_{n=1}^k d_n e^{-\frac{t}{nT}} \quad , \text{ a paper by R. Prony entitled}$$

"Essai expérimentale et analytique" which appeared in vol. 1, No. 2, page 24 - 76 of J. Ecole Polytechnique of 1795. The present writer, at least, had never seen the original paper, but relied on the reference given by others.

With the help of a friend, I have now been able to obtain a copy of this paper, and should like to comment on its contents.

It may be of interest to your readers to know that the paper is actually dated Floreal (20 April - 20 May) and Pairial in the Year III. The French revolution, usually dated 1789, did away with the accepted calendar and renamed the months of the year. It was Napoleon who reaffirmed the discarded calendar.

The full title of the paper is "Essai expérimental et analytique sur les lois de la Dilatabilité des fluides élastiques et sur celles de la Force expansive de la vapeur de l'eau et la vapeur de l'alkool, à différentes températures". The editors of learned journals in the Year III were obviously well disposed to titles which explained the purpose and contents of a paper, abstracts not being the fashion of the time. Perhaps some thought should be given to reverting to this style — it may make Rheology Abstracts simpler to read! The modern synonym for Force in the title is, of course, pressure; Prony uses an atmosphere of 75.7708 cms of mercury, equal to 28 pouces (inches), which shows that the inch must have shrunk by 1.661 mm over less than 200 years — or are French thumbs longer than English thumbs?

The part of the paper of direct interest is really an exercise in curve fitting. The equation proposed by Prony is not written as above, but in the form

$$Z = \mu_1 p_1^x + \mu_2 p_2^x + \dots \mu_n p_n^x$$

where  $Z$  and  $x$  are the variables, and  $\mu_k$  and  $p_k$  are constants which must be determined for each gas or vapour investigated. Nowhere is it stated that  $p_2 = p_1^2$  or  $p_n = p_1^n$  which would make this the equivalent of the modern so-called Prony series. Prony produces algorithms for even or odd numbers of pairs of the variables, adding one term in the series for every two pairs of variables  $Z$  and  $x$ . Prony then uses his series for recalculating intermediate points which he compares, to his eminent satisfaction, with experimental observations.

The writer has not been able to locate an algorithm for the fitting of the "modern" Prony series to observations (so-called collocation) and will be happy for assistance from any reader of this note.

In conclusion, I cannot but help praising the personal style of Monsieur R. Prony and the bit of philosophy he brings into his introductory paragraphs. Prony distinguishes sharply between "the explanation of effects" and their measurement. By "explanation", Prony means identifying the separate simple or primitive phenomena which give rise to the complex behaviour being studied.

## MEMBERSHIP NEWS

### APPLICATIONS FOR MEMBERSHIP

The following applications were approved by Council at its last meeting (December 1979).

Roger Burley, B.Sc., Ph.D.  
f.et.sa, F.G.H.J.L.O.

Vincent Ralf Withers, M.A.,  
Dipl. Flow. Meas.  
A.(i) D.F.O.

Richard Alan Dawe, M.A., Ph.D.  
A.(i)

Jack Rowles Knox, B.S., M.S., Ph.D.  
f.et.sa, B.C.D.O.

Walter Regel, Dr. Phil., Dipl. Chem.  
f.et.s, D.M.

Gwyn Jones, B.Sc., Ph.D., C.Chem.,  
M.R.I.C., M.I.Z.C.  
A.(ii) D.E.G.H.

James C. Taylor, C.Eng., M.I.E.R.E.,  
M.I.E.D.  
f.e,a,O.

Kenneth Arthur Evans, C.Chem.,  
M.R.I.C.  
p,e,a,G.H.L.

Prof. Cecil Wilfred Nutt, B.Sc., Ph.D.,  
D.Sc., C.Eng., M.I.Chem.E.,  
F.R.I.C., F.R.S.A.  
e,t,a,D.E.F.G.J.O.

Masaharu Sakuta, M.Eng.  
f.et.sa,K.

Russell Charles Frost, B.Sc.Eng.,  
M.Sc., Ph.D.  
f.et,a,E.G.M.

Izzidin Mustafa Kaffaf, B.Sc.  
p.et.as,C.D.

Heriot-Watt University  
Department of Chemical and  
Process Engineering  
Chambers Street  
Edinburgh EH1 1HX  
BP Research Centre  
Chertsey Road  
Sunbury-on-Thames TW16 7LN

Imperial College  
Mineral Resources Engineering  
Department  
London SW7 2AZ

Amoco Chemical Corp.  
P.O. Box 400  
Naperville  
Illinois 60540 U.S.A.

Institut für Makromolekulare Chemie  
Stefan-Meier-Str. 31  
D78 Freiburg  
West Germany

British Celanese Ltd.  
P.O. Box 5  
Spondon, Derby

Ferranti Instrumentation Ltd.  
St. Mary's Road  
Moston, Manchester

United Biscuits (U.K.) Ltd.  
Group R & D Centre  
St. Peter's Road  
Furze Platt  
Maidenhead, Berks. SL6 7QU

Heriot-Watt University  
Department of Chemical and  
Process Engineering  
Chambers Street  
Edinburgh EH1 1HX

King's College  
Department of Civil Engineering  
Strand  
London WC2R 2LS

Water Research Centre  
Stevenage Laboratory  
Elder Way  
Stevenage, Herts. SG1 1TH

Institute of Polymer Technology  
Loughborough University of  
Technology  
Ashby Road  
Loughborough  
Leics. LE11 3TU

David George Smoker, B.Sc.  
f,e,sa,C.D.

S. De Jong, Ph.D.  
f,et,sa,G.J.L.N.

#### **Honorary Membership**

F. J. Rigby

#### **Resignations**

Dr. L. D. Easton

A. J. Lovett

L. J. Williamson

R. P. Faulhaber

#### **Death**

The Society has just been informed of the death of Dr. R. J. B. Marsden, I.C.I. Ltd., Fibres Division, Harrogate, who died in April 1977.

Institute of Polymer Technology  
Loughborough University of  
Technology  
Ashby Road  
Loughborough  
Leics. LE11 3TU  
Unilever Research  
P.O. Box 114  
3130 AC Vlaardingen  
Netherlands

45 Bennoch Road  
Kirkcaldy  
Fife

John & E. Sturge Ltd.  
Birmingham

University of Aston  
Birmingham

Burrell Colours Ltd.  
Stockport

Unilever Research  
Netherlands

### **FUTURE EVENT**

The Formula 80 Exhibition will take place from the 9 - 13 June 1980 and will cover raw materials, measuring and control equipment, computer systems and tools, mechanical aids, patent products and processes for the paint, varnish, lacquer, printing ink and allied industries; also for the treatment and regeneration of water, air and waste matter in the manufacture of paints, varnish, etc.

Under the same roof will be held the Fatipec Congress; the theme of the Congress being the 'Activities of the Coatings Industry in the framework of ecology, energy and economy problems'.

Both these events will take place in the RAI Exhibition Centre, Amsterdam.

### **VISITING RHEOLOGIST**

Professor W. W. Graessley, the Bingham medallist this year, is visiting the Cavendish Laboratory, Madingley Road, Cambridge, for one academic year.

## RESEARCH VACANCIES

### Research Fellow

Applications are invited for a POSTDOCTORAL RESEARCH FELLOWSHIP funded by the SRC in the DEPARTMENT OF FIBRE SCIENCE AND TEXTILE TECHNOLOGY for work on the measurement of ELONGATIONAL VISCOSITY. The post is suitable for a chemist, physicist or applied mathematician. A knowledge of rheology is desirable but not essential.

Appointment will be on Range IA of the national salary structure for research and analogous staff with a commencing salary within the Range £4,333 - £4,910. Placing according to qualifications and experience. Superannuation benefit.

Appointment will be for three years, commencing from 1 February 1980 or as soon as possible thereafter.

Written applications naming two referees and (quoting R47/79) should be forwarded to Dr. J. Ferguson, Department of Fibre Science and Textile Technology, University of Strathclyde, Glasgow G1 1XW, from whom further information can be obtained.

### DIARY

1980

26th-28th March. "Practical Rheology in Polymer Processing" —  
Loughborough.

26th March. B.S.R. Council Meeting.

14th-16th May. Rheogoniometry Course — Ross Priory.

16th-17th July. "Liquid Crystal Polymers" — Leeds.