

**THE
BRITISH SOCIETY
OF RHEOLOGY**

BULLETIN — No. 3, 1966

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The Presentation



Professor Reiner's Reply

MARKUS REINER DINNER

PRESENTATION TO PROFESSOR MARKUS REINER

Professor Markus Reiner was the guest of the Society at a Dinner held at Skindles Hotel, Maidenhead, on August 4th, 1966. More than 30 members and several guests were present to honour Professor Reiner on attaining his 80th birthday, and to celebrate the award to him of the first gold medal of the Society.

Dr. G. W. Scott Blair, a founder member of the British Society of Rheology, spoke of his long friendship and years of collaboration with Professor Reiner. He outlined Markus Reiner's career in Continental Europe, Great Britain, the United States, Palestine under the British Mandate, and now in Israel. (Although the table was decorated with the flags of Britain and Israel it became obvious that several other nations ought to have been represented.) After an initial, distinguished, career as a civil engineer, Professor Reiner extended his interests and thereby became one of the founders of modern rheological science. We were celebrating an 80th birthday, and honouring an illustrious past career, but an equally distinguished future was still to come. At 80, Markus Reiner was still working hard, travelling widely, and widening his interests, therefore the appropriate toast should be to "Young Markus Reiner."

The President, Professor A. J. Kennedy, then presented Professor Reiner with a framed address reading "In tribute to Markus Reiner on the occasion of the presentation of the first gold medal of the British Society of Rheology, awarded in recognition of his classic contributions to the study of rheology and to honour his 80th year."

Professor Reiner thanked the Society for its award, and explained how 40 years ago, whilst working at Lafayette College, he, a civil engineer, had found that certain mathematical problems that concerned him were of interest also to Professor Bingham, who was a chemist. These problems cut across conventional subject divisions, and it was decided, therefore, to form a small group of those interested in the mathematical representation of processes of deformation and flow. A concise word to describe these processes was required; the Professor of Classics was consulted; and the word "rheology" came into being. Rheology might be a new word, but rheological behaviour was known to the Old Testament prophets: the mountains flow before the Lord—in whose sight an age is but an hour. Now, once again, there is widespread interest in the slow deformation of the earth's crust.

The Dinner, the first of its kind organised by the Society, was such a pronounced success that those present are looking forward to the next similar occasion—hoping that it will not be necessary to wait until Professor Reiner's 90th birthday.

D. W. H.

(Copies of the photographs in this Bulletin, approximate size 6½in. x 4½in., may be obtained from D. W. Hadley, J. J. Thomson, Physical Laboratory, Whiteknights, Reading. Price, including postage 1s. 6d. each. Please state whether glossy or lustre finish is required.)

THE BRITISH SOCIETY OF RHEOLOGY MEDAL FOR APPLIED RHEOLOGICAL RESEARCH

The British Society of Rheology wishes to encourage workers, both in industry and in the universities, to make greater practical use of fundamental rheological principles. To this end it is proposed to award a gold medal once every three years for the application of rheological science to the study of industrial problems.

Applications for the first award are now invited, and should be sent to the Secretary of the Society's Research Committee at the address below, not later than May 1st, 1967. All persons who have carried out work of an appropriate character during the past few years are eligible to apply, whether members of the Society or not.

Work submitted for consideration will be judged on its merits, and not necessarily by either its economic value to industry or its suitability for publication in a scientific journal. The one essential is that the applicant must have made a genuine attempt to solve some practical problem of industrial importance, not by trial-and-error methods but by the logical application of rheological principles. The rheological principles involved need not be of a particularly advanced nature, since the merit of the work will be assessed mainly by the aptness of the way in which those principles have been applied. Consequently the competition affords an opportunity for younger rheologists and technologists to compete on equal terms with their more eminent colleagues.

Rules

1. The medal will be awarded by the British Society of Rheology, acting on the recommendation of its Research Committee, to the entrant who is deemed to have made the best contribution to the solution of an industrial problem by the application of fundamental rheological knowledge.
2. Any persons, other than members of the Research Committee of the British Society of Rheology, shall be eligible to enter for the award if they have carried out research and/or development work of a rheological character within the United Kingdom. Work done in any other country may be held to qualify only if it is done on behalf of and for the benefit of some section of British industry.
3. Persons wishing to be considered for the award should submit an account of their work (8 copies) to the Secretary of the Research Committee by May 1st, 1967. This may be in the form of an open publication, an internal report, or an account written especially for the purpose. If the last alternative is adopted, the British Society of Rheology shall have the right to arrange for publication of the account, either in full or in abstract, in one of its journals or elsewhere.

4. Entries should preferably be from individuals. A paper submitted by a single entrant which is published in the name of himself and one or more co-authors will be considered only if it is accompanied by a statement of the part played in the work by the entrant; this statement must be signed by both the entrant and his co-authors. Where two or more persons have played an approximately equal part in the work, a joint entry should be made by the workers concerned.
5. The Committee may recommend that no award be made if it considers that none of the entries received is of sufficient merit.
6. The award will be announced at the Society's Annual General Meeting in September 1967.

A. T. J. HAYWARD,
Secretary to the Research Committee of the
British Society of Rheology,
National Engineering Laboratory,
East Kilbride, Glasgow.

A RHEOLOGY MISCELLANY

An afternoon meeting of the Society, at which three papers were read and a film shown, was held at Skindles Hotel, Maidenhead, on August 4th, 1966, immediately preceding the Markus Reiner Presentation Dinner.

The session began with a paper by Professor D. Dowson (Leeds University) entitled "The study of lubricant rheology in elasto-hydrodynamic lubrication." An approximate solution for the behaviour of a thin film of oil between meshing gears is given by a model in which the film lies between a cylinder and a plane. Under high pressures the cylinder is flattened, to give an oil film which is almost parallel-sided. Most theoretical work then assumes the film to be a Newtonian fluid, enabling predictions to be made of the shape and thickness of the oil film under known pressures, and its temperature rise as it passes through the contact region. Account can be taken of the increase in viscosity by several orders of magnitude as the pressure is raised from atmospheric to several hundred tons per square inch. Predicted temperature rises are only a few degrees, but since the film thickness may be only 10^{-4} cm. the temperature gradients are large. A short survey of methods used to test these predictions was then given, and the results of several experimental groups were compared. Two main methods of measuring the thickness of the oil film were used: variation of capacitance with the oil film acting as a dielectric; and an X-ray transmission method.

Good agreement with theory was obtained for mineral oils, but only poor agreement with silicone fluids, the experimental thickness being less than that predicted because of the visco-elastic nature of the fluid.

The following paper, by Dr. A. Dyson (Thornton Research Centre) described "Non-Newtonian behaviour in elasto-hydrodynamic lubrication." The shear rates involved in these studies were too high for continuous shear viscometers to be used, and so experiments were performed at high frequencies and small shears using an oscillating quartz crystal.

Using an Aldroyd model the validity of this approach was demonstrated by showing an analogy between the stress term in continuous shear and the real and imaginary parts of the modulus in oscillatory shear.

Several materials, including oil thickened with polymer, had been investigated at film thicknesses down to 100A (only 3 or 4 molecules thick). Experiment and theory were in fair agreement for film thickness measurements, but the observed variation in frictional traction was not readily explainable.

In reply to a question by Professor Reiner it was agreed that the theory might not always hold, because the maximum shear stress might be limited due to rupture of the oil film.

Tea break, protracted because of the misbehaviour of the hired film projector, provided a pleasant, and still too short, interlude for discussion, suggesting that at all one day meetings ample time should be arranged for private conversations.

The second half of the meeting began with the film "Rheological behaviour of fluids," with demonstrations and commentary by H. Markovitz. This film, one of a series produced by the (U.S.) National Committee for Fluid Mechanics, contrasts, in a series of demonstrations, the behaviour of Newtonian and non-Newtonian liquids. The demonstrations were selected so that the film provides a useful aid for an introductory undergraduate course on non-Newtonian flow.

Following these experimental demonstrations was a theoretical paper by Dr. J. R. Jones (Swansea Univ. Coll.) entitled "A first approximation to some flows of non-Newtonian fluids." The virtual force method, due to R. S. Jones, was used to calculate the secondary flow patterns in possible experimental systems. Fictitious body forces are introduced to give simple flow systems. The body forces are then removed, and the instantaneous flow patterns are calculated.

Two systems were treated in detail, in each case the results being compared with the steady state flow patterns obtained from the full theory. Both in the case of a sphere rotating in an unbounded liquid and for flow between two non-concentric cylinders the instantaneous flow virtual force method showed quite good agreement with the results of a full steady state analysis. It was concluded, therefore, that in other systems the early motion would give a good guide to eventual steady state conditions. Dr. Jones claimed that when a method of solution had been found the calculations involved were simple and rapidly performed. One could then predict almost immediately whether a proposed experiment would be meaningful, whereas a full analysis would be a lengthy process.

A lively discussion ensued in which Dr. Walters was prominent. He commented that although the calculations might be rapid when a solution had been found, a possible method of solution appeared a lengthy process. Additionally, is the lengthy nature of a steady state solution really a drawback; one good theory could keep experimentalists busy for several years.

At this stage the proceedings were brought to an unorthodox conclusion by the reversion of the lecture room to a Bar, and its opening to the general public. (Prospective Chairmen may be interested to learn that any meeting may be brought to a rapid termination by the simple expedient of having a waiter walk across the room at frequent intervals, carrying successively: a bunch of keys; a till; a money bag; and an armful of bottles.)

Thus, for the second time, A. T. J. Hayward failed to obtain a showing for his film "The growth of ice tubes." These tubes are formed during the rapid freezing of water which is at the same time both superheated and supercooled (see "Nature," 1966, 211, 172-73).

It is possible, however, for those interested in this fascinating phenomenon to borrow a copy of the 16 mm. sound film from: The Director, National Engineering Laboratory, East Kilbride, Glasgow.

Holding an afternoon meeting in an hotel has both advantages and drawbacks. Pleasant and comfortable surroundings, and an informal atmosphere, compensate for lack of full lecture theatre facilities. The all-important factor is to make certain that there will be sufficient time available to complete the full programme.

D. W. H.

First International Conference on Hemorheology

The First International Conference on Hemorheology was held at the University of Iceland, Reykjavik, from July 10th to 16th, 1966.

Before the Conference started, a new Society: the International Society of Hemorheology, was founded so that the Conference was sponsored by this Society. The Officers and Council of the Society were elected but it was left to the Council to draw up a Constitution, based on a draft which had already been prepared. The Conference Chairman, Professor A. L. Copley (U.S.A.) was unanimously elected President.

Hemorheology, the study of the flow of blood and its components, of its coagulation and lysis and of the mechanical properties of the vessel walls, is of such practical importance that it was felt well worth while to organise a series of Conferences on the subject and to have a Society responsible for such organisation and international co-ordination.

Should an International Society of Rheology as a whole, or of Biorheology, be formed at some future date, it was agreed that the new Society would consider some form of affiliation.

There were about a hundred members of the Conference, some coming from as far away as Australia and Japan.

At a special Session a gold medal, cast in honour of Poiseuille, "the first hemorheologist," was presented to Professor Robin Fahraeus in recognition of his pioneer work on blood flow and sedimentation.

Perhaps the most valuable outcome of the Conference was that it gave the medical half of the audience an up-to-date picture of rheological developments; and the rheologists learned much about the medical problems for which their work is being or might be used.

It is hoped to publish the Proceedings in book form. The Secretary of the International Society is Dr. George Bugliarello, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh (Pa.) U.S.A. The next Conference of the Society will be held in France in 1969.

Dr. G. W. SCOTT BLAIR.

French Rheological Terminology

Bulletin 1965 (3) gave literal translations of definitions of 20 rheological terms approved by the Council of Groupe Français de Rhéologie. Further definitions (21–46) have now been adopted, and are given below. Phrases in parentheses are what G.F.R. considers to be English equivalents.

21. *Directions principales d'un tenseur symétrique.* (Principal axes of a symmetrical tensor.)

The directions of axes of quadrics associated with the tensor (the quadrics of the equations $\sum_{ij} \sigma_{ij} x_i y_j = \pm \frac{1}{\sigma_{ij}}$ designate the cartesian co-ordinates of the tensor).

In taking these directions as axes of co-ordinates, the matrix of the tensor takes the so-called diagonal form:

$$\begin{bmatrix} \sigma_1 & 0 & 0 \\ 0 & \sigma_2 & 0 \\ 0 & 0 & \sigma_3 \end{bmatrix}$$

22. *Valeurs principales d'un tenseur symétrique.* (Principal values of a symmetrical tensor.)

Values of σ_1 , σ_2 and σ_3 (cf. 21). If $\sigma_1 \geq \sigma_2 \geq \sigma_3$, σ_1 and σ_2 are called extreme principal values, σ_2 the intermediate principal value.

23. *Tenseur isotrope ou sphérique.* (Isotropic or spherical tensor.)

Tensor in which the three principal values are equal. Then associated quadrics are spheres.

24. *Déviateur d'un tenseur.* (Deviator of a tensor.)

The tensor s obtained by subtracting from a tensor σ of the principal values σ_1 , σ_2 , σ_3 , an isotropic tensor with principal values equal to $\frac{1}{3}(\sigma_1 + \sigma_2 + \sigma_3)$. The sum of the three principal values s_1 , s_2 , s_3 of the deviator is then zero. The quantity $\sqrt{s_1^2 + s_2^2 + s_3^2}$ is called the norm of the deviator.

In the case of a stress tensor, the deviator of the tensor is called in short: *déviateur des contraintes* (stress deviator).

25. *Fluide.* (Fluid.)

A body which can remain in equilibrium only when the imposed stress is spherical (cf. 23). If a stress deviator exists, however small, the body will deform indefinitely, there not existing a limiting value at definite strains.

26. *Solide* (Solid.)

A body whose deformation remains finite when the norm of the stress deviator is less than a certain positive value (which may be a function of the mean stress $\frac{1}{3}(\sigma_1 + \sigma_2 + \sigma_3)$, of the orientations and ratios of the principal stresses, of the history of loading, etc.). *Note:* There exist bodies not entering within the scope of the previous two definitions (certain thixotropic, nematic, smectic, bodies).

27. *Elasticité complète et élasticité idéale.* (Complete elasticity and ideal elasticity.)

The elasticity is said to be complete when there is no permanent deformation (the residual deformation tends towards zero at the end of a sufficiently long time).

The elasticity is said to be ideal when there is no residual deformation (the body returns immediately to its initial shape). When the elasticity is ideal there exists a doubly unique relation between stress and strain. When this relation is linear the ideal elasticity is called *linéaire*.

28. *Déformation retardée ou différée.* (Delayed deformation.)

The system of loads, which was initially zero, being held constant from the time t_0 , the delayed deformation is that which is produced after a time $t_0 + \tau$, where τ is the response time of the system of observation used.

29. *Déformation élastique retardée.* (Elastic after effect.)

This term designates a delayed deformation which is recoverable after unloading, or the corresponding delayed recovery.

30. *Fluage.* (Creep.)

In the case of solids: delayed deformation not recoverable at unloading. The delayed recovery is zero.

31. *Fragile.* (Brittle.)

Said of the behaviour of a slightly deformable solid when it breaks without appreciable permanent deformation.

Also, the mode of rupture of a solid when the separation of the two parts of the solid is not preceded by relative slip in the zone of rupture.

32. *Plastique.* (Plastic.)

Said of permanent deformations of a solid, and of the behaviour of a solid when it undergoes permanent deformations.

33. *Seuil de plasticité.* (Yield point.)

Value of the load (for a solid body), of a function of components of the stress tensor, *e.g.*, the norm of the stress deviator (for a solid element), above which permanent deformations appear. It may depend on the precision with which the deformations can be detected. It may depend on the loading history, the temperature, and, in the case of an element, on the mean stress, the orientations and ratios of the principal stresses, etc.

34. *Durcissement.* (Hardening.)

Elevation of the yield point following a previous mechanical process. In case of possible confusion with hardening arising from other causes, one can talk of *rheodurcissement* (work hardening or strain hardening).

35. *Amollissement.* (Softening.)

The inverse phenomenon to hardening.

36. *Ecrouissage*. (No English equivalent given.)

This term is used to describe:

- (a) in a general sense, all the modifications of physical properties resulting from a mechanical action which is produced by permanent deformation.
- (b) in a particular sense, the hardening which may result from such an action. It is preferable to use the terms *durcissement* or *rhéodurcissement* (cf. 34).

37. *Raideur*. (Stiffness.)

The property of a solid characterising the magnitude of the deformation which it undergoes for a given increase in stress. The smaller that deformation the stiffer the body.

38. *Module*. (Modulus.)

In a general way, in the case of an imposed strain, the ratio between the increase of stress caused by the strain (more precisely in experiments of relaxation, or vibration) and that strain. The stress considered is that associated with the strain in the expression for the work.

39. *Souplesse*. (Suppleness.)

The opposite of *raideur*.

40. *Complaisance*. (Compliance.)

In a general way, in the case of an increase in imposed stress, the ratio between the corresponding strain (more precisely in experiments of creep (*expérience de retard*) or vibration) and that increase of stress. The strain considered is that associated with the stress in the expression for the work.

41. *Vitesse de dilatation*. (Strain rate.)

The speed of relative variation of the distance between two points, $\frac{dl}{dt}$, that is to say $\frac{dl}{dt}$, if l is the distance between the two points at the instant t .

42. *Vitesse de distorsion*. (Shear rate.)

The speed of variation of the angle formed between two segments which were perpendicular at time t .

43. *Objectivité*. (Objectivity.)

The fact that the laws of behaviour are independent of the movement of the reference axes used. A magnitude independent of movement of axes is said to be *objective*.

44. *Tenseur gradient de vitesse*. (Velocity gradient tensor.)

A tensor whose matrix has elements $g_{ij} = \frac{\partial u_i}{\partial x_j}$, i and j take the values 1, 2 and 3; x_1 , x_2 and x_3 designate orthonormal co-ordinates; u_1 , u_2 and u_3 are the velocity components of a point. This tensor is not objective (cf. 43).

45. *Tenseur vitesse de déformation*. (Strain rate tensor.)

The symmetric tensor representing the set of velocities of dilatation

and distortion around a point. It is the symmetric part of the velocity gradient tensor (cf. 44), that is to say the matrix has for elements:

$$v_{ij} = \frac{1}{2}(g_{ij} + g_{ji}) = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)$$

The tensor is objective (cf. 43).

46. *Dureté*. (Hardness.)

This term denotes the resistance of a solid to penetration (by a needle, a ball, or a tool), that is to say a deformation of its surface. The properties brought into being by such a resistance are different for visco-elastic and plastic deformations, and it is necessary to distinguish the two cases.

- (a) In the case of permanent deformation (hardness as defined by mineralogists and metallurgists), hardness is measured by a stress (the quotient of the force exerted by the area of the impression) which is bound to the properties concerning permanent deformation, such as the threshold of plasticity (cf. 33) or the resistance to rupture (in the case where the deformed surface layers have the same properties as the material constituting the interior of the solid).
- (b) In the case of visco-elastic deformation (polymers), the resistance to deformation is related to the modulus (cf. 38).

To avoid confusion it is recommended that *dureté* be used in sense (a), for the resistance to a permanent deformation of the surface. For the case of a recoverable visco-elastic deformation one should use the word *fermeté*.

Several of the above definitions differ radically from those in common use in Britain. Probably the most obvious difference occurs in the definition of creep, which is normally considered to consist both of recoverable and non-recoverable components. (Often before a creep experiment is begun, a preliminary mechanical conditioning process is performed, with the object of removing the non-recoverable component.)

Dr. R. Roscoe, a past-President of the Society, makes the following comments on the definitions of fluid and solid.

In order that formal definitions of the terms "fluid" and "solid" may be of any value, they must be such as to enable common materials to be placed unambiguously in one category or the other on the basis of experimental tests. Now the great majority of materials commonly regarded as solids exhibit recoverable creep under small tensile or shear stress, and under prolonged stressing this creep increases either logarithmically with time or as some low power of the time. Observations have been carried out for months and even years on certain materials and such laws are found to continue to hold: the rate of creep decreasing continuously, but the creep itself increasing without any apparent tendency to reach a limiting value. The observed creep may always be small, but there are few (if any) recorded cases in

which it demonstrably approaches a limit. Thus if it is assumed that creep measurements may be extrapolated to indefinitely long times, materials such as steel and rubber (to take two obvious examples) must be regarded as fluids under the definition 25. On the other hand, it is sometimes asserted dogmatically that the creep of these materials must eventually approach a limit (provided of course that the stress is well below the "yield value" so that there is no irrecoverable deformation) and this would place them as solids under definition 26. Neither assumption can be demonstrated to be correct.

Obviously any formal definitions must be such as to place steel and rubber firmly in the category of solids in accordance with common usage. It has been shown¹ that it is quite simple to give such definitions using recovery after removal of stress rather than deformation under continuously applied stress.

¹ Bulletin of the British Society of Rheology, 1965, No. 1, pp. 1-11 and No. 2, p. 10.

Professor Reiner and Dr. Scott Blair, as the result of a discussion with several other members of the Society, make the following comments on the 46 definitions so far published.

2. *Contrainte*. The alternative term *vecteur contrainte* would distinguish even more clearly from the state of stress.
9. A better translation in English would be "deformation."
10. *Dilatation*. Could this be changed to "*extension*" in the French, with English translation "extension?"
- 11 (a) and (b). We feel that in both cases the best English translation is "distortion."
- 13 (b). It seems that "*distorsion*" has two meanings in French. Should not this situation be clarified?
27. "Ideal elasticity" in English does not necessarily imply complete elasticity.
30. "Creep" in English does not make any distinction between recoverable and non-recoverable; it refers simply to the slow extension of a solid under constant load or stress.
34. We are not clear about the precise meaning of the French words, especially *écrouissage*. In English "work hardening" means an increase in yield value caused by stretching and "strain hardening" generally means any increase in consistency produced by straining.

Further discussion of the French definitions would be welcome, considering that schemes for standardisation of rheological nomenclature are proposed for Britain and Australia as well as in France. Comments should be sent to the Editor, or to: M. B. Persoz, Groupe Français de Rhéologie, 68 Boulevard Saint-Michel, Paris 6e.

Fifth International Congress on Rheology

The Fifth International Congress on Rheology will be held from October 7th–11th, 1968, at the Kyoto International Conference Hall, Kyoto, Japan, under the auspices of the International Committee on Rheology with the Society of Materials Science, Japan, and the Society of Polymer Science, Japan, as the host societies

The programme of the Congress will cover the entire field of rheology. In addition to contributed papers, the programme will include a number of lectures of special current interest by invited speakers, and social events on which rheologists from various countries represented may exchange views.

Professor Masao Horio and Professor Bun'ichi Tamamushi are co-Chairmen of the Organising Committee of the Congress. All inquiries regarding the Congress should be addressed to:

Professor Masao Horio,
Co-Chairman,
The Organising Committee,
The Fifth International Congress on Rheology,
Department of Polymer Chemistry,
Kyoto University, Kyoto, Japan.

Information for Plastics Users

A would-be user of any plastic soon discovers the available information on physical properties to be insufficient for the required purpose. The behaviour will be described only by a few simple tests, and graphical presentation of the interactions of stress, strain, temperature and time is found difficult or impossible to unearth.

One must welcome, therefore, the proposal by Materials Data Ltd., of Farnham, to begin issuing during 1967 data sheets for every plastic material commercially available in Great Britain. A method of data presentation has been agreed with representatives of major manufacturers and the British Standards Institute, and both tabulated and graphical data will be given.

For several years the proposed system will suffer from the inconsistency between different methods of test, resulting in indexing difficulties for mechanical and physical property data. It will not be possible, therefore, to retrieve through these properties, and initial retrieval parameters will be concerned with processing and fabrication techniques.

Lack of correlation between testing methods, and insufficient data (with much of that available being given for non-rigorously characterised samples) are recognised as major problems in attempting to extend the range of processing methods or applications for polymeric materials. A strong plea for more systematic work in these fields was made at the joint Institution of the Rubber Industry-Plastic Institute

Symposium on "Areas For Further Research In Polymer Technology" held at Loughborough earlier this year.

Although it would be too idealistic to expect all of the fundamentally sound, but obviously expensive and time-consuming, proposals made at this meeting to be achieved within the immediate future, the symposium will have been a success if it has helped to advance the progress of *systematic* time and temperature dependent measurements on *chemically well characterised* plastics.

Measurement of simple properties, such as extensional creep or dynamic modulus over a range of temperatures, are, however, not sufficient for practical purposes: materials in everyday use undergo a complex mixture of wear and deformation processes, and before we begin tabulating our plastics data we ought to know which laboratory measurements and tests will yield results of value to the technologist or designer. The ultimate suitability of an object may depend on a subjective assessment of "goodness," and in such an evaluation application of the embryo science of psycho-physics would seem to be of great assistance. Psycho-physical methods can be used to treat all materials, plastics being only an example, and may enable us to sort out the relevant parameters involved in characterising useful properties.

There can be no magic involved in making a material fit a given specification, the existing inability to achieve the objective with certainty being the result of ignorance both of the material and the specification. Present weaknesses may lie not only in our ignorance, but even in an inability to define the limits of that ignorance itself.

Industry cannot, in present circumstances, contribute large amounts of time and expenditure to projects of such a long term nature as those outlined earlier, whilst established universities are largely concerned with fundamental studies in a small field. Perhaps the newer academic institutions, such as the Technological University of Loughborough, with its unique links with industry and the research institutions, will be able to play a major part in enabling us to characterise complex properties of complex materials in a scientifically useful manner.

Fluid Mechanics Films

The (U.S.) National Committee for Fluid Mechanics Films consists of a group of college staff who have undertaken to produce a series of undergraduate level films that will act as an aid to—but not as a replacement for—the lecturer involved.

Two classes of films are being produced. About 25 sound films, each of approximately half an hour duration, present comprehensive experimental expositions of various concepts in fluid mechanics. In addition, more than 100, four minute long, film loops will provide an experimental demonstration of a specific point.

A list of films now available is given below, together with the names of the author-commentators involved.

Boundary Layer Control (D. C. Hazen; Princeton).

Rheological Behaviour of Fluids (H. Markovitz; Mellon Inst.).

Secondary Flow (E. S. Taylor; M.I.T.).

Waves in Fluids (A. E. Bryson; Harvard).

Surface Tension in Fluid Mechanics (L. M. Trefethen; Tufts).

Flow Visualisation (S. J. Kline; Stanford).

Deformation of Continuous Media (J. Lumley; Penn. State).

Pressure Fields and Fluid Acceleration (A. H. Shapiro; M.I.T.).

Vorticity (A. H. Shapiro; M.I.T.).

The Fluid Dynamics of Drag (in four parts) (A. H. Shapiro; M.I.T.).

Further details of both films and film loops can be obtained from: National Committee for Fluid Mechanics Films, Educational Services Inc., 47 Galen St., Watertown, 72, Mass., U.S.A.

Sound films may be hired from: Central Office of Information, Films and Television Division, Hercules Rd., Westminster Bridge Rd., London, S.E.1; and also from: National Library of Australia, Film Division, 113 London Circuit, Canberra City, A.C.T., Australia.

Symposium on mechanical properties

A long-term investigation into mechanical properties, particularly of complex metals and alloys, has recently been completed at the National Gas Turbine Establishment by a team led by A. Graham. The results of this investigation will be presented and discussed at a symposium entitled "A phenomenological approach to mechanical properties," to be held at City and Guilds College, January 5th-6th, 1967.

There will be three sessions:

- (1) identification of true mechanical properties that characterise the behaviour of a material in different circumstances;
- (2) use of the principles concerned for providing creep, fatigue and other mechanical test data;
- (3) use of the principles for purposes of design.

In the first session evidence will be presented for the existence of a quantitative system of regularities in mechanical properties, especially of metals. The following sessions will be concerned with problems of application.

Members of B.S.R. are cordially invited to attend. Applications should be sent to Professor J. M. Alexander, City and Guilds College, Exhibition Road, London, S.W.7, by November 30th, 1966.

Courses and Conferences

The proposed University of Bradford is running a M.Sc. course in Powder Technology. Further particulars from the Registrar, Bradford Institute of Technology, Bradford, 7

A postgraduate short course in Plastics and Rubber Technology will be held at Farnborough Technical College, Hants. Details may be obtained from the College.

Guildford County Technical College will run a special course on High Polymers. Further information from Head of Dept. of Science, Technical College, Stoke Park, Guildford, Surrey.

A postgraduate course on the Theory and Practice of Rheology will be held in Dept. of Physics, Battersea College of Technology, London, S.W.11.

A three-week intensive course in Engineering Aspects of Lubrication is held each year at Imperial College. Further details and a syllabus can be obtained from the Registrar, Imperial College, London, S.W.7.

The Society of Glass Technology will hold its Golden Jubilee Celebrations in Sheffield, November 8th and 9th, 1966. Further information from Asst. Secretary, Thornton, 20 Hallam Gate Road, Sheffield, 10.

The Institute of Physics and the Physical Society announce the following two conferences.

The Teaching of Mathematics in the Training of Physicists, Exeter, April 13th–14th, 1967.

Point Defects in Metals, Reading, April 12th–13th, 1967 Short contributions are invited, and should be sent to Dr. J. N. Lomer, J. J. Thomson Physical Laboratory, Whiteknights, Reading.

Further details are in each case obtainable from Meetings Officer, 47 Belgrave Square, London, S.W.1.

The Institution of the Rubber Industry is holding a conference at Brighton on May 15th–18th, 1967. The provisional programme is: (i) relation between polymer and network structure and properties of compounds; (ii) combination of rubber with other materials; (iii) advance in processing technology; (iv) productivity, automation and production programming; (v) developments in products and applications; (vi) engineering design of rubber components; (vii) the borderline between rubbers and plastics; and (viii) testing methods—theory and practice. Further details from the Institution of the Rubber Industry, Kensington Palace Gardens, London, W.8.

The British Polymer Physics Group will hold a symposium on Surface Characteristics of Polymers at Churchill College, Cambridge, on January 6th and 7th, 1967. Short contributions can still be considered for inclusion. Additional information from Mr. E. B. Atkin-

son, B.X.L. Research and Development Division, Lawford Place, Manningtree, Essex.

The Institution of Mechanical Engineers announces the following two meetings.

There will be a major five-day conference on High Pressure Engineering on September 11th-15th, 1967. Papers and reviews are now being sought on high pressure equipment and processes where the pressure involved causes a departure from conventional engineering techniques. Transmission, containment and material properties will be examined, together with extrusion and pressing processes. In addition an exhibition will be arranged in conjunction with the conference.

A symposium on Lubrication and Wear in Living and Artificial Human Joints is to be held in London on April 7th, 1967. It is hoped to include, in addition to technical papers, an exhibition of models and devices, a selection of films and slides, and a session for the presentation of up-to-the-minute reports on current research projects.

Further information on both meetings is available from the Institution at 1 Birdcage Walk, Westminster, London, S.W.1.

Dr. Scott Blair wishes to dispose of two complete sets, both unopened, of the four volumes of the Proceedings of the Fourth International Congress on Rheology. Libraries, or individuals, interested in obtaining these Proceedings can obtain further information from Dr. G. W. Scott Blair, National Institute for Research in Dairying, Shinfield, Reading, Berks.