Meetings

Fluid Mechanics before the Society for Natural Philosophy

The second meeting of the Society for Natural Philosophy, held on 11 and 12 November at the Mellon Institute, Pittsburgh, Pennsylvania, was devoted to fluid mechanics. As is desired in meetings of the society, the audience and speakers were drawn from the fields of mathematics, physics, chemistry, and engineering.

In the opening lecture C. Truesdell of Johns Hopkins outlined the concepts of fluid implied or defined in work from the beginnings down to about 1900. In the evolution of ideas of fluid pressure and fluid friction, he remarked that correct and important work was done very early on the basis of special or even dubious hypotheses, which formed a block as well as providing the stimulus for further progress. The failure of the second half of the 19th century to accomplish anything of importance toward a more general theory of fluid behavior he attributed to want of clear objectives as well as lack of adequate mathematical concepts. W. Noll of Carnegie Institute of Technology, after briefly reviewing the success of Reiner, Rivlin, Ericksen, and A. E. Green in creating comprehensive yet concrete theories of nonlinear viscosity in 1945–1957, explained his own more general concept of a "simple fluid." This fluid may respond in any way to its deformation history, as compared with its present state. Noll outlined the direct and elegant general solution of the viscometric problem for simple fluids which he and Coleman recently discovered. He emphasized the position of theories of the rate type, proposed by Oldroyd and others, as special cases of his theory.

A comprehensive summary of mathematically exact results in the classical theory of viscous fluids was given by two of the leading experts, J. Serrin (University of Minnesota) and R. Finn (Stanford). Serrin presented some recent general theorems of universal stability and uniqueness. He then explained progress on the initial-value problem, from the classic work of Leray through the results of Kiselev and Ladizhenskaya and their recent refinements and extensions. In two dimensions, a solution exists for all time. In three dimensions, a solution exists for a certain finite time, which can be estimated simply in terms of the mean initial speed and acceleration. For slow enough initial motion, this time is infinite, but for rapid initial motion, it may be very short. Whether or not the solution really breaks down after a time of this order remains the most significant open problem in this subject. Finn described new and extremely difficult work on steady flow. He remarked that it has been possible to obtain good results by improper methods. Stokes's formula for the drag of a sphere, for example, holds fairly well even when the flow fails to show the forward-backward symmetry implied by his theory of slow motions. Finn exhibited a new, rigorous estimate of the error made by Stokes's formula. After a penetrating discussion of the effect of the rate of decrease of the flow perturbation at infinity and its relation to the theory of Leray, he presented an exact theory of the nature of the wake behind an obstacle.

Among the unformalized but no less earnest tenets of the society is belief that good food and good wine are friends of science. The local committee, consisting of B. D. Coleman and H. Markovitz of the Mellon Institute, presented supporting data in the form of a cocktail party and banquet, unpenalized by before-dinner, during-dinner, or after-dinner speakers, at the University Club. The intercourse begun under these auspices continued the next morning at the round-table discussion, another regular feature of the society's meetings. Coleman presided. Among the short communications should be mentioned the proposal by J. L. Ericksen (Johns Hopkins) of a theory of the statics of liquid crystals in a magnetic field, the explanation of the hexagonal pattern of convection cells in a heated fluid layer by L. A. Segel (M.I.T.), and the rational theory of streaming birefringence in nonlinearly viscous fluids developed by Coleman and R. A. Toupin (Watson Laboratory). The morning session closed with a vigorous exchange of views between R. S. Rivlin (Brown) and Noll on the general requirements of invariance for the constitutive equations of materials.

C.-C. Lin of M.I.T. alarmed his audience by a slide bearing the caption "Engineering Opportunities" beneath a portrait of a spiral nebula. After assurance that the nebulous nature of nebulae is a fit object of natural philosophy, Lin proceeded to a careful analysis of the astronomical data and the possible processes and variables governing galactic structure. For the main effects he eliminated all but classical mechanics and Newtonian gravitation, leading to the Boltzmann equation for a gas whose molecules, so sparse as to experience no collisions, are subject to a strong field of mutual gravitation. The resulting integro-differential equation being intractable, he replaced it by equations of Eulerian hydrodynamics when all mass is concentrated on a spinning disk. An approximation process leading to configurations of spiral form was then described. Thus pure gravitation seems to account, *grosso modo*, for the spiral structure of nebulae.

The last lecture, by Markovitz, collected and compared the data of several observers on nonlinear viscosity and normal-stress effects in polymer solutions, besides describing some instruments now being constructed on the basis of flow geometries for which theory exists but measurement is wanting. Consistent data for the three functions governing all these situations in a simple fluid was obtained. Various special relations, such as that asserted by Weissenberg, are decisively contradicted. One of the slides was described only as showing "an early experimenter and his apparatus." When, after a brief pause for converting to units appropriate to a decade's growth in a Natural Philosopher, it was recognized as a portrait of Rivlin, now chairman of the society, a round of applause followed.

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