Recent Advances in Applied Mechanics

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THIS publication is a unique collection of more than one hundred papers dealing with the subject of Applied Mechanics. They represent the work of many eminent research workers gathered together for the Fifth International Congress of Applied Mechanics held at Cambridge (Massachusetts U.S.A.), during September 12–16, 1938. The papers are classified under the heads:—

(1) Elasticity and properties of Materials: There are 47 of these preceded by three general papers. (2) Mechanics of fluids: These are 66 in number, of which three are of a general character. And (3) Dynamics. There are 17 papers in this Section. Although some of the papers are purely theoretical and mathematical in character, the bulk deal with the application of theory to problems of great practical importance to the engineer. Experimental methods for testing the truth of the theory are described in a number of them and conclusions drawn to serve as a guide for the future progress in design. It would probably be invidious to select from among the papers, but the following references are merely given as samples.

Dr. D. M. Smith of the *Metropolitan Vickers* has contributed a paper in which an attempt is made to estimate the stress and deflection in a built-up half diaphragm as commonly used in Impulse Steam Turbines. The deflection is obtained by calculating separately the deflections of the centre and of the blading assuming a certain distribution for the supporting reactions round the periphery. Curves are given for enabling ready calculation. The values as deduced by this theory were tested experimentally by loading of a large number of diaphragms by means of hydraulic rams. The agreement was very satisfactory, especially in the case of diaphragms with relatively thin centres.

A study of the stresses and displacements in two-hinged Vierendeel Truss arches is made by Professor Maugh of the *Michegan University* with the aid of brass and celluloid models. Some of the conclusions drawn are of general interest in the design of continuous frame structures, notably the one about the stiffness being dependent on the physical characteristics of the joints, and the possibility of the joint-action being expressed in suitable slope-deflection coefficients.

A method of measuring "integrated roughness" of surfaces machined or hand finished is described by Pierre Nicolaw making use of an apparatus which is called "Micrometre Pneumatique Solex". Air is allowed to escape through a specially constructed orifice placed over the surface whose roughness is to be measured. A scale of roughness could be constructed from the quantity escaping which is observed by a manometer measuring the air pressure.

Professor H. F. Moore of Illinois and R. L. Jordan contribute a paper on stress concentration in steel shafts with semi-circular notches based on an experimental study. Fatigue tests were made with the Standard Woehler Type of machine.

The problem of failure of materials under combined stresses forms the subject of an experimental investigation by Prof. Lessels and Mac Gregor of the Massachusetts Institute of Technology. The hollow test bars were subject to internal pressure and at the same time, axial tension. The lateral strains were noted with a newly developed hydraulic lateral extensometer which gave the average strain over a considerable gauge length from the displacement of a quantity of water placed in a metal jacket surrounding the test piece. It is stated that the constant energy of distortion theory was well supported by the test results.

The application of Photo-elastic methods of studying stress problems is described in three papers. The beautiful photographs illustrating the "Frozen Fringe Patterns" obtained with a transparent bakelite test piece by M. Hetenji, as well as other investigators described in these papers indicate that in this method the research worker has in his hands a valuable tool giving

a visual picture of the state of stress in a body.

An automatic relaxation machine to measure the creep properties of a metal stressed under high temperatures was used by Dr. A. Nadai and J. Boyd of the *Westinghouse Research Laboratories*. The work was undertaken with special reference to bolted flanges where the total deformation (elastic + plastic) remains constant and creep takes place under decreasing stress. The work is stated to be still in progress with a view to present a comparison of the test results obtained with creep data already available under a condition of constant loading.

In the section of Mechanics of Fluids, Mr. C. H. Chatfield of the *United Air-Craft Corporation*, U.S.A., surveys in a paper the entire field of development of the air plane structure along with the engine. No part of the aeroplane has been left untouched in this connection. The problems that have confronted Aeronautical Engineers in the past have been carefully analysed and the ways by which successful solutions were obtained are described in a clear and concise manner. Trends in future design both as regards new material and its application are predicted and the conclusion is drawn that research in applied mechanics would be of great help as in the past to the aeronautical engineer in overcoming his special difficulties leading to steady progress.

The phenomenon of turbulence in fluid motion is the subject of a number of papers. The statistical theory is discussed in several papers by Professor Th. Von Karman. Professor Norbert Wicner and others. Professor Kampe de Feriet of the *University of Lille*, France, describes some researches in this connection made to measure the diffusion of very small soap bubbles (3 to 4 m.m. in size) in vertical and horizontal wind tunnels.

The reduction of drag in air-craft is of paramount interest and there are a number of papers dealing with this subject. The effect of surface roughness is the subject of an experimental study by E. F. Relf of the *National Physical Laboratory*. A model of the R. 101 air-ship envelope about 4 feet long was tested. The effect of rivet heads, lapped plates on aerofoils was also studied. Full-scale tests generally confirmed the deductions from model work. Dr. William Bollay of the *Harward University* develops a theory applicable to planing surfaces like sea-plane floats, explaining the differences observed by experimenters between the behaviour of air-foil and gliding surfaces.

The lines of flow in an aerodynamic field are studied by Professor J. Valensi (Marseilles), with the aid of smoke consisting of air charged with ammonium hydrochloride. The injection of the smoke is either continuous or in puffs whose frequency may be regulated. The flow lines are observed by illumination from a source of light which may vary to give a stroboscopic effect or may be continuous. Motion round propeller blades, and different wing profiles have been studied.

Professor Knapp and Dr. Ippen contribute a paper on the characteristics of "shooting flow" in open channels round curves. In a long curve a series of rises and falls in level occur both along the outer and the inner walls of the channel and this pattern persists to a considerable distance downstream. A tilting platform 100 feet by 10 feet was used to vary the slope in the experimental channels. These experiments were necessitated by the concern felt by the engineers over the design of curves for the storm water channels of the Los Angeles County Flood Control. It is stated that sills and transition curves suitably placed damp out the disturbance pattern appreciably in the case of rectangular channels.

The mechanics of sediment suspension is a subject of topical interest to hydraulic engineers the world over with reference to irrigation, river-regulation, &c. Some experiments to elucidate this matter conducted by Professor Rouse of Pasadena are described in a paper. A theory is developed for the distribution of sediment under equilibrium conditions based on the analogy of an expression which has been used for the transport of momentum per unit fluid volume in a liquid in which fully developed turbulence exists.

The question of transfer of heat across metal partitions under conditions leading to evaporation of liquids at a high or low pressure is the subject-matter of a paper by Professor Max. Jakob of Chicago. The coefficient of heat transfer in tubes (such as are used in boilers) under such circumstances is higher than in wide vessels. A formula is developed based on various assumptions to apply to the case of horizontal or vertical walls, and fairly good agreement has been

found experimentally but it is admitted further work is necessary. The effect of vibration on heat transfer from a horizontal cylinder is studied by Professor Boelter and Martinelli with the aid of a special apparatus devised by them.

The phenomenon of cavitation is studied by Professors H. Peters and B. G. Rightmire by the vibratory method using a brass test specimen screwed into a nickel tube and vibrating in fresh water, the vibrations being produced electrically. The test results lend support to the hypothesis that the damage suffered under these circumstances is due to a series of impacts produced on the specimen by the periodic collapse of vapour at the vibrating surface.

Four papers on the mechanism of fluid film lubrication in journal bearings are included. There has been a vast amount of work in this field and both research and theory have enabled one to form a fairly correct picture of what is happening. Recently the effect of pressure in increasing the viscosity has been studied. This is of importance in heavily loaded bearings like those of roll necks of rolling mills. There is then the phenomenon of oil film whirl or instability in the position of journal producing objectionable vibrations. The application of the results of research to the field of practical bearing design is still not so well established as one would desire. The work done in the United States regarding these problems is presented in the form of a summary by Professor Karelitz, De Newkirk and Needs, members of the special research committee on lubrication appointed by the *American Institution of Mechanical Engineers.*

In the Dynamics section, Dean A. R. El. Sawy of the *Egyptian University* contributes a paper on a method of computing the I.M.E.P. of an internal combustion engine working on the 4-stroke cycle. It is stated that the point in the stroke where the pressure is equal to the mean effective pressure is the same for all the cards taken from an engine in normal operation at different loads and speeds. Theoretical and experimental work in support of this contention is offered.

The measurement of transient impact strains by the change in electrical resistance undergone in a thin strip of elastic material cemented to the strained surface is described in a paper by Professor De Forest, of the *Massachusetts Institute of Technology.* The changes in strain could be recorded photographically by means of the Cathode-ray Oscillograph. A check calibration was carried out using a U-shaped metal bar and allowing it to vibrate as a tuning fork. The recorded strain was compared with that obtained by calculation from the St. Venant Formula. The difference was only ½ per cent. It is stated that this method enables one to measure stresses propagated at the speed of sound and "impact strains need no longer remain in the realm of conjecture".

The subject of vibrations and their cure from the topic of a number of papers among which may be mentioned the following: "Vibration Isolation of Air-craft power plants", by E. S. Taylor and K. A. Browne. "Sur La Suppression Des Vibrations a Bord des Grands Paquebots", by Henry Beghin. The latter has reference to the disturbing vibrations experienced in the ship "*Normandie*" when she first put out to sea. The paper on "Spiral" vibration of rotating machinery by R. P. Kroon and W. A. Williams contains a theory based on the hypothesis that temperature distortion of the roter is responsible for the continuous change in unbalance observed under these circumstances. A simple test set-up was used to check up the theory. Further work is considered desirable, to reduce the number of assumptions that are made in what is stated to be a preliminary investigation.

The Cathode-ray Oscillograph is employed by Professor Draper and Philip M. Morse for finding the size and location of the region of detonation in an Internal Combustion Engine. The application of acoustic theory of standing waves is made in this connection. Use was made of the properties of these waves as predicted by the theory and instantaneous pressure Oscillations were simultaneously observed at two different points within the engine cylinder. An interesting conclusion made by the authors is that the detonating region is next to the cylinder wall and often has a greater spread along the wall than away from the wall.

This collection of papers is thus of very great interest and importance to workers even in kindred subjects and the new methods of attack described offer great scope for further research. The typography and get-up leave nothing to be desired and the illustrations and graphs form additional attractive features.

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