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A STUDY OF SHEAR STRESS AT A FLUID-SOLID
INTERFACE MEASUREMENT OF THE
ELECTROKINETIC POTENTIAL

Status Report

by

J. E. Cermak

1 March 1960

ENGINEERING RESEARCH
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A STUDY OF SHEAR STRESS AT A FLUID-SOLID INTERFACE
BY
MEASUREMENT OF THE ELECTROKINETIC POTENTIAL

STATUS REPORT

by

J. E Cermak

Prepared for
Research Corporation
405 Lexington Avenue
New York 17, N. Y.

Colorado State University
Fort Collins, Colorado
1 March 1960

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A STUDY OF SHEAR STRESS AT A FLUID-SOLID INTERFACE
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(Status Report)

INTRODUCTION

The purpose of this report is to describe the way in which a grant from the Research Corporation has been utilized to establish a research program relating electrokinetics to fluid dynamics. After a brief review of sponsorship for this study, a summary of accomplishments and anticipated activities will be presented. This will be followed by a statement on project personnel and a financial statement covering funds received under the Research Corporation grant.

PROJECT SPONSORSHIP:

Material support for this study was obtained in June 1956 through a \$1000 grant to the writer from the Colorado State University Research Foundation. These funds permitted several items of equipment to be purchased. Upon conducting a simple preliminary experiment the feasibility of studying certain aspects of fluid dynamics by making electrokinetic potential measurements became apparent as well as a need for additional and more refined equipment. Accordingly, further sponsorship of the work was sought.

As a result of this effort a \$5000 grant was provided by the Research Corporation in October 1957. This grant permitted a research-assistantship stipend to be provided for a doctoral candidate and enabled additional equipment to be purchased or constructed. Furthermore, a considerable amount of data was obtained. To ensure continuation of the study additional support was sought from the National Science Foundation.

In November 1959, primarily as a result of initial work under the Research Corporation grant, a National Science Foundation grant was received. This grant is in the amount of \$ 30,900 for two year's support of the work.

SUMMARY OF ACCOMPLISHMENTS

The main accomplishment has been development of satisfactory equipment to permit a controlled and systematic study of the relationships between fluid flow characteristics in a circular tube and electrokinetic potentials. Figure 1 shows a schematic representation of the fluid flow system now in operation. With this system a steady flow may be maintained over a sufficiently wide range of flow rates to achieve states of flow from completely laminar to fully developed turbulent. Because the electrical signals being measured are small the entire flow system is enveloped by a metal covering to form a Faraday Cage for minimizing electrical pick-up. The measurement system is shown in Figure 2. The main consideration in the study up to this time has been to determine characteristics describing the fluctuating features of the electrokinetic potential when the fluid flow is turbulent. Therefore, the electrokinetic potential after being amplified is fed into an oscilloscope for viewing and into an harmonic analyzer to determine the power spectrum of the signal. An electrometer tube circuit was constructed at the beginning of the work for insertion ahead of the amplifier; however, measurements made with and without this device indicated that it produced serious attenuations at some frequencies without improving performance in the remaining frequency range. Accordingly, the electrometer is not currently in use.

Beside obtaining data to check the characteristics of the measurement circuits; data have been obtained to determine the

effect of electrode configuration and composition, electrode spacing, fluid conductance, flow rate (Reynolds number), and electrode location relative to the tube inlet upon the electrokinetic potential spectra. The result of greatest interest and value is that the power spectra are distinctly a function of the discharge (Reynolds number)--as the Reynolds number increases relatively more energy is associated with the higher frequency fluctuations. Furthermore, the general shape of the power spectra curves are somewhat similar to those for turbulent intensities measured with a hot-wire anemometer in air flowing through a pipe.

A Ph.D. Dissertation is now being prepared by Mr. Gilbert Binder, graduate research assistant, on the findings of the first phase of this study. Completion of the dissertation is anticipated in September 1960.

PERSONNEL

The following personnel in addition to the writer have been actively engaged in this study:

Gilbert Binder -- Mr. Binder has been working half-time as a research assistant since January 1, 1958. His home is in Mulhouse, France and he received the Diplome d'Ingenieur from the Ecole Nationale des Ponts et Chaussees in 1957. He has majored in fluid dynamics (Civil Engineering) and minored in mathematics and physics at Colorado State University. His academic achievements while here have placed him in the upper two per cent of those enrolled in the Graduate School. Requirements for the Ph.D. are scheduled to be completed in September 1960.

Hsing Chuang -- Mr. Chuang began his association with this study in January 1960. He received a B.S. degree in Agricultural Engineering with a major in hydraulics from National Taiwan University (1954) and a M.S. degree in Civil Engineering with a major in hydrodynamics from the University of Minnesota (1959). As a research assistant on this study he will use his findings in the preparation of a Ph.D. Dissertation.

FINANCIAL STATEMENT (Research Corporation Grant)

A. Equipment and Supplies

- | | |
|---|-----------|
| 1. Precision bore glass pipe and couplings | \$1697.00 |
| 2. Plastic tubing and pipe; misc. electronic components, hardware, film | 278.00 |

B. Assistants' Stipends

- | | |
|---|---------|
| 1. Gilbert Binder - Graduate Research Assistant (Ph.D. Candidate) | 4025.00 |
|---|---------|

January 1958 - July 1960

\$ 5000.00

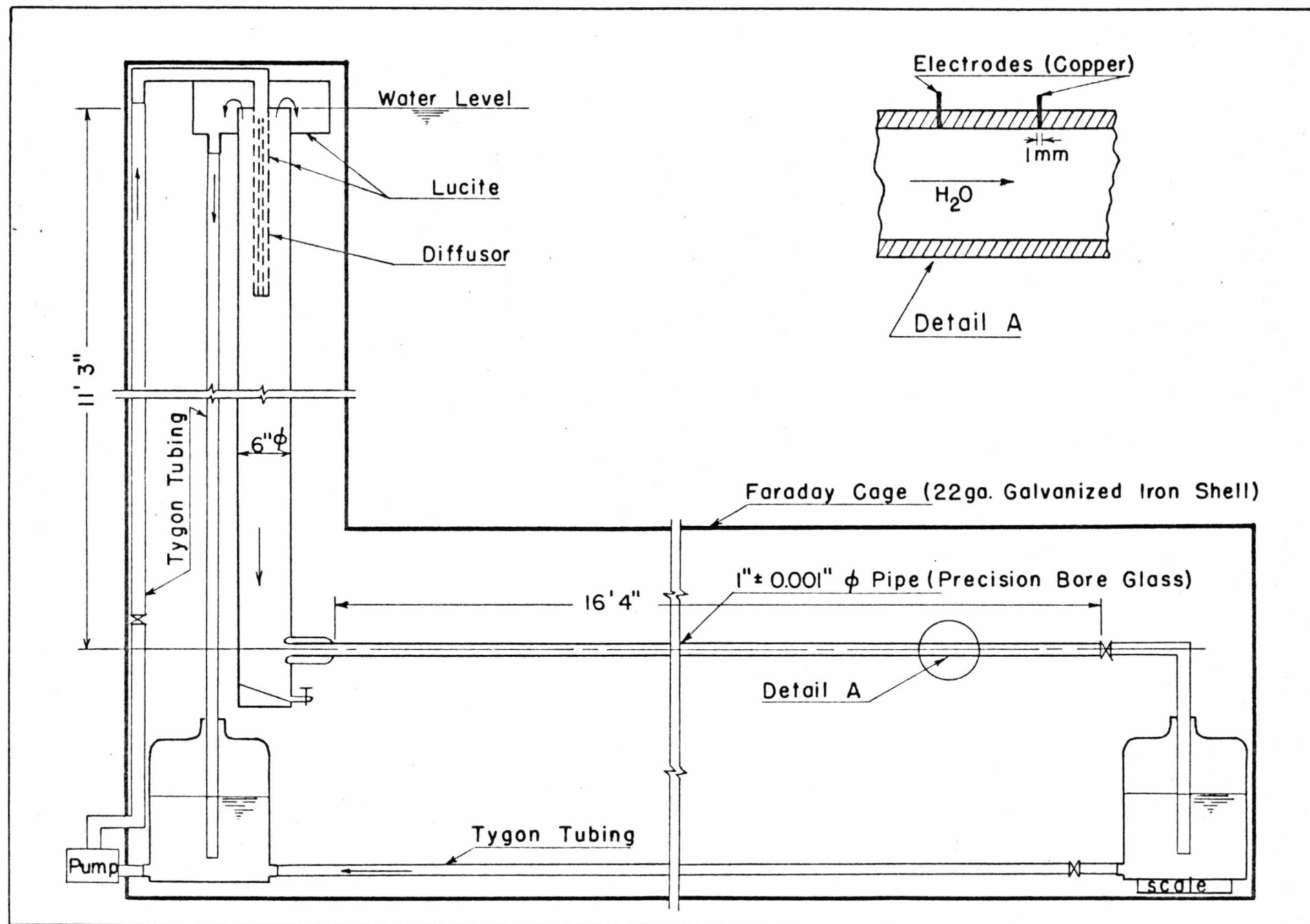


Fig.1 Fluid Flow System

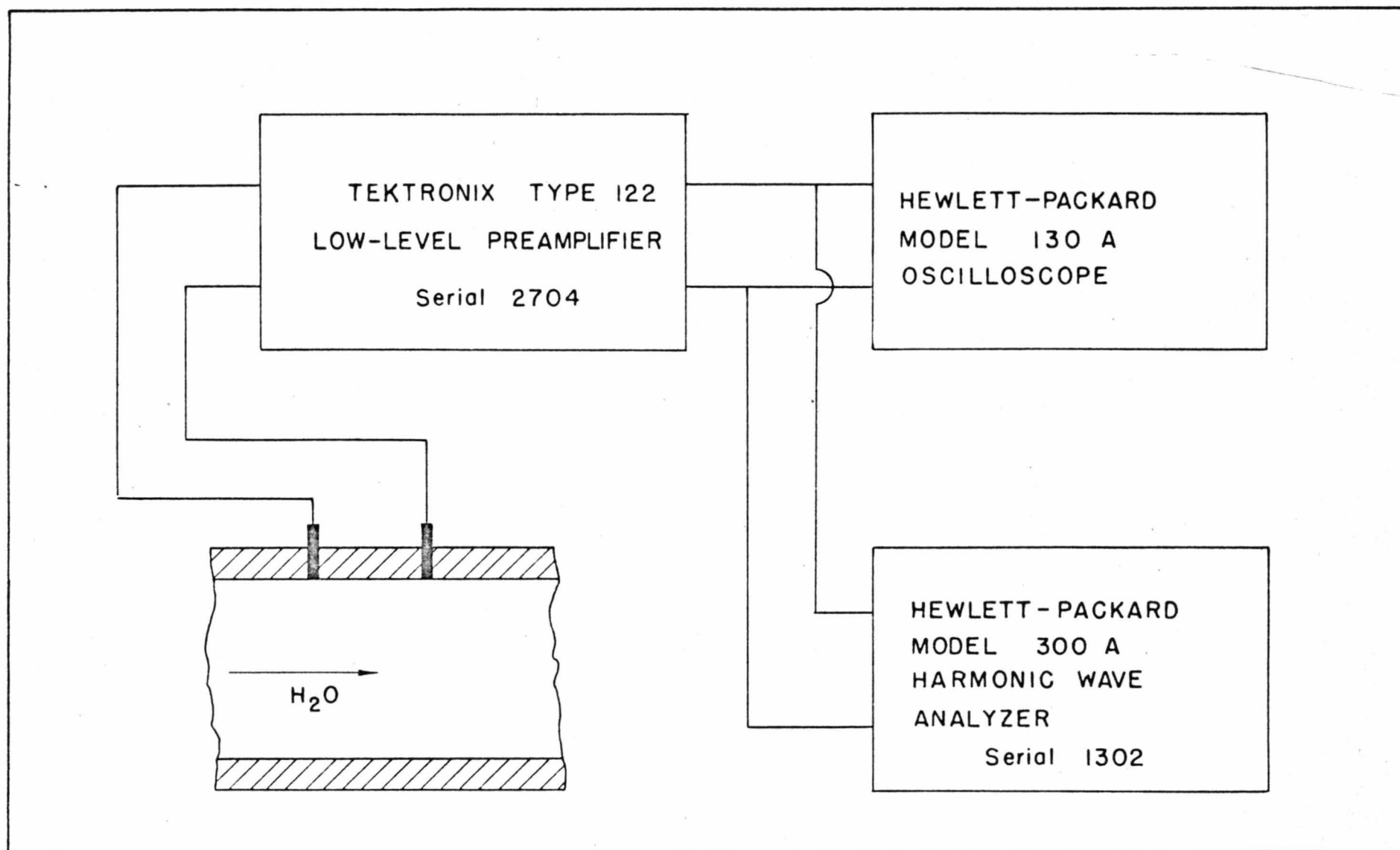


Fig. 2 Electrokinetic Potential Measurement System