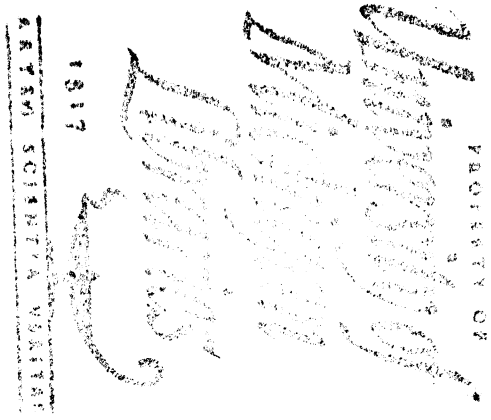
Report 03637-1P

Status Report No. 1

"Velocity and Absorption of Sound in Equilibrium Chemical Systems"

The University of Michigan Research Institute

March 10 - June 9, 1960



OOR Project No. 235-5

Contract No. DA 20-018-ORD-22375

Gordon Atkinson, Project Supervisor

Robert L. Jones

In this initial project period the time was primarily spent in the final design of the ultrasonic spectrometer and in the accumulating of the electronics equipment for the work.

A. Electronic Design: The electronic design for the sound absorption measurements is given as a block diagram in Figure I. It was decided to adopt a direct differential measurement, solvent versus solution, to increase precision. This is particularly important in the frequency range 1-10 mc where absorption is low. The apparatus for velocity measurement is block diagrammaed in figure II. The way selected has not been used before in solution work but has had some success in ultrasonic delay line testing. The measurement of velocities with a pulse system in a direct fashion has never given high accuracy because of the necessity of measuring small time intervals with great precision. It will be noted that the main electronic components for both velocity and absorption measurements are the same so that both measurements can be performed on the same chemical systems by merely throwing a few switches. All the electronic equipment has been ordered or construction started. Unfortunately a long delivery time on the pulsed oscillator may handicap initiation of measurements.

B. Mechanical Design: The final design for the ultrasonic cells, cell holder, crystal mounts and crystal separation measurement has been completed and final drawings are being prepared for the shops. All mechanical parts that had to be purchased have been procured. Final sketches of the design will be included in the next report. The constant temperature bath equipment

and pumps have been ordered.

C. Chemistry:

Most of the literature on ultrasonic absorption and velocity in 2-2 electrolyte solutions has been surveyed and an extensive analysis of the data is in progress. It is hoped that an interim report will be issued at the end of the summer giving both the literature survey and a critical analysis. The survey makes it quite clear that although many mechanisms have been proposed for the excess absorption and velocity dispersion in solutions of salts like $MgSO_4$, $MnSO_4$, and $CuSO_4$, no treatment yet has adequately explained all of the experimental results. The following processes are the most frequently involved (where M is some divalent metal)

1. $MSO_4 \rightleftarrows M^{+2} + SO_4^{=}$ Dissociation

2. $M^{+2} + SO_4^{=} \rightleftarrows MSO_4$ association

3. $MSO_4 + H_2O \rightleftarrows MSO_4 \cdot H_2O$ dipole-dipole

4. $MH_2OSO_4 \longrightarrow MH_2O^{+2} + SO_4^{=}$

$\searrow$ $MOH^{+} + HSO_4^{-}$ hydrolysis

Recently this laboratory has succeeded in making the first completely dissociated 2-2 electrolyte, copper m-benzene disulfonate. Our first systems to study with the ultrasonic spectrometers, then, will be CuBDS versus $CuSO_4$ and MnBDS versus

$MnSO_4$. The BDS salts will help us decide on the mechanism responsible for the $SO_4^{=}$ absorption peaks since they eliminate some of the possibilities.

The general plan will be to measure both absorption and velocity in the pair of salts as a function of the variables:

1. Concentration of salt (0 → 0.1 molar),
2. frequency (1 - 80 mc initially),
3. dielectric constant of solvent
   a. using both dioxane-water and methanol-water mixtures
4. ionic strength (using $NaClO_4$ as an inert electrolyte)
5. temperature

D. Personnel:

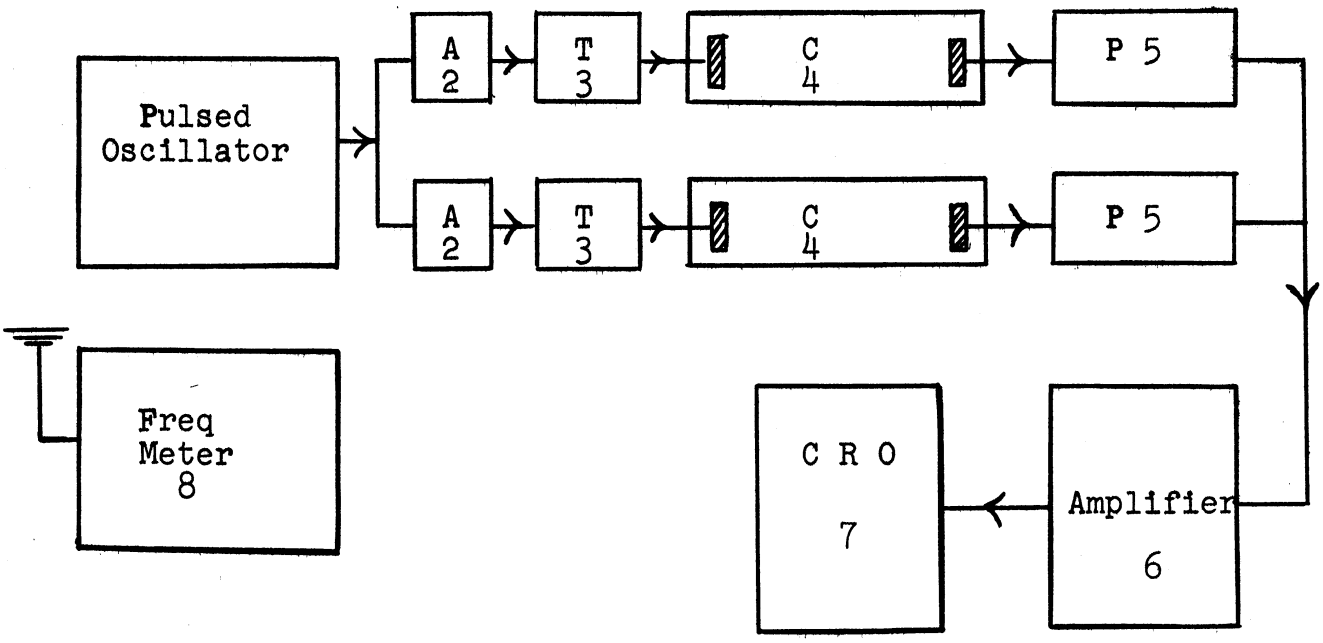
Mr. Robert L. Jones, graduate student in Chemistry, has completed his teaching fellowship and will be employed by the project as a research assistant as of June 15, 1960. Mr. Jones is doing his doctoral research under the direction of Dr. Atkinson and hopes to use part of the ultrasonic data obtained in the work for his dissertation.

We have been fortunate to have been able to procure the services of Dr. Daisaku Tabuchi for the project. Dr. Tabuchi is on the staff of Osaka University in Osaka, Japan and is one of the leading Japanese experts in the field of ultrasonic transmission theory. He has published over 15 papers in the field as well as numerous book chapters. Dr. Tabuchi joined us in June 5 coming to Ann Arbor from London where he has been

associated with Professor J. Lamb in the latter's ultrasonics laboratory for the last year. He will spend most of this summer helping in the assembly of the apparatus and adapting his theory for the analysis of the 2-2 electrolyte problem.

Figure I.

Block Diagram of Absorption Measurement Electronics

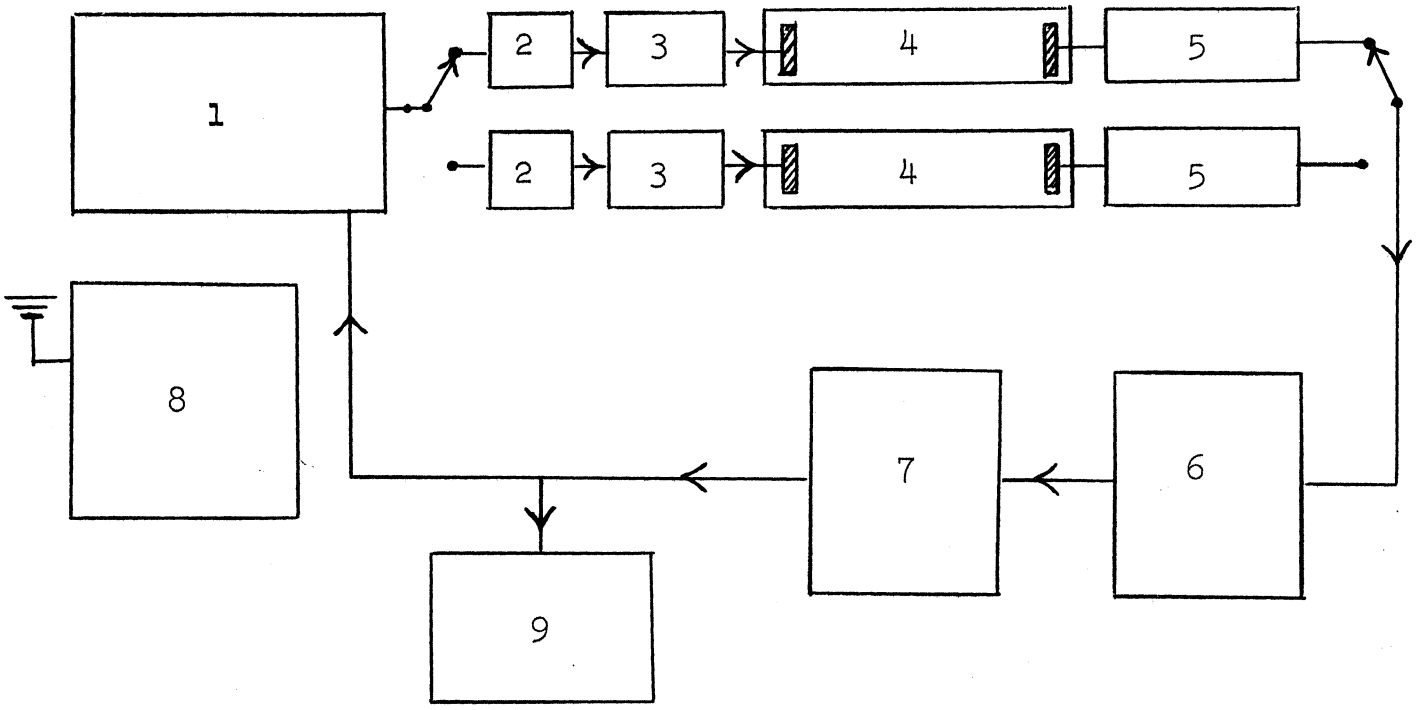


1. Pulsed Oscillator: Arenberg PG 650C
2. Attenuators : (2) Arenberg ATT 93
3. Tuners : (2) Final crystal matching tuners (to be constructed here)
4. Ultrasonic Cells
5. Preamplifiers : Arenberg PA620
6. Wide Band Amplifier: Arenberg WA 600
7. Oscilloscope : Tektronix 513 C
   or
   Dumont 256 E
   (both furnished by UMRI)
8. Frequency Meters : BC221 (1 - 20 mc)
   Gertsch FM3 (20 mc up)
   (furnished by UMRI and Department of Chemistry)

Figure II

Block Diagram of Velocity Measurement

"Sing Around" Method



Components 1 - 8 are same as Figure I

9. Electronic Counter: Berkeley 7360
(furnished by UMRI)