Utah State University

DigitalCommons@USU

1974

Measurement of Soil Water Potential by Adsorption Conductivity

V. Philip Rasmussen Jr.
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/honors

Part of the Plant Sciences Commons

Recommended Citation

Rasmussen, V. Philip Jr., "Measurement of Soil Water Potential by Adsorption Conductivity" (1974). *Undergraduate Honors Capstone Projects*. 175.
https://digitalcommons.usu.edu/honors/175

This Thesis is brought to you for free and open access by the Honors Program at DigitalCommons@USU. It has been accepted for inclusion in Undergraduate Honors Capstone Projects by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.

MEASUREMENT OF SOIL WATER POTENTIAL BY ADSORPTION CONDUCTIVITY

by

V. Philip Rasmussen, Jr.

A thesis submitted in partial fulfillment
of the requirements for the degree

of

HONORS BACHELOR OF SCIENCE

in

Soil Science

Approved:

R J Hanks
Advising Professor

Raymond T Sanders
Director, Honors Program

UTAH STATE UNIVERSITY
Logan, Utah

1974

ACKNOWLEDGMENTS

The author wishes to express appreciation to Dr. R. J. Hanks, whose unceasing creativity provided the basis of this study. The experience gained as an employee of Dr. Hanks will be appreciated for many years to come. His encouragement and advice has been invaluable throughout this study.

I should also thank my wife, Linda, for her sacrifice and devotion. Without her help, my education would have been impossible.

V. Philip Rasmussen

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Measurement of Soil Water Potential by Adsorption Conductivity

by

V. Philip Rasmussen, Jr.

Utah State University, 1974

Major Professor: Dr. R. John Hanks
Department: Soil Science and Biometeorology

Current methods of measuring soil water potential are reviewed, and the limitations of each are noted. The need for a transducer that will measure soil water potential over a wide moisture range for long periods of time is delineated. The concept of utilizing an adsorptive surface that resembles the soil in its water holding capacity as a transducer is discussed. Various designs and materials are tested for such a transducer.

All designs tested did not fulfill the requirements needed for a truly useful transducer. However, experimental results show that modification of the adsorptive surface should allow construction of a unit that will be useful in soil water research.

(50 pages)

INTRODUCTION

The ability to measure the available water in the soil, soil water potential, simply and accurately has been sought after by scientists and agri-businessmen alike for many years. Proper management of soil water has long been known as a key to maximum production of food. Measurement of the soil water status provides a means whereby irrigation and production can be more carefully managed in a world where food is becoming increasingly more scarce and expensive. An inexpensive and simple tool that would allow the farmer and the scientist to detect small changes in the water status of the soil is needed today, perhaps more than ever before.

In June, 1972, this investigator undertook a project suggested by Dr. R. J. Hanks to develop such a tool. Utilizing a method and concept tested at Utah State University, the author investigated methods of measuring small changes of water adsorbed onto a porous surface. The results of this investigation form the basis of this thesis. As with most scientific undertakings, the results seem incomplete to the investigator. Much more investigation is needed in this area. However, some important results were observed and are noted herein. It is hoped that this will aid future investigators who concern themselves with the problems of agricultural irrigation management and research.

REVIEW OF LITERATURE

Soil water potential

The nature of water in the soil has been the source of much discussion in agricultural scientific circles for a number of years. Agronomists, soil scientists, plant physiologists, and climatologists alike are all concerned with water relations in the soil-plant-atmosphere continuum. In defining the status of water of a given soil, all have agreed that stating the moisture percentage is not enough (Taylor, Evans, and Kemper, 1961). Different soils with the same moisture percentage retain water with different degrees of tenacity, due to the colloidal nature of the soil-water interface and the large difference in particle sizes of different soils. To overcome the problems thus associated with water content measurements, a thermodynamic description is used. This system of measurement defines water in the soil system in terms of potential energy units. R. J. Hanks relates the reasons for a thermodynamic approach in terms of an analogy:

> The heat content (analogous to water content) of a soil is a property of a material that is useful for many purposes but it will not tell us directly whether heat will flow unless we can deduce a different property--the temperature. We need a soil water property analogous to temperature. This property is called the water potential. (Hanks, 1972, p. 51)

Thus, by using this system of measurement, a soil with a given water potential will possess the same degree of water availability as any other soil with the same water potential (Taylor, Evans, and Kemper, 1961).

This system of measurement is not without fault (Taylor and Slayter, 1962). For some time many different units, both positive and negative, have been associated with water potentials of the same potential energy. There are two general approaches used, each correct, that lead to these ambiguous values for water potential. Both systems relate to the energy required to remove water from the system under study. However, one system relates the potential energy of removal to the water itself (giving a negative value), and one relates this energy to the system removing water (giving a positive value) as shown by Taylor, Evans, and Kemper (1961). This sign difference often leads to much confusion by both schooled and unschooled persons. However, by stating the system of measurement used in the proper context, the confusion can usually be eliminated (Salisbury and Ross, 1969; Wiebe et al., 1971).

The basis of both of these thermodynamic approaches to soil water is the Gibbs Free Energy of the system. In defining water potential, Salisbury and Ross (1969) state the Gibbs Free Energy Equation thusly:

$$G = E + PV - TS$$

where E is internal energy of the system, PV is the pressure-volume product as in the Ideal Gas law, T is temperature in degrees Kelvin, and S is the entropy (degree of disorganization) of the system. This equation is extended by Salisbury (1969) through Roault's law to:

$$\psi = \frac{RT}{V_1} \ln \frac{p^\circ}{p}$$

and then to:

$$\psi = 10.7T\log_{10}(\frac{100}{RH})$$

where RH is the relative humidity in the atmosphere of the system and ψ is the water potential. Through this equation, water potential of a given soil can be directly calculated if the relative humidity of the atmosphere of the soil is known.

By using the classical approach shown above, the measurements of the water potential (often referred to by chemists as the chemical potential of a water solution) are taken to be negative and are measured in energy units or in negative atmospheres (suction of the system for pure free water). The approach of Taylor and Slayter (1962) and others recently has been to express these units of suction for pure free water (water potential) as positive values. To do this, Taylor, Evans, and Kemper (1961, p. 8) define water potential as: "... the minimum additional work required to remove water from the soil system in excess of the work required to remove pure free water from the same location in space." This approach and definition will be used by the author throughout this text.

Water potential is thus a measurement of the energy relations of the soil-water system. It allows us to define the amount of tenacity with which the soil holds water. This allows us to describe the water in the soil as the growing plant senses it--the amount of energy required to remove water from the soil. In viewing water relations in this way, we are able to measure and manage water in the soil from the standpoint of the plant and the atmosphere that expend energy to remove water from the soil. Thus, the total system can be accurately described mathematically and managed more fully for the benefit of man.

Instruments to measure water potential

There are many instruments currently available to measure directly and indirectly the water status of the soil. However, all have certain limitations (Taylor, Evans, and Kemper, 1961).

Taylor, Evans, and Kemper (1961) and Buckman and Brady (1969) describe an instrument that has gained wide acceptance for use with crops of high water consumption. The tensiometer, as the instrument is called, is an instrument consisting of a long plastic tube that extends down into the soil and is fitted at the end with a porous clay cup. The tube is filled with water, is sealed at the top, and a mercury manometer or vacuum guage is attached at the surface to monitor the vacuum created as water is sucked through the clay cup by the soil. This unit measures soil water matric potential only as high as one bar. Taylor, Evans, and Kemper (1961) also described problems with accuracy and temperature stability.

The gypsum resistance block (Taylor, Evans, and Kemper, 1961) has been fabricated in many designs, but all rely on the electrical conductivity changes of a block of gypsum placed into the soil. Within this block are two metal electrodes attached to wires that lead to the surface of the soil. At the soil surface the wires can be connected to a suitable a.c. resistance bridge for measurement. As the porous gypsum ($CaSO_4 \cdot 2H_2O$) equilibrates with the water in the soil, its hygroscopic nature allows it to compete with the soil for the available water. As water is absorbed into the block, the salts of gypsum go into solution, and thus they are able to conduct electricity between the electrodes. The resistance between the electrodes, then, is a function of the water in the soil, and this resistance can be measured with the bridge previously mentioned. Salts in the soil that are in large concentrations when compared to the gypsum salts can change the calibration of these blocks (Taylor, Evans, and Kemper, 1961). Each block must be calibrated separately; gypsum is gradually dispersed in the soil. Thus, gypsum blocks have inherent problems as a transducer also.

Freezing point depression and ceramic porosity have also been used to measure water potential in the soil. Their use, however, is limited to laboratory situations at the present time. Their accuracy also has been questioned (Taylor, Evans, and Kemper, 1961; Wiebe et al., 1972).

Thermocouple psychrometers (Taylor, Evans, and Kemper, 1961; Wiebe et al., 1971) have been continuously perfected in the past ten years. They operate by a reverse current flow condensing water on a double thermocouple junction (Peltier effect), and then the differential temperature is monitored as this water evaporates. The psychrometer, then, works as a wet-dry thermometer pair and measures the relative humidity of the soil atmosphere. This measurement can be related to water potential by the previously noted equation:

$$\psi = 10.7T\log_{10}(\frac{100}{RH})$$

There are limitations with this method, however. The thermocouple junction is contaminated very easily. Also, the condensation is virtually impossible as the soil gets very dry.

Thus, we can see that there are basic problems with any of the presently available techniques. This is the same problem of most scientific measurements--the instrumentation leaves much to be desired. However, a few improvements could add dramatically to the available information about soil water. If a transducer could be developed that would be able to measure water potential <u>over a wide range</u> and would be inexpensive enough for large scale application, tremendous advances in agricultural management could be realized.

Measurement of soil water potential by adsorptive phenomena

A method proposed by Gardner (1937) and perfected by McQueen and Miller (1968) was studied by Al-Khafaf and Hanks (1972). This procedure involves measuring the water absorbed by a bacteriostatically treated filter paper disc when placed in a closed atmosphere with a sample of soil. Water vapor in the soil equilibrates with the filter paper. Since the filter paper has a large range of particle size distribution, like the soil, its adsorptive curve closely resembles that of the soil. Thus, the filter paper can be removed from the closed system (a small metal soil sample can) and weighed. The water content can be determined by the difference in the wet and dry weight divided by the dry weight. This water content than can be calibrated to the water potential of the system. The filter paper is used because the porosity of the filter paper is similar from one sample to the next and is commercially available with well-defined properties. This method has an added advantage in that the soil water matric potential can be measured merely by letting the paper come in direct contact with the soil, rather than only equilibrating with the atmosphere above the soil.

This method is suitable and accurate over a wider range than any method previously mentioned. However, it is time-consuming and must be done in a laboratory equipped with an analytical balance and a humidor to facilitate precise weighing without loss of water from the filter paper.

DELINEATION OF SPECIFIC PROBLEM

Areas where knowledge is lacking

As presented in the Literature Review, the author has found significant problems with each of the methods of measurement mentioned. It is felt that to obtain optimum measurements of soil water potential, the following requirements should be met by a transducer:

1. It should be small and easily installed in the soil.
2. It should be semi-permanent in its durability, and thus it could be left installed for at least two seasons of use.
3. Constant interrogation of the state of available water near the transducer should be possible.
4. It should not be dangerous to use or destructive to the soil (e.g., radioactive).
5. It should resemble the soil in its ability to hold and compete for available water, thus having a wide measurement range.
6. It should have uniform calibration characteristics.
7. It should be inexpensive enough for large-scale application.

None of the present methods fulfill all of these requirements. The study undertaken by the author uncovered some methods that hold promise for solving the problems associated with methods at the present time.

Specific objectives

The objectives of thus study were to (1) construct and develop adsorptive transducers that accurately measure soil water potential over a wide range, and (2) develop from this technique, inexpensive transducer designs for use by agriculturists. The method of Al-Khafaf and

Hanks (1972) was chosen to expand upon because of its ability to measure moisture over a wide range. By capitalizing on this method and adapting it to a continuous transducer, the six requirements previously noted can best be fulfilled.

The basic theory of operation of such transducers involves utilizing the change in electrical resistive properties of an adsorptive medium as water is adsorbed to indicate the amount of water contained therein. The experimentation thus entailed testing and evaluation of transducers designed with this theory in mind. Different materials were tested, and an optimum unit was tested in a soil environment.

PROCEDURE AND RESULTS

The bulk of this study was concerned with the design and evaluation of a variety of transducers. The author prefers to give an account of each investigation, in the order that they were performed. This allows the reader to follow the reasoning that preceeded each change in design. Thus, this section will deal with the design of each transducer and enumerate briefly the results that led to each subsequent design.

Instrumentation

Prior to the start of the experimentation, instrumentation was obtained to monitor the state of the transducers. Instrumentation was limited almost entirely to resistance and temperature apparatus because of the nature of the study. A resistance meter was needed that could measure very large and very small resistances accurately. Noise isolation and stability were desirable assets to the system also. Temperature measurements were needed within ±0.01 C, to properly monitor the constant temperature environment.

A Barnstead Conductivity Bridge, Model PM 70CB, was chosen as a resistance indicator. It had an a.c. oscillator circuit that prevented polarization of the transducers. It could measure resistances as high as one hundred million ohms with a constant accuracy throughout its range of one percent. It was portable and battery operated. This prevented noise contamination through an a.c. power supply.

The wires of all transducers were composed of double-shielded Belden #8640 instrumentation wire or, in later variations, Belden heavy-duty coaxial cable, to prevent noise contamination of the electrical signals. A shielded rotary switch was used in multiple transducer investigations to facilitate measurement without disturbing the transducer test chamber.

Temperature measurements were made with an S-B Systems Thermocouple Reference Junction (0 C) with copper-constantan thermocouples. By bucking a 20 C equivalent voltage against the signal voltage with a Leeds and Northrup K-3 Potentiometer, a very small change from 20.0 C could be measured. Amplification of this extremely small signal was accomplished with a Leeds and Northrup D.C. Null Detector-Amplifier. This amplified signal was directed to a Heathkit IR-18 pen recorder. Changes as small as 0.01 C could easily be distinguished.

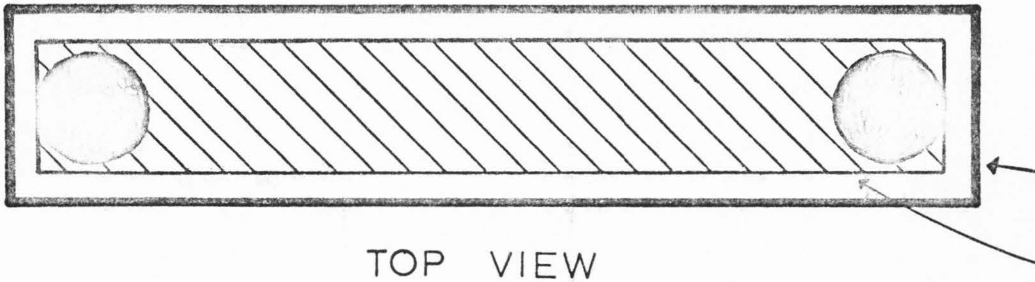
Filter paper transducers

The initial design of transducers utilized filter paper as the adsorptive surface. The design (see Figure 1) consisted of 0.3175 cm thick plexiglass cut into a 1 cm by 3 cm rectangular piece. Two small holes were drilled at each end. Two #6/32 machine screws and nuts with brass washers held the paper against the plexiglass support frame. Two lead wires (Belden #8640) were attached to the paper with the screws.

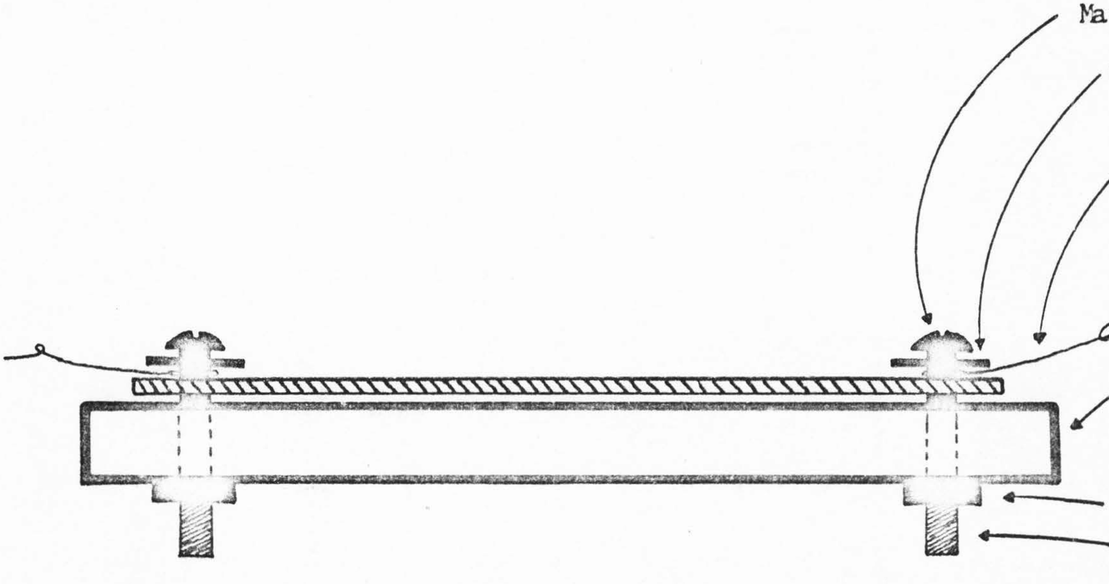
Two transducers of this type were constructed and placed in 500 ml filter flasks which were then sealed (see Figure 2). One flask contained distilled water (a 0.0 bar water potential equivalent) and one contained KCl solution (a 22.4 bar water potential equivalent). The flasks were placed in a polyfoam "picnic cooler" for thermal isolation. All test experiments were conducted in a 20 C constant-temperature room.

Readings were taken with the Barnstead bridge over a period of several days. This data is summarized in Figure 3. It can be seen that equilibrium was reached within one day. However, instability was

Figure 1. Basic filter paper transducer design.



TOP VIEW



SIDE VIEW

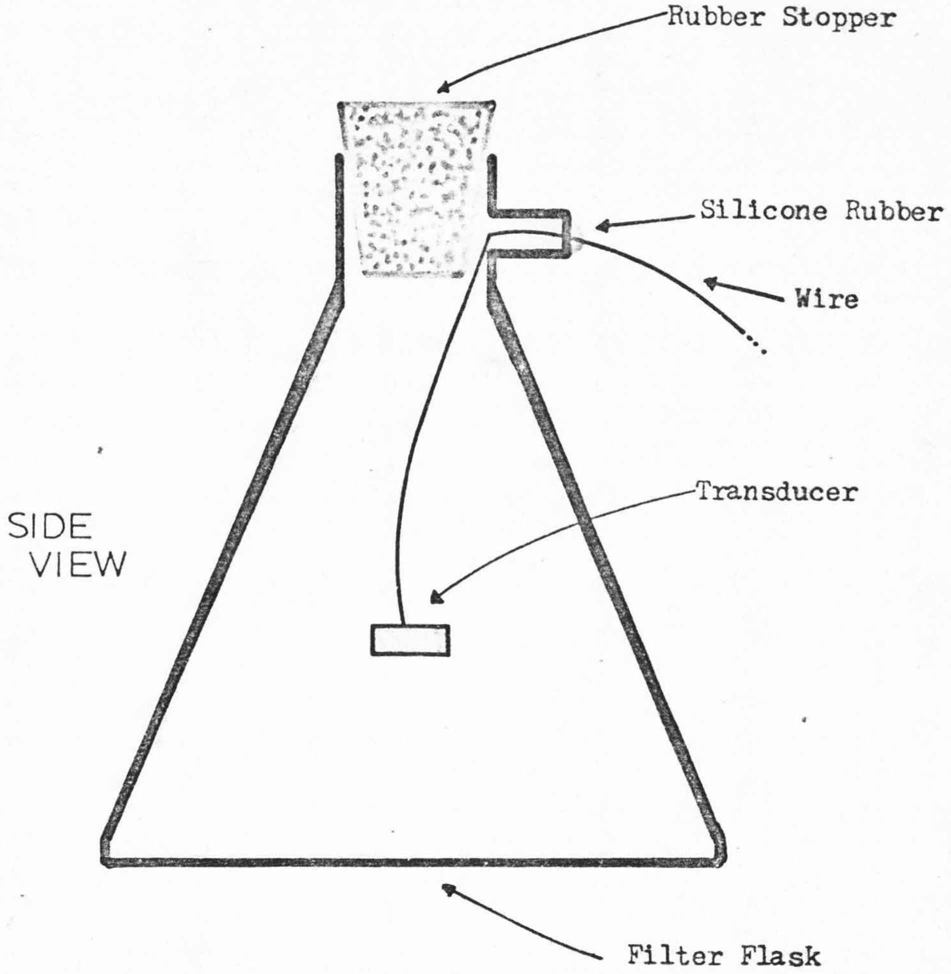
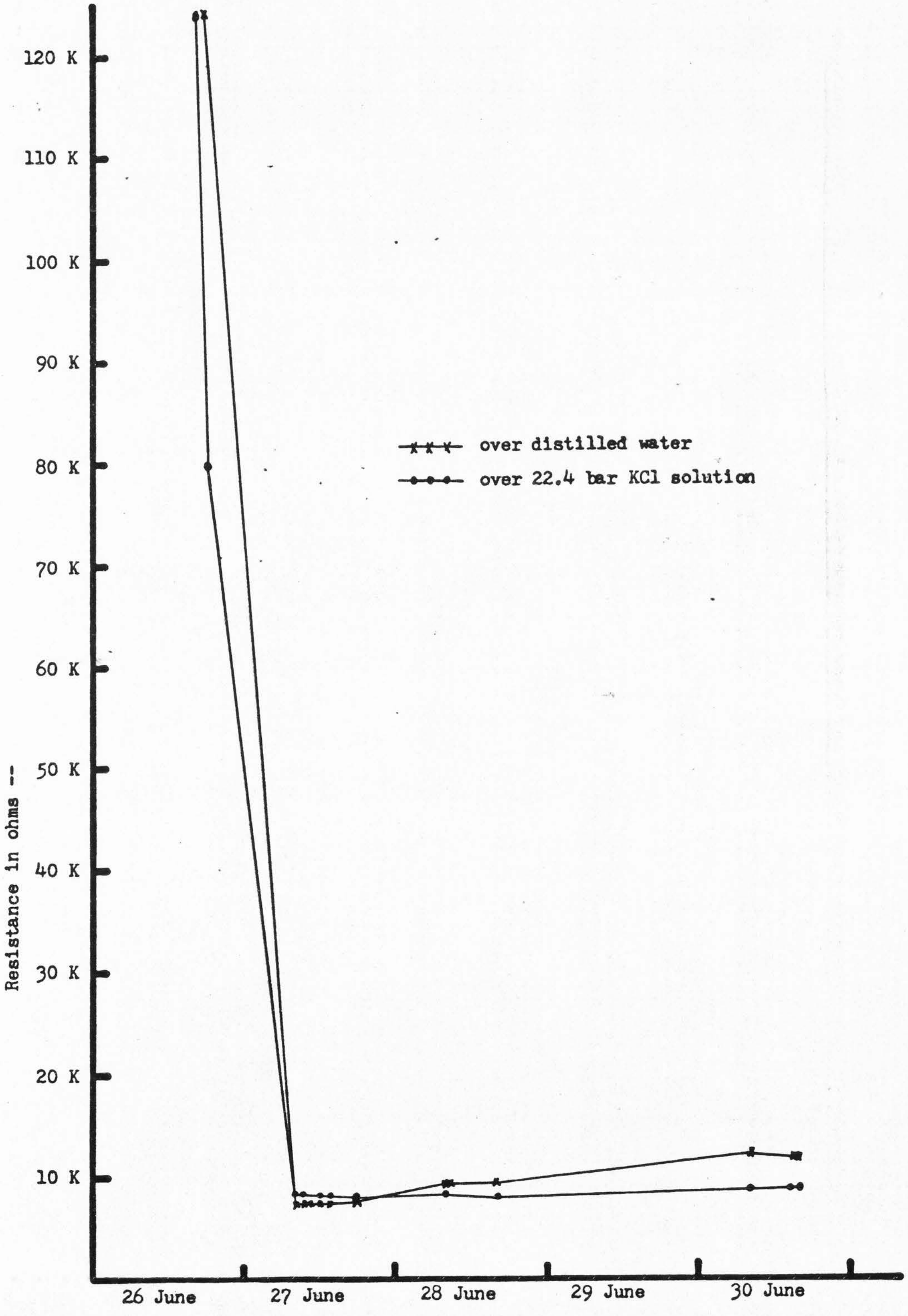


Figure 2. Test Flask Arrangement

Figure 3. Initial tests of filter paper transducers over test solutions.


120 K
110 K
100 K
90 K
80 K
70 K
60 K
50 K
40 K
30 K
20 K
10 K
Resistance in ohms --
over distilled water
over 22.4 bar KCl solution
26 June
27 June
28 June
29 June
30 June

noted after two days. Severe corrosion of the machine screws and the washers was seen--especially in the KCl test environment. Readings were instable due to this and also the constant swelling and contraction of the paper.

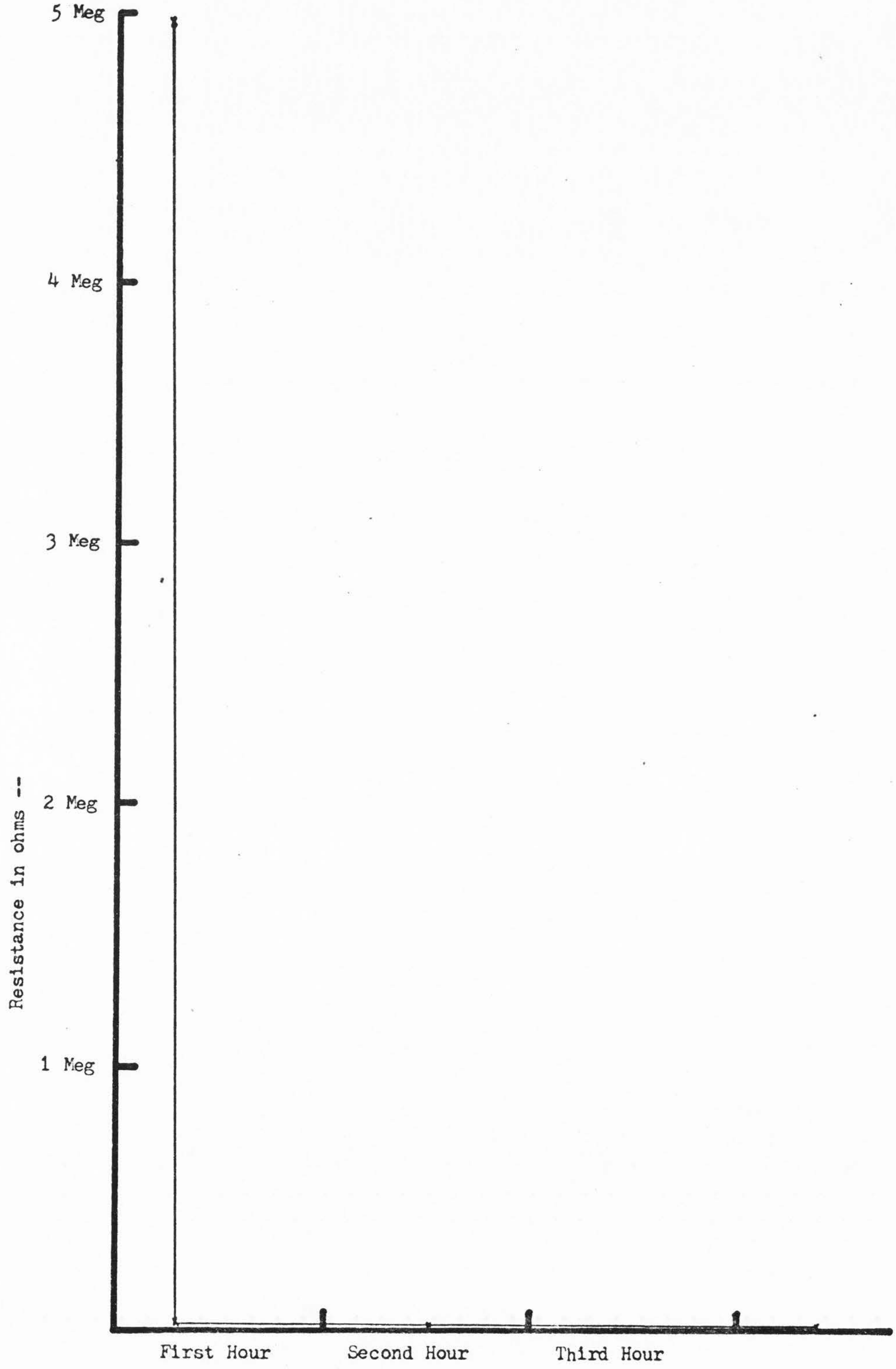
As water was adsorbed onto the paper particles, swelling immediately took place. Although the resistance of the paper matrix to electrical current was reduced by the water carrying electrical current, the swelling of the paper changed the distance of current travel--thus continually altering the resistance observed. A more stable adsorptive media was needed.

Lithium chloride transducers

Due to the problems encountered with the filter paper method, another adsorptive media was tested. Lithium chloride, a hygroscopic salt, has been used by climatologists as an adsorptive media for relative humidity measurements for many years (Wexler, 1965; Monteith, 1972). It was thought that these might be utilized for use in the soil. Limitations had been noted by Wexler (1965) for these transducers and others used in weather analysis such as the carbon and hair hygrometers. However, no experimentation with high humidities such as encountered in soils (an extremely dry soil would equilibrate with a microatmosphere to a humidity of 98 percent) could be found.

A Varian lithium chloride humidity sensor was placed in the flask arrangement shown in Figure 2. A very fast equilibration time was noted and this is shown in Figure 4. No differentiation of readings in the 98 to 100 percent relative humidity range could be observed, however. This transducer design was thus abandoned.

Figure 4. Lithium chloride humidity transducer over distilled water.


5 Meg
4 Meg
3 Meg
2 Meg
1 Meg
Resistance in ohms --
First Hour
Second Hour
Third Hour

Gypsum block transducers

A gypsum soil moisture block was placed into the test flask and tested over distilled water and 22.4 bar KCl solution. Figure 5 shows the extremely long equilibration time noted for this type of media. This media was abandoned temporarily at this time in favor of a faster response media.

Coors porcelain transducers

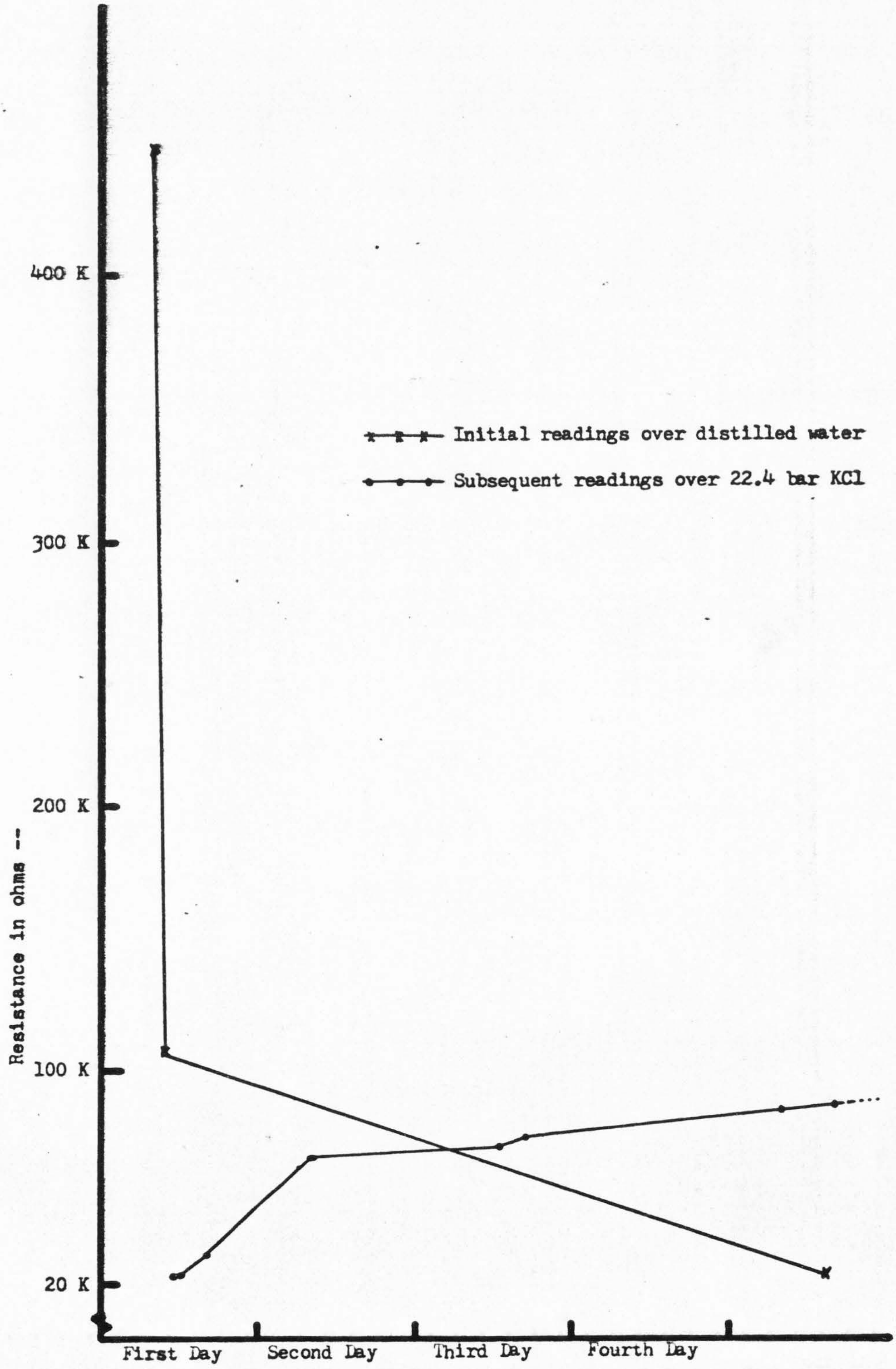
At this point several transducers had been constructed and none were feasable for further consideration. An adsorptive media that resembled the soil in its moisture holding characteristics was still needed. Coors porcelain was suggested as a porous material that might be stable and usable as an adsorptive surface. If inherent ionic concentrations were low, salts could be "doped" into the porcelain to allow electrical resistance to decrease as water is adsorbed.

A transducer was constructed as shown in Figure 6. Two sheets of 0.3175 cm thick plexiglass were cut into two 36 mm by 17 mm rectangles and small holes were drilled at each end. The two sheets were fastened on each side of a 17 mm by 13 mm (6 mm thick) porcelain block with two #6/32 stainless steel bolts and nylon nuts (to control corrosion). Lead wires were connected on the top side (Belden #8640).

An initial test was made of an unwashed P-10-C (pore size notation of the Coors Porcelain Company) block over distilled water. This data is shown graphically in Figure 7. It was noted that a fast equilibration time was exhibited, and stability was much better than with the previous transducers.

A second generation design of porcelain transducers was then constructed (see Figure 8) with the lead wires at opposite ends of the

Figure 5. Gypsum block transducer over distilled water then over 22.4 bar KCl solution.


Resistance in ohms --
400 K
300 K
200 K
100 K
20 K
First Day
Second Day
Third Day
Fourth Day
Initial readings over distilled water
Subsequent readings over 22.4 bar KCl

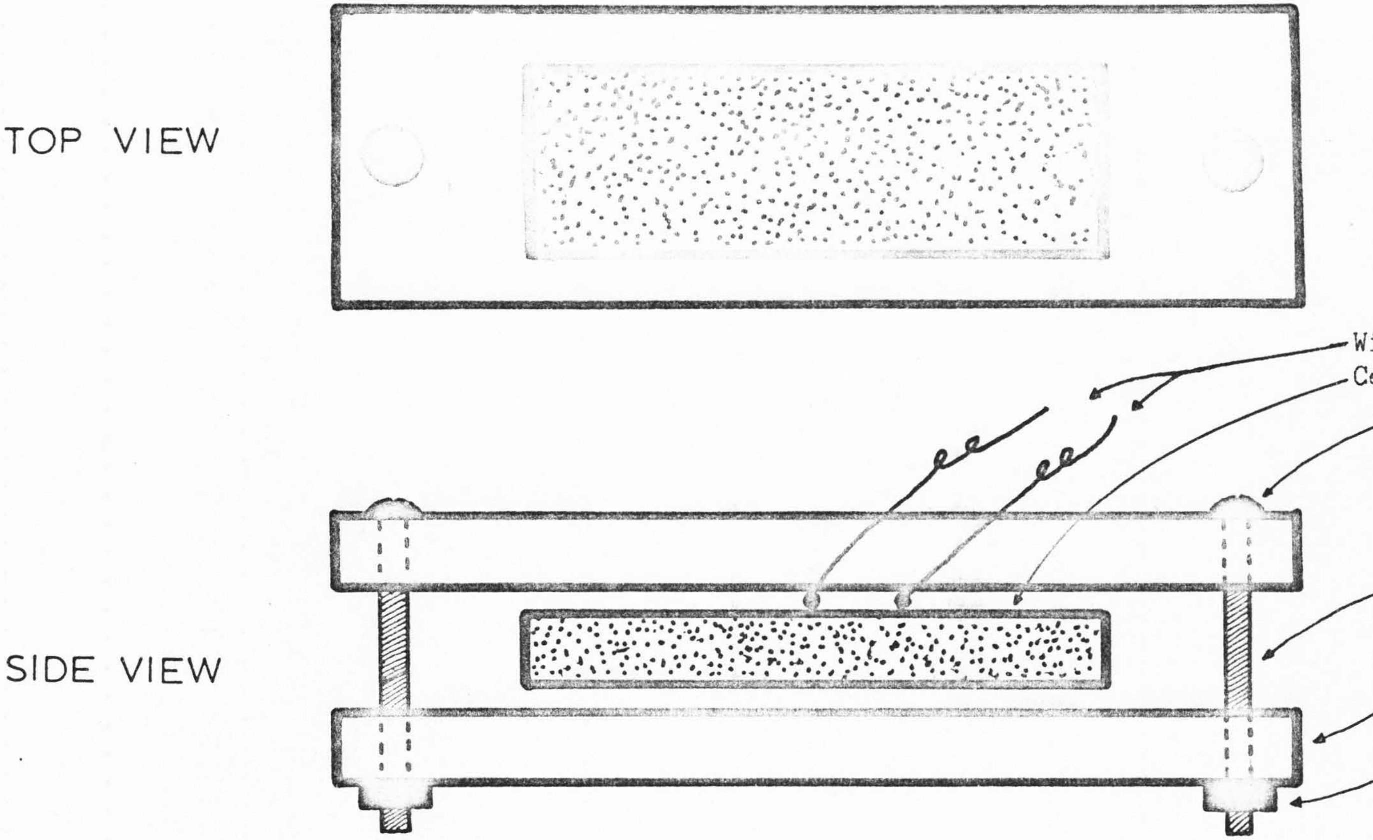
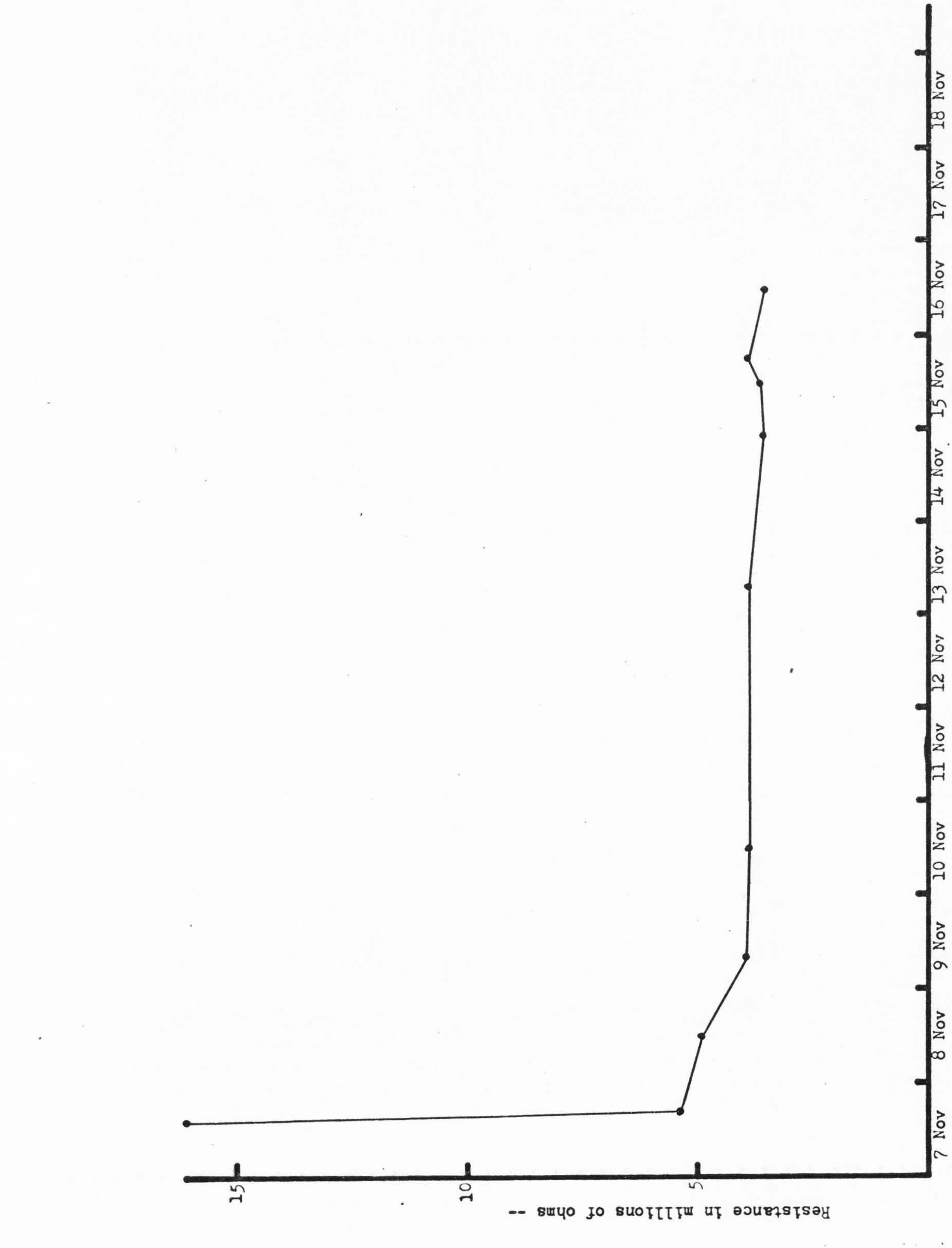


Figure 6. Initial design of ceramic element transducer.

Figure 7. Initial ceramic transducer constructed from unwashed P-10-C porcelain.


Resistance in millions of ohms --
15
10
5
7 Nov
8 Nov
9 Nov
10 Nov
11 Nov
12 Nov
13 Nov
14 Nov
15 Nov
16 Nov
17 Nov
18 Nov

porous block, to obtain a more representative reading of the resistance throughout the media. Transducers were constructed of different porosities from the coarse P-100-C, medium P-16-C, and fine P-20-C porcelain.

A washed and unwashed block was assembled into a transducer for each of the three types. An extra washed P-10-C transducer was constructed as a check for consistency. To monitor flask temperature, a copper-constantan thermocouple was placed inside the extra P-10-C transducer test flask. The flasks were all filled with distilled water test solution.

A test experiment was carried out with these seven transducers. The data are shown in Figures 9a and 9b. Temperature was also plotted for reference. The P-100-C data is not shown because the resistances never came within range of the measurement apparatus. It was seen that the most finely divided porcelain was the best suited for further test due to its low resistance. It was also seen that the unwashed porcelain did not contain enough salts to provide adequate resistance values for measurement.

A third generation of transducers was constructed as shown in Figure 8. These were all constructed out of the most finely divided porcelain available, the P-3-C type. All of these porcelain blocks were washed in boiling distilled water and detergents and then treated with varying concentrations of KCl solution.

The transducers thus constructed were placed into the test flasks and then into the insulated test chamber. A P-10-C transducer with a thermocouple temperature monitor was used in this experiment.

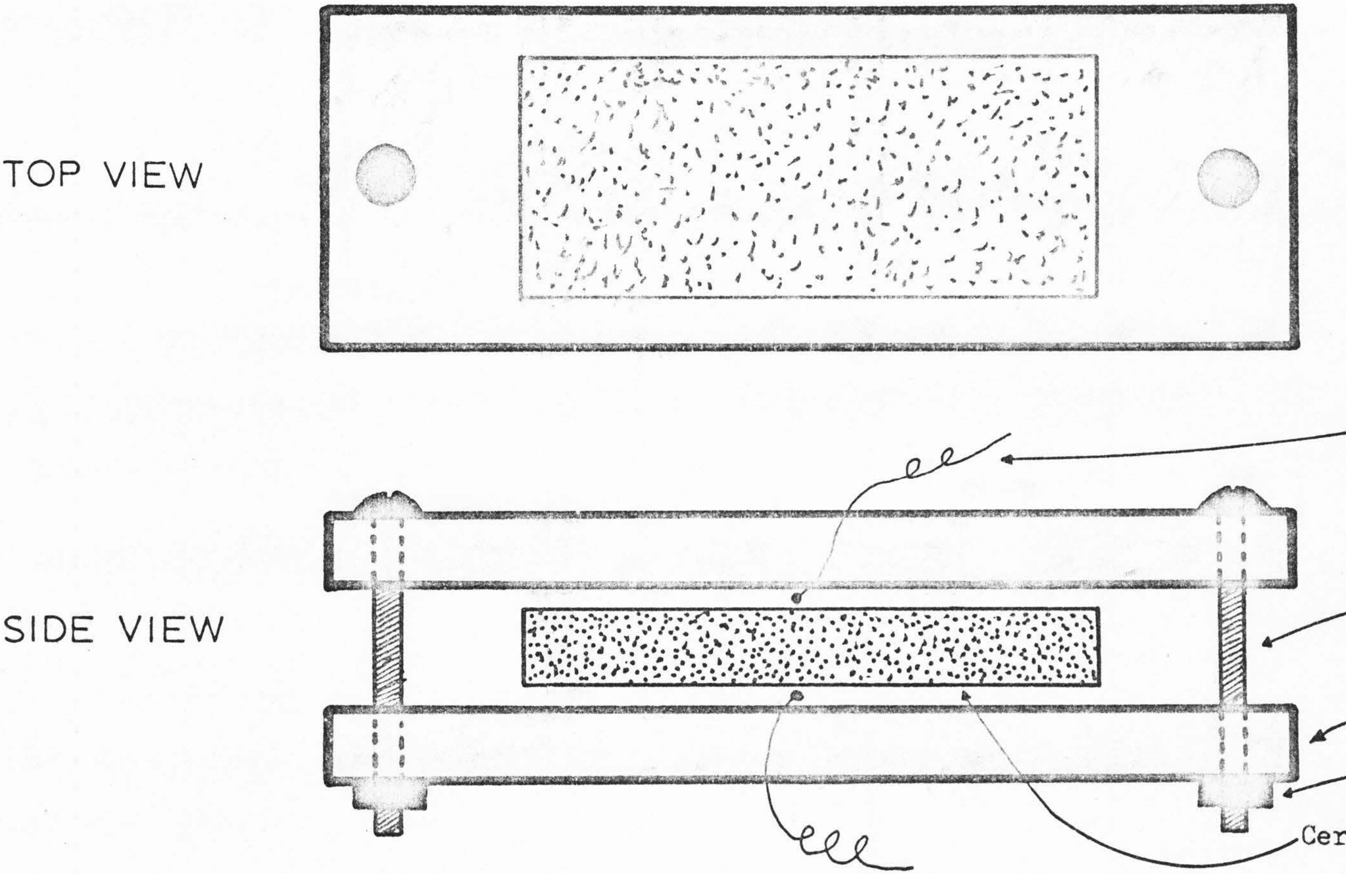


Figure 8. Subsequent design of ceramic element transducer.

Figure 9a. Second generation ceramic element transducer test runs.

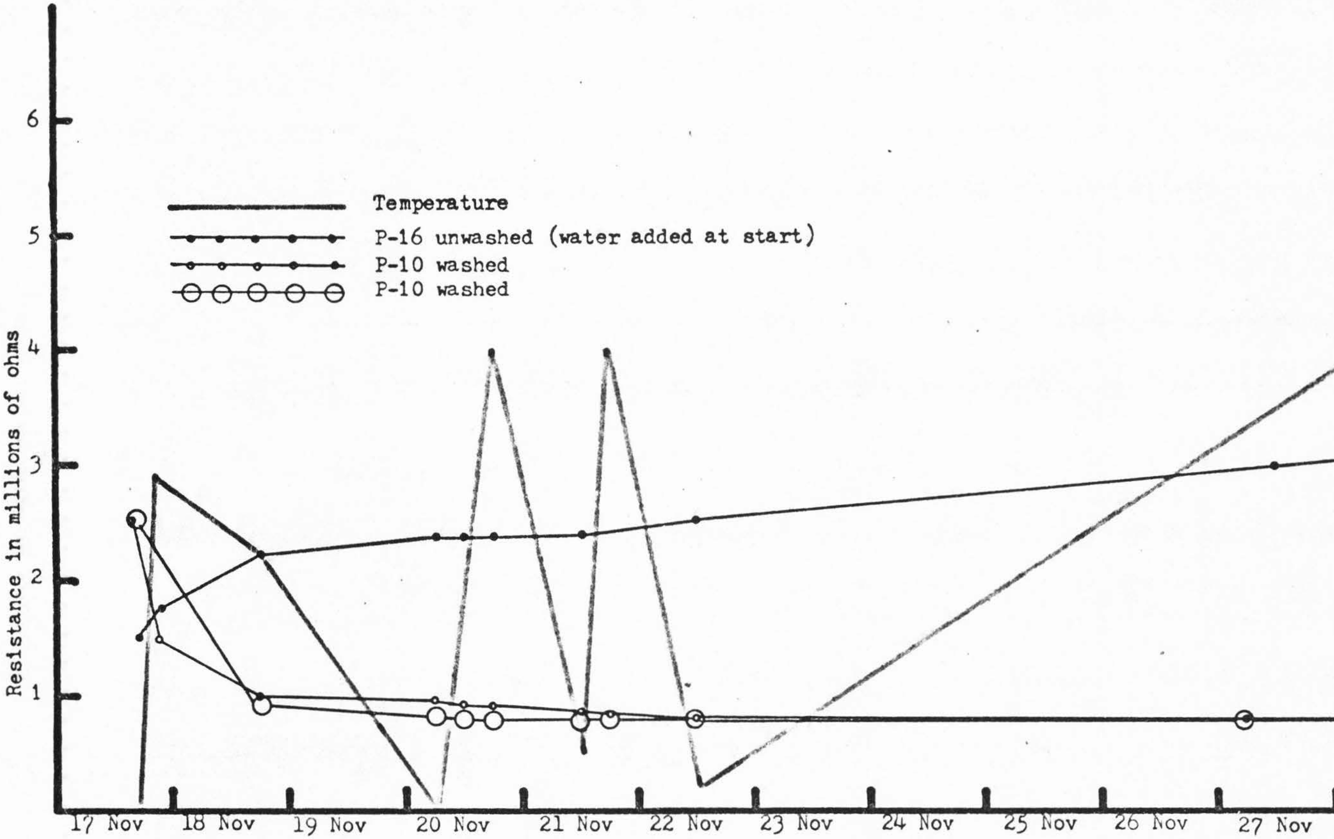
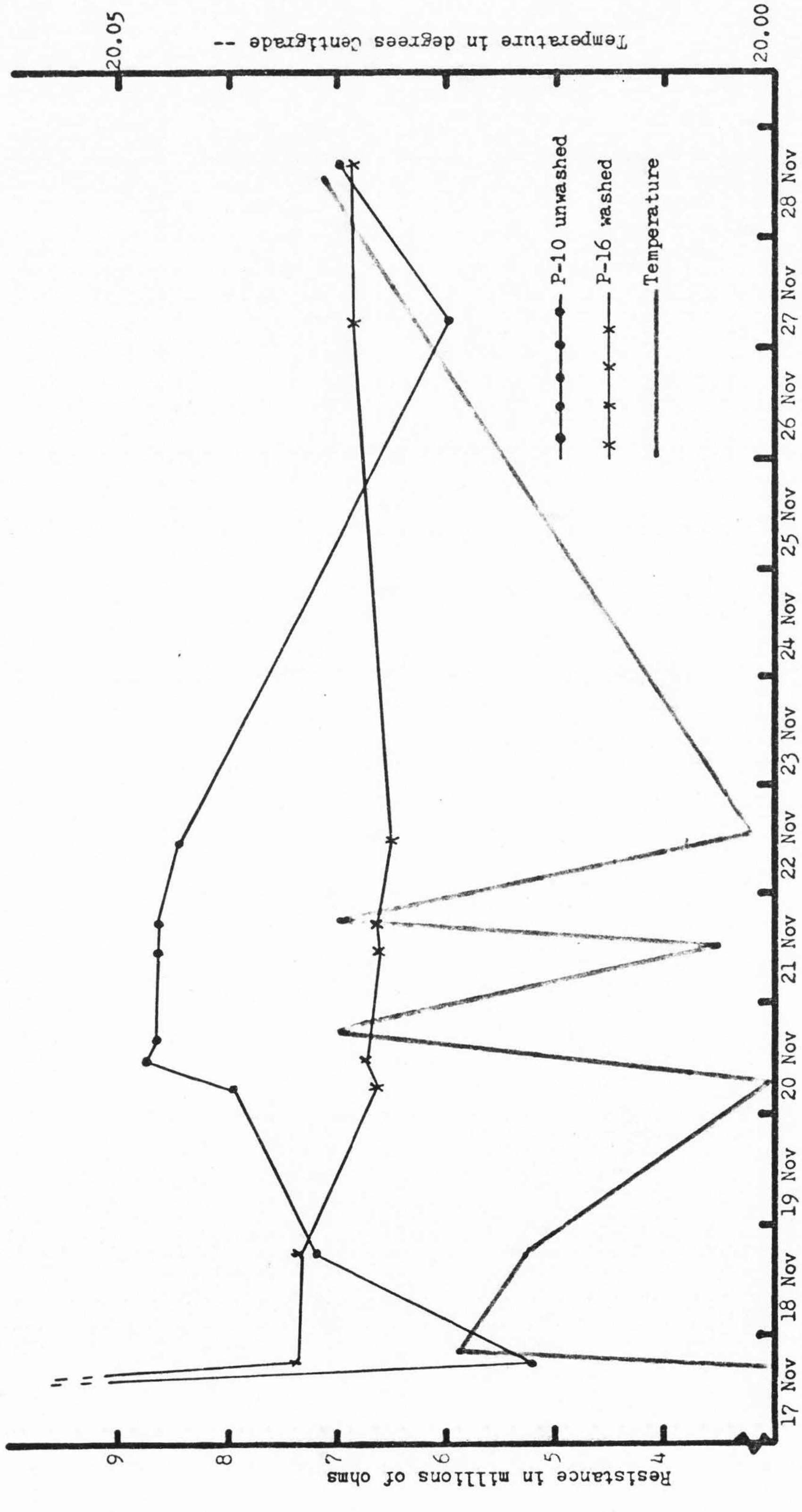

Temperature
P-16 unwashed (water added at start)
P-10 washed
P-10 washed
Resistance in millions of ohms
6
5
4
3
2
1
17 Nov
18 Nov
19 Nov
20 Nov
21 Nov
22 Nov
23 Nov
24 Nov
25 Nov
26 Nov
27 Nov

Figure 9b. Second generation ceramic element transducer test runs.


Temperature in degrees Centigrade --
20.05
20.00
Resistance in millions of ohms
9
8
7
6
5
4
17 Nov
18 Nov
19 Nov
20 Nov
21 Nov
22 Nov
23 Nov
24 Nov
25 Nov
26 Nov
27 Nov
28 Nov
P-10 unwashed
P-16 washed
Temperature

These transducers were tested for a longer period of time than any previous experiments. Data is plotted in Figure 10. It can be seen that these transducers worked well and in a desirable resistance range. However the KCl caused severe corrosion of the lead wires after considerable time. Vertical lines at the measurement points on the graph note the instability caused by this corrosion. Temperature had some effect on the readings. It would be of little significance, however, if the transducers were placed deep into the soil where temperature is constant.

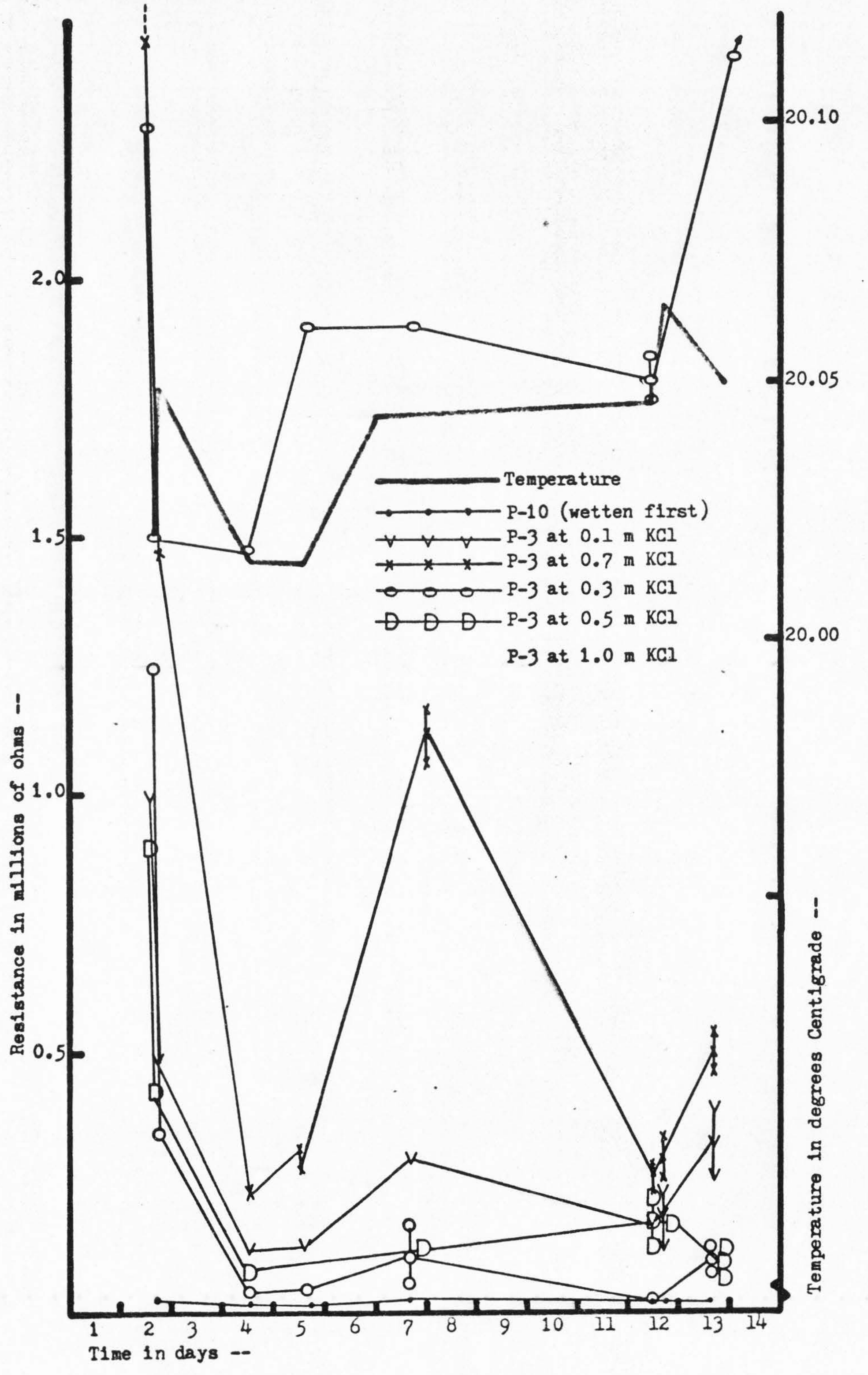
Revised gypsum block transducers

At this time, problems had been encountered with every transducer. The most recent problem being the recurrent corrosion of the contact wires after a week of testing. The Coors porcelain was a poor adsorptive surface because it is manufactured with the intent to create a very uniform particle size. Thus, it did not fulfill the intent of the research--to develop a transducer that had a wide range of particle sizes. The gypsum block seemed the best of the adsorptive surfaces yet encountered.

A transducer was constructed so that the gypsum block was completely isolated from touching any area of the soil environment. This was accomplished by sawing open a tensiometer cup (high pressure porous clay) and inserting the small gypsum block (see Figure 11). The cup was then sealed and the block firmly attached with epoxy resin.

A test apparatus was constructed that more closely typified the field conditions that a transducer would be installed in. A cardboard ice-cream container was filled with a weighed amount of soil. Two transducers were placed in this soil along with two tensiometers that would measure soil matric potential. The soil was then saturated to

Figure 10. Third generation ceramic element transducers (treated with KCl solutions) with temperature plotted also.


Temperature
P-10 (wetten first)
P-3 at 0.1 m KCl
P-3 at 0.7 m KCl
P-3 at 0.3 m KCl
P-3 at 0.5 m KCl
P-3 at 1.0 m KCl
2.0
1.5
1.0
0.5
Resistance in millions of ohms --
20.10
20.05
20.00
Temperature in degrees Centigrade --
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Time in days --

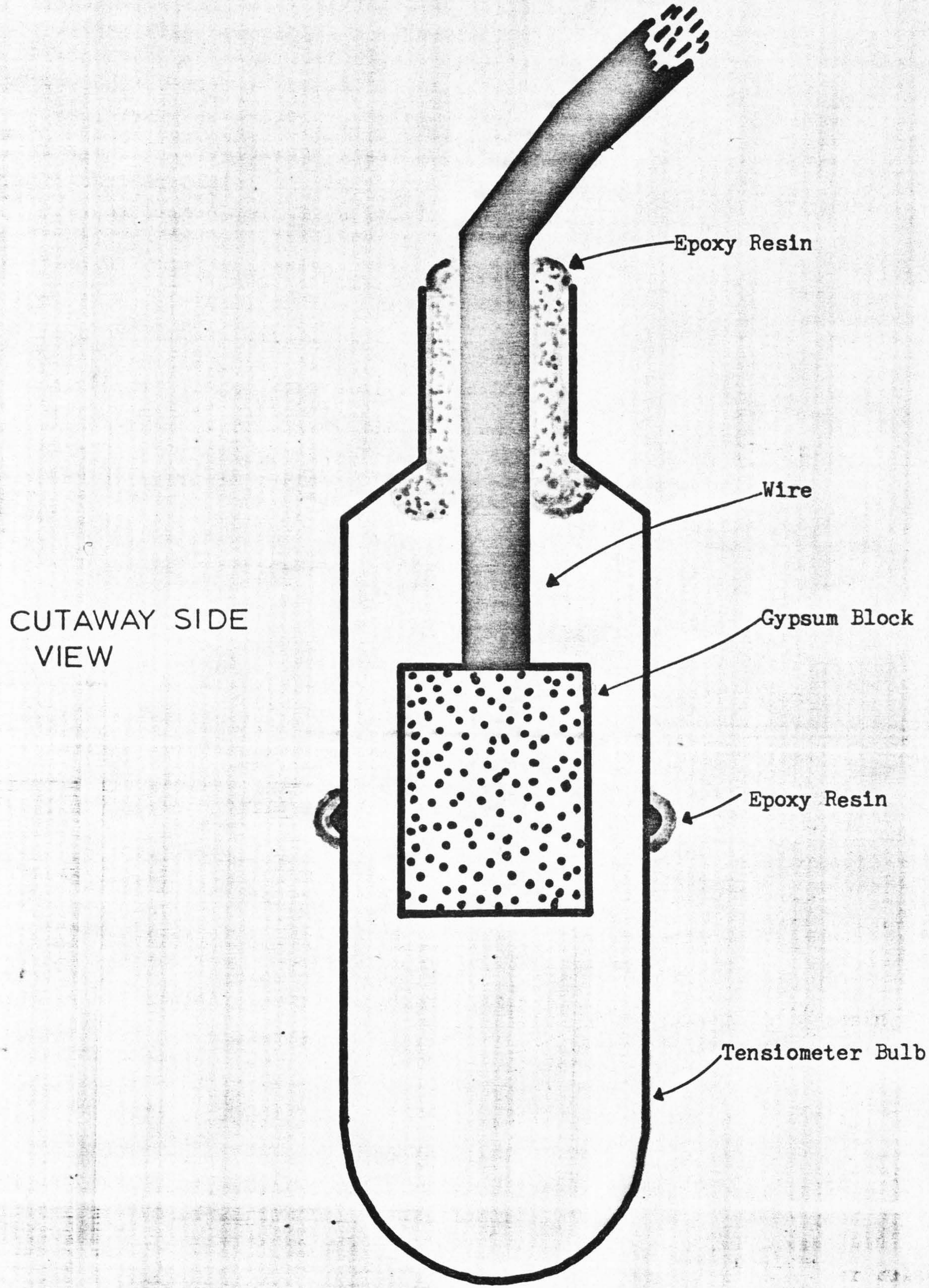


Figure 11. Optimized vapor-adsorption transducer with a gypsum block as the active element.

near field capacity with a known amount of water. A small amount of coarse sand (2 cm in depth) was placed on the soil surface. The sand and the cardboard container minimize border effects by allowing the soil to dry out uniformly from all directions (see Figure 12).

By knowing the amount of soil and the amount of water and also the weight of all components added, the water content of the soil could be constantly monitored by merely weighing the container. Matric potential could be monitored throughout the experiment by the tensiometers. An extra tensiometer and extra transducer were added in case the main units failed.

The test unit was checked at regular intervals for over one month as the soil dried slowly. Resistance values of the transducers, soil matric potential, and water content were all recorded daily throughout this period. The data are summarized in Figures 13 and 14. Figure 13 has the transducer values plotted against time with the water content of the system superimposed. Figure 14 has the transducer values plotted against time with the matric potential of the system (numerically equal to the water potential under most conditions) superimposed. Note how the response times of the transducers are so slow that the values continue to go down during the complete period while the matric potential is rising. Also note that water is continually being adsorbed, while the water content of the soil is dropping to its minimum value. The values of the transducer dramatically increase when the soil reaches this minimum value (air dry). This is caused by the hygroscopicity of the calcium sulfate--which allows it to continually draw water from the soil atmosphere until it reaches a critical point. At this point (near air dry) the block suddenly looses the retained moisture to the soil

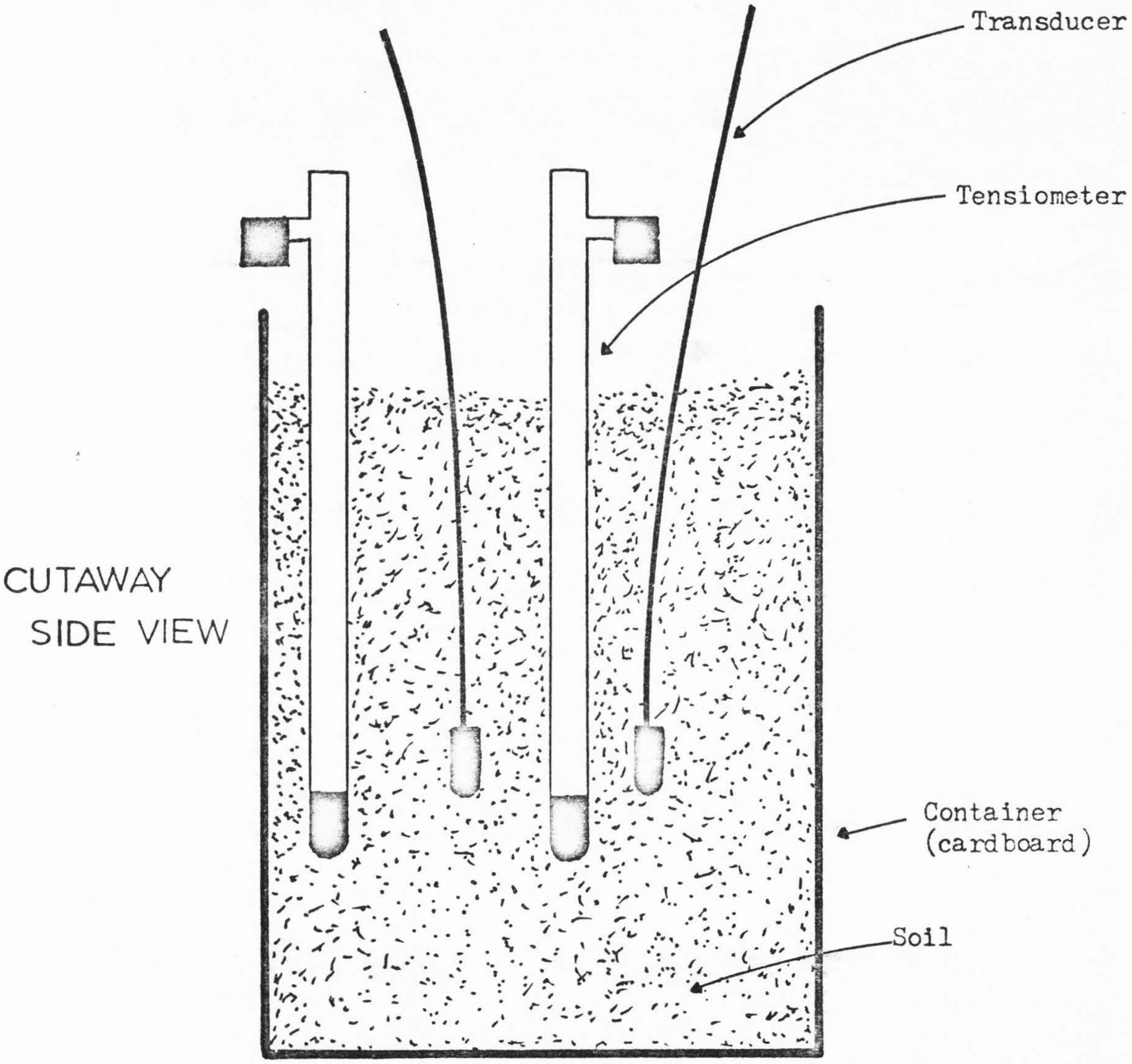


Figure 12. Test arrangement for evaluating gypsum block transducers in a soil environment.

Figure 13. Test run with optimized gypsum block transducers plotted with graviametric water content of the test soil.

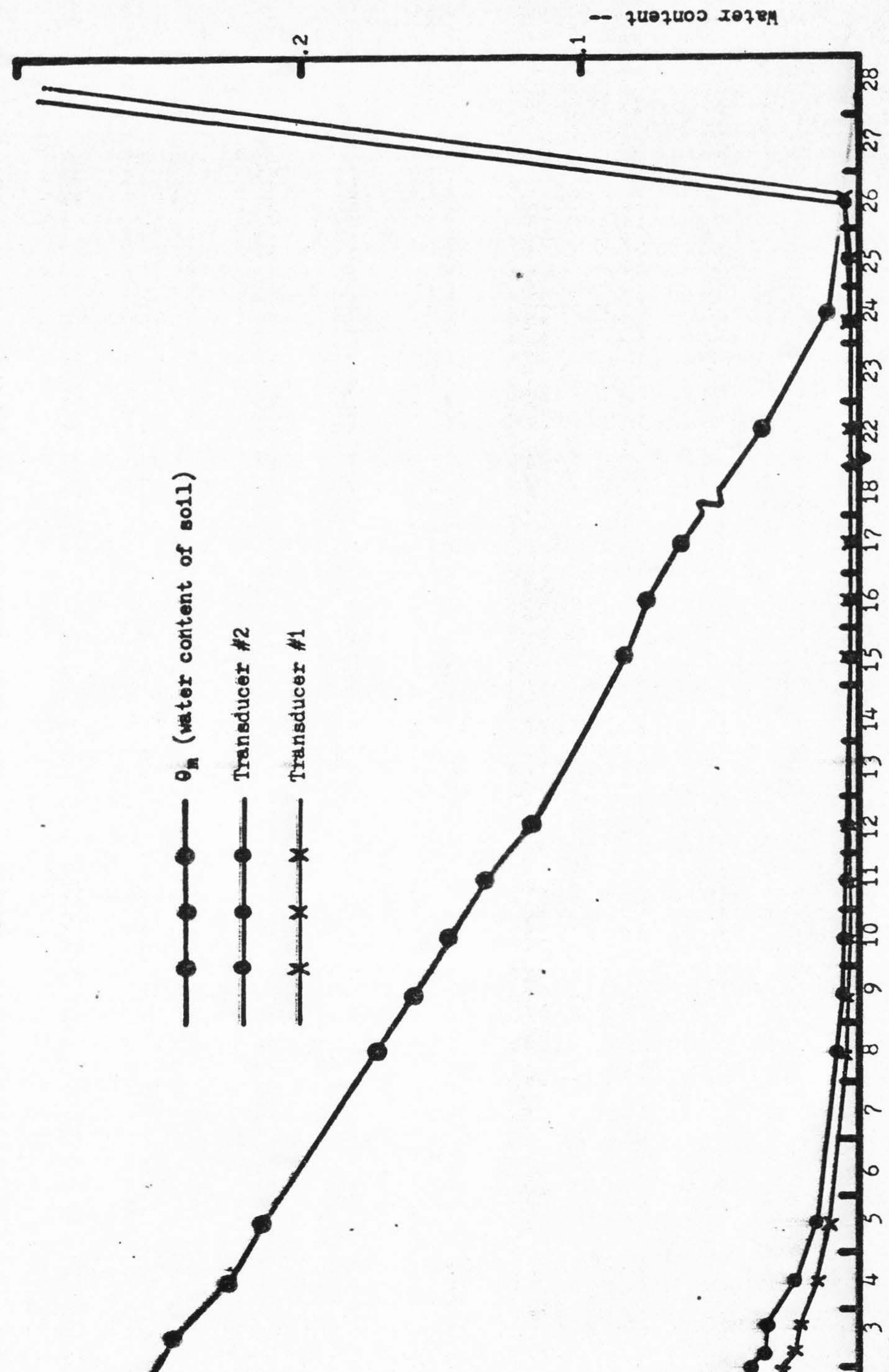
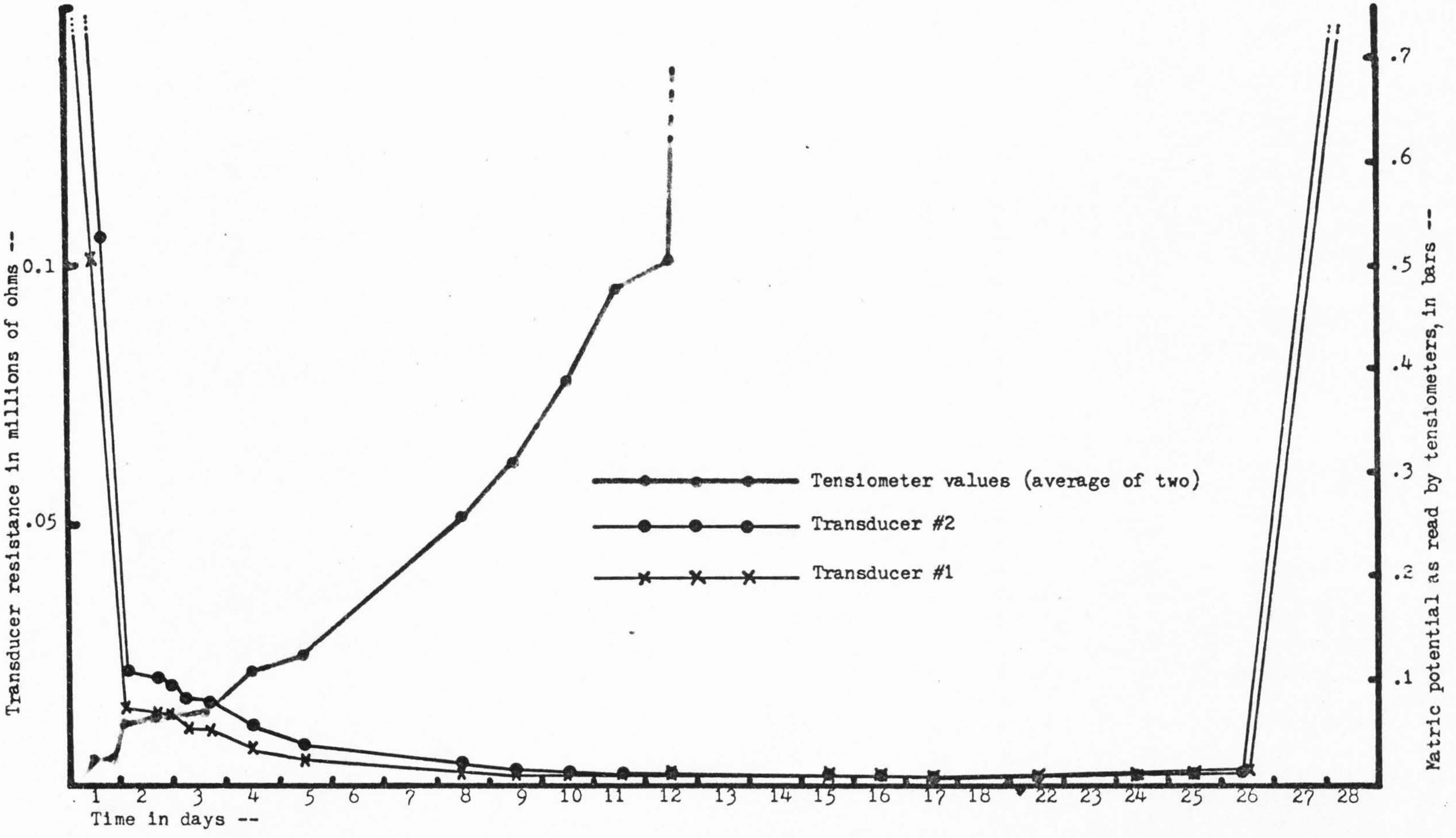

θ_m (water content of soil)
Transducer #2
Transducer #1
Water content --
.2
.1
Transducer resistance in millions of ohms --
0.1
.05
Time in days --
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
22
23
24
25
26
27
28

Figure 14. Test run with optimized gypsum block transducers plotted with matric potential of the test soil.


Transducer resistance in millions of ohms --
0.1
.05
Time in days --
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
22
23
24
25
26
27
28
Matric potential as read by tensiometers, in bars --
.7
.6
.5
.4
.3
.2
.1
Tensiometer values (average of two)
Transducer #2
Transducer #1

atmosphere, because the soil has reached a water potential that is higher than that of the salty block solution.

It can easily be seen that the gypsum block is not a suitable adsorptive medium, due to the extremely long equilibration time and its inherent hygroscopicity.

DISCUSSION AND CONCLUSIONS

None of the transducers tested fulfilled the criteria that were established. However, several significant conclusions can be made. The adsorptive media transducer would be in a workable form once the media was found that could resemble the soil in its properties and yet not expand or cause other interfering effects. It is proposed that a baked clay media would offer these advantages and could be doped with KCl salt to lower its inherent resistance. The only transducer that did not suffer from severe corrosion was the gypsum block transducer. It is proposed that if stainless steel screens were used in the clay transducer, as they are in the gypsum block, that this problem would be eliminated.

Therefore, the author suggests further experimentation with adsorptive media transducers. It is felt that if a clay can be found that has suitable characteristics, a transducer much like the final design would prove effective, reliable, and inexpensive.

LITERATURE CITED

Al-Khafaf, S., and R. J. Hanks. 1974. Evaluation of the filter paper method for estimating soil water potential. Soil Science 117: 194-199.

Buckman, H. O., and N. C. Brady. 1969. The nature and properties of soils. The Macmillan Company. New York, New York.

Gardner, Robert. 1937. A method for measuring the capillary tension of the soil moisture over a wide moisture range. Soil Science 43:277-283.

Hanks, R. J. 1972. Unpublished notes for soil physics instruction. Department of Soil Science and Biometeorology, Utah State University, Logan, Utah.

McQueen, I. S., and R. F. Miller. 1968. Calibration and evaluation of a wide-range graviametric method for measuring moisture stress. Soil Science 106:225-231.

Monteith, J. L. 1972. Survey of instruments for micrometeorology. IBP Handbook Number 22. Blackwell Scientific Publications, London, England.

Salisbury, F. B., and C. Ross. 1969. Plant Physiology. Wadsworth Publishing Company, Inc. Belmont, California.

Taylor, S. A., D. D. Evans, and W. D. Kemper. 1961. Evaluating soil water. Utah State Agricultural Experiment Station Bulletin 426.

Taylor, S. A., and R. D. Slayter. 1962. Proposal for a unified terminology in studies of plant-soil-water relations. UNESCO arid zone research 161:339-349.

Wexler, Arnold (Ed.). 1965. Humidity and moisture, Volume 1: Principles and methods of measuring humidity in gases. Reinhold Publishing Corporation, New York, New York.

Wiebe, H. H., G. S. Campbell, W. H. Gardner, S. L. Rawlins, J. W. Cary, and R. W. Brown. Measurement of plant and soil water status. Utah State Agricultural Experiment Station Bulletin 484.

VITA

V. Philip Rasmussen, Jr.

Candidate for the Degree of

Honors Bachelor of Science

Thesis: Measurement of Soil Water Potential by Adsorption Conductivity

Major Field: Soil Science

Biographical Information:

Personal Data: Born in Logan, Utah, April 3, 1950, son of Victor P. and Velda Petersen Rasmussen; married Linda Kay Schamber September 6, 1973; no children.

Education: Attended elementary school in Clarkston, Utah; graduated from Sky View High School in 1968; received Bachelor of Science degree from Utah State University, with a major in Soil Science and a minor in Physics.

Professional Experience and Honors: 1965-1968, research aide, Department of Soil Science and Biometeorology, Utah State University; 1971-1974, research technician, Department of Soil Science and Biometeorology, Utah State University; 1974-present, special assistant and computer programmer, Project 411, Utah State University Experiment Station, Utah State University. Member of Alpha Zeta and Phi Kappa Phi honorary fraternities.