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Size Measurement of Fine Sediments By Electrical Resistance

D. H. Mikkelson

SIZE MEASUREMENT OF FINE SEDIMENTS
BY ELECTRICAL RESISTANCE

A THESIS

Presented to

the Faculty of the Department of Geology

University of North Dakota

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science of Geology

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by

D.H. Mikkelson

January 1956

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Acknowledgment is gratefully extended to the assistance of the faculty of the University of North Dakota for the use of the equipment of the various departments, but more especially to the generous way in which they, busy with their own problems, took time to encourage and assist me.

Among those to whom I owe thanks especially are Mr. F.D. Holland, Jr., my advisor, for correcting the form of my data, Dr. John R. Bergstrom for urging me to get on with my work, and Mr. N.N. Kohanowski for stirring my imagination of a new method of measuring particle size and whose common sense punctured my zeal sufficiently to realize not to expect world-shaking results. To Mr. Van O. Nicolai, for the use of equipment from the Physics Department, and to Mr. John D. Dixon, who generously appointed me space in the communications laboratory in the Department of Electrical Engineering with the use of equipment for which he is responsible, I owe my gratitude. I appreciate the kindness of Dr. Richard E. Frank in helping me to analyze the results of my experiments in the light of his superior knowledge of chemistry.

ABSTRACT

The purpose of the experiment herein reported is to establish whether or not a correlation exists between the settling velocities of the fine particles of sediments and the change in resistance to the flow of electricity through a fluid containing the sediments. It was assumed that the sediments would behave according to Stokes' Law regarding the velocities of their settling, and the pipette method of analysis was used to measure the particle size with which to compare the results of measuring change of resistance.

The equipment used in measuring the change of resistance as the particles settled was a 1,000 ml. graduated cylinder, drilled and fitted with electrodes, and joined to an electrical circuit as one of the resistances of a Wheatstone Bridge. A decade box was used as a balancing resistance and the point of balance was determined with an oscilloscope. Filling the cylinder with distilled water and introducing the sediments caused an unbalance in the bridge which was balanced by the decade box and the amount of change was noted against time.

Before a satisfactory circuit was found for accomplishing the measurement just described, the order of magnitude of the resistance, the type of load caused by the fluid and the sediment, the effect of both alternating and direct current, the effect of addition of electrolytes into the fluid, the effect of variation of the chemical composition of the sediment, the effect on conductivity from allowing the sediment to remain in solution for five hours and later for two days, the effect on conductivity by increasing the amount of sediment, all had to be investigated. The report consists mainly of the results of these investigations. Further investigations than these are necessary to establish the nature of any correlation which may exist between particle size and electrical resistance.

The experiment points to the fact that solution activity is so great when sediments are introduced into water that the electrical properties of the sediment change in accordance to the rate of solubility, and that since this is true, other physical properties of sediments may be so greatly changed upon their introduction into solutions that any attempt to measure these properties may result in serious errors. Particle size is probably one of these properties.

TABLE OF CONTENTS

TABLE OF ILLUSTRATIONS

The chronology of this report is in the same order as the parts of the experiment were conducted. Unless otherwise designate, any reference to a sediment refers to a sample of glacial till collected by Mr. Ron Kresl from the north central part of Sec. 28, T. 142 N., R. 64 W., Stutsman County, North Dakota, seived to less than 1/16 mm. The sediment was disaggregated by the method suggested by Krumbein and Pettijohn (1938), using N/100 solution of ammonium oxylate in place of sodium oxylate. The sample was examined under a microscope after setting for 48 hours. The disaggregation was complete.

Part I - Order of Magnitude of Resistance

After filling the graduated cylinder with tap water an electrical circuit as is shown in Figure I was made. An electrolyte of ammonium oxylate in strength of N/1000 was introduced and a rheostat (range 0 - 85 ohms) was connected in series as shown to control the amount of current in the circuit. The current was then measured.

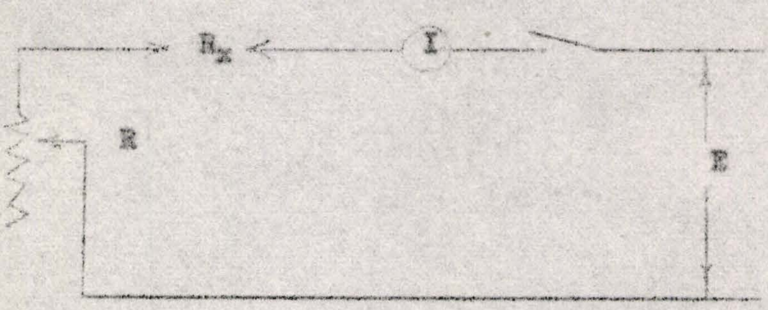

Fig. I

1. R - 100% of 55 ohms

$E_{measured}$ - 117 volts AC $I_{measured}$ - 88 milliampers

$$E = I(R + R_x)$$

$$117 = 88 \times 10^{-3} (55 + R_x)$$

$$R_x = \frac{117 - 55(88 \times 10^{-3})}{88 \times 10^{-3}}$$

$$R_x = 1263 \text{ ohms}$$

2. R - 0% of 55 ohms

$E_{measured}$ - 117 volts AC $I_{measured}$ - 92.5 ma.

$$E = I(R + R_x)$$

$$R_x = \frac{117}{92.5 \times 10^{-3}}$$

$$R_x = 1265 \text{ ohms}$$

Conclusions: The resistance across the electrodes through a solution of tap water and N/1000 ammonium oxylate is 1264 ohms.

3. Approximately one gram of sediment was introduced into the graduated cylinder to notice the effect upon resistance. The current was measured to be 100 ma. when the rheostat was at 0 giving a resistance across the electrodes of 1170 ohms.

Conclusions: Addition of sediment reduced the resistance by 95 ohms. It was observed that more accurate measuring equipment would be necessary in that small error in reading of current would result in quite large differences in calculated resistance.

Part II - TYPE OF LOAD

In order to determine that the load introduced by the sediment was pure resistance rather than partly inductive or capacitive a frequency generator was used as a power source in place of the 117 volt AC current in Fig. I.

The same solution was used as in Part I and the frequency was varied.

1. $E_{measured}$ - 54 volts, 20 cycles per second

   $I_{measured}$ - 35 ma.

$$R_x = \frac{54}{35 \times 10^{-3}}$$

$$R_x = 1,544 \text{ ohms}$$

2. $E_{measured}$ - 54 volts, 10,000 cycles per second

   $I_{measured}$ - 35 ma.

$$R_x = 1,544 \text{ ohms}$$

Conclusions: The load is pure resistance.(1)

PART III - THE EFFECT OF DIRECT CURRENT AND ALTERNATING CURRENT

From the use of alternating current in the previous parts I and II no unusual, upsetting incidents were observed. To determine whether this would result from the use of direct current an inverter was used as the power source in place of the 117 volt AC current in Fig. I. Tap water both with and without the sediment was used in the graduated cylinder. As the circuit remained closed, bubbles appeared at the electrodes and clouding occurred in the upper portions indicating electrolysis which increased the conductivity of the solution.

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(1) X_C - capacitive reactance, X_L - inductive reactance, X - total reactance

$$X = X_L - X_C$$

When $X_C = X_L$, the power factor is unity and the total impedance is the resistance ($Z = r + jX = r$). Since $f = \frac{1}{2\pi\sqrt{LC}}$, the impedance equals the resistance only at one frequency, at resonance, when the load is partially inductive and partially capacitive. (U.S. Naval Institute, Basic Course in Radio, pp. 1-24, 1944)

1. Without sediment:

	$E_{measured}$	$I_{measured}$	R_x
	50 volts	35 ma	1428 ohms
	75	53.3	1457
	100	72.5	1389
	117	86	1361

2. With sediment:

	117	81	1445
after 3 min.	117	85	1376

Conclusions: Electrolysis resulting from the use of direct current discouraged its use in favor of alternating current. As the current remained on, colloid formation became evident, with bubbling near the electrodes. There was also a marked separation of particles, some collecting on the bottom and some on the top when the sediment was introduced. By shutting off the current, the apparatus was checked with a galvanometer to determine whether or not a charge had developed. By dropping an insulated wire, bare at the terminal, to the bottom of the graduated cylinder and introducing another lead at the top of the solution, the charge was read to be 12 microampers, negatively charged at the bottom. When the leads were connected to the electrodes, the current measured off scale. On a microvoltmeter, the voltage read .06 volts. Therefore, using direct current, a battery action was built up, andit was decided that all future experiments would be made using alternating current.

PART IV - THE ELECTRICAL CIRCUIT

A Wheatstone Bridge [1] was built to establish a circuit from which measurements might be obtained for the difference in resistance between settled and unsettled sediments as is shown in Figure II.

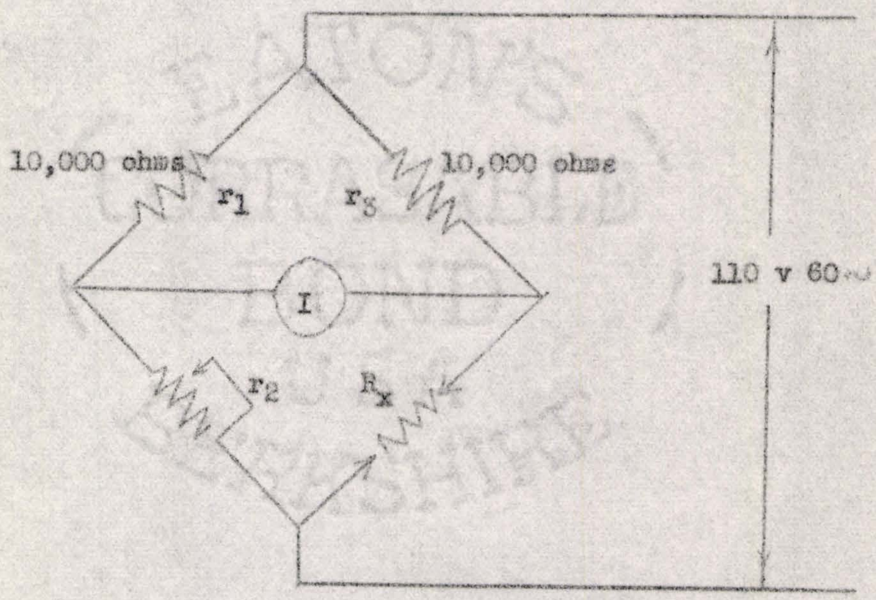

Figure II

Two known resistances of 10,000 ohms were used with a decade box which registered from 0 - 9999 ohms. Another variable resistor with a range from 0 - 1 ohm was connected in series with the decade box for fine balance adjustment. Anoscilloscope was used as a detecting device to determine the

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1. Wheatstone Bridge:

$$\frac{R_x}{r_1} = \frac{r_2}{r_3}$$

$$R_x = \frac{r_1\, r_2}{r_3}$$

(Oscar M. Stewart, Physics, pp. 454-467, 1931) point of balance. Actual value of resistance of the solution in the graduated cylinder was obviously unimportant when difference in resistance between settled and unsettled sediments is the quantity desired. With the Wheatstone Bridge the desired difference can be read from the amount of resistance necessary in the decade box to balance the resistance in the graduated cylinder. Plate I, enclosed in the folder on the back cover, shows schematically the application of the Wheatstone Bridge with the equipment used.

When the sediment from Part III was used in the circuit, it was found that the balance resistance of the decade box was 1160 ohms. Adjustment on the rheostat from 0 - 1 ohm showed no registration on the oscilloscope. The sine wave appearing on the oscilloscope could not be entirely reduced to a straight line, and it was thought that there might be some induction or capacitance in the load, but connecting the load to an impedance bridge showed nothing but pure resistance in the load. A galvanometer across the terminals of the graduated cylinder showed that a charge was built up even with alternating current. In order to check the other elements of the circuit, a resistance of 1,000 ohms was placed in the circuit instead of the solution. A true balance was obtained. To check the proper function of the decade box a vacuum tube potentiometer was used to register variation in resistance of the decade box. The results were that the decade box was functioning properly within the range of accuracy of the vacuum tube potentiometer. The inability to reduce the reading of the oscilloscope to a straight line was believed to be due to stray pick-up of 60 cycle current, but grounding the oscilloscope had no effect, so it was decided that the experiments following would be run without the use of the fine rheostat, and that balance resistance would be considered to be that resistance at which the oscilloscope reading most nearly approached a straight line.

PART V - THE CONDUCTIVITY EFFECT OF ELECTROLYTES

The circuit shown schematically in Plate I was used for this and all experiments following. The previous experiments indicated that a certain amount of electrolysis occurred in this circuit,and to determine just how much this might be,distilled water was mixed with ammonium oxylate to strength of N/100 in hopes that a suitable fluid might be obtained. Using distilled water alone, a charge of 2 microampers before closing the circuit increased to a steady reading of 7 microampers, read at intervals of one, two, and three minutes of continual operation. Balance resistance was 19,959 ohms, obtained by adding a 10,000 ohm resistor in series with the decade box. Using N/100 solution of distilled water and ammonium oxylate, a charge of .4 milliampers remained at .4 milliampers after ten minutes of continual operation. Balance resistance in this case was 1,181 ohms. Although the charge of the ammonium oxylate solution was considerably higher, the value remained constant with continual operation, and the conductivity through the ammonium oxylate solution was considerably more than through distilled water alone. It was concluded that either distilled water alone or with ammonium oxylate might be a suitable fluid since no unusual charge seemed to be building up and no electrolysis was apparent at the electrodes.

PART VI - THE CONDUCTIVITY EFFECT OF SEDIMENTS

Sediment was introduced into distilled water to determine the conductivity effect and to determine the electrolytic effect. A charge across the electrodes of 7 microampers before closing the circuit increased to 17 microampers after ten minutes of continual operation. Balance resistance immediately after introducingthe sediment into the water was 7,910 ohms. The resistance decreased as the circuit remained closed, and it was thought that this was due to the settling of the particles in the solution, so an attempt to record this rate was made with the following results:

Time	Balance Resistance
0	5841 ohms
58 sec.	5702
1 min. 56 sec.	5701
(Circuit was disconnected and the charge across the terminals was read to be 22 microampers)	
7 min. 44 sec.	5505
(Circuit was disconnected and the charge across the terminals was again read to be 22 microampers.)	
31 min. 10 sec.	5262
(Circuit was disconnected and the charge across the terminals was again read to be 22 microampers.)	

Approximately one gram of sediment was used. Concluding that the change in balancing resistance was due to settling of the sediments, the writer decided to investigate the effect of changing the mineral composition of the sediment. It should be pointed out that this conclusion was in error, as will be shown from the following experiments.

PART VII - THE CONDUCTIVITY EFFECT OF CHEMICAL COMPOSITION CHANGE

Minerals were selected with as great variation in electrical properties as possible. [1] Samples of one gram each of relatively pure hematite, galena,

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1 Taggart, Handbook of Mineral Dressing, pp. 13,40 - 13.44, 1945.

Sulfur	Time	Balance Resistance	Diff.
	0 min.	19,132 ohms	0 ohms
	3	18,812	320
	6	18,763	369
	9	18,743	389
	12	18,734	398
	15	18,714	418
	18	18,655	477
Bauxite	0 min.	19,706 ohms	0 ohms
	3	19,204	502
	6	19,134	572
	9	19,056	650
	12	18,953	753
	15	18,874	832
	18	18,872	834

After 25 minutes the solution was agitated and allowed to settle again. At 0 time the balance resistance was found to be 18,862 ohms, which was less than after 18 minutes of settling shown above. It was assumed that the major factor changing the resistance was not due to settling but to the formation of solutions.

Sediment			
	0 min.	14,600 ohms	0 ohms
	3	13,972	628
	6	13,805	795
	9	13,606	994
	12	13,450	1150

chalcopyrite, sulfur, bauxite, and sediment were ground with a mortar and seived to size between .0024 - .0049 inch diameter. They were introduced into distilled water and the balance resistance rate was noted as follows:

Hematite	Time	Balance Resistance	Diff.
	0 min.	17,601 ohms	0 ohms
	3 min.	16,999	602
	6	16,997	604
	9	16,996	605
	12	16,986	615
	15	16,985	616
	18	16,979	622
Chalcopyrite	0 min.	18,700 ohms	0 ohms
	3	18,094	606
	6	17,995	705
	9	17,995	705
	12	17,964	736
	15	17,896	804
	18	17,894	806
Galena	0 min.	18,402 ohms	0 ohms
	3	17,913	489
	6	17,905	497
	9	17,824	578
	12	17,804	598
	15	17,802	600
	18	17,774	628

Time	Balance Resistance	Diff.
15 min	13,323 ohms	1,277 ohms
18	13,211	1,389

After 20 minutes the sediment was agitated and balance resistance was found to be 12,290 ohms, which was less than 0 time. The sediment appeared to be going into solution. It was reasoned that if the solution could be made saturated by allowing the sediment to stand for some time, perhaps the resistance upon agitation could be made to remain constant. The sediment was allowed to stand for five hours with the following results:

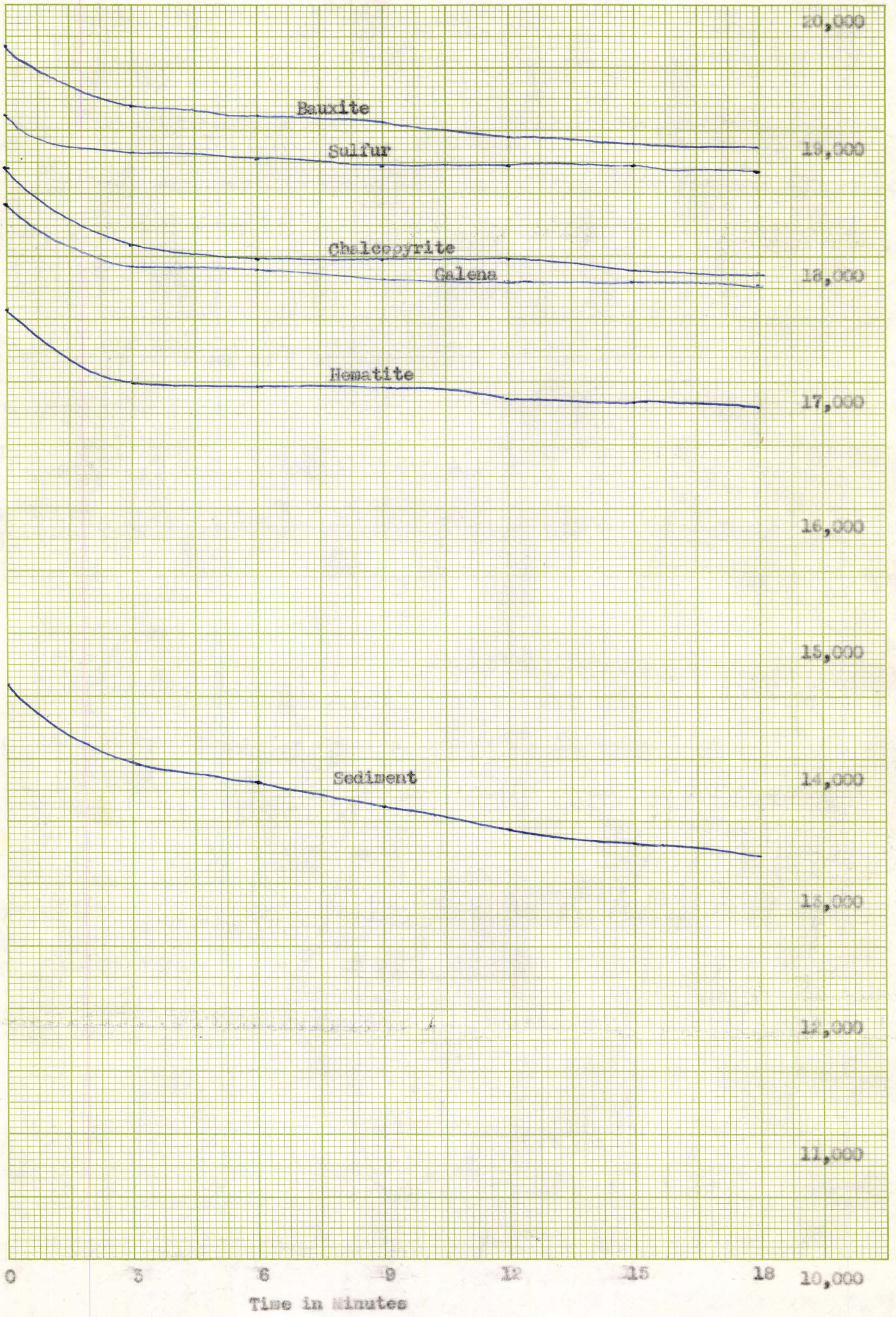
Sediment in fluid for five hours

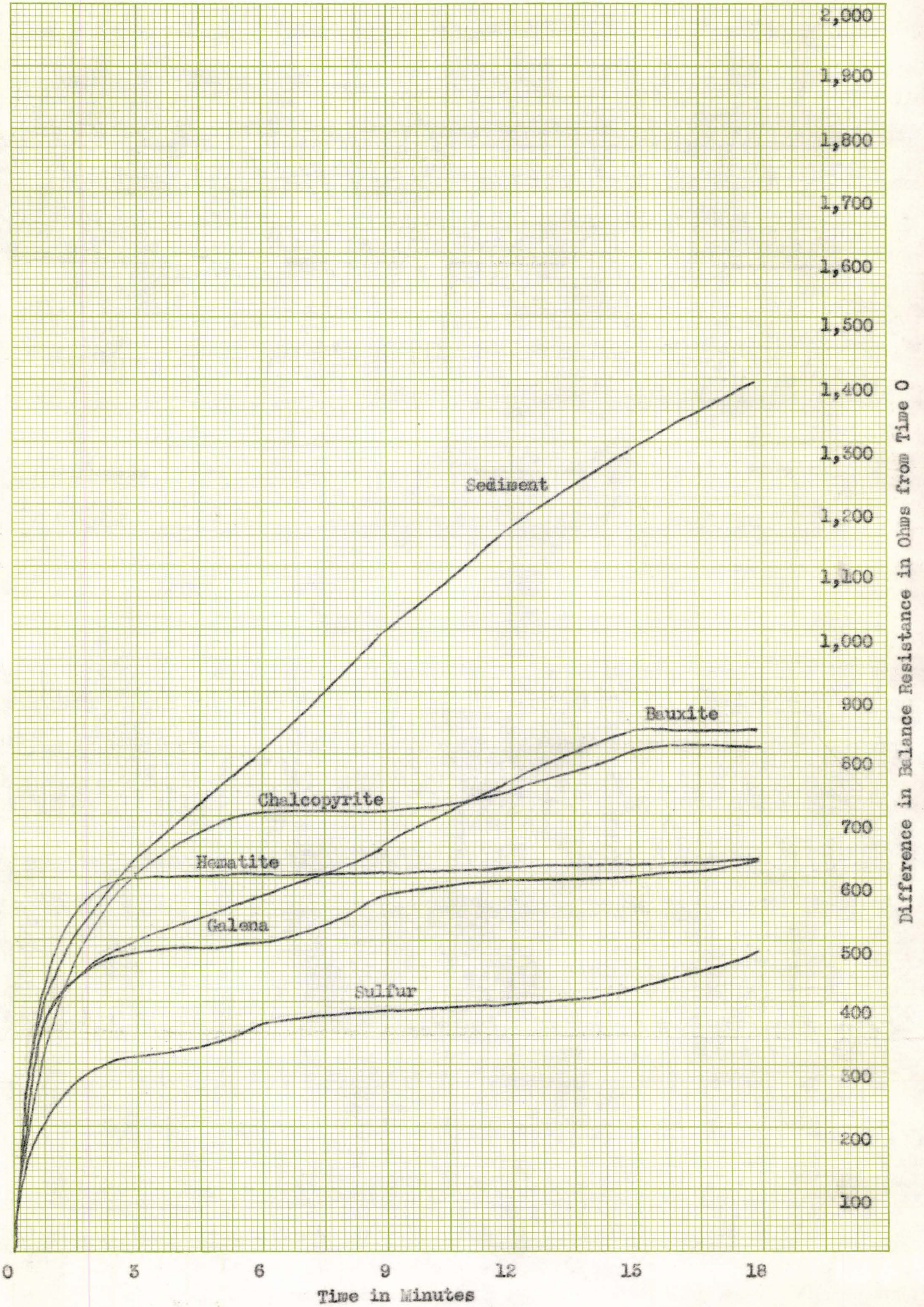
0 min	10,301 ohms	0 ohms
3	10,099	202
6	9,433	868
9	9,372	929
12	9,225	1,070
15	9,214	1,087
18	9,208	1,093

After 18 minutes the sediment was again agitated, but the balance resistance did not go above the last reading before agitation, so it was concluded that saturation had not occurred. By increasing the amount of sediment and agitating vigorously saturation might be reached. An investigation of this follows in a later part.

Although the results of this part of the experiment are inconclusive, rapid comparison of the rate of change in resistance due to chemical compositon change can be seen from Figure III, wherein balance resistance is plotted against time and from Figure IV, wherein difference in balance resistance from time 0 is plotted against time. Chemical composition does not appear to be as important as might be expected.

FIGURE III


Bauxite
Sulfur
Chalcopyrite
Galena
Hematite
Sediment
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
0
3
6
9
12
15
18
Time in Minutes
Balance Resistance in Ohms


Sediment
Bauxite
Chalcopyrite
Hematite
Galena
Sulfur
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
Difference in Balance Resistance in Ohms from Time 0
0
3
6
9
12
15
18
Time in Minutes

PART VIII - THE EFFECT OF CHANGE IN DEPTH OF ELECTRODES

While waiting for five hours attempting to reach a steady balance resistance reading after agitation in the previous part, the effect of change in depth of the electrodes was investigated. Sediment was used in the graduated cylinder and the depth of the electrode was roughly measured at 4, 3, and 2 inches from the surface. Each time the sediment was agitated at the beginning of the experiment. The results were:

Depth	Time	Balance Resistance
Depth of 4 inches	0 min.	12,906 ohms
	3	12,700
	6	12,675
	9	12,662
	12	12,660
	15	12,654
	18	12,650
Depth of 3 inches	0	12,650
	3	12,552
	6	12,525
	9	12,522
	12	12,521
	15	12,515
	18	12,502
Depth of 2 inches	0	12,502
	3	12,500
	6	12,410
	9	12,410
	12	12,410

Depth of 2 inches	Time	Balance Resistance
	15 min.	12,402 ohms
	18	12,400

It is apparent that the depth of the electrodes has little or no effect on the conductivity of the fluid, there being a steady decrease in resistance with time, the rate increasing with agitation.

PART IX - THE CONDUCTIVITY EFFECT OF SETTING FOR TWO DAYS

Another sample of .7907 grams of sediment was introduced into distilled water in the graduated sediment after disaggregation and the rate of balance resistance was noted. The sediment was then allowed to set for two days, the thought being that in that time a constant balance resistance might be obtained after agitation and the difference noted between such a solution and one in which the sediment had just been introduced. The results are:

Immediately after introducing the sediment and agitating

Time	Balance Resistance	Difference
0 min.	6,573 ohms	0 ohms
58 sec.	6,530	43
1 min. 56 sec.	6,483	90
5 min.	6,451	122
6 min.	6,390	183
7 min. 44 sec.	6,355	218
9 min.	6,336	237
12	6,304	269
15	6,294	279
18	6,292	281
21	6,283	290
24	6,274	299
27	6,262	311

Time	Balance Resistance	Difference
30 min.	6,251 ohms	322 ohms
33	6,234	339
36	6,221	352

After setting for 2 days and agitating

0	5,102	0
58 sec.	5,080	22
1 min. 56 sec.	5,050	52
3 min.	5,031	71
6	5,001	101
7 min. 44 sec.	4,983	119
9 min.	4,972	130
12	4,952	150
15	4,950	152
18	4,948	154
21	4,943	159
24	4,936	166
27	4,931	171
30	4,926	176
31	4,923	179
33	4,922	180
36	4,920	182
42	4,909	193
48	4,894	208
54	4,883	219
1 hr.	4,876	226

Agitation did not bring the balance resistance back to the 0 time amount, so it was decided that the sediment was continually dissolving. To eliminate this, later experiments were run using considerably more sediment, hoping to obtain a saturated solution. Figures V and VI show the results of this part graphically.

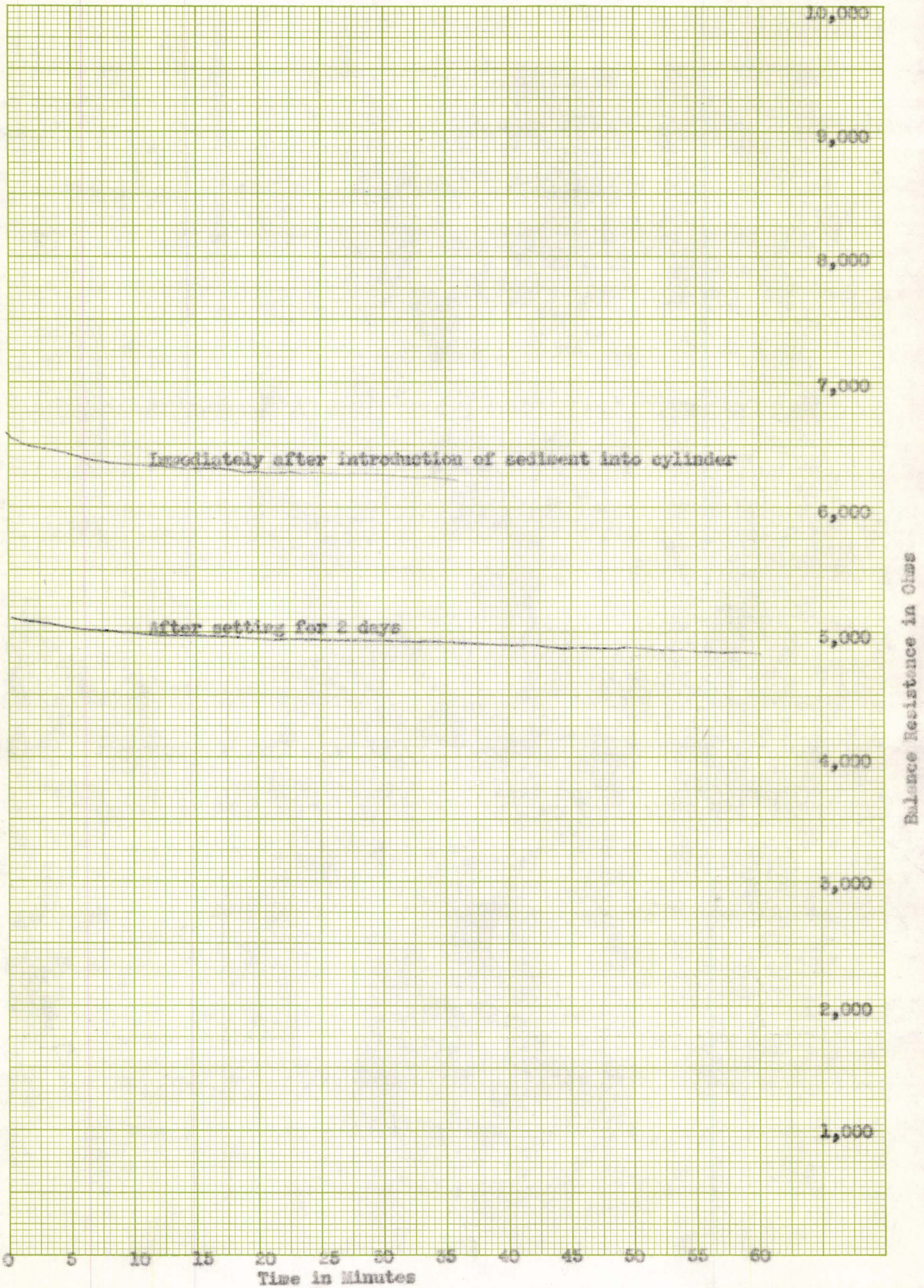
During this part of the experiment an attempt was made to subdue the distortion in the oscilloscope screen, thought to be due to stray 60 cycle current pick-up. A frequency generator was applied as a current source using 80 volts and a frequency of 5,000 cps, but distortion persisted. The writer lacks the necessary knowledge to account for this distortion, and time would not permit further investigation, so the oscilloscope was balanced as near a straight line indication as was possible. It was noticed that the oscilloscope required about 15 seconds to settle down if the power was shut off between readings. No unusually large charge builds up with continual operation, so the current was left on for the entire run in the second test of this part.

PART X - THE CONDUCTIVITY EFFECT OF INCREASE IN AMOUNT OF SEDIMENT

A large sample of sediment , 25.2862 grams were prepared and introduced into the graduated cylinder with distilled water. The solution was vigorously agitated and the rate of balance resistance was noted as follows:

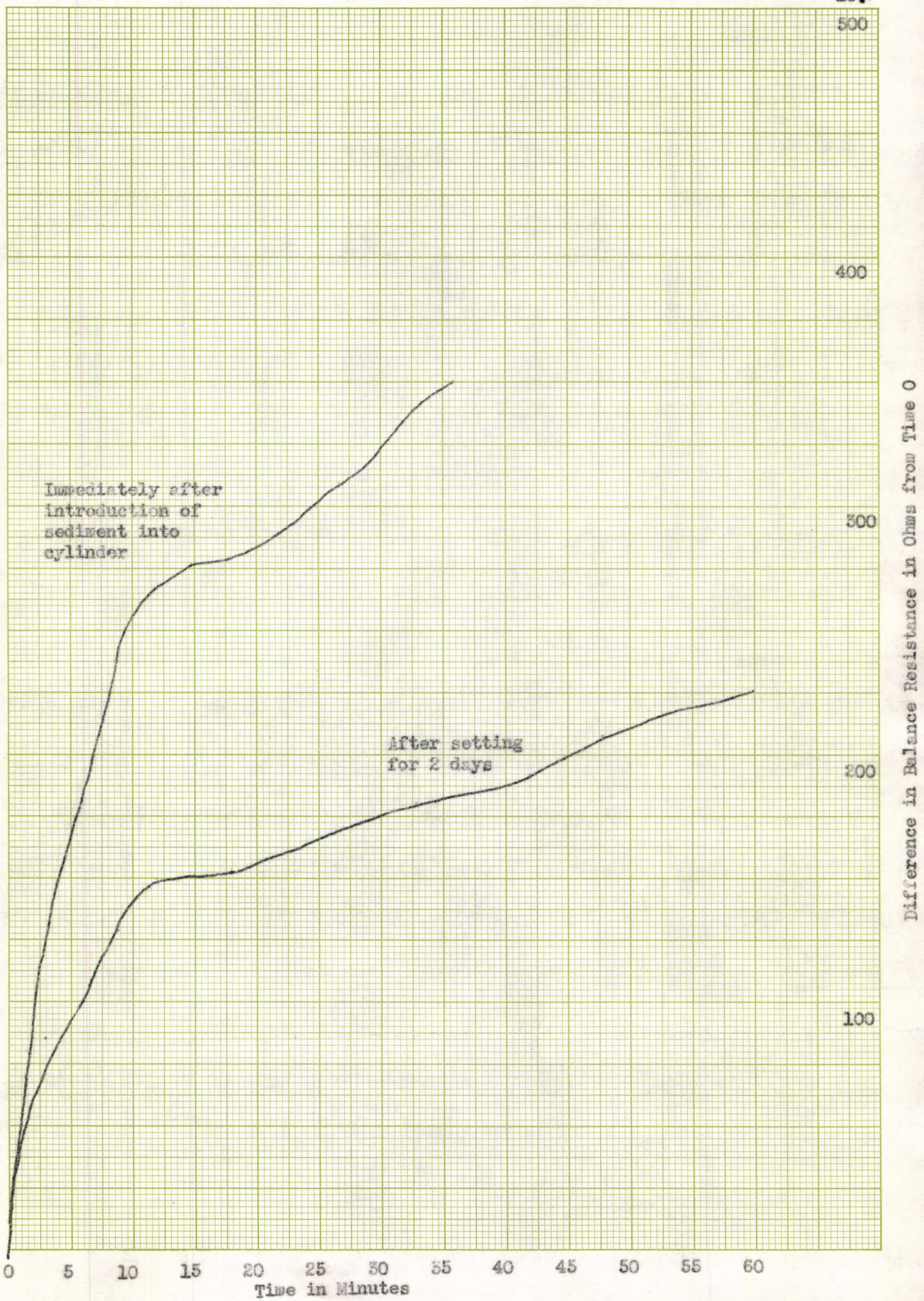
Time	Balance Resistance	Difference
0	4,533 ohms	0 ohms
1 min. 56 sec.	4,512	21
3 min. 52 sec.	4,500	33
6 min.	4,421	112
9	4,390	143

FIGURE V



No. 5780-20
20 SQUARES TO THE INCH
Made in U. S. A.

FIGURE VI


500
400
300
200
100
Immediately after introduction of sediment into cylinder
After setting for 2 days
0
5
10
15
20
25
30
35
40
45
50
55
60
Time in Minutes
Difference in Balance Resistance in Ohms from Time 0

Time	Balance Resistance	Difference
12 min.	4,344 ohms	189 ohms
15	4,322	211
20	4,311	222
25	4,273	260
30	4,252	281
40	4,230	303
50	4,211	322
1 hr. 1 min.	4,131	402
1 hr. 15 min.	4,123	410
1 hr. 30 min.	4,112	421
1 hr. 45 min.	4,063	470
2 hr.	4,074	459
2 hr. 30 min.	4,043	490
3 hr.	4,053	480
3 hr. 15 min.	3,995	538
3 hr. 30 min.	3,992	541
4 hr. 5 min.	3,985	548

After 24 hours, the sediment was agitated and the resistance balance was measured to be 3,854 ohms which is less than the last reading in the test above. Therefore, the solution was not saturated even by substantial increase in amount of sediment, although the rate change in the balance resistance was decreased both by allowing the sediment to stand for some time and by increasing the amount of sediment. The writer suggests that saturation may be reached and balance resistance after agitation may be made constant by mixing about 25 grams of sediment with one liter of distilled water and mechanically agitating the mixture for about 24 hours. With close temperature control, it might be possible to establish the nature of any correlation which may exist between particle size and balance resistance, providing internal chemical reaction in the sediment is at a minimum. The writer had insufficient time to investigate this possibility.

The results of this part of the experiment are shown graphically in Figure VII. It had been hoped that the results of the pipette method of analysis might be shown on the same graph, but this was not done because of the upsetting solution action encountered. The results of the pipette method of analysis have been included in the next part.

PART XI - PIPETTE ANALYSIS OF THE SEDIMENT

A pipette method of analysis [1] was made to determine the amount of particles in various size ranges below 1/16 mm.. These are the results:

1 -	1 min. 56 sec.	at 20 cm. depth	.4643 g. of sediment decanted
2 -	3 min. 53 sec.	10	.3310
3 -	15 min.	10	.2322
4 -	1 hr. 1 min.	10	.1197
5 -	4 hr. 5 min.	10	.0438

25 ml. were drawn off at each time interval. $\frac{1,000}{25} = 40$

1 - 40 x .4543 = 18.5720 grams

2 - 40 x .3310 = 13.240

3 - 40 x .2322 = 9.2880

4 - 40 x .1197 = 4.7880

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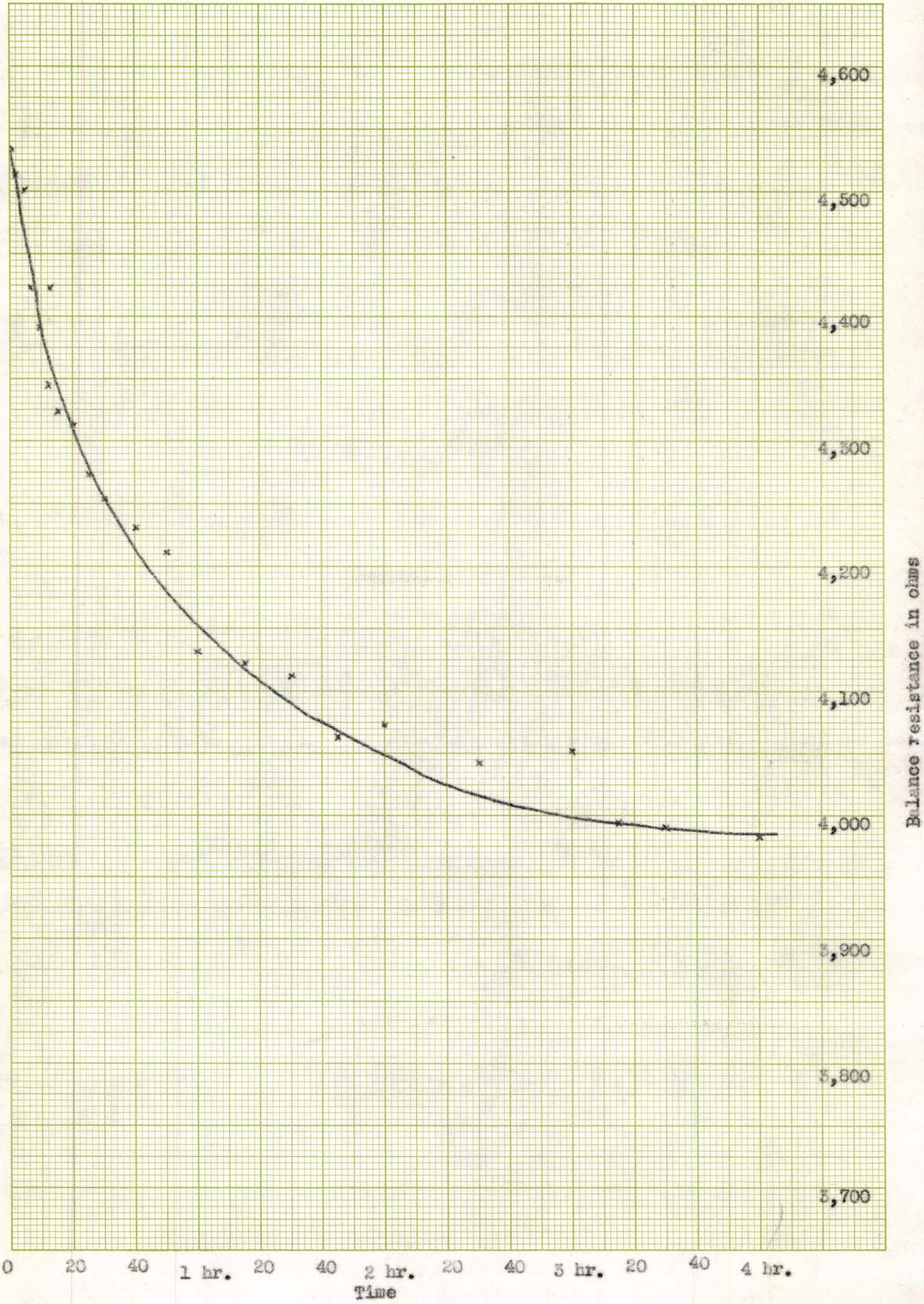
1. Krumbein, W.C. & Pettijohn, F.J., Manual of Sedimentary Petrography, pp. 166 - 172, 1938.

Figure VII


4,600
4,500
4,400
4,300
4,200
4,100
4,000
3,900
3,800
3,700
Balance resistance in ohms
0
20
40
1 hr.
20
40
2 hr.
20
40
3 hr.
20
40
4 hr.
Time

5 - 40 x .0438 = .1752

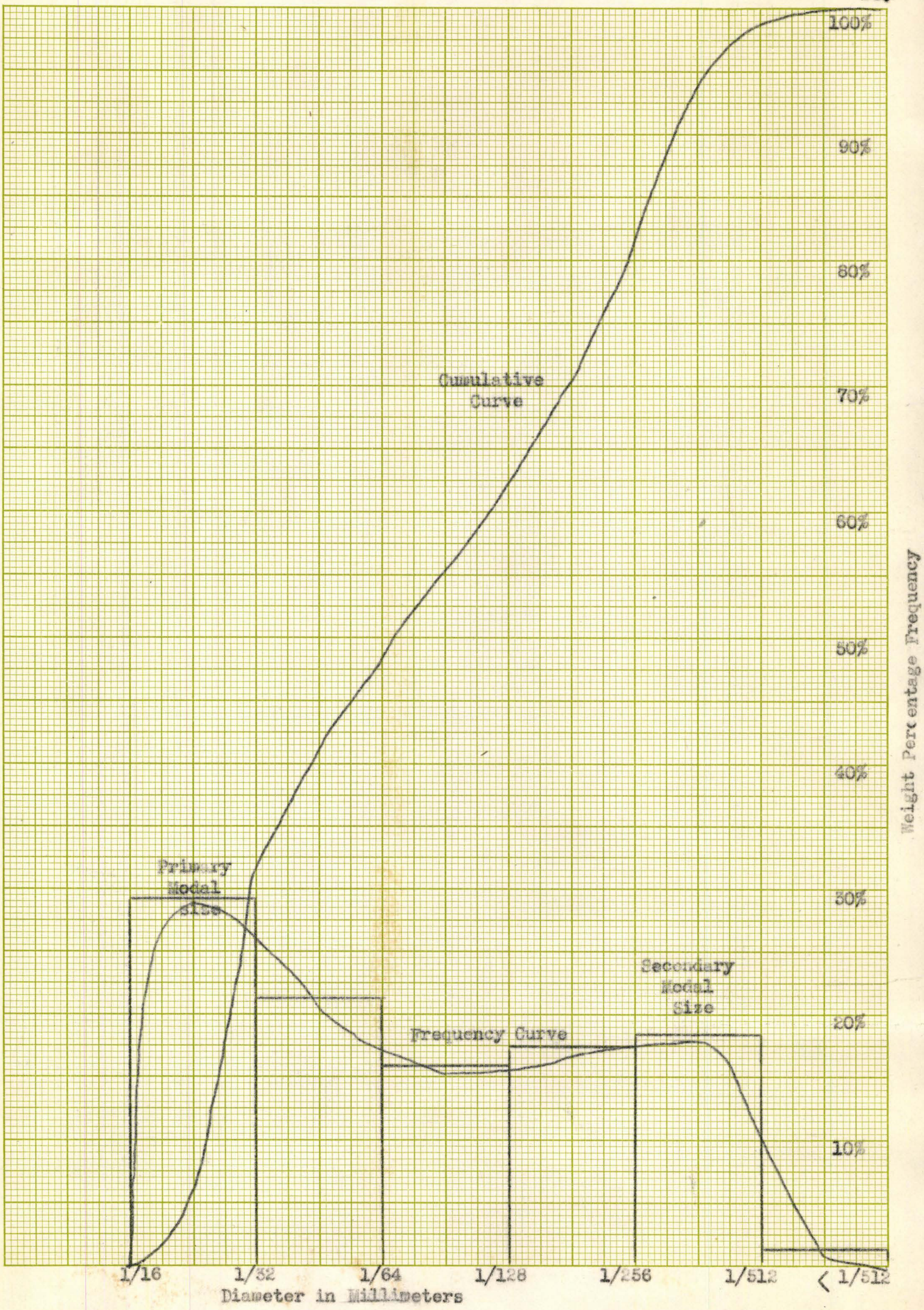
1/16 - 1/32 inch dia.	25.2862 g. 18.5720 6.7142	26.6%
1/32 - 1/64	18.5720 13.2400 5.3320	21.1%
1/64 - 1/128	13.2400 9.2880 3.9520	15.6%
1/128 - 1/256	9.2880 4.7880 4.4000	17.4%
1/256 - 1/512	4.7880 .1752 4.6128	18.2%
less than 1/512	25.2862 25.0110 .2752	1.1%

Figure VIII dipplays the analysis graphically by means of a cumulative curve, a frequency curve, and a histogram. From the graph it is seen that the sorting of the sediment is bi-modal as might be expected from a sample of glacial till.

PART XII CONCLUSIONS

From the experiments conducted, there is no proof that any correlation exists between resistance to the passage of electricity in sediments settling in water and the rate of such settling. There is proof, however, that different substances have different rates of solubility and that the rate of solubility is a parabolic function, varying from the time of introduction of the sediment until a saturated solution is reached. It would be interesting to further investigate the possibilities of a relationship of resistance to settling. In order to do this with the equipment used in this experiment it would be necessary to

FIGURE VIII


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
Cumulative Curve
Primary Modal Size
Secondary Modal Size
Frequency Curve
1/16
1/32
1/64
1/128
1/256
1/512
< 1/512
Diameter in Millimeters
Weight Percentage Frequency

begin with a saturated solution of sediment and distilled water, controlling the temperature carefully, and eliminating any stray pick-up which tends to distort the picture on the oscilloscope. Any difference in resistance attributable to settling of the particles in the solution will probably be quite small, and this method of measuring sorting, even if perfected, will probably be too cumbersome to be of any real aid in classifying sediments.

Perhaps the greatest value in this experiment is that it points to a criticism of the present methods of measuring sediment size after introducing the sediment into water. When introduced into liquids, sediments begin to change both chemically and physically. The one physical change which is proved by this experiment is that resistance to electrical current changes rapidly. It is suggested that other physical changes may also occur. Among the changes, size is very apt to be changed considerably. Highly soluble particles in the sediment will rapidly change to colloidal size. The very nature of the word <u>disaggregation</u> suggests it. How far shall we disaggregate? Which ofthe particles will disaggregate? Because of these conspicuous questions, the writer suggests that to compare sediments' sizes, a standard set of rules must be applied to both the preparation and measurment of the sediments compared, and that inherent in any system which introduces sediments into water are errors due to chemical change affecting physical change. It would seem more appropriate to prepare dry and to measure dry, and that further investigations be made in perfecting air elutriation methods.

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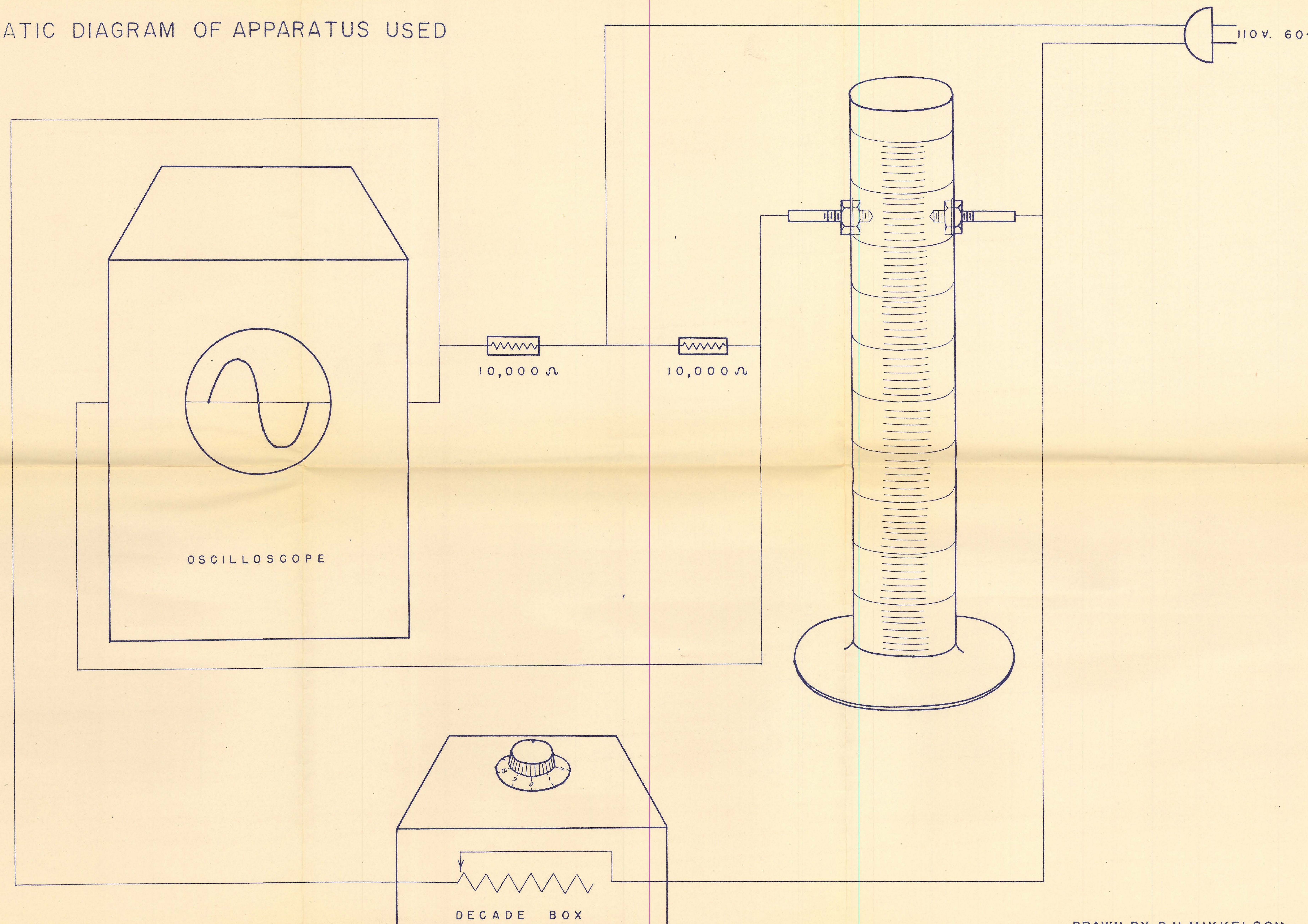
SCHEMATIC DIAGRAM OF APPARATUS USED



DRAWN BY D.H. MIKKELSON