The Imbibition of Various Liquids by Vulcanized Caoutchouc

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by

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I. Introduction.

Imbibition is important for various reasons, the two most generally mentioned are its relation to solubility and its relation to osmosis. In this discussion, however, we are not so much concerned with its relation to either one of these phenomena as with the principles that govern imbibition. The distending or swelling of cacutchouc is the result of two phenomena, imbibition or capillary absorption and the solution pressure of the liquid in which the caoutchouc is immersed.

The work that has been done on the imbibition of cacutchouc is not extensive. Among the investigators that have done work in this line it is still a question whether the capillary absorption theory or the solubility theory is more applicable or whether the phenomena of imbibition is partly due to capillary absorption and partly to solubility.

At different times Flusin (1,2,3,) has published
-(1,2,3,) see bibliography.-

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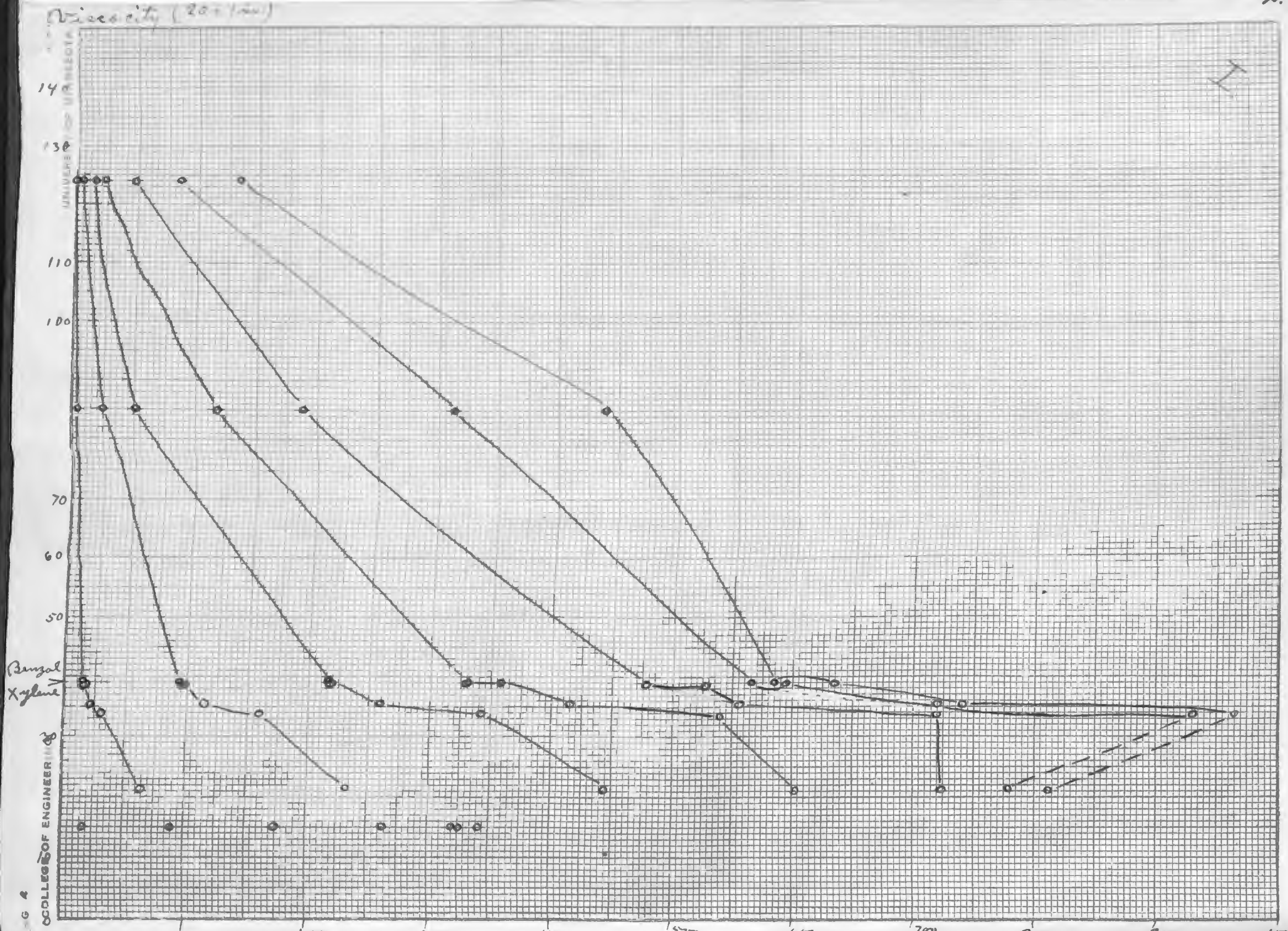
results on the affect of nineteen liquids upon five different substances, one of which is caoutchouc. The object of his investigation was to show the relation between imbibition and osmosis, which he found to be proportional to each other, but from the study of his results it is seen that there is a direct relation between imbibition and the viscosity of the liquids. He observes the increase in weight due to the imbibed liquid and expresses his results in cc. of the liquid taken up by 100 grams of rubber during the various periods of time.

From his data it appears evident that the viscosity of the liquids is the primary factor governing the initial period of imbibition. The following is a table of his results to which a column, giving the relative viscosity of the liquids, has been added.

p. 3 A.


Viscosity (20 + 1 ...)
I
14
130
110
100
70
60
50
Benzol
Xylene
30
100
200
300
400
500
600
700
800
900
1000
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Imbibition of Caoutchouc.

Active Liquids	Viscocity	1 min	5 min	15 min	30 min	1 hrs	3 hrs	24 hrs
Carbon disulphide.....	21.5	64.9	233	445	602	724	778	810
Chloroform............	34.0	32.6	159	343	538	721	929	964
Toluene...............	35.4	24.2	116	260	417	556	720	740
Ether.................	15.0	18.7	90	175	264	320	324	343
Benzol................	39.3	17.1	96	218	358	478	565	586
Xylene................	39.3	15.4	95	216	330	528	294	635
Essence of petroleum..		12.6	71	160	267	366	434	438
Benzylchoride.........	84.7	6.8	25	53	119	189	313	439
Essence of turpentine.		4.3	17	43	94	139	385	552
Petroleum oil.........		2.7	10	25	56	78	217	367
Nitrobenzene..........	124.3	2.0	6	16	24	47	86	136

As seen in graph I ether is the only liquid that does not fall in line for the shorter periods of time. It seems plausible, however, that this may be ascribed to the fact that ether is so volatile which makes it impossible to obtain accurate results for ether by this method.

F. Kirchhoff (4) has recently published data showing the relation between the degree of vulcanization of caoutchouc and imbibition. He has studied the effect of benzol, carbon tetra chloride, carbon-bisulphide, and benzine on caoutchouc of five different degrees of vulcanization and holds that the solvent power of the liquid is a criterion to the swelling power of the liquid. The theory of the swelling is expressed as a solution of the rubber in the solvent. The globules in the case of raw rubber take up the solvent which then results in the rubber swelling to the limit of the tension of the globules, finally breaking the tension to form a solution. In the case of the vulcanized rubber the tension of the globules is so great that the solvent power of the liquid cannot break it.

W.A.Caspari (5) has proven that the different kinds of caoutchouc with the same degree of vulcanization show different swelling maxima. When one wishes to compare results by different investigators for the imbibition of liquids by caoutchouc it is necessary to know not only the degree of vulcanization but also the source of the rubber.

Pasnjak (6) has studied the imbibition of caoutchouc by observing the pressure exerted in the process, and noting also the volume of liquid taken up. He found that between the impressed pressure (P) and the content of the swelling substance (c) the relation $P = P_1 c^k$ holds, when P_1 and K are constant. P_1 varies from liquid to liquid while K is a constant about 3. Pasnjak holds that the imbibition of liquids by caoutchouc is a capillary phenomena and says: "In ihrer Gesamtheit sprechen diese Ergebnisse mehr zu gunsten der Annahme, dass die Quellung ein wesentlich capillarer Vorgang ist; weniger dafuer, dass es sich hier um einen reinen Loesungsvorgang handelt."

Bell and Cameron (7) have shown that the flow of water, alcohol and benzol out of capillary tubes is in accordance with the expression $y^n = Kt$ when y is the length of the capillary and t the time. This formula is deduced from Poiseuille's law. These authors have also noted that $y^n = Kt$ describes the movement of water and of solutions thru porous materials such as blotting paper and dry soils. The value of (n) is above two in most cases.

Biglow (8) has shown that the flow of water thru collodion, Gold beater's skin, parchment paper and porcelain membranes is in accordance with the relation established by Poiseuille $Q = \frac{k\ P\ D\ T}{L}$ where Q is the quantity of water passing in time T, P is the pressure, D the diameter, L the length of the capillary and k a constant which is a function of the temperature and viscosity. The conclusion drawn is that in these membranes the liquids pass thru capillary spaces. Biglow says, "Pfeffer's results indicate that the capillary laws apply to the passage of water thru copper ferro cyanide membrances, and Schmidt's indicate the same for animal membranes, therefore we are justified in saying that the rate of passage of liquids thru molecular interstices is expressible by the same law which formulates the rate of passage of liquids thru capillary tubes."

From the work of the men mentioned above we have seen that imbibition of liquids by rubber is greatly influenced by the degree to which the caoutchouc is vulcanized and also that imbibition differs greatly with rubber from different sources. From Flusin's work it appears that imbibition and viscosity are directly related. Other men have shown that in many membranes the flow of liquids is a viscosity flow and Posnjak is lead to believe from his work that this is also the case in caoutchouc. That there is a direct relation between the velocity of imbibition and the viscosity of a liquid is shown by the results obtained with various liquids, as detailed below.

II. QUALITATIVE EXPERIMENTS.

The caoutchouc used in this work with one or two exceptions was all taken from the same roll of vulcanized dental rubber. It varied in thickness from 0.20 to 0.23 mm. An arithmetical average of ten measurements was found to be 0.21 mm. and this is what is referred to when the thickness is mentioned without giving a numerical value. All the work was done at room temperature, about 24 C. All the qualitative work was done in this room and also the first experiment discussed under semi-quatitative Experiments. Later the work was done in another room where the temperature ranged around 27.

When results are expressed in terms of imbibition they are always given in cc. of liquid imbibed by 100 grams of rubber during the time interval specified, unless other-wise stated.

Experiments I. A piece of caoutchouc weighing 5.7750 grams was immersed in ethyl acetate (sp. gr. 0.88) and the increase of weight was observed from time to time. In one day its weight had increased to 8.6460 grams, in two days to 9.0020 grams, in five days to 9.1395 grams, and in seven days to 9.1405 grams. If these results are expressed in terms of imbibition they are 57.3 cc., 63.3 cc, 65.4 cc, and 66.2 cc for one, two, five and seven days respectively. Duplicate experiments were carried out and similar results were obtained.

Experiment II. A piece of caoutchouc weighing 8.5785 grams was suspended in the vapor of ethyl acetate at room temperature. After one day the caoutchouc weighed 11.4500 grams before blotting and 10.6865 grams after blotting, after two days it weighed 12.0405 grams before blotting and 11.1035 grams after blotting, and when it had been in the vapor for five days it weighed 12.4240 gs. before blotting and 11.8075 gs. after blotting. When these changes in weight are expressed in terms of imbibition they are 37.0, 45.8, and 50.8 for one, two, and five days respectively taking the figures obtained by weighing before blotting and 27.9, 33.5 and 42.7 for one, two and five days respectively taking the figures obtained when weighing after blotting.

Experiment III. The effect of the vapor of eighteen different liquids on caoutchouc was studied. This was done by suspending small pieces of caoutchouc, the weight of which had been determined closely, in the vapor of the various liquids. The strips were attached to cork stoppers and thus suspended in test-tubes which carried small amounts of the different liquids. Two weighings were made, one at the end of the second day and another at the end of the twenty-seventh day.

TABLE I

Liquids	Wt of rubber	Wt after 2 days	Wt after 27 days	Remarks
CS_2	0.5775	1.5665	2.2325	tensile strength fairly good - original color retained
Chloroform	0.3665	1.2260		a viscous mass, color darker than original.
Toluene	0.5765	0.8175	1.3445	Was bleached and tore easily.
Ether	0.4700	0.7830	0.9030	Bleached, surface somewhat sticky, tensile strength diminished.
Benzol	0.5915	1.1110	1.5245	Slightly bleached, tensile strength slightly diminished
Xylene	0.4725	0.6255		Nearly dissolved.
Nitrobenzene	0.5180	0.5330	1.0780	Turned yellow, tensile strength diminished.
Acetone	1.0330	1.1395	1.2025	Tenacity slightly diminished.
Acetic acid	1.1570	1.2640	1.3525	Turned red, tenacity diminished.
AMYL alcohol	1.1890	1.1850	1.2915	Bleached, tears easily.
Ethyl "	1.2590	1.2930	1.3055	Bleached, tears easily.
Methyl "	0.9760	1.0380	1.0625	Bleached, lost tenacity partly.
96% "	1.0505	1.4920	2.1175	Bleached, lost tenacity partly.
Isobutyl"	0.9895	1.0430	1.0835	Bleached, tears very easily.
N propyl"	0.9210	0.9640	1.0025	Bleached, tears very easily.

TABLE I.

Liquids.	Wt.	after 2 da.	-27 da.	Remarks
Isopropyl alcohol	0.8740	0.9265	0.9625	Bleached, lost tenacity partly.
Water	1.0110	1.0480	1.0675	Bleached.
Pyridine	0.9670	1.1810	1.3925	Turned yellow much disintegrated.

From these results it appears that the vapor of chloroform and xylene affect the caoutchouc most. Caoutchouc is bleached in all of the alcohols and the higher alcohols have a greater effect on its tensile strength. All of the liquids are only slightly imbibed and there seems to be but slight differences between the higher and the lower alcohols.

Experiment IV. This experiment was carried out to note whether any temperature change is involved in the process of imbibition. Both the vapor and liquid were studied. A Beckmann thermometer was used so as to be able to detect small changes if any might be observed. To do this, small stripes of caoutchouc were wound about the bulb of the thermometer.

At room temperature a Beckmann thermometer read 2.45

C. but when placed into ether it read 2.58 C at the end of one minute, 2.66 after the second minute, 2.75 after the third, 2.84 after the fourth, and 2.94 after the fifth minute. The thermometer was then removed from the flask, rinsed, and wiped dry. After a piece of caoutchouc had been wound about the bulb of the thermometer and it had reached constant temperature it read 2.40 C. It was now put into the ether vapor and at the end of one minute it read 3.40, at the end of the second minute 4.05, of the third 4.65, of the fourth 4.85, and at the end of the fifth minute it read 5.64C.

In the vapor of benzol the thermometer rose from 2.75 to 2.78, 2.80 and 2.81 when it was read at minute intervals. When the thermometer had again been cleaned and had gained constant temperature after a piece of caoutchouc had been wound about the bulb it rose from 2.65 to 3.09, 3.23, 3.33, 3.42, and 3.48 in five minutes.

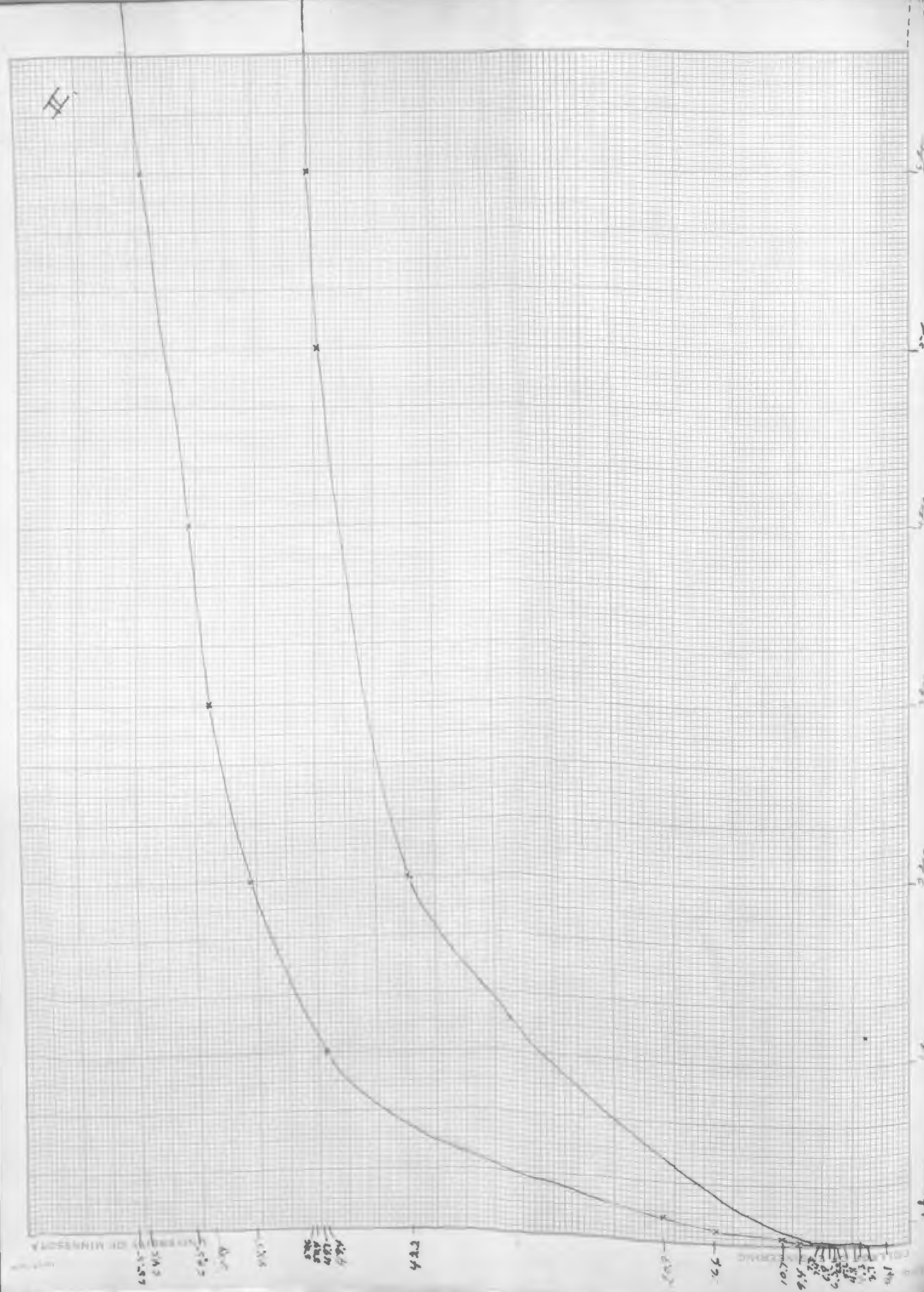
The same proceedure was gone thru inserting the thermometer into the liquid, both ether and benzol, but no changes were observed. From these observations it appears that imbibitions of liquids, at least in these two cases, does not involve temperature changes and that the temperature rise observed when working in the vapor are simply due to the heat given up by the vapors as they condense in the caoutchouc.

Experiment V. When a piece of caoutchouc which has been immersed in a liquid long enough so that it has reached its maximum imbibition is shaken it gives a metallic sound. The sound is similar to what we hear when a piece of rubber that is stretched over a hoop is touched. The great increase in size of a piece of caoutchouc when it has been immersed in a strongly imbibed liquid for several minutes and this tympanic phenomena both go to prove that the strongly imbibed caoutchouc is under great tension. Another phenomena that goes to corroberate this fact is that such a piece of caoutchouc shows greatly diminished tensile strength while the imbibed liquid is in the caoutchouc but regains its original tensile strength after the liquid has had time to evaporate. This statement refers to a piece that has been in the liquid long enough to gain nearly its maximum imbibition, which would be less than ten minutes for strongly imbibed liquids of low viscosity. After the liquid has acted upon it long enough to dissolve an appreciable amount of the caoutchouc the tensile strength decreases proportionately.

III. Semi-Quantitative Experiments.

(a) Imbibition of vapor.

To show to some extent the quantitative relationship between the imbibition of vapors and of liquids by caoutchouc a few determinations were made of the imbibition of ethyl acetate vapor. For this work the caoutchouc was wound about nickle gauze and suspended over ethyl acetate in a glass jar. This jar was placed on a support over the pan of the balance so as to allow the pan to swing freely. From the gauze a fine wire was run to the balance beam thru a glass tube in the cork of the jar. The wire used as a support carried a glass bead in such a way that when it was released from the beam the bead



served as a stopper for the tube in the cork. With this apparatus it was possible to weigh the caoutchouc in the vapor of the liquid thus avoiding all loss due to evaporation. This loss is considerable if the rubber is transferred to a weighing bottle.

TABLE II.
IMBIBITION OF CAOUTCHOUC OF ETHYL ACETATE VAPOR.

Time	Wt of liquid absorbed by 3.1345 g. of rubber.	Imbibition B	Wt of liquid absorbed by 3.4365 g. of rubber.	Imbibition A
5 min	0.110	3.7	0.065	2.1
10 "	0.140	4.8		
15 "	0.160	5.6	0.135	4.3
20 "	0.177	6.2		
25 "	0.195	6.8		
30 "	0.210	7.4	0.205	6.5
35 "	0.225	7.7		
50 "			0.295	9.4
1 hr.			0.335	10.7
2 "			0.519	16.6
3 "			0.655	20.9
1 day			1.553	49.4
2 "	1.210	42.2	1.743	55.5
3. "			1.841	58.9
4 "			1.890	60.5
5 "	1.416	49.7		
6 "	1.422	50.4	2.019	64.6
7 "	1.428	50.6	2.027	65.5
8 "	1.459	51.7		
9 "	1.461	51.8		

b) The flow of liquid in a glass capillary.

The data given in table III are obtained from an experiment that was performed in the following way. A glass capillary ninety cm. long was sealed to a small stopcock which in turn was attached to an aspirator bottle. The "length of tube" is read from a scale placed under the capillary which lies on the table in a horizontal position. "Pressure height" is measured from the middle of the bore of the capillary to the surface of the liquid in the bottle. $K = \frac{p\,t}{l^2}$ is obtained from the second (2) equation given under Theoretical Discussions, by equating viscosity, r^4, and "four" to a constant K. It is evident that these are constant when the same liquid and the same capillary are considered. The second (2) equation as seen from the following section is derived from $N = \frac{p \pi r^4 t}{8 V l}$ which is the expression for Poiseuille's law.

The capillary tube was removed and dried before each measurement.

TABLE III

FLOW OF ABSOLUTE ETHER INTO A GLASS CAPILLARY.

affect of surface tension is 1.3 cm.

Time of flow in sec.	Length of tube in cm.	Pressure height in cm.	$K = \frac{pt}{l^2}$
1.2	10	1.3	0.0156
2.8	20	1.3	0.0054
5.5	30	1.3	0.0079
8.5	40	1.3	0.0069
14.0	50	1.3	0.0073
22.0	60	1.3	0.0079
27.0	60	0.8	0.0060
14.5	60	2.0	0.0081
12.2	60	2.5	0.0089

IV THEORETICAL DISCUSSION.

On the assumption that imbibition is capillary flow it is possible to express the results by Poiseuille's law of capillary action,

$$\eta = \frac{P \pi r^4 t}{8 V l} \qquad (1)$$

When this expression is applied to a tube of uniform bore V may be expressed as $\pi r^2 l$, where l is length of tube flowed through, r is the radius. In case the flow into a tube is considered the volume flowing at any time is proportional to the length and the expression becomes $Vl = \frac{\pi r^2 l^2}{2}$. If this expression for volume is substituted in the first equation we have,

$$\eta = \frac{P r^2 t}{4 l^2}. \qquad (2)$$

From the expression for surface tension,

$$\gamma = \frac{h r s g}{2} \qquad (3)$$

$$\text{and } \frac{2\gamma}{rg} = hs. \qquad (4)$$

Since hs in this (4) equation is an expression for pressure we may substitute its equivalent $\frac{2\gamma}{rg}$ in the second (2) equation

$$\text{and } \eta = \frac{\frac{2\gamma}{rg} r^2 t}{4 l^2} \qquad (5)$$

$$\eta = \frac{\gamma r t}{2 g l^2} \qquad (6)$$

$$\text{and } \frac{2 \eta g}{\gamma r} = \frac{t}{l^2}. \qquad (7)$$

Cameron's data as well as those given in Table III show that the flow of a liquid thru a glass capillary is in accord with this expression. It is seen that in case we deal with a glass tube where r is a constant that the left hand member of this (7) equation is a constant,

$$K = \frac{t}{l^2} \qquad (8)$$

On the assumption that the space between the particles of a membrance is constant after the liquid has once entered it this expression may also be applied to the flow of liquids into membrances.

The following experiments show that for the initial period $\frac{t}{l^2} = K$ is a close expression for imbibition except for the first measurement and this may be explained if we assume that imbibition does not begin at the precise interval when the rubber is plunged into the liquid but that it takes an appreciable length of time for the liquid to wet the rubber. When this time of wetting is denoted by t_x then $\frac{t}{l^2} = K$ becomes $\frac{t - t_x}{l^2} = K$. (9) With the less imbibed liquids t is a larger quantity than with the greatly imbibed which supports our assumption that some time elapses before imbibition begins.

When $\frac{t}{l^2} = K$ is given as an logarithmic expression

$$2 \lg l - \lg t = \lg K. \qquad (10)$$

and lgl is plotted against lgt we observe that the results obtained from the following experiments are expressed by two straight lines as shown in the accompanying graphs. The time of wetting is calculated from the values lying on the first line, by equating $\frac{t_1 - t_x}{l_1^2}$ to $\frac{t_2 - t_x}{l_2^2}$. The expression for the second line differs from that of the first only by the exponent of l. Since this line expresses not only the capillary but also the solubility affect and the time devoted to this work did not permit the study of this second affect more in detail the constant for the second affect has not been calculated.

V QUANTITATIVE EXPERIMENTS.

a) Blotting with mercury.

When the liquid adhering to the surface of caoutchouc is removed by blotting with filter-paper before weighing there is considerable loss due to evaporation, which lessens the accuracy of the results. In order to diminish this loss a new way of blotting was devised. This new method was to draw the caoutchouc thru mercury which should remove the adhering liquid but would not absorb any of the liquid already imbibed by the rubber as filter-paper does. Another advantage which this method possesses is that there is no chance for evaporation to go on during the process of blotting. When this method is applied the liquid is retained in a small glass jar over mercury and the caoutchouc is removed from the vessel by drawing it thru the mercury. After the caoutchouc had been drawn thru the mercury it was centrifuged by a sharp swing of the hand in order to remove mercury that might cling to it and then quickly transferred to a weighing bottle. The following results were obtained by the use of this method.

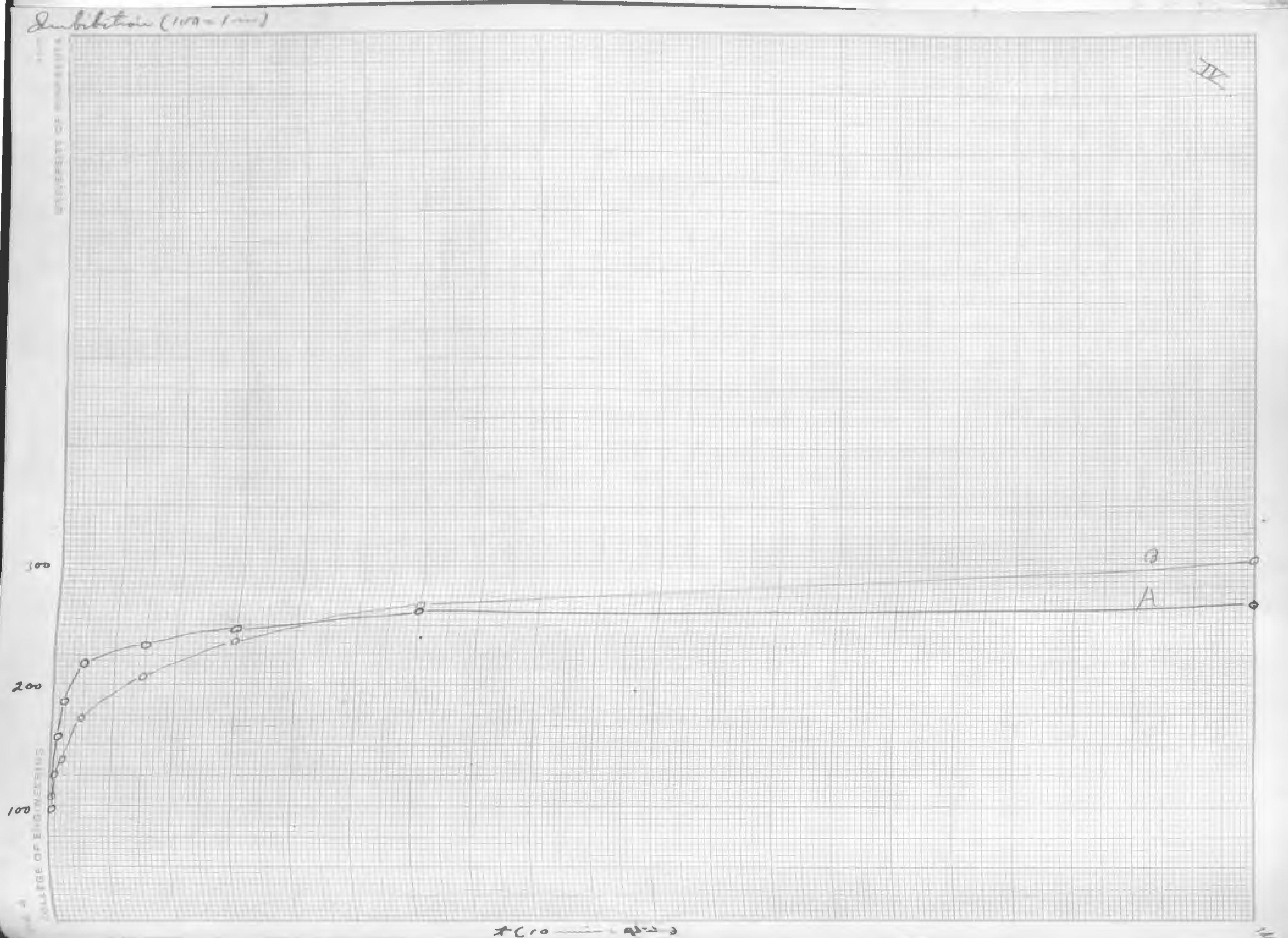

Imbibition (1100 = 1 in)
IV
B
A
300
200
100
t (10 min = 1 div)

TABLE IV.

Imbibition of caoutchouc in absolute ether.

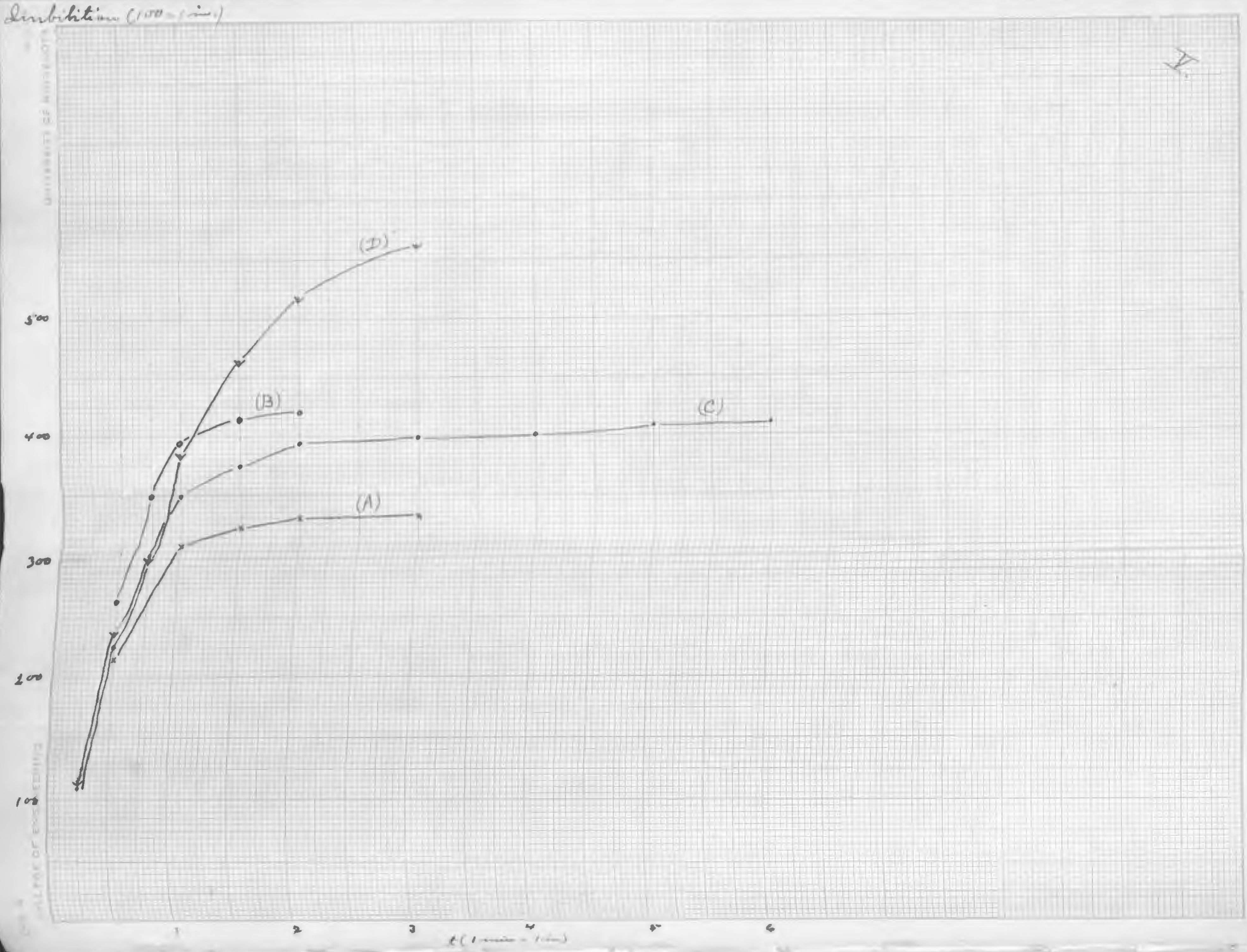
Time	Weight increase of 0.8405 grams caoutchouc.	Imbibition A.	$\frac{t}{I^2}$
30 sec	1.415	95.	.000055
1 min	1.765	154.	.000042
2 "	1.935	183.	.000059
5 "	2.135	214.	.000108
15 "	2.215	229.	.00028
30 "	2.315	246.	.00049
1 hour	2.395	258.	.00090
1 day	2.425	265.	.0205
2 "	2.455	271.	.039
3 "	2.505	278.	.055
4 "	2.515	280.	.073
6 "	2.525	281.	.109
7 "	2.535	283.	.128
9 "	2.535	283.	constant
	Wt inc. of 1.2195 gram caoutchouc.	Imbibition B	$\frac{t}{I^2}$
30 sec	2.141	104.	.000046
1 min	2.291	123.	.000066
2 "	2.390	134.	.000111
5 "	2.730	170.	.000173
15 "	3.000	204.	.000360
30 "	3.280	236.	.00045
1 hour	3.430	265.	.00085
1 day	3.850	302.	.015
2 "	....	....	....
3 "	4.150	336.	.038
4 "	....	....	....

b) Displacing.

With liquids that are not very volatile the method just described works very well. The following new method devised by us, was , however, considered preferable because with it the caoutchouc does not get into contact with the air at all after the experiment is once started and thus allows no loss by evaporation. This condition is realized when the caoutchouc is weighed in mercury instead of in air. The thing that was of greatest consideration in setting up an apparatus to carry out the work in this way was to get a sinker the density of which was appreciably greater than that of mercury. The method was given a trial by using several platinum crucibles as a sinker. This worked well enough to show that the method might be employed if a good sinker could be obtained. Thru the kindness of the College of Dentistry gold could be obtained for a time sufficient to complete the work. This kindness and the help received from Mr. D. Crowthers added materially to the success of this part of the work. Mr. Crowthers shaped the gold into a very serviceable sinker. Before the sinker was used it was nickleplated to prevent the gold from amalgamating with the mercury. Since the plate appeared somewhat porous it was in turn covered with a thin layer of bakelite, to make sure that the sinker would retain its constant weight.

For this work the balance was placed on a support in such a way that a large wide-mouthed bottle could be placed under it. One of the pans was removed and a wire run from the sinker directly to the balance beam. From the sinker up thru the mercury and the liquid a very fine platinum wire was used. This was important since the smaller the variability of displacement while balancing the scales the greater the sensitiveness of the balance. With the displacement and surface tension affect reduced to a minimum the balance could be read to the nearest mg. with a fair degree of accuracy when a piece of caoutchouc weighing three tenths of a gram was used. A large wide mouthed bottle was used as a container for mercury and the liquid. The caoutchouc was attached to a simple platinum frame which in turn was attached to the sinker.

When this method was employed the weight of the caoutchouc used was determined by the use of another balance. After the weight of the sinker including the frame had been observed in the mercury the caoutchouc was attached and the weight of the whole system found, after the liquid had been poured into the bottle. The difference between these two weights thus obtained gives us the weight of the caoutchouc in mercury, from which the density of the caoutchouc may be calculated. For the study of imbibition the time during which the caoutchouc is raised into the liquid can be observed very closely and thus it is possible to study this phenomena for short time intervals. The following results were obtained b y the use of this apparatus.



Imbibition (100 = 1 in.)
V.
500
400
300
200
100
(D)
(B)
(C)
(A)
1
2
3
4
5
6
t (1 min = 1 in.)

TABLES VA, VB, VC

Imbibition of caoutchouc in absolute ether.

Time	Change of wt in Hg of 0.2580g of caoutchouc	Imbibition A	$\frac{t}{I^2}$	Change of wt in Hg of 0.2960g of caoutchouc	Imbibition B	$\frac{t}{I^2}$
0 sec	......	......	......	4.208 gs.		
15 "	......	......	......	......	......	......
30 "	5.313 gs.	215	.0000108	7.548	264	.0000071
45 "	......	......	......	9.951	348	.0000061
1 min	7.653	309	.0000104	11.236	394	.0000064
1½ "	7.933	321	.000014	11.878	414	.0000087
2 "	8.118	329	.000018	12.061	419	.0000113
3 "	8.188	331	.000027	......	......	......
4 "	......	......	......	......	......	......

Time	Change of wt. in Hg of 0.3003 g of caoutchouc	Imbibition C	$\frac{t}{I^2}$
0 sec	3.390		
15 "	3.424	119	.0000176
30 "	6.537	226	.0000098
45 "	8.662	303	.0000081
1 min	10.112	349	.0000082
1½ "	11.014	374	.0000107
2 "	11.415	394	.0000122
3 "	11.522	398	.0000189
4 "	11.596	401	.0000248
5 "	11.844	409	.000029
6 "	11.891	411	.000035

TABLE V D

Imbibition of caoutchouc in Benzol (Kahlbaum's Benzol, cryst. Free from Thiophen)

Time	Change of wt. in Hg. of 0.3001 g of caoutchouc.	Imbibition D	$\frac{t}{I^2}$	$\frac{t}{r}$	$\frac{t}{I}$
0 sec.	4.229	0	....	....	....
15 "	3.977	111	.0000203	1.35	.135
35 "	8.471	237	.0000103	1.25	.146
45 "	10.765	302	.0000082	1.50	.149
60 "	13.659	383	.0000068	1.57	.156
1½ min.	16.480	462	.0000070	1.90	.194
2 "	18.456	517	.0000075		.232
3 "	20.120	562	.0000091		.320

C) Observing distention

As stated above caoutchouc distends greatly when immersed in what Flusin calls active liquids. In these liquids this distention proceeds at such a rate that it can well be noted and it reaches a maximum within several minutes with the most active liquids. The time of course depends upon the thickness of the pieces used. By having a piece of caoutchouc of known length clamped to the bottom of a crystallizing dish which is placed on a scale the distention of the caoutchouc can be read off quite accurately at any desired time interval. Since the cube of the length is an expression of the volume this distention may be calculated to volume for comparison with previous work.

The following data are obtained by observing the distention. When working with the more active liquids the work was done in a crystallizing dish. This dish was placed on a scale which was graduated to mm. A piece of caoutchouc was clamped to the bottom of the dish. Crumpling was prevented by placing a glass rod a little distance above the rubber. The liquid was poured on the caoutchouc and the distention was read at fifteen second intervals. A piece of caoutchouc five by two cm. proved itself to be of very suitable size for this purpose. In all the following work pieces of this size were used, when working in an evaporating dish, unless otherwise stated. When working with the less imbibed liquids the distention is not great enough to be observed in this way. With these liquids the distention was observed by suspending a piece of caoutchouc 0.5 by 30 cm. in the liquid in a gas burette which was graduated to mm.

log l (0.1 – 0.5 in.) l = micr. per cm.

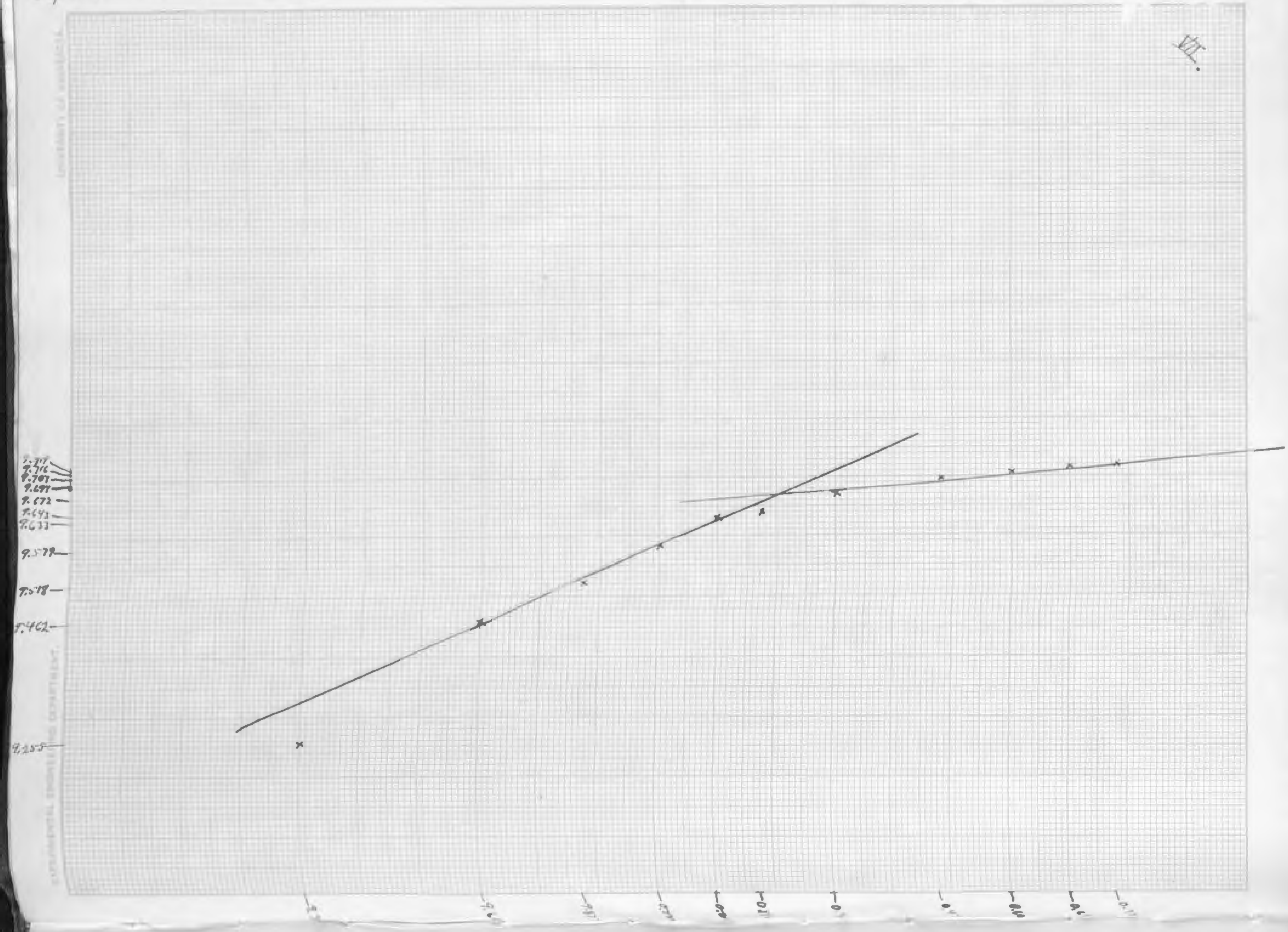
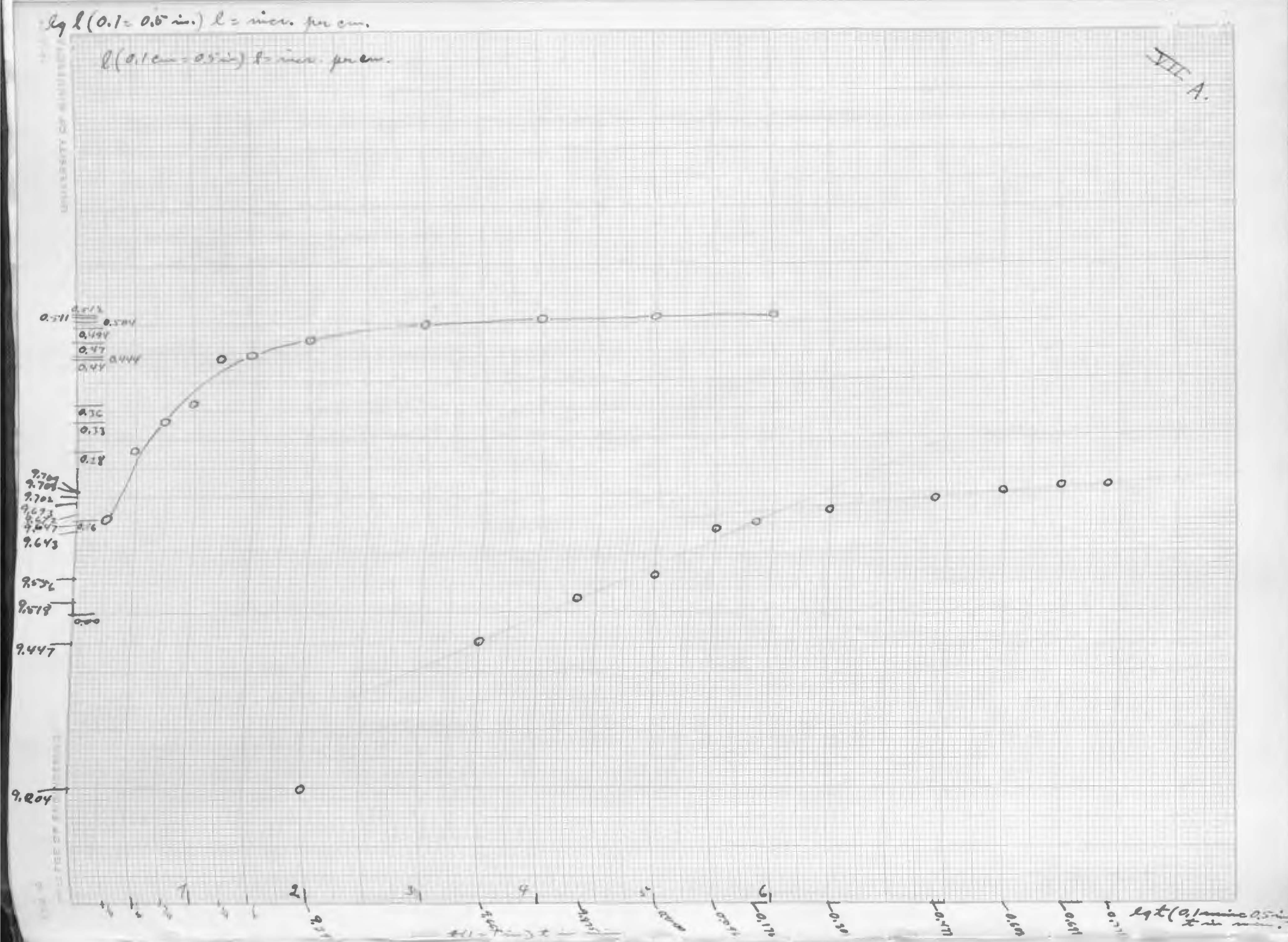


TABLE VII.

Sulphuric Ether

An average for three pieces of rubber. The time for wetting t_x as calculated from graph VII. is 2.5 sec.

Time	Increase in cm.	Increase per cm. of rubber.	$\frac{t}{l^2}$	$\frac{t - t_x}{l^2}$	t_x in sec
15 sec	0.90	0.18	463.0	384	...
30 "	1.46	0.29	358.8	326	5.62
45 "	1.68	0.33	427.0	389	2.35
1 min	1.90	0.38	415.5	398	1.96
15 "	2.16	0.43	410.7	390	2.81
30 "	2.21	0.44	455.7	450	0.18
45 "	2.29	0.45	500.0	...	...
2 min	2.36	0.47	529.0	...	...
15 "	2.40	0.48	...	...	...
30 "	2.43	0.486	...	...	...
45 "	...	...	...	...	...
3 min	2.49	0.498	...	...	...
15 "	2.52	...	...	...	...
30 "	2.50	...	...	...	...
45 "	2.54	...	...	...	...
4 min	2.55	0.51	(923)	...	...
15 "	2.56	...	...	...	...
30 "	2.58	...	...	...	...
45 "	2.60	0.52	...	...	...
5 min	...	...	...	...	...
15 "	...	...	...	...	...
30 "	2.61	...	...	...	...
45 "	2.62	0.524	(1253)	...	...
6 min	2.64	0.524	(Complete distention)		



VII A.
log l (0.1 = 0.5 in.) l = micr. per cm.
l (0.1 cm = 0.5 in.) l = micr. per cm.
log t (0.1 = 0.5 in.) t in min.
0.511
0.504
0.494
0.47
0.444
0.44
0.36
0.33
0.28
9.702
9.643
9.518
9.447
9.204
0.170
0.30
0.477
0.699
1
2
3
4
5
6

TABLE VII A.

Sulphuric Ether.
Observations for first piece of rubber.

Time minutes.	Length cm.	Increase cm.	Increase per cm. cm.
.25	5.80	0.80	0.16
.50	6.40	1.40	0.28
.75	6.65	1.65	0.33
1.00	6.80	1.80	0.36
.25	7.203	2.203	0.44
.50	7.223	2.223	0.444
.75	7.30	2.30	0.46
2.00	7.35	2.35	0.47
.25	7.38	2.38	0.476
.50	7.40	2.40	0.48
.75	7.45	2.45	0.49
3.00	7.47.	2.47	0.494
.25	7.49	2.49	0.498
.50	7.50	2.50	0.50
.75	- --	- --	- --
4.00	7.52	2.52	0.504
.25	7.54	2.54	0.508
.50	7.55	2.55	0.51
.75	- --	- --	- --
5.00	- --	- --	- --
.25	- --	- --	- --
.50	7.56	2.56	0.512
.75	- --	- --	- --
6.00	7.56	2.56	0.512

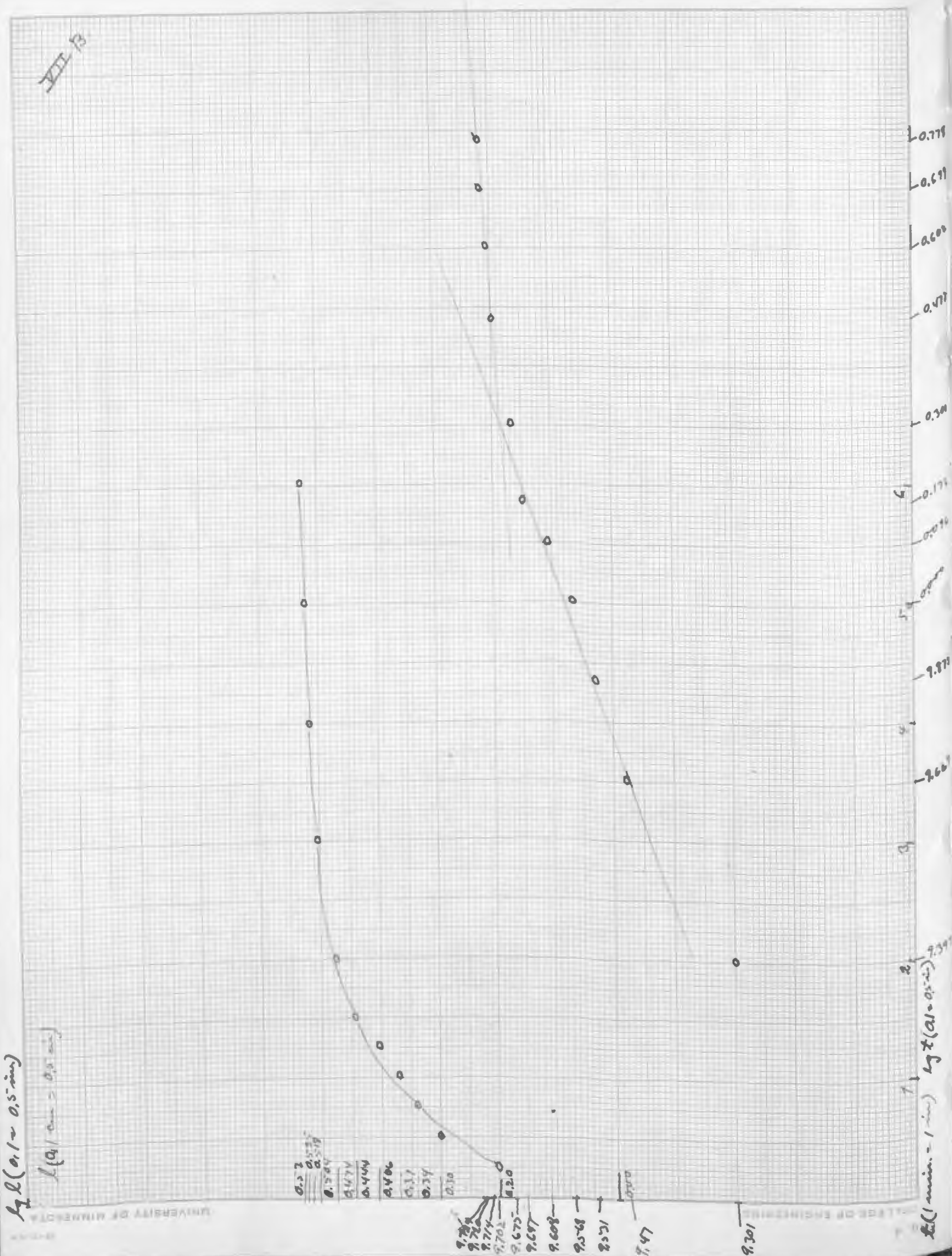


TABLE VII B

Sulphuric Ether.
Observations for second piece of rubber.

Time minutes.	Length cm.	Increase cm.	Increase per cm. cm.
0.00	5.00	.00	0.00
.25	6.00	1.00	0.20
.50	6.50	1.50	.30
.75	6.70	1.70	.34
1.00	6.95	1.95	.37
.25	7.03	2.03	.406
.50	7.22	2.22	.444
.75	7.30	2.30	.46
2.00	7.37	2.37	.474
.25	7.42	2.42	.484
.50	7.47	2.47	.494
.75	7.50	2.50	.50
3.00	7.52	2.52	.504
.25	7.55	2.55	.51
.50	- --	- --	---
.75	7.57	2.57	.514
4.00	7.59	2.59	.518
.25	- --	- --	----
.50	7.61	2.61	.522
.75	7.62	2.62	.524
5.00	- --	- --	----
.25	- --	- --	----
.50	7.63	2.63	.526
.75	- --	- --	----
6.00	7.65	2.65	.53

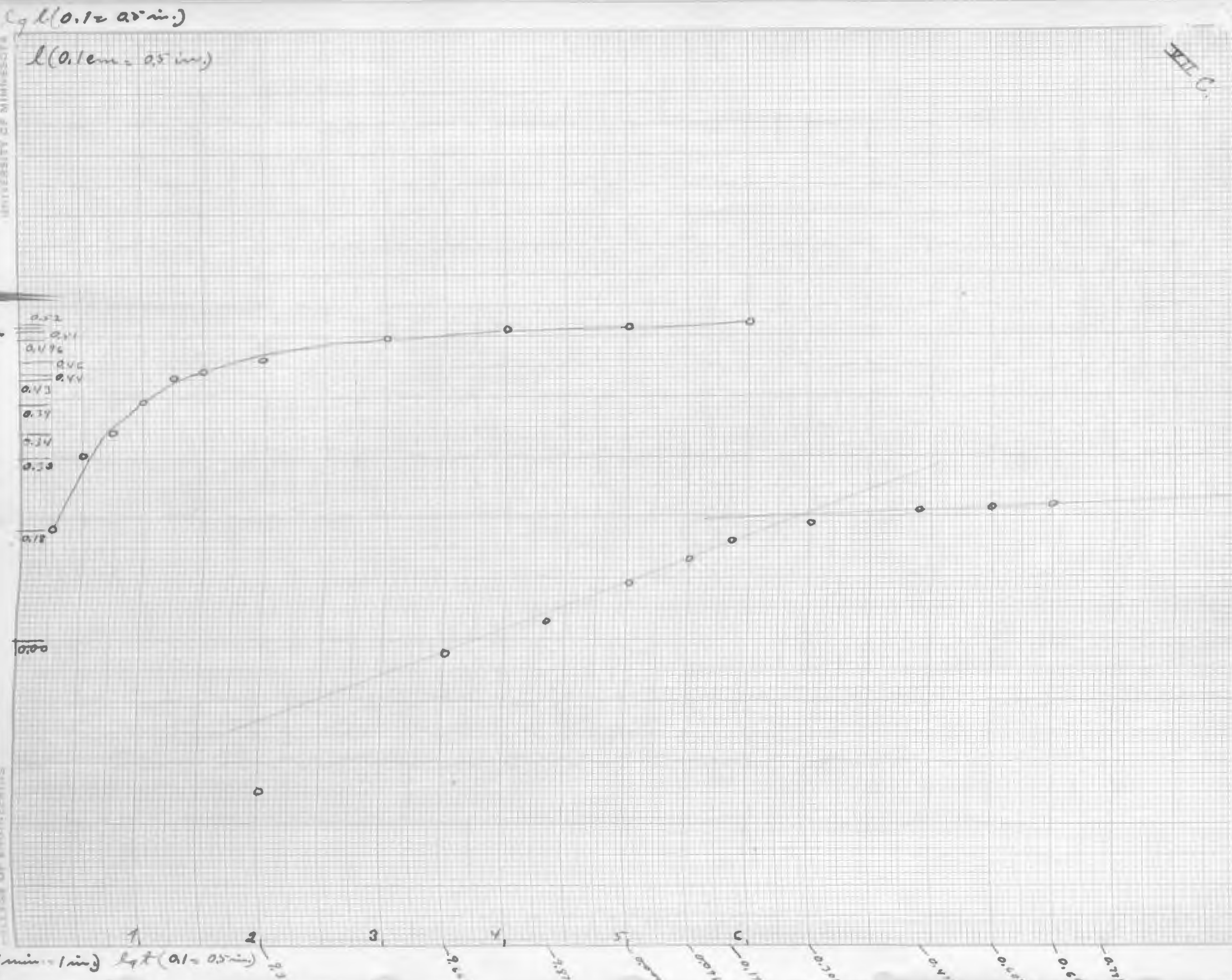


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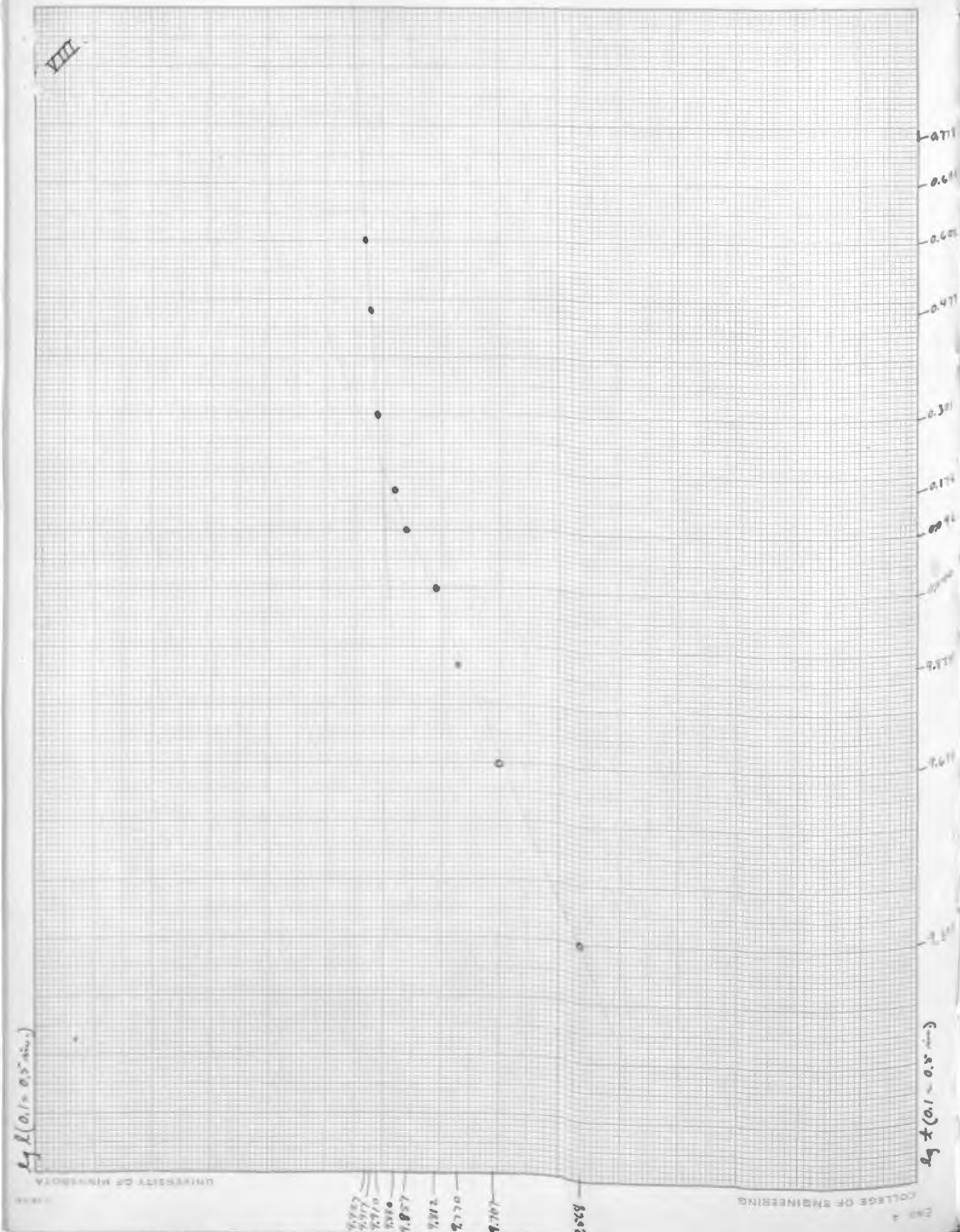
TABLE VII C

Sulphuric Ether.

Observations for third piece of rubber.

Time minutes.	Length cm.	Increase cm.	Increase per cm. cm.
.00	5.00	.00	0.00
.25	.90	.90	.18
.50	6.50	1.50	.30
.75	.75	.70	.34
1.00	.95	.95	.39
.25	7.15	2.15	.43
.50	.20	.20	.44
.75	.28	.28	.456
2.00	.30	.30	.46
.25	.37	.37	.474
.50	.39	.39	.478
.75	.43	.43	.486
3.00	.48	.48	.496
.25	.50	.50	.50
.50	--	--	--
.75	.52	.52	.504
4.00	.55	.55	.51
.25	.56	.56	.512
.50	.57	.57	.514
.75	.58	.58	.516
5.00	--	--	---
.25	--	----	---

6.00	.60	.60	.52



VIII

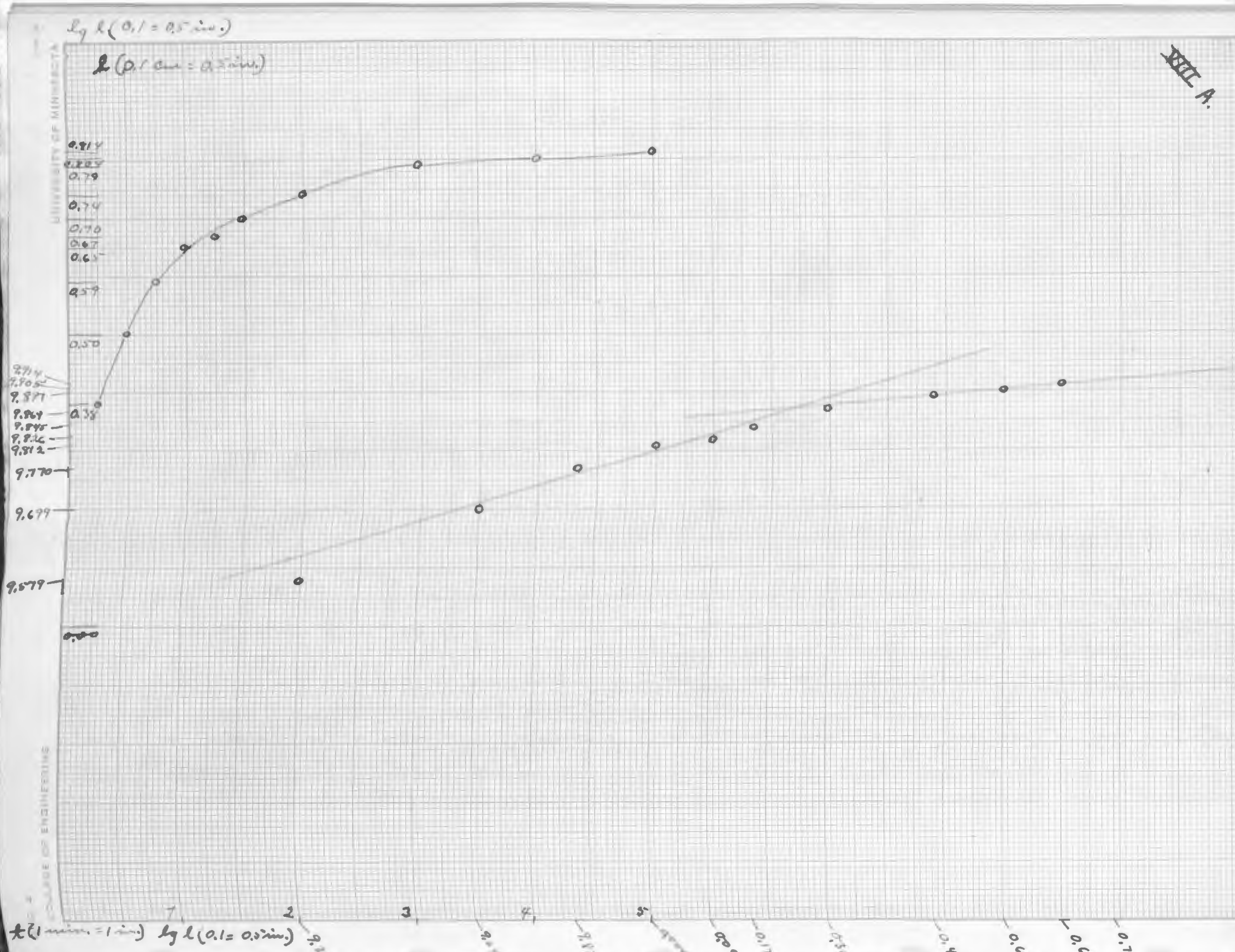
TABLE VIII.

Carbon Disulphide

(Redistilled, b, pt. 45.5)

An average for five different pieces of rubber. The time for wetting, t_x as calculated from graph VIII. is 41

Time	Increase in cm.	Increase per cm of rubber.	$\frac{t}{I^{x}}$	$\frac{t - t_x}{I^{x}}$	t_x
15 sec	1.88	0.37	132.0	138	......
30 "	2.55	0.51	115.2	130	1.6
45 "	2.95	0.59	129.0	140	4.4
1 min	3.24	0.65	143.7	151	6.3
15 "	3.42	0.68	160.5	170	.....
30 "	3.60	0.72	173.0	181	.....
45 "	3.70	0.74	.....	199	.....
2 min "	3.82	0.76	.....	215	.....
15 "	3.90	0.78	....		
30 "	3.98	....			
45 "	4.03	....			
3 min	4.07	0.814	....		
15 "	4.10	....			
30 "	4.16	....			
45 "	4.12	....			
4 min	4.13	0.826			
15 "	4.15				
30 "	4.17				
45 "	4.18				
5 min	4.26	0.852	....		
12 min	4.50	0.9000	(Complete distention)...		



XIII A.
lg l (0,1 = 0,5 in.)
l (0,1 cm = 0,5 in.)
t (1 min. = 1 in.)
lg l (0.1 = 0.5 in.)
0,914
0,805
0,79
0,74
0,70
0,67
0,65
0,59
0,50
0,38
9,871
9,864
9,845
9,826
9,812
9,770
9,699
9,579
1
2
3
4
5
0,301
0,477
0,781
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TABLE VIII A.

Carbon Disulphide.

Observations for one peice of rubber.

Time min.	Length cm.	Increase cm.	Increase per cm. cm.
0.00	5.00	0.00	0.00
.25	6.90	1.90	.35
.50	7.50	2.50	.50
.75	.95	.95	.59
1.00	8.25	3.25	.65
.25	.35	.35	.67
.50	.50	.50	.70
.75	.60	.60	.72
2.00	.70	.70	.74
.25	.77	.77	.754
.50	.85	.85	.77
.75	.90	.90	.78
3.00	.95	.95	.79
.25	9.00	4.00	.80
.50	.00	.00	.80
.75	....	....	....
4.00	.02	.02	.804
.25	.05	.05	.81
.50	....	....	....
.75	.07	.07	.814
12.00	.15	.15	.83
.....	....	....	....

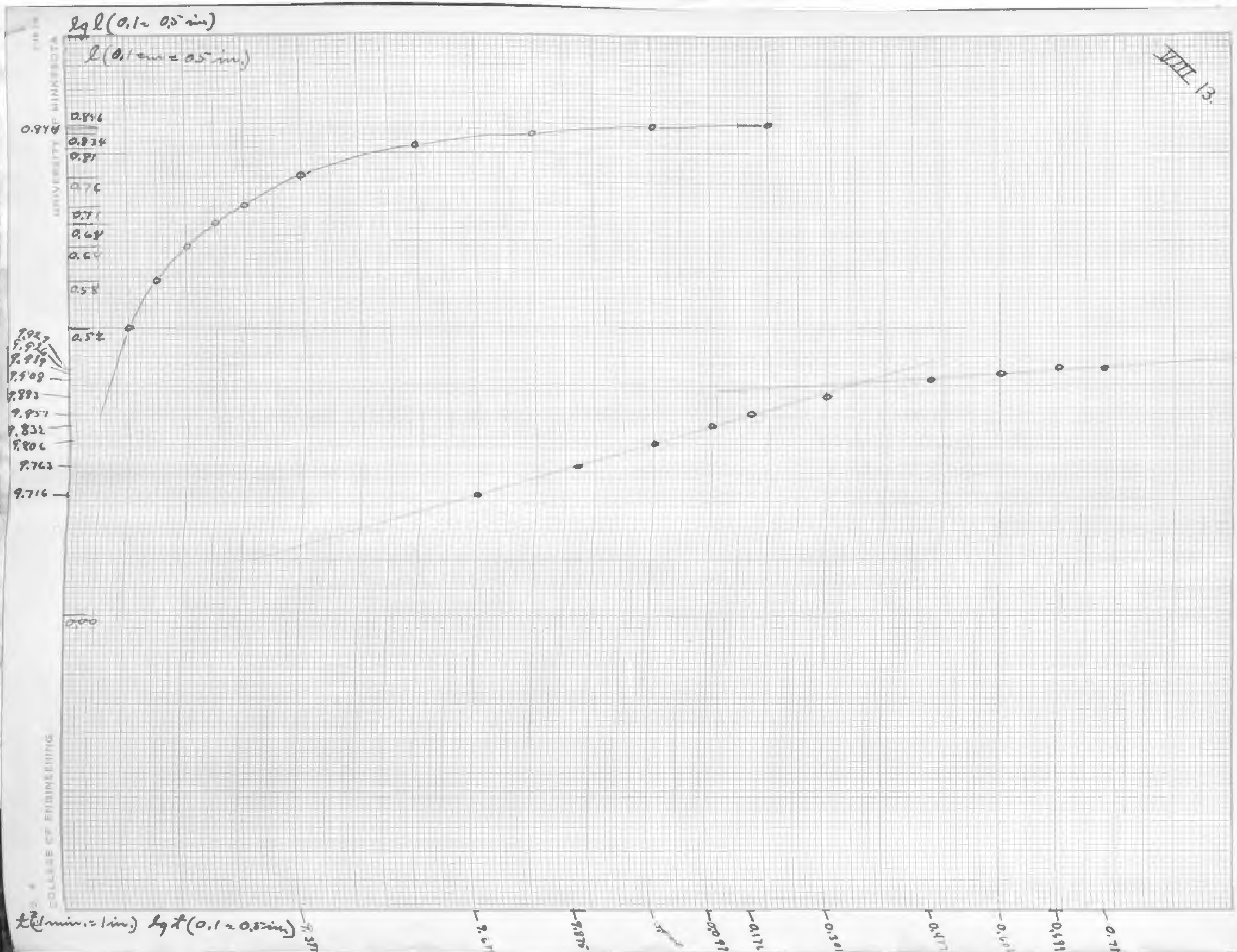
VIII 13.
lg l (0.1 = 0.5 in)
l (0.1 cm = 0.5 in.)
0.848
0.846
0.834
0.81
0.76
0.71
0.68
0.64
0.58
0.52
9.929
9.926
9.919
9.908
9.883
9.857
9.832
9.806
9.763
9.716
t (1 min. = 1 in.) lg t (0.1 = 0.5 in)
9.377
9.677
9.875
0.097
0.176
0.301
0.477
0.602
0.699
0.778
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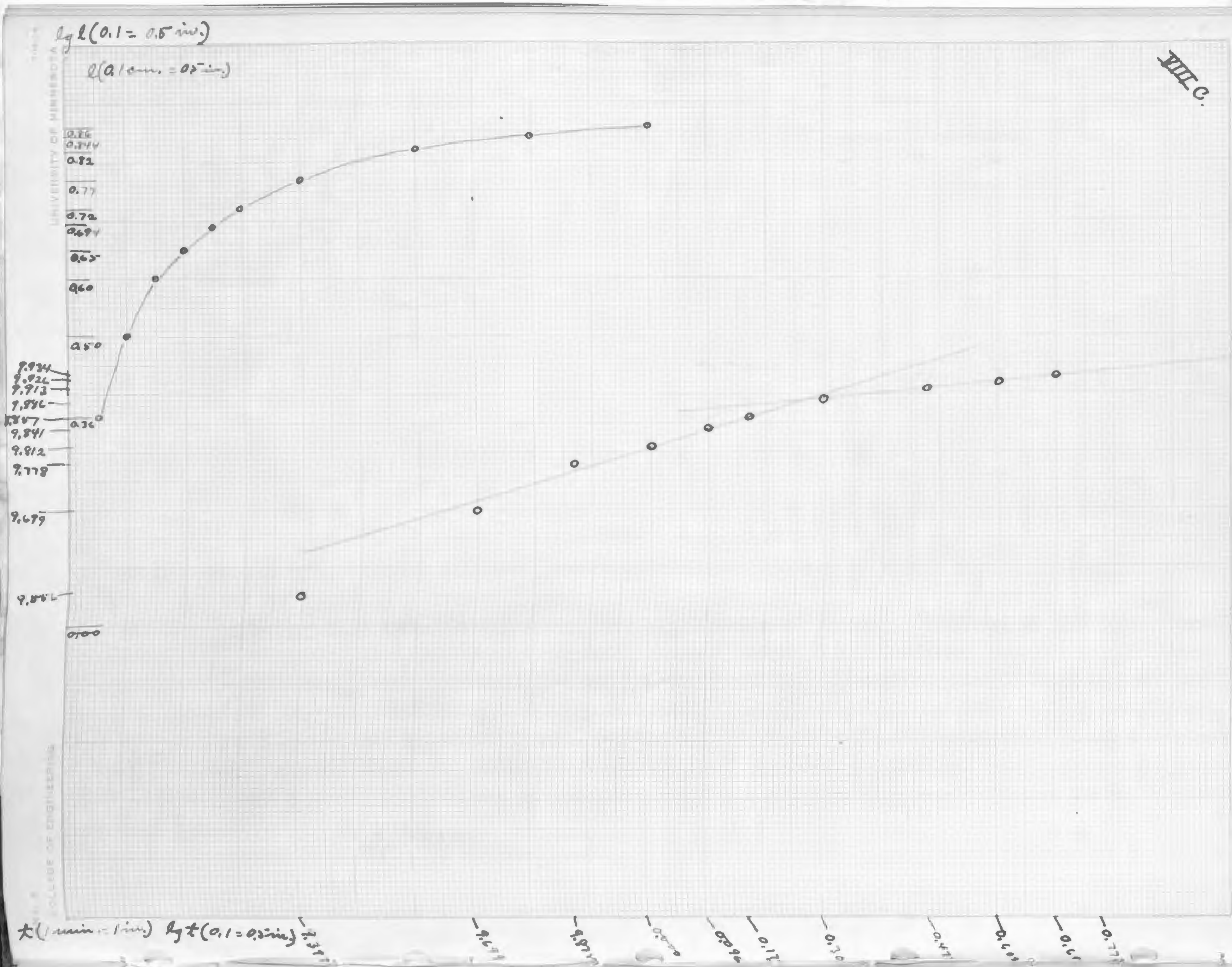
TABLE VIII B.

Carbon Disulphide.

Observations from second piece of rubber.

Time min	Length cm.	Increase cm.	Increase per cm. cm.
0.00	5.00	0.00	0.00
.25	....	....	....
.50	7.60	2.60	.52
.75	.90	.90	.58
1.00	8.20	3.20	.64
.25	.40	.40	.68
.50	..57	.57	.71
.75	.70	.70	.74
2.00	.80	.80	.76
.25	.90	.90	.78
.50	.95	.95	.79
.75	9.00	4.00	.80
3.00	.05	.05	.81
.25	.08	.08	.816
.50	.12	.12	.824
.75	.15	.15	.830
4.00	.17	.17	.834
.25	.19	.19	.838
.50	....	....	.....
.75	.20	.20	.840
5.00	.22	.22	.844
6.00	.23	.23	.846
....	....	....	.....



VIII C.
log l (0.1 = 0.5 in.)
l (0.1 cm. = 0.5 in.)
t (1 min. = 1 in.) log t (0.1 = 0.5 in.)
0.86
0.844
0.82
0.77
0.72
0.694
0.65
0.60
0.50
0.36
0.00
9.934
9.926
9.913
9.886
9.847
9.841
9.812
9.778
9.699

TABLE VIIIC.

Carbon Disulphide.

Observations for one peice of rubber.

Time min.	Length cm.	Increase cm.	Increase per cm. cm.
0.00	5.00	0.00	0.00
.25	6.80	1.80	.36
.50	7.50	2.50	.50
.75	8.00	3.00	.60
1.00	.25	.25	.65
.25	.47	.47	.694
.50	.60	.60	.72
.75	.75	.75	.75
2.00	.85	.85	.77
.25	.90	.90	.78
.50	.98	.98	.796
.75	9.05	4.05	.81
3.00	.10	.10	.82
.25	.15	.15	.83
.50	.17	.17	.834
.75	.20	.20	.84
4.00	.22	.22	.844
.25	.24	.24	.848
.50	.25	.25	.85
.75	.28	.28	.856
5.00	.30	.30	.86
13.00	.35	.35	.87
29.00	.35	.35	.87
.....	....	....	....

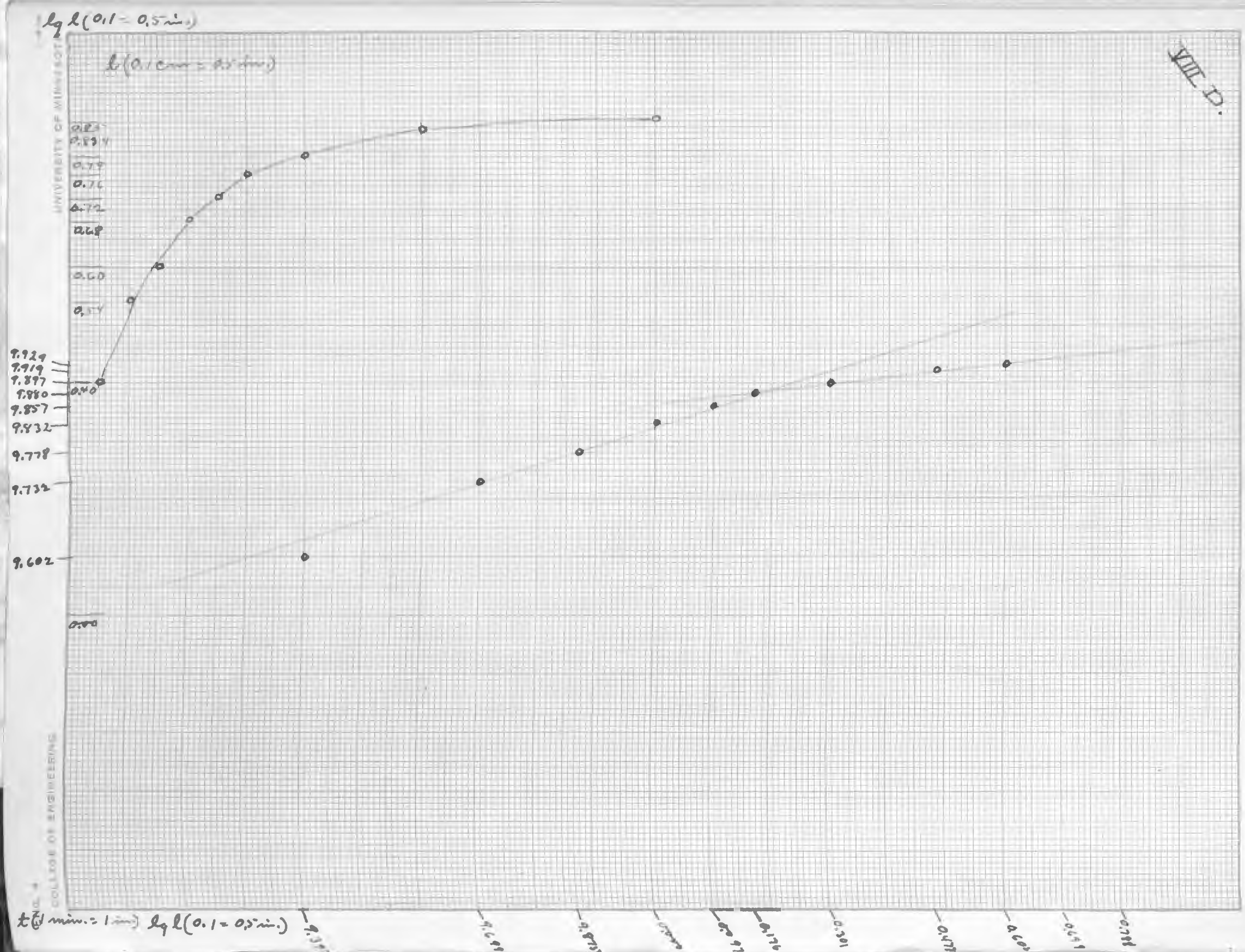

VIII D.
lg l (0.1 = 0.5 in.)
l (0.1 cm = 0.5 in.)
9.929
9.919
9.897
9.880
9.857
9.832
9.778
9.732
9.602
0.83
0.40
0.54
0.60
0.68
0.72
0.76
0.79
0.00
t (1 min. = 1 in.) lg l (0.1 = 0.5 in.)
9.397
9.699
0.301
0.477
0.602
0.699
0.778
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TABLE VIII D.

Carbon Disulphide.

Observations for ome piece of rubber.

Time min.	Length cm.	Increase cm.	Increase per cm. cm.
0.00	5.00	0.00	0.00
.25	7.05	2.05	.41
.50	.70	.70	.54
.75	8.00	3.00	.60
1.00	.40	.40	.68
.25	.60	.60	.72
.50	.80	.80	.76
.75	.85	.85	.77
2.00	.95	.95	.79
.25	9.05	4.05	.81
.50	.15	.15	.83
.75	....	....	....
3.00	.17	.17	.834
.25	.18	.18	.836
.50	.20	.20	.84
5.00	.25	.25	.85
....	....	....	....

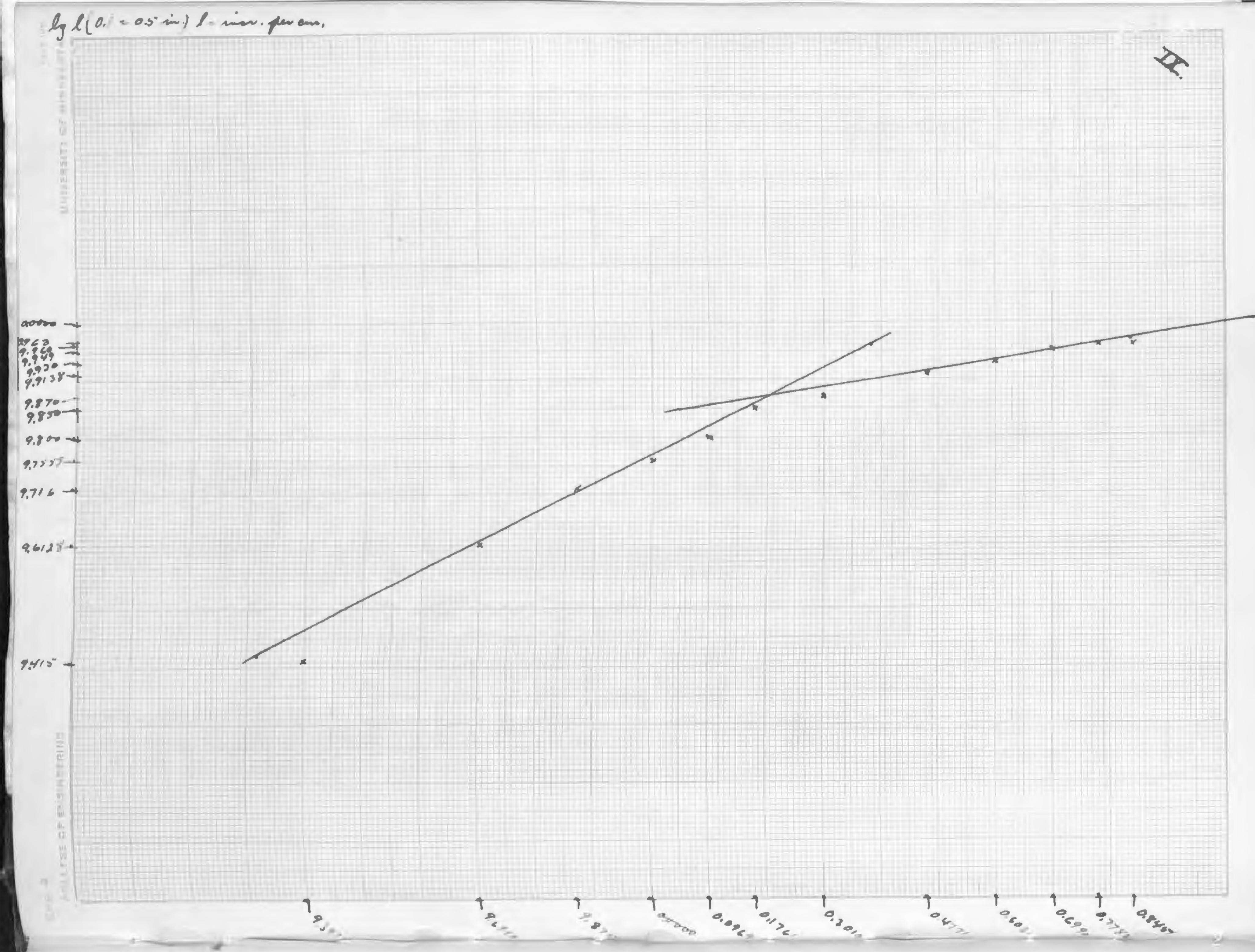
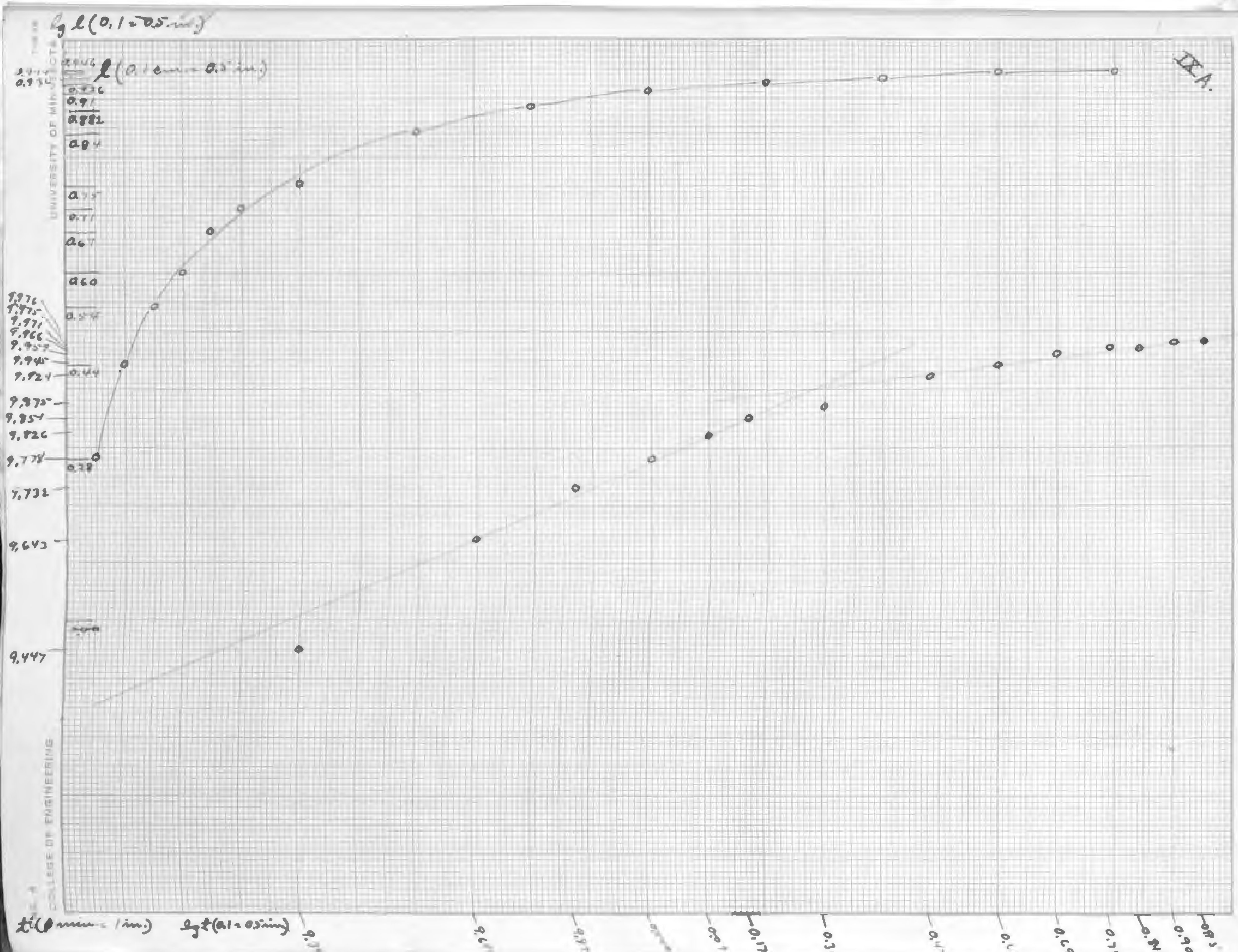

log l (0.1 = 0.5 in.) 1 = inv. per cm.
IX.
0.0000
9.963
9.959
9.949
9.930
9.9138
9.870
9.850
9.800
9.7557
9.716
9.6128
9.415
0.0000
0.0969
0.176
0.301
0.477
0.603
0.699
0.778
0.8407

TABLE IX.

Chloroform.
(Merk's redistilled b.pt.60)

An average for four pieces of rubber. the time fot wetting, t_x,as calculated from graph IX is four second.

Time min.	Increase cm.	Increase per cm. of rubber	$\frac{t}{l}$	$\frac{t-t_x}{l}$	$\frac{t}{t_x}$
0.00	0.00	0.00	000.0	000	0.0
.25	1.30	.26	221.7	167	...
.50	2.95	.41	176.8	157	4.0
.75	.60	.52	186.2	153	5.1
1.00	.89	.57	187.5	187	2.2
.25	3.22	.64	180.8	174	3.1
.50	.62	.72	176.5	167	4.2
.75	.64	.73	190.0	190	...
2.00	.76	.75	.....	203	...
.25	.84	.76	.....	228	...
.50	.94	.79	.....	234	...
.75	4.02	.80	.....	252	...
3.00	.18	.82	.....	259	...
.25	.24	.83	.....	278	...
.50	.29	.84	.....	...	...
.75	.31	.85	.....	...	...
4.00	.35	.86	.....	...	...
.25	.39	....	.....	...	...
.50	.44	....	.....	...	...
.75	.46	....	.....	...	...
5.00	.49	.89	.....	...	...
.25	.50	....	.....	...	...
.50	.51	....	.....	...	...
.75	.51	....	.....	...	...
6.00	4.53	.906	.....	...	...
.15	.57	....	.....	...	...
.25	.59	....	.....	...	...
.50	.61	....	.....	...	...
7.00	.62	.920	.....	...	...
15.00	.67	.934	.....	...	...
.....	....	.....	.....	...	...


IX A.
lg l (0,1 = 0.5 in.)
l (0.1 cm = 0.5 in.)
t (0 min = 1 in.)
lg t (0.1 = 0.5 in.)
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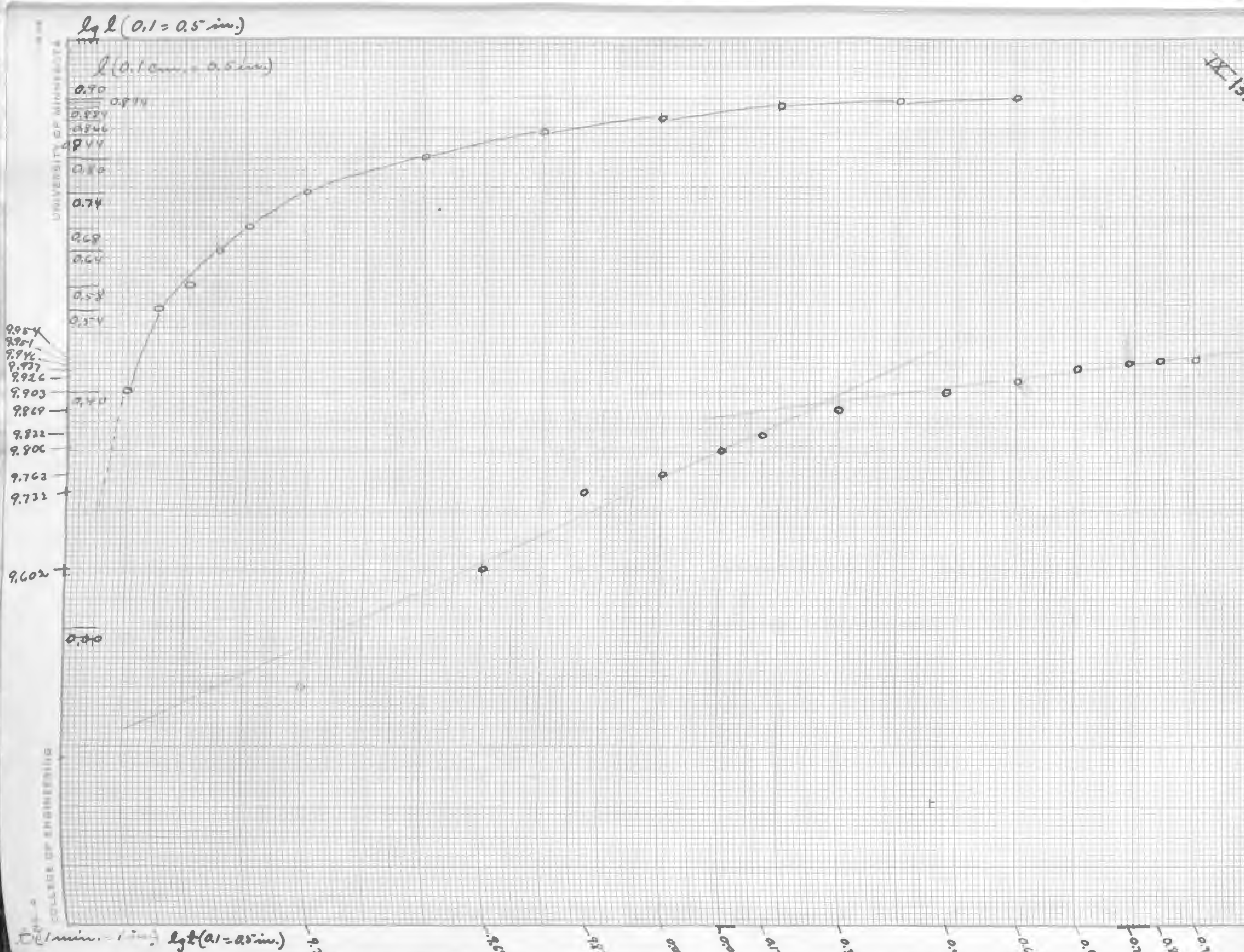
9,976
9,971
9,966
9,940
9,924
9,875
9,854
9,826
9,778
9,732
9,643
9,447
0,936
0.91
0,882
0,84
0,67
0,60
0,44
0,28
9,6
0,176
0,30
0,47
0,69
0,78
0,90

TABLE IX A

Chloroform.

Observations for one piece of rubber.

Time min.	Length cm.	Increase per cm. cm.
0.00	5.00	0.00
.25	6.40	.28
.50	7.20	.44
.75	.70	.54
1.00	8.00	.60
.25	.35	.67
.50	.55	.71
.75	.70	.74
2.00	.85	.75
.25	.87	.794
.50	9.02	.804
.75	.15	.83
3.00	.20	.84
.25	.27	.854
.50	.33	.866
.75	.40	.8[illegible]
4.00	.41	.882
.25	.46	.892
.50	.50	.90
.75	.52	.904
5.00	.55	.91
.25	.58	.916
.50	.60	.92
.75	.62	.924
6.00	.63	.926
.25	.64	.928
.50	.65	.93
.75	.67	.934
7.00	.68	.936
.25	.68	.938
.50	.70	.94
.75	.71	.942
8.00	.72	.944
.25	.73	.946
9.00	.73	.946
19.25	.78	.956
2 hrs 27 min.	.78	.956
.....	....	.....


IX 13.
lg l (0.1 = 0.5 in.)
l (0.1 cm. = 0.5 in.)
lg t (0.1 = 0.5 in.)
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0.90
0.894
0.884
0.846
0.80
0.74
0.68
0.64
0.58
0.54
0.40
0.00
9.954
9.951
9.946
9.937
9.926
9.903
9.869
9.832
9.806
9.763
9.732
9.602
9.30
9.699
0.000
0.176
0.301
0.477
0.602
0.903

TABLE IX B.

Chloroform.

Observations for one piece of rubber.

Time min.	Length cm.	Increase per cm. cm.
0.00	5.00	0.00
.25	....	....
.50	7.00	.40
.75	.70	.54
1.00	.90	.58
.25	8.20	.64
.50	.40	.68
.75	.65	.73
2.00	.70	.74
.25	.80	.76
.50	.87	.774
.75	.92	.784
3.00	9.00	.80
.25	.10	.82
.50	.15	.83
.75	.20	.84
4.00	.22	.844
.25	.25	.85
.50	.29	.856
.75	.30	.86
5.00	.33	.866
.25	.37	.874
.50	.38	.876
.75	.40	.88
6.00	.42	.884
.25	.43	.886
.50	.45	.89
.75	....	....
7.00	.47	.894
.25	....	.....
.50	.48	.896
.75	....	......
8.00	.50	.90
14.00	.55	.91
44.00	.55	.91
.....	....	....

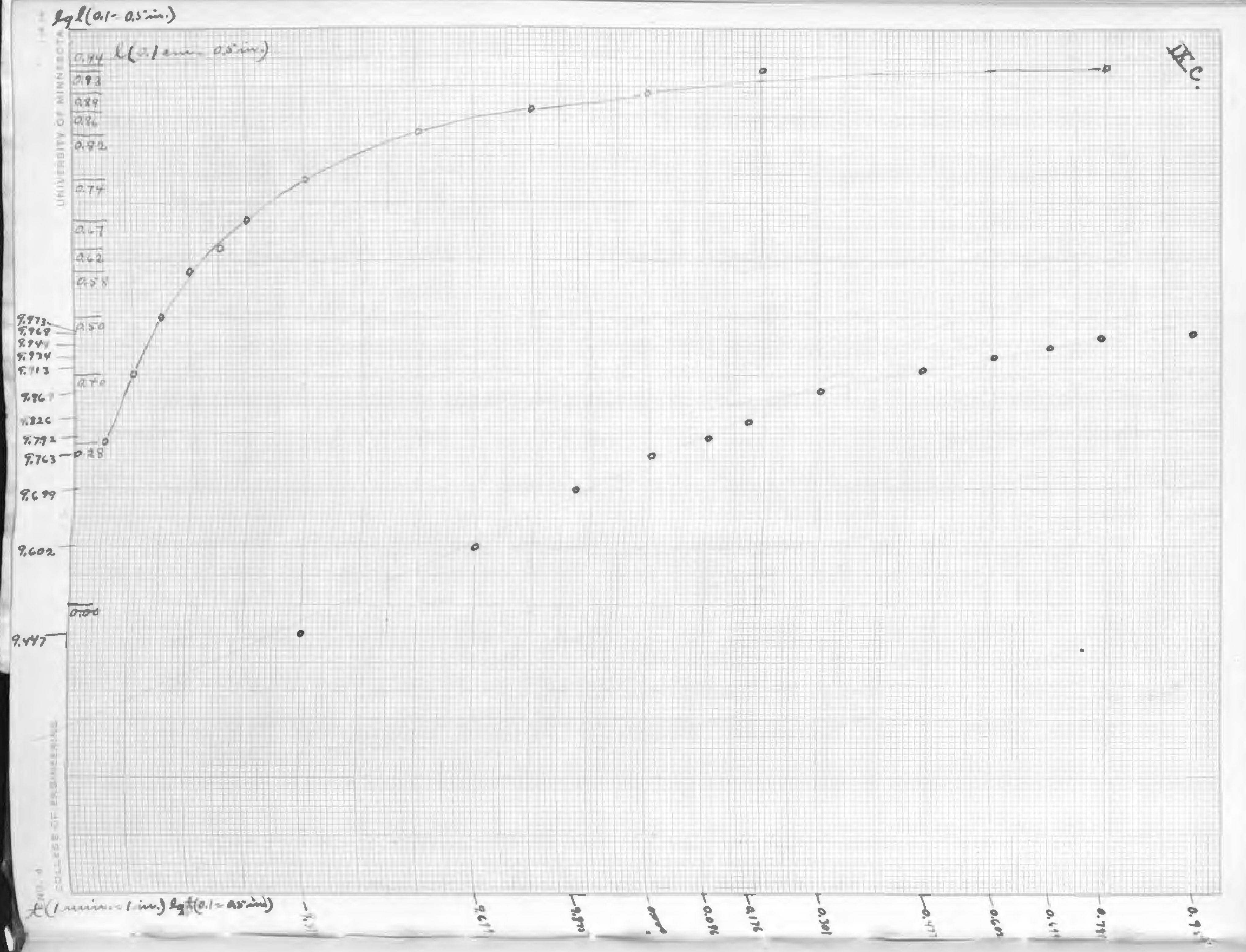
IX C.
log l (0.1 = 0.5 in.)
l (0.1 cm = 0.5 in.)
0.94
0.93
0.89
0.86
0.82
0.74
0.67
0.62
0.58
0.50
0.40
0.28
0.00
9.973
9.968
9.949
9.934
9.913
9.869
9.826
9.792
9.763
9.699
9.602
9.447
t (1 min. = 1 in.) log t (0.1 = 0.5 in.)
0.096
0.176
0.301
0.602
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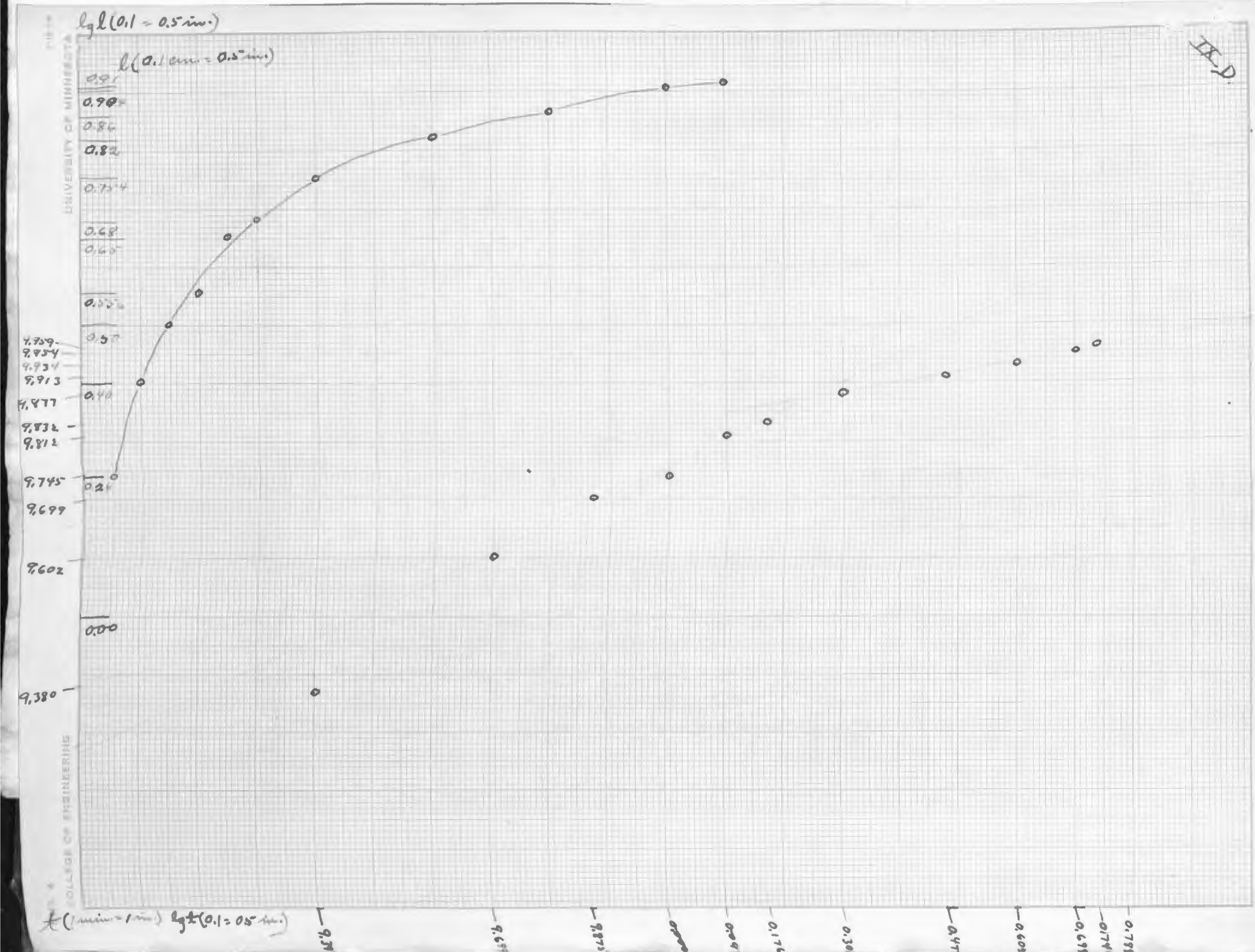
TABLE IX C.

Chloroform.

Observations for one piece of rubber.

Time, min.	Length, cm.	Increase per cm., cm.
0.00	5.00	0.00
.25	6.40	.28
.50	7.00	.40
.75	.50	.50
1.00	.90	.58
.25	8.10	.62
.50	.35	.67
.75	.55	.71
2.00	.70	.74
.25	.83	.766
.50	.95	.79
.75	9.00	.80
3.00	.10	.82
.25	.18	.836
.50	.20	.84
4.00	.28	.856
.25	.30	.86
.50	.35	.87
.75	.38	.876
5.00	.40	.88
.25	.45	.89
.50	.48	.896
.75	.50	.898
6.00	.52	.90
9.00	.65	.93
12.00	.68	.936
.....	....	.....



IX D
log l (0.1 = 0.5 in.)
l (0.1 cm = 0.5 in.)
t (1 min = 1 in.) log t (0.1 = 0.5 in.)
0.92
0.90
0.86
0.82
0.754
0.68
0.65
0.555
0.52
0.48
0.26
0.00
9.959
9.954
9.934
9.913
9.877
9.832
9.812
9.745
9.699
9.602
9.380
0.788
0.174
0.699
0.602
0.477
0.301
0.176
0.097
0.000
9.875
9.699
9.398

TABLE IX D.

Chloroform.

Observations for one piece of rubber.

Time, min.	Length, cm.	Increase per cm., cm.
0.00	5.00	0.00
.25	6.20	.24
.50	7.00	.40
.75	.50	.50
1.00	.78	.556
.25	8.25	.65
.50	.40	.68
.75	.69	.738
2.00	.77	.754
.25	.85	.77
.50	.95	.79
.75	9.02	.804
3.00	.10	.82
.25	.18	.836
.50	.27	.854
.75	.29	.858
4.00	.30	.86
.25	.33	.866
.50	.40	.88
.75	.43	.886
5.00	.52	.90
.25	....	....
.50	.55	.91
....	....	....

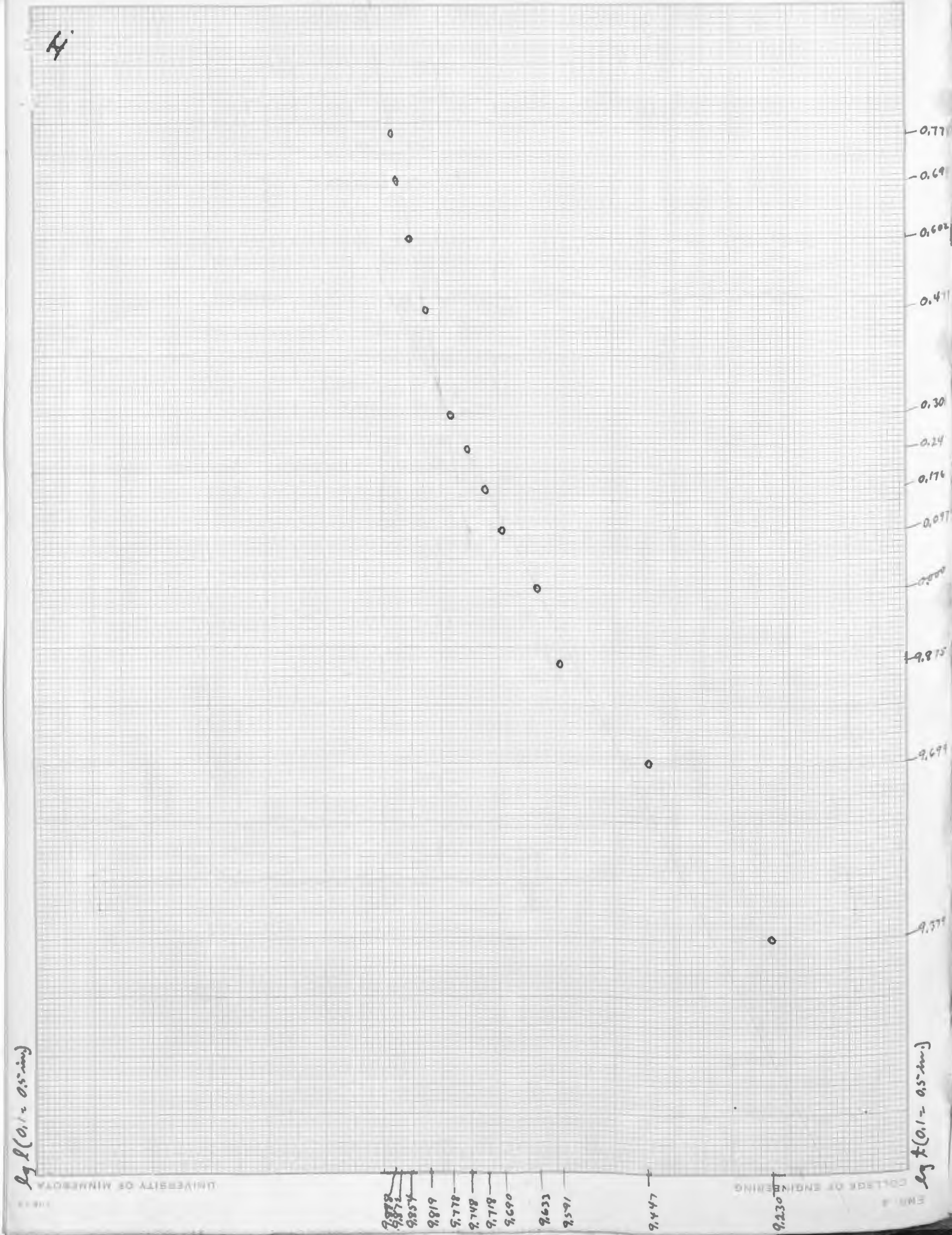

4.
0.602
0.176
9.854
9.819
9.778
9.748
9.719
9.690
9.633
9.591
9.447
9.230

TABLE X.

Benzol.

(Kahlbaum's c.p.cryst. free from thiophen)

An average for three different pieces of rubber. The time for wetting, t ,as calculated from graph X is 3 sec.

Time min.	Increase cm.	Increase per cm. cm.	$\frac{t}{l^2}$	$\frac{t-t_x}{l^2}$	t_x.
0.25	0.86	0.17	505.6	296	...
.50	1.43	.28	353.6	325	6.1
.75	1.95	.39	296.0	254	7.5
1.00	2.15	.43	324.2	290	6.7
.25	.46	.49	309.2	298	6.7
.50	.66	.53	317.7	313	6.2
.75	.83	.56	328.0	316	...
2.00	3.00	.60	333.2	335	...
.25	.10	.62	351.0	350	...
.50	.23	.64	.....	363	...
.75	.31	.66	.....	...	...
3.00	.32	.66	.....	...	...
.25	.35	.67	.....	...	...
.50	.45	.69	.....	427	...
.75	.53	....	.....	...	...
4.00	.58	.716	.....	...	...
.25	.61	.....	.....	...	...
.50	.67	.....	.....	...	...
.75	.70	.....	.....	...	...
5.00	.73	.746	.....	...	...
.25	.75	.....	.....	...	...
.50	.77	.....	.....	...	...
.75	.78	.....	.....	...	...
6.00	.78	.756	.....	...	...
.....	....	.....	.....	...	...

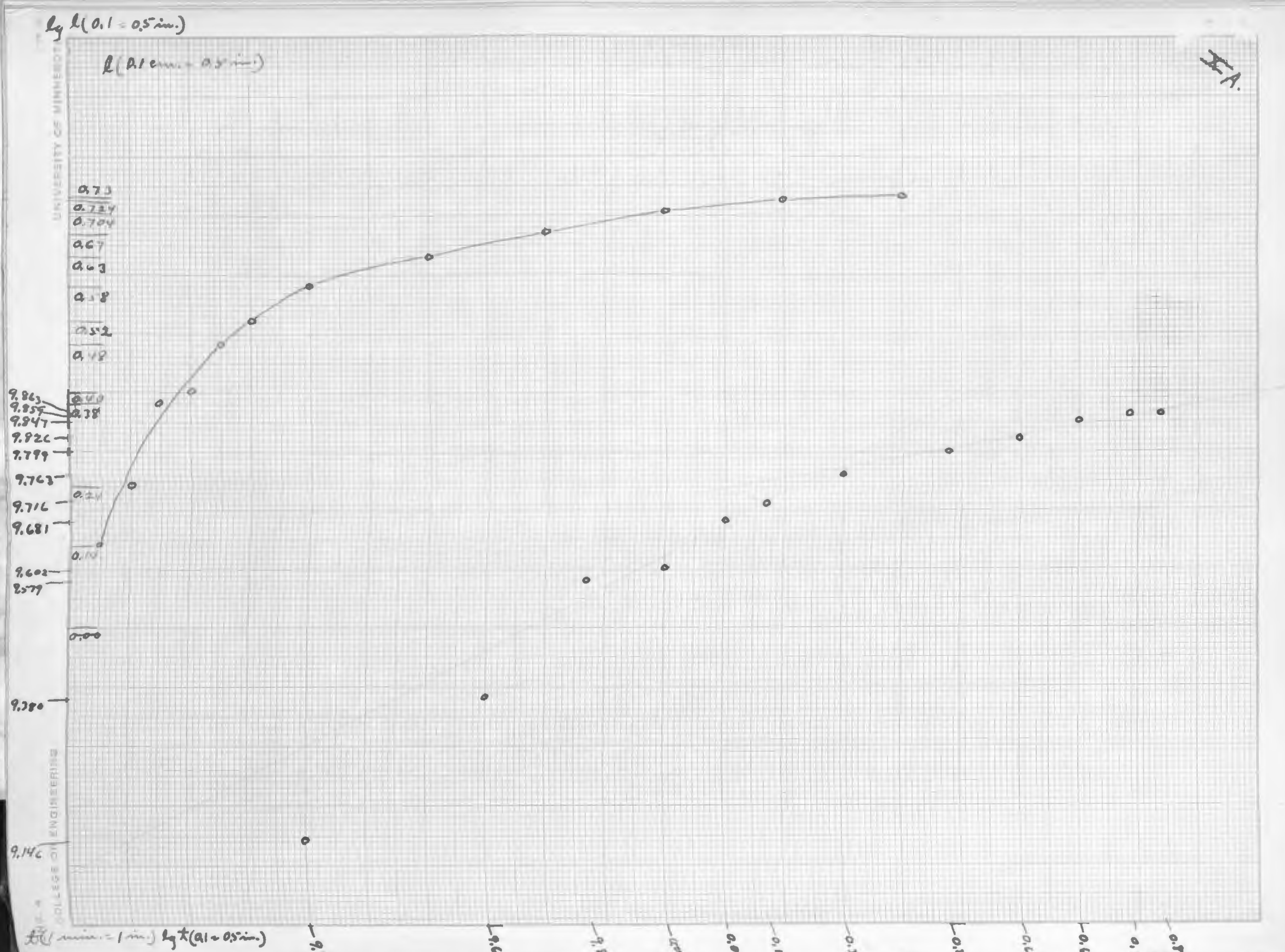
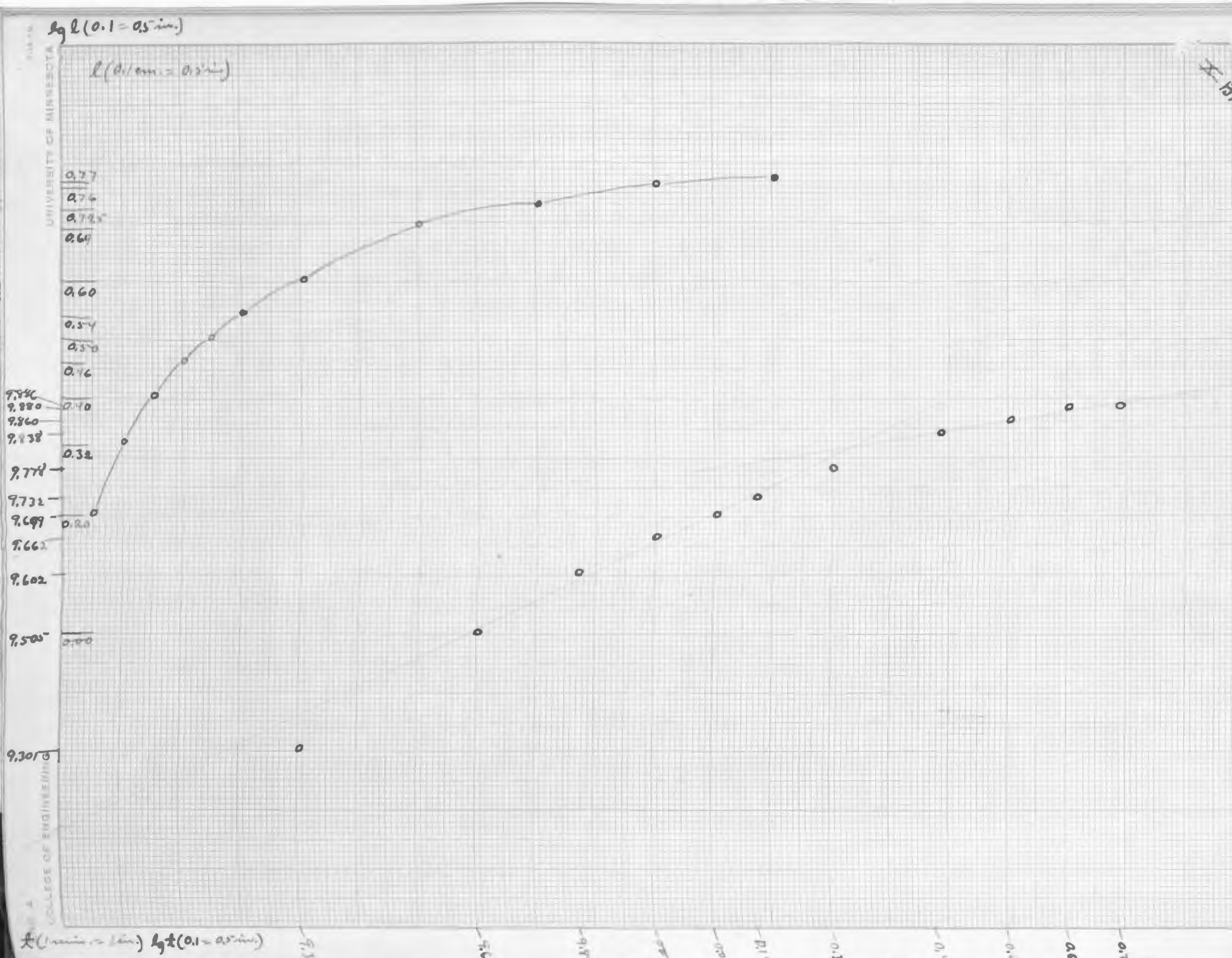

XA.
log l (0.1 = 0.5 in.)
l (0.1 cm. = 0.5 in.)
log t (0.1 = 0.5 in.)
0.73
0.724
0.704
0.67
0.63
0.58
0.52
0.48
0.40
0.38
0.24
0.10
0.00
9.863
9.855
9.847
9.826
9.799
9.763
9.716
9.681
9.602
9.579
9.380
9.146
0.097
0.176
0.602
0.699

TABLE X A.

Benzol.

Observations for one piece of rubber.

Time, min.	Length, cm.	Increase per cm. cm.
0.00	5.00	0.00
.25	.70	.14
.50	6.20	.24
.75	.90	.38
1.00	7.00	.40
.25	.40	.48
.50	.60	.52
.75	.70	.54
2.00	.90	.58
.25	8.00	.60
.50	.10	.62
.75	.13	.626
3.00	.15	.63
.25	.25	.65
.50	.27	.654
.75	.30	.66
4.00	.35	.67
.25	.40	.68
.50	.47	.694
.75	.50	.70
5.00	.52	.704
.25	.55	.71
.50	.58	.716
.75	.60	.72
6.00	.62	.724
.50	.65	.73
7.00	.65	.73
....	....	....



log l (0.1 = 0.5 in.)
l (0.1 cm. = 0.5 in.)
X-13.
0.77
0.76
0.725
0.69
0.60
0.54
0.50
0.46
0.40
0.32
0.20
0.00
9.940
9.880
9.860
9.838
9.778
9.732
9.699
9.662
9.602
9.505
9.301
t (1 min. = 1 in.) log t (0.1 = 0.5 in.)
9.397
9.699
9.875
0.097
0.176
0.301
0.477
0.699
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TABLE X B.

Benzol.

Observations for one piece of rubber.

Time min.	Length cm.	Increase per cm. cm.
0.00	5.00	0.00
.25	6.00	.20
.50	6.60	.32
.75	7.00	.40
1.00	.30	.46
.25	.50	.50
.50	.70	.54
.75	.90	.58
2.00	8.00	.60
.25	.20	.64
.50	.30	.66
.75	.40	.68
3.00	.....	....
.25	.50	.70
.50	....	....
.75	.60	.72
4.00	....	....
.25	.65	.73
.50	.70	.74
.75	....	....
5.00	.80	.76
.25	....	....
.50	.85	.77
.75	....	....
6.00	.85	.77
.....	....	....

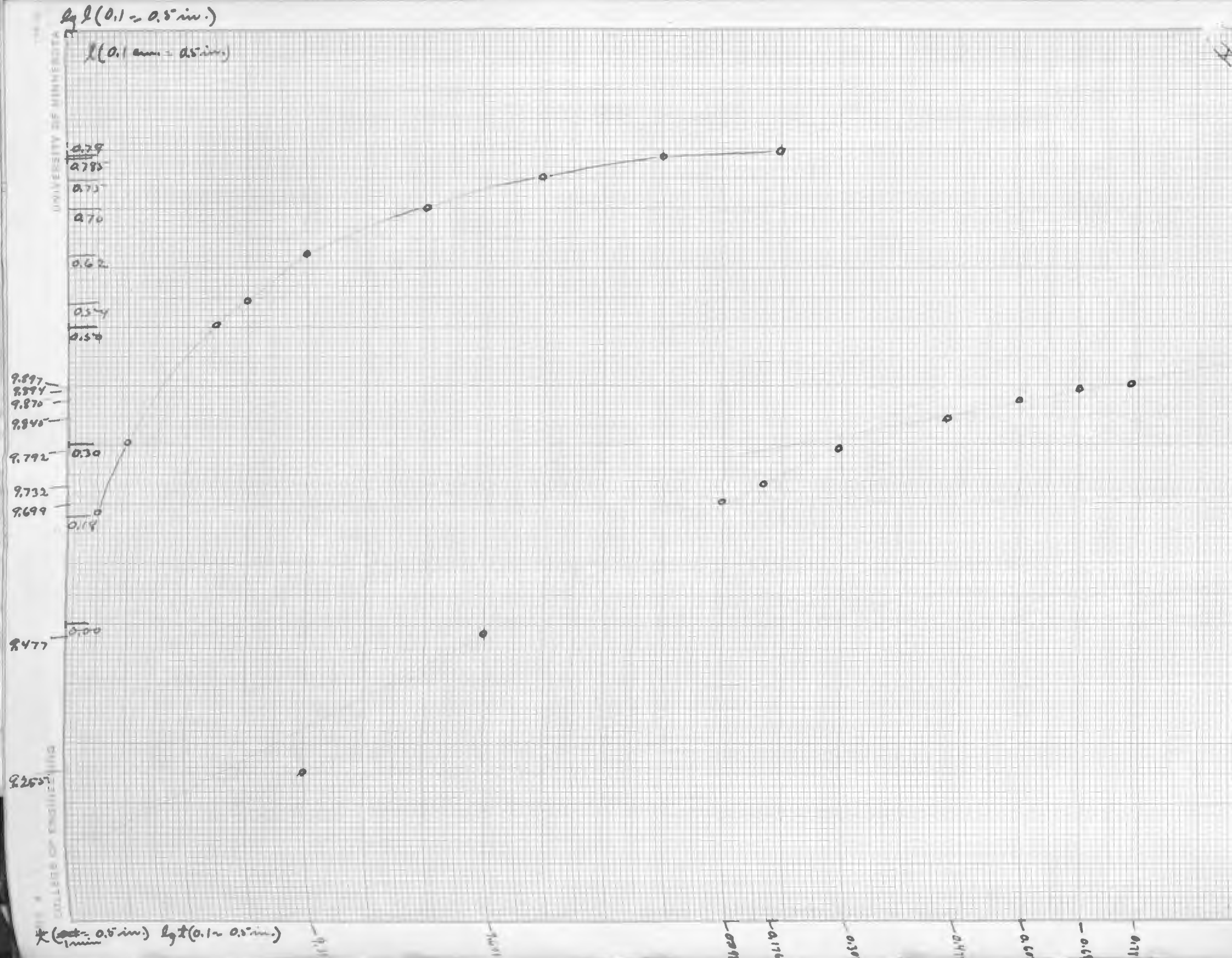
X C.
log l (0.1 = 0.5 in.)
l (0.1 mm = 0.5 in.)
0.79
0.785
0.75
0.70
0.62
0.54
0.50
0.30
0.18
0.00
9.897
9.884
9.870
9.840
9.792
9.732
9.699
9.477
9.255
t (1 min = 0.5 in.) log t (0.1 = 0.5 in.)
0.176
0.30
0.477
0.60
0.69
0.78

TABLE X C.

Bencol.

Observations for one piece of rubber.

Time, min.	Lemgth, cm.	Increase per cm. cm.
0.00	5.00	0.00
.25	.90	.18
.50	6.50	.30
.75	....	....
1.00	....	....
.25	7.50	.50
.50	.70	.54
.75	.90	.58
2.00	8.10	.62
.25	....	....
.50	.30	.66
.75	.40	.68
3.00	.50	.70
.25	....	....
.50	....	....
.75	.70	.74
4.00	....	....
.25	.80	.76
.50	....	....
.75	..90	.78
5.00	....	....
.25	.95	.79
.50	....	....
.75	.95	.79
6.00	....	....
....	....	....

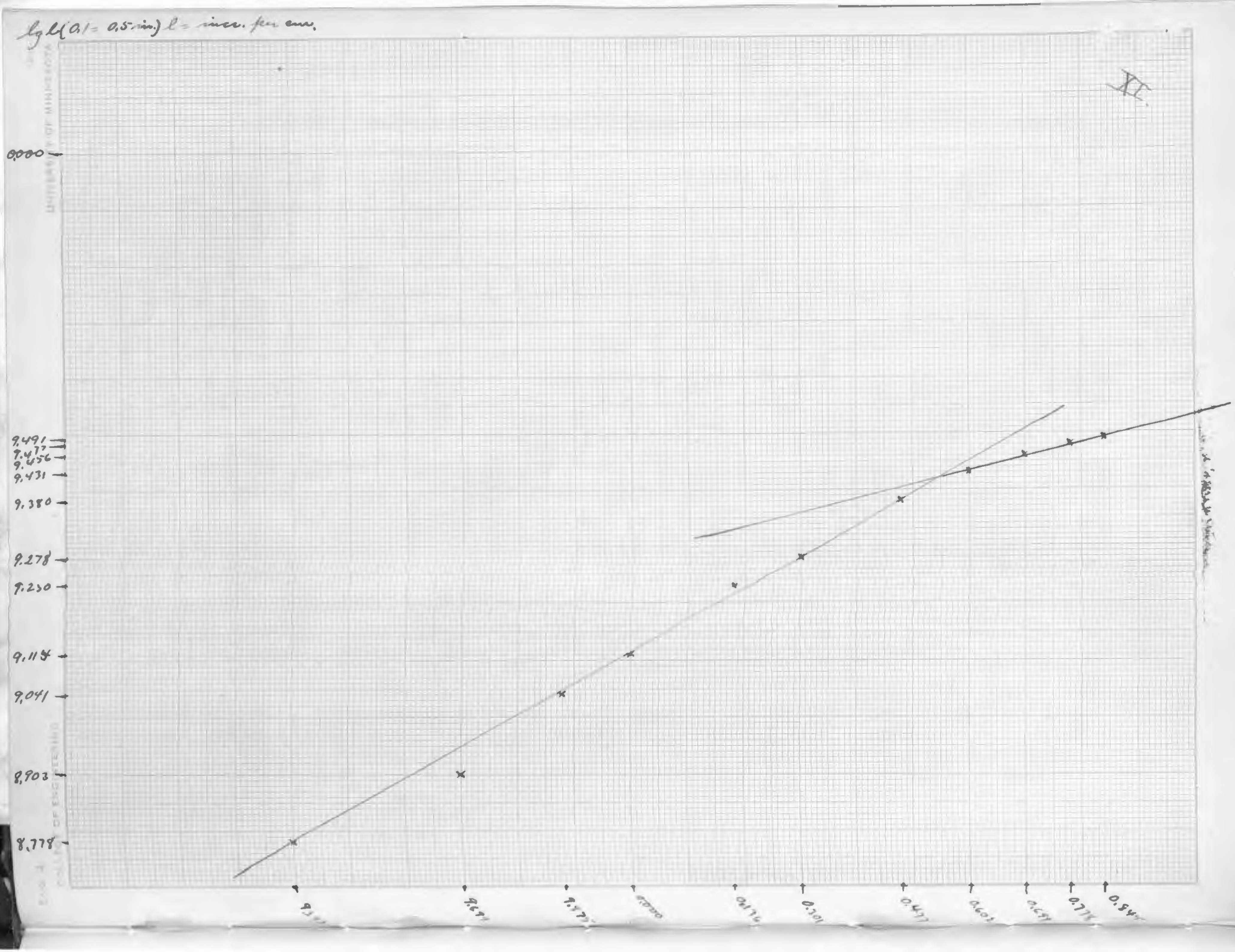
log L (a1 = 0.5 in.) L = incr. per cm.
XI
0.000
9.491
9.477
9.456
9.431
9.380
9.278
9.230
9.114
9.041
8.903
8.778
0.301
0.477
0.602
0.699
0.778
0.845

TABLE XI.

Pyridine. (Merk's dried over NaOH and redistilled, b. pt. 114.2-115.3)

An average for three pieces of rubber. The time for wetting t_x, as calculated from graph XI is 3 sec.

Time min.	Increase cm.	Increase per cm, cm.	$\frac{t}{l^2}$	$\frac{t-t_x}{l^2}$	t_x.
0.25	0.30	0.06	416.5	333.0	....
.50	.43	.08	469.0	422.0	4.28
.75	0.56	.11	358.7	347.0	0.22
1.00	0.66	.13	336.2	338.0	3.66
.25	0.78	.15	[illegible]	320.0	3.55
.50	[illegible]	.17	304.2	315.0	4.35
.75	0.93	.18	306.0	324.0	3.75
2.00	0.99	.19	301.2	300.0	3.00
.25	1.06	.21	321.4	302.0	4.32
.50	1.08	.22	317.2	306.6	4.15
.75	1.14	.23	308.0	307.0	3.86
3.00	1.21	.24	316.5	307.0	4.00
.25	1.24	.25	328.2	306.0	4.00
.50	1.29	.26	317.7	315.0	4.28
.75	1.33	.266	329.0	325.0	....
4.00	1.35	.270	361.0	356.0	....
.50	1.37	.274	.....	362.0	....
5.00	1.43	.286	.....	362.0	....
.50	1.49	[illegible]	.....	.....	....
6.00	1.50	.300	.....	397.0	....
7.00	1.55	.310	437.0	435.0	....
16.00	1.86	.372	.....	.....	....
.....	....	.....	.....	.....	....

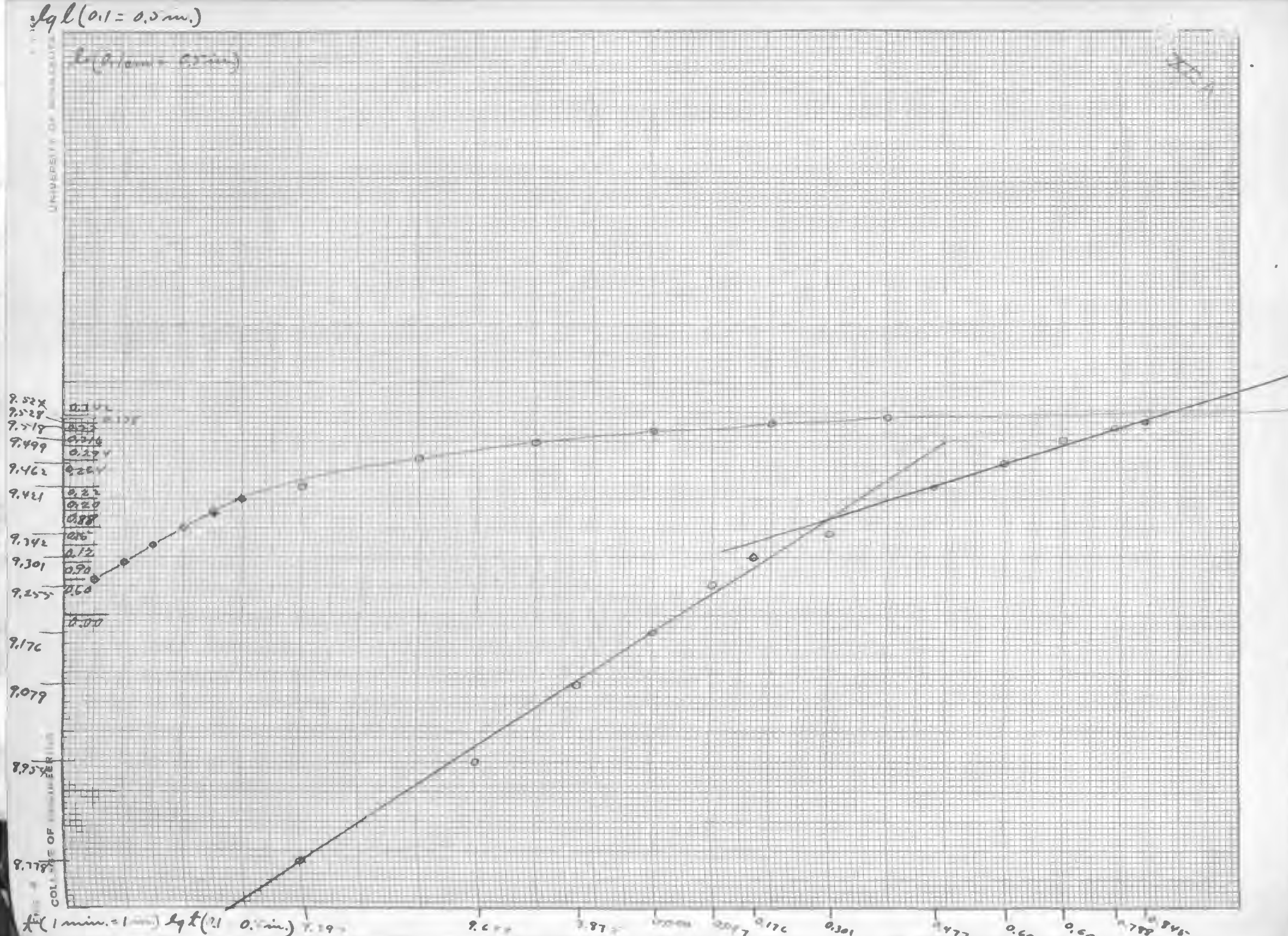
log l (0.1 = 0.5 in.)
log t (0.1 = 0.5 in.)
9.421
9.301
9.176
9.079
0.301
0.477
0.602

TABLE XI A.

Pyridine.

Observations for one piece of rubber.

Time (min)	Length (cm)	Length per cm.(cm)
0.00	5.00	0.00
.25	.30	.06
.50	.45	.09
.75	.67	.12
1.00	.75	.15
.25	.90	.18
.50	6.00	.20
.75	.05	.21
2.00	.10	.22
.25	.18	.236
.50	.20	.24
.75	.28	.256
3.00	.32	.264
.25	.37	.274
.50	...	....
.75	.45	.29
4.00	.47	.294
.25	.49	.298
.50	.50	.30
.75	.53	.306
5.00	.58	.316
.25	...	....
.50	.60	.32
.75	.62	.324
6.00	.65	.33
.50	.68	.336
7.00	.69	.338
.50	.70	.34
13.00	.71	.342
16.00	.72	.344
20.00	.72	.344
.....	...	....

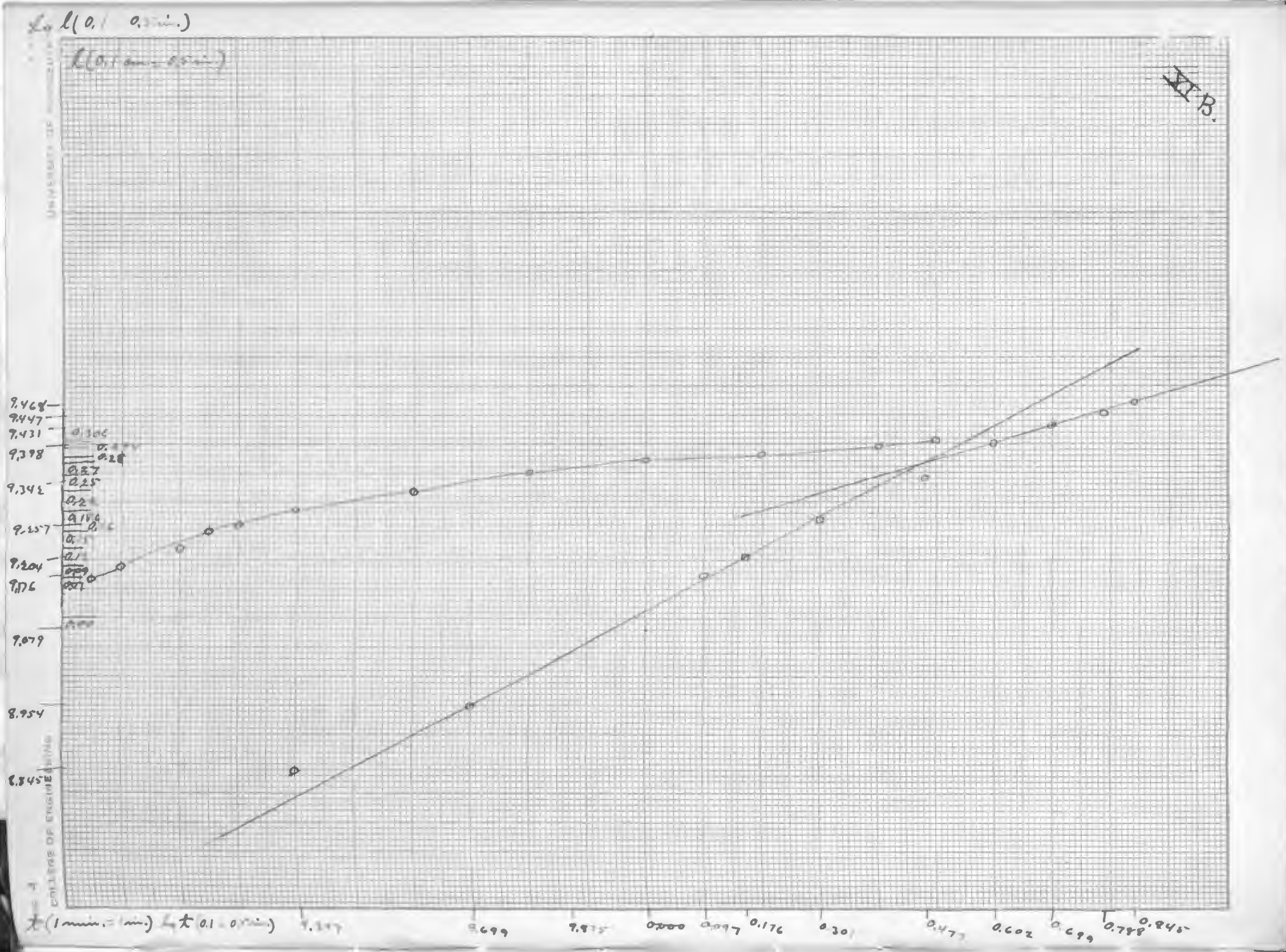
XI B.
9.468
9.447
9.431
9.398
9.342
9.257
9.204
9.176
9.079
8.954
8.845
0.699
0.000
0.176
0.301
0.477
0.602
0.699
0.778
0.845

TABLE XI B.

Pyridine.

observations for one piece of rubber.

Time ,min.	Length, cm.	Increase per cm., cm.
0.00	5.00	0.00
.25	.35	.07
.50	.45	.09
.75	...	...
1.00	.60	.12
.25	.75	.15
.50	.80	.16
.75	.88	.176
2.00	.93	.186
.25	6.00	.20
.50	.03	.206
.75	.07	.214
3.00	.10	.22
.25	.16	.223
.50	.19	.228
.75	.24	.25
4.00	.25	.25
.50	.28	.256
5.00	.35	.27
.50	.38	.276
6.00	.40	.28
7.00	.47	.294
.50	.53	.306
11.00	.65	.33
15.00	.72	.344
25.00	.72	.344
.....	...	....

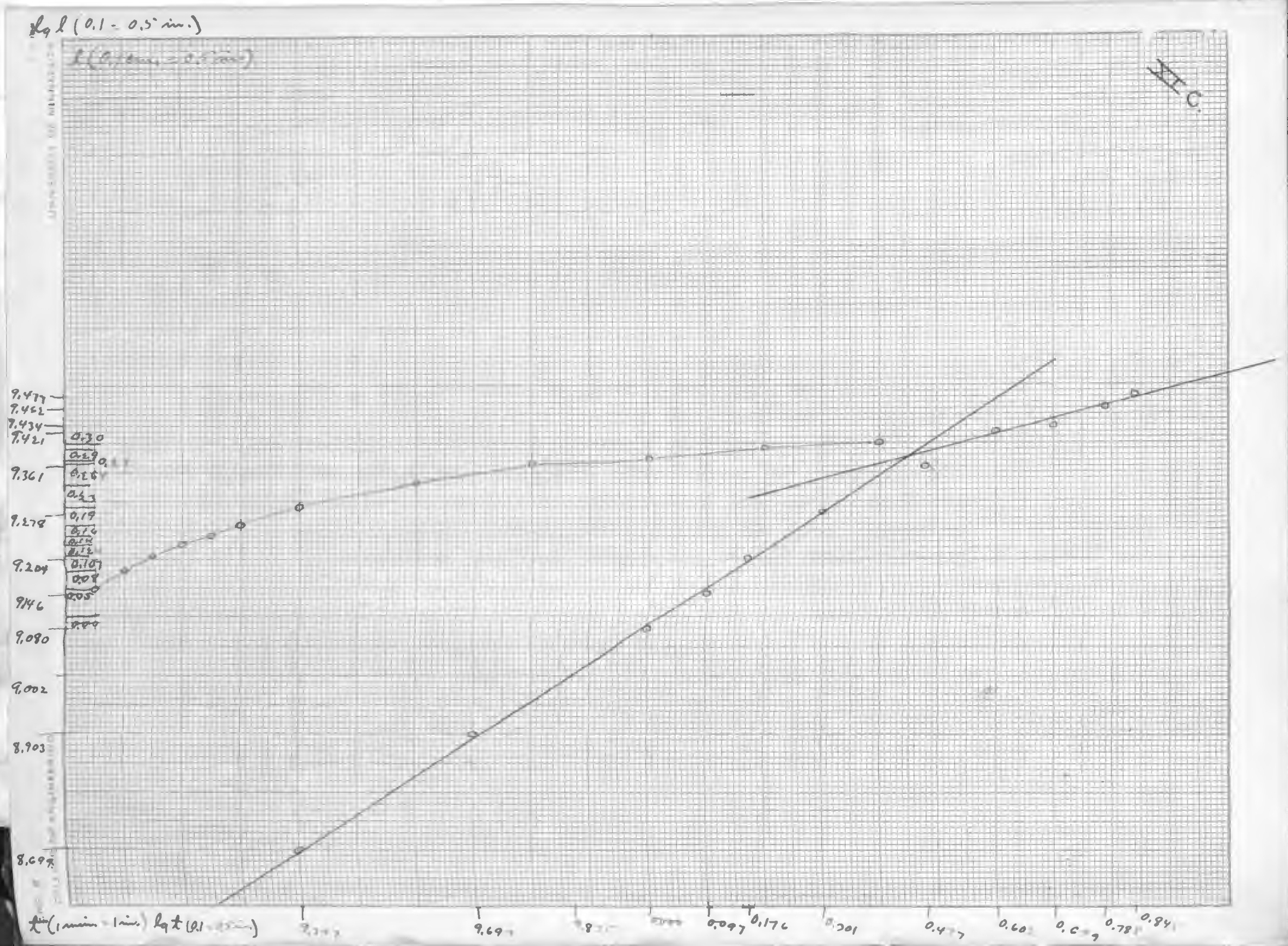
XI C.
lg l (0.1 - 0.5' in.)
9,477
9,452
9,434
9,421
9,361
9,278
9,204
9,146
9,080
9,002
8,903
8,697
0,30
0,29
0,19
0,10
0,08
0,05
9,69
0,097
0,176
0,301
0,477
0,60
0,78
0,84
lg t (0.1

TABLE XI C.

Pyridine.

observations for one piece of rubber.

Time, min.	Length, cm.	Increase per cm., cm.
0.00	5.00	0.00
.25	.25	.05
.50	.40	.08
.75	.53	.106
1.00	.62	.124
.25	.70	.14
.50	.80	.16
.75	.86	.172
2.00	.95	.19
.25	6.00	.20
.50	.02	.204
.75	.08	.216
3.00	...	....
.25	.20	.24
.50	.25	.25
.75	.30	.26
4.00	.32	.264
.25	...	....
.50	.35	.27
.75	...	...
5.00	.36	.272
6.00	.45	.29
7.00	.50	.30
60.00	.63	.326
.....	....	....

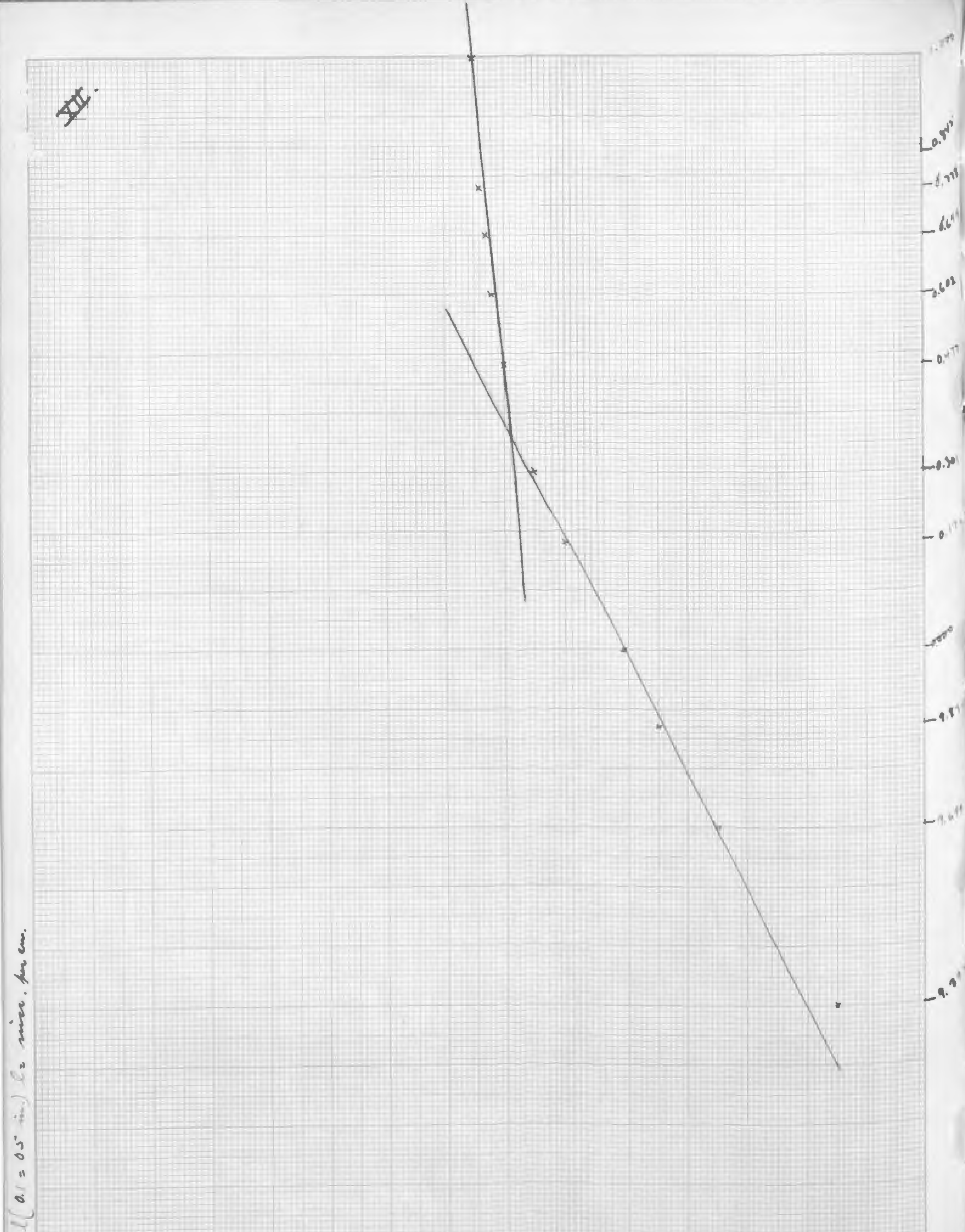
XII.
log l (0.1 = 0.5 in.) C₂ min. per cm.
9.255
9.146
9.100
9.013
8.904
8.603
0.845
0.602
0.477
0.301

TABLE XII.

Ethyl Acetate.

(Kahlbaum's resistilled b. pt. 73-75)

An average for three different pieces of rubber. Time for wetting, t_x, as calculated from graph XII is 3.5 sec.

Time. min.	Increase. cm.	Increase per cm., cm.	t/l^2	$\frac{t-t_x}{l^2}$	t_x.
0.25	1.40	0.046	694.7	543	....
.50	2.15	.071	578.5	525	5.12
.75	2.70	.090	531.7	513	5.20
1.00	3.10	.103	584.5	533	3.77
.25	.48	.116	558.0	534	4.53
.50	.78	.126	566.0	547	3.36
.75	4.06	.135	566.7	557	3.17
2.00	.22	.140	606.7	595	2.25
.25	.52	.150	595.7	...	2.50
.50	.56	.156	649.7	...	1.36
.75	.66	.156	.....	...	....
3.00	.76	.158	.....	692	....
.25	...	....	.....	...	....
.50	...	....	.....	...	....
.75	...	....	.....	...	....
4.00	5.00	.166	673.0	860	....
.25	...	....	.....	...	....
.50	....	....	.....	...	....
.75	...	....	.....	...	....
5.00	.10	.170	1038.0	...	....
6.00	.20	.173	.....	...	....
10.00	.30	.176		complete	distension.
.....	...	....	.....	...	....

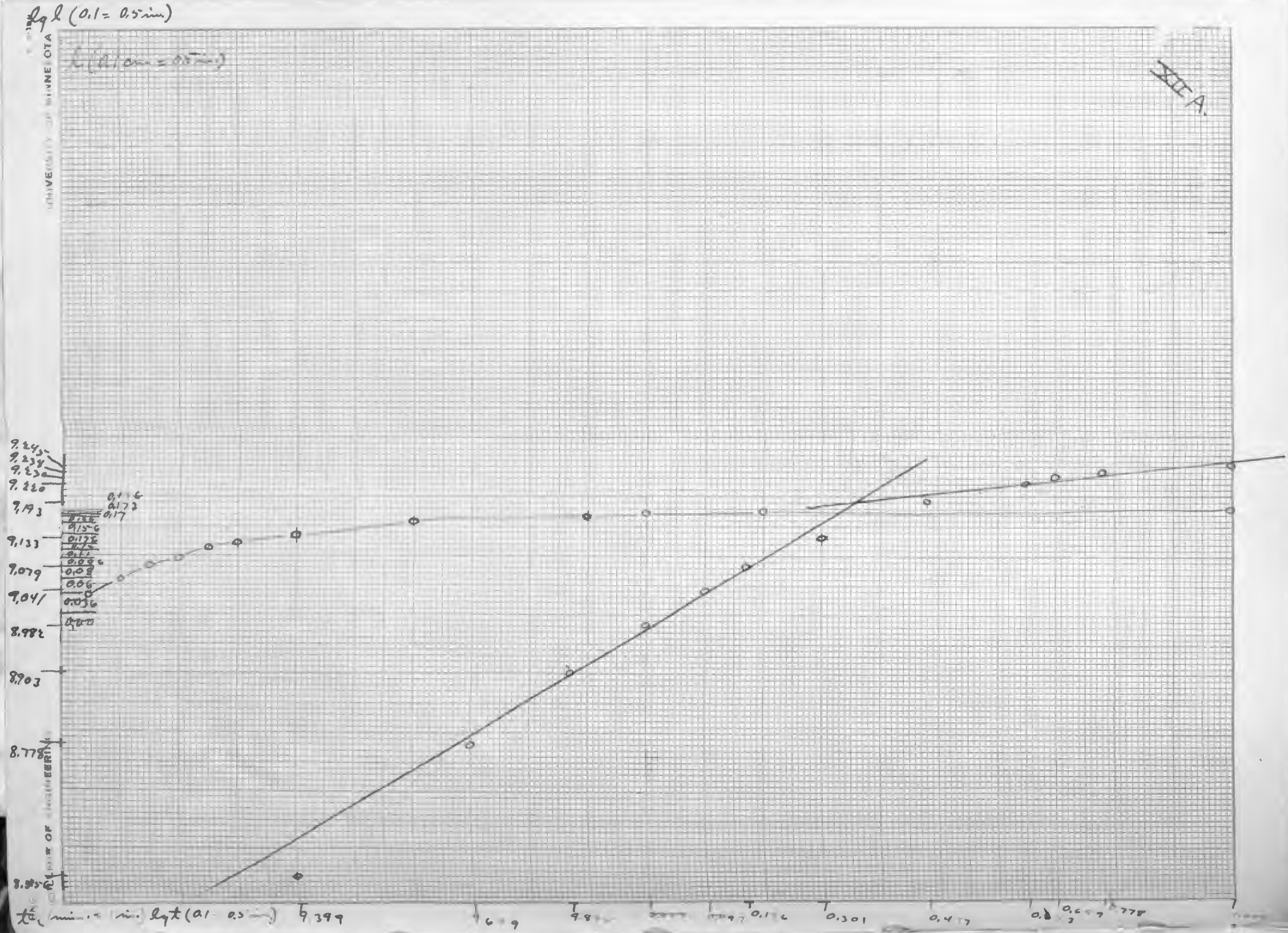
XII A.
log l (0.1 = 0.5 in)
9.245
9.234
9.230
9.220
9.193
9.133
9.079
9.041
8.982
8.903
8.778
0.176
0.172
0.17
0.096
0.08
0.06
0.036
0.301
0.477
6.9
9.399
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TABLE XII A.

Ethyl Acetate.

Observations for one piece of rubber.

Time, min.	Length, cm.	Increase per cm., cm.
0.00	30.4	0.000
.25	31.5	.036
.50	32.2	.060
.75	.8	.080
1.00	33.3	.096
.25	.7	.110
.50	34.0	.120
.75	.3	.130
2.00	.5	.136
.25	.7	.143
.50	.95	.150
.75	35.0	.153
3.00	.1	.156
.75	.3	.163
4.50	.4	.166
5.00	.5	.170
6.00	.6	.173
10.00	.7	.176
26.00	.7	.176
.....	....	....

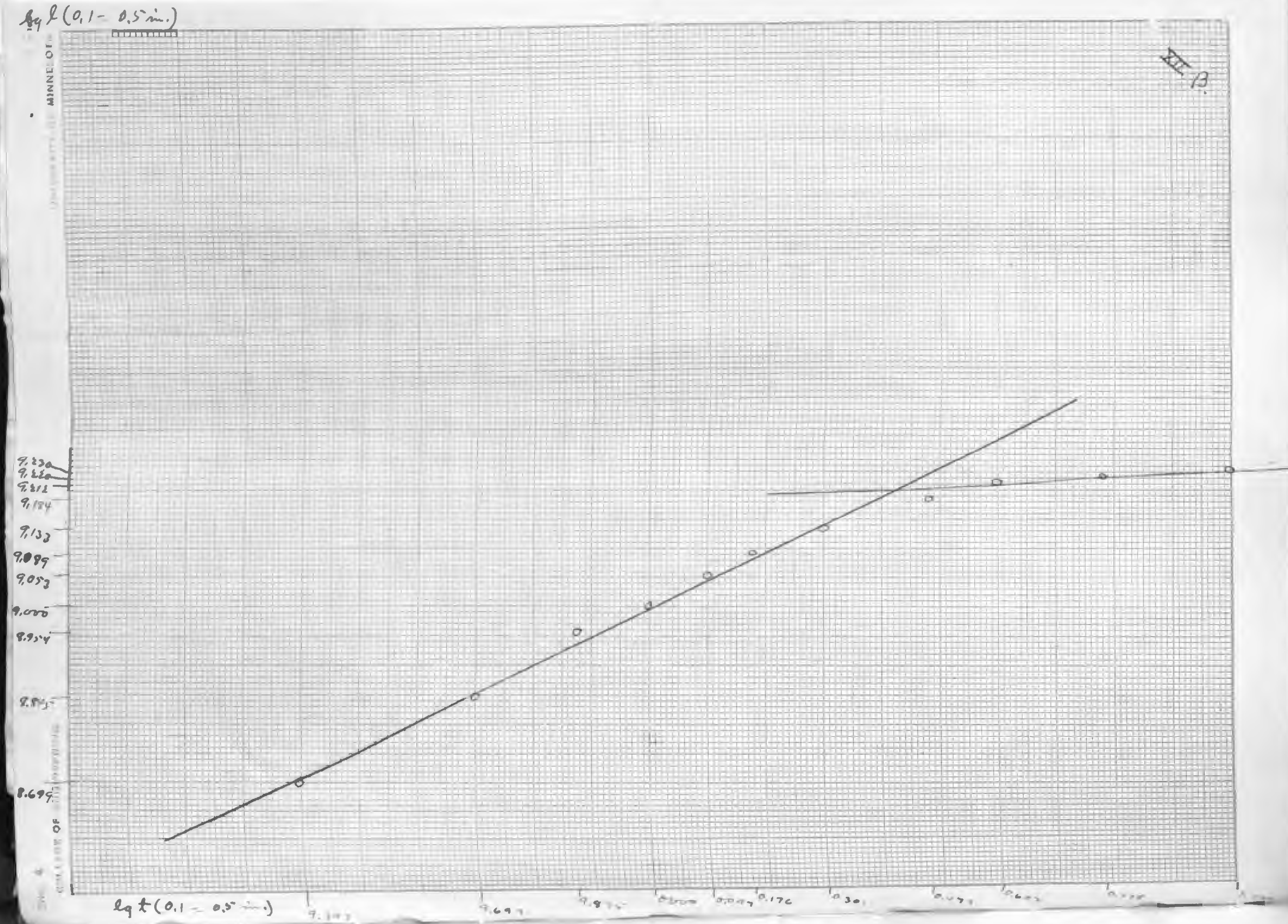

XII β.
log l (0,1- 0,5 in.)
log t (0,1 - 0,5 in.)
9,230
9,220
9,212
9,184
9,133
9,099
9,053
9,000
8,954
8,845
8.699

TABLE XII B.

Ethyl Acetate.

Observations for one piece of rubber.

Time, min.	Lemgth, cm.	Increase per cm., cm.
0.00	30.4	0.000
.25	31.9	.050
.50	32.5	.070
.75	33.1	.090
1.00	.4	.100
.25	.8	.113
.50	34.1	.123
.75	.4	.133
2.00	.52	.136
.25	.7	.143
.50	.82	.146
.75	.9	.150
3.00	35.0	.153
.25	.1	.156
.50	.2	.160
.75	.3	.163
4.00	.3	.163
6.00	.4	.166
10.00	.5	.170
28.00	.5	.170
.....	....	....

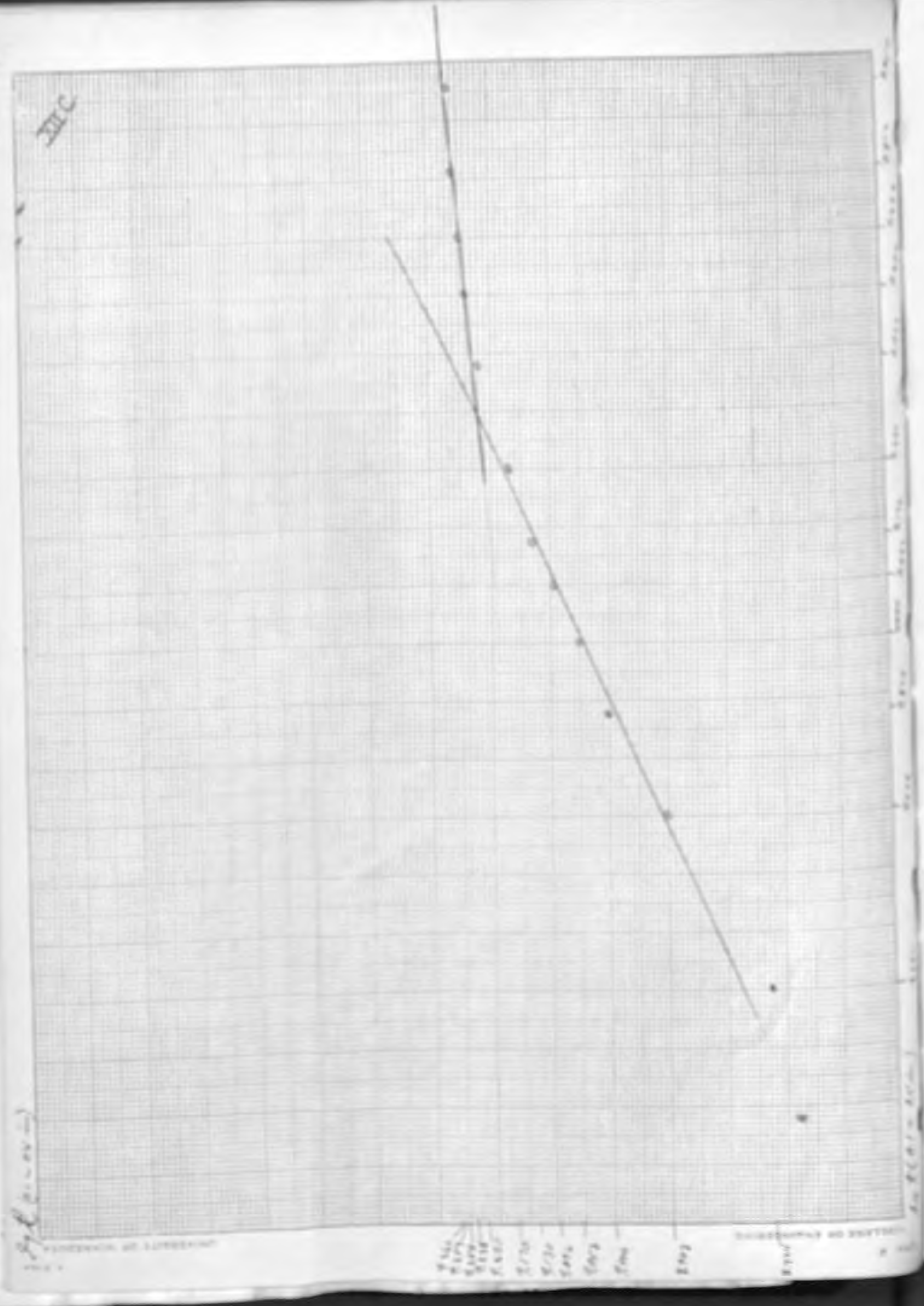
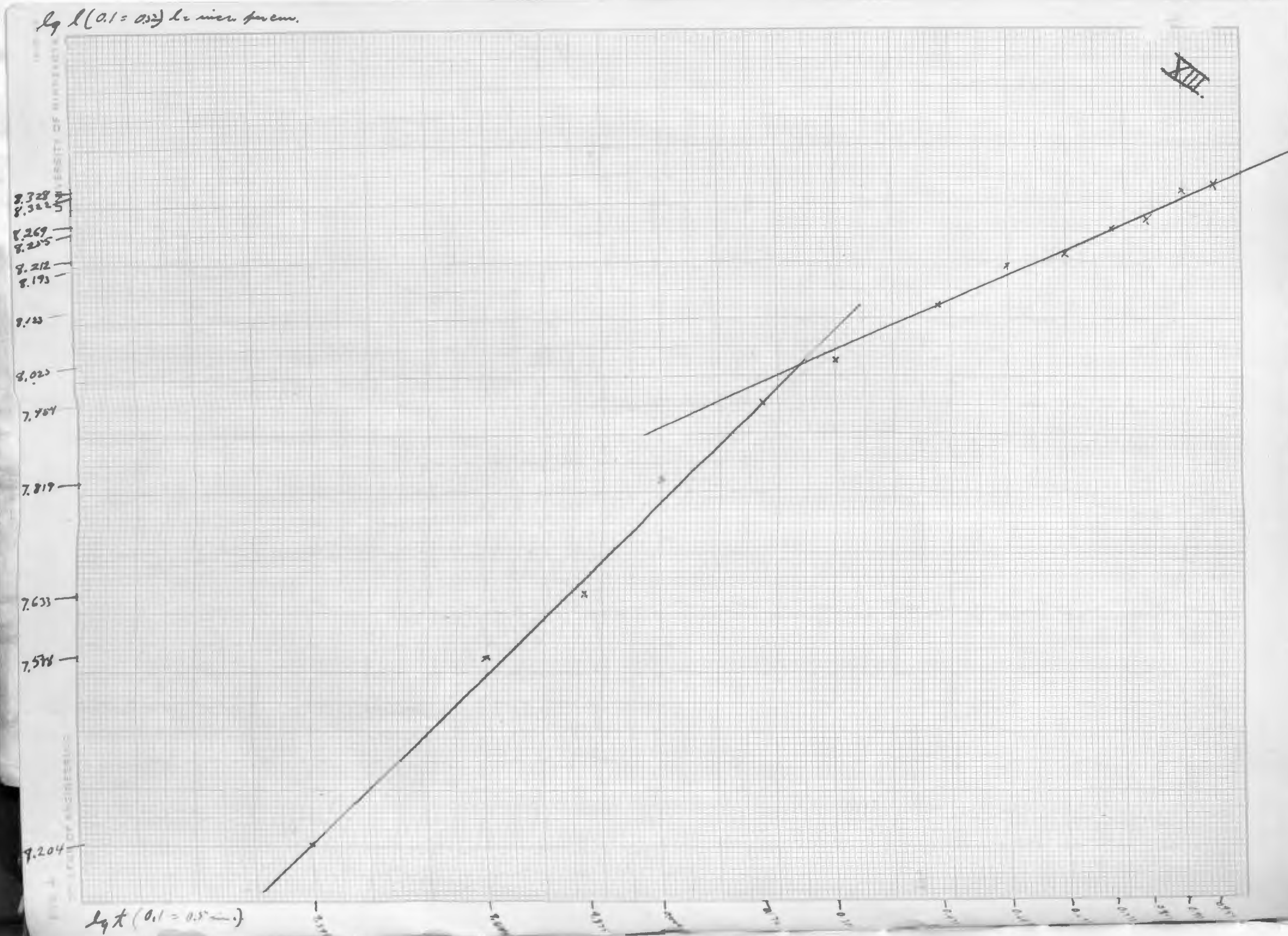


TABLE XII C

Ethyl Acetate
Observations for one piece of rubber

Time minutes	Length cm.	Increase per cm. cm.
0.00	30.4	0.000
.25	32.0	.053
.50	32.8	.08
.75	33.4	.10
1.00	33.8	.113
.25	34.15	.125
.50	34.45	.135
.75	34.70	.143
2.00	34.85	.148
.25	35.05	.155
.50	35.2	.16
.75	35.3	.163
3.00	35.4	.166
.25	35.45	.168
.50	35.52	.17
.75	35.58	.171
4.00	35.6	.173
.25	35.65	.175
.50	35.7	.176
.75	35.72	.177
5.00	35.75	.178
.25	35.78	.179
.50	35.8	.18
.75	35.82	.18
6.50	35.85	.181
9.00	35.9	.183
30.00	35.9	.183



lg l (0.1 = 0.32) lᵤ nieu per em.
XIII.
8.328
8.322
8.269
8.255
8.212
8.193
8.123
8.023
7.984
7.819
7.633
7.578
7.204
lg t (0.1 = 0.5 ...)

TABLE XIII

Acetic Acid.
(Kahlbaum's 99-100 %)

An average for three different pieces of rubber. The time for wetting t_x as calculated from graph XIII is 14.5 sec.

Time	Increase in cm.	Increase per cm of rubber	t/l^2	$\frac{t - t_x}{l^2}$	t_x.
15 sec	0.05	0.0016	585.10	195.10	.....
30 "	.10	.0033	275.10	142.10	10.33
45 "	.13	.0043	247.10	165.10	10.15
1 min	.20	.0066	137.10	104.10	12.40
15 "	.25	.0083	108.10	88.10	12.67
30 "	.27	.0090	111.10	93.10	25.30
45 "	.30	.0100	105.10	90.10	16.60
2 min	.32	.0106	106.10	93.10	
30 "	.36	.0120	104.10	94.10	
3 min	.40	.0133	101.10	94.10	
30 "	.45	.0150	93.10	86.80	
4 min	.47	.0156	98.10	94.10	
5 "	.49	.0163	113.10	107.10	
6 "	.54	.0180	222.10	106.10	
7 "	.56	.0186	121.10	114.10	
8 "	.63	.0210	108.10	105.10	
9 "	.64	.0213	117.10	115.10	
31 "	.78	.0260	Complete Distension.		

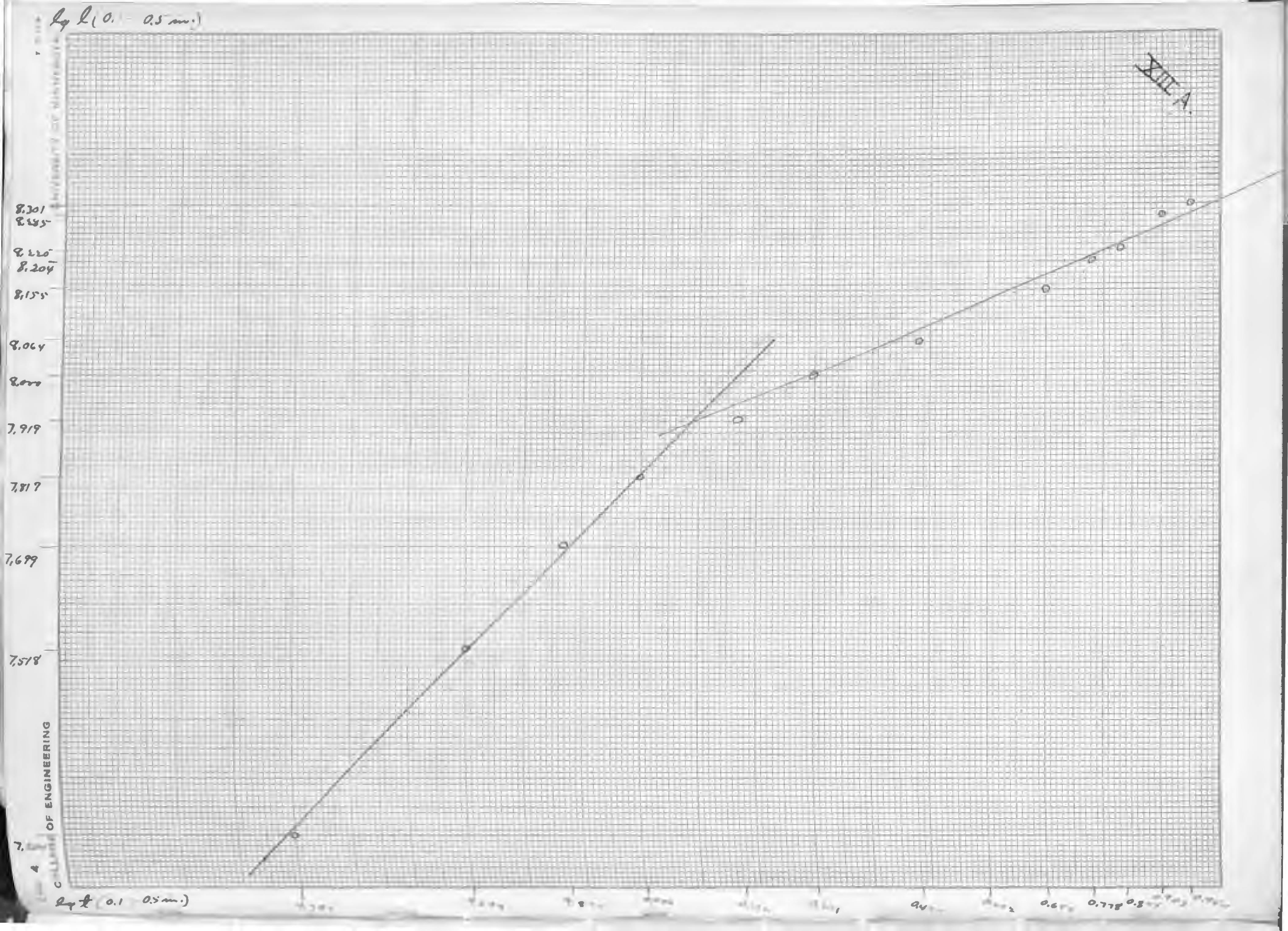

XIII A.
log l (0.1 – 0.5 m.)
log t (0.1 – 0.5 m.)
8.301
8.285
8.220
8.204
8.155
8.064
8.000
7.919
7.817
7.699
7.518
0.778
0.8
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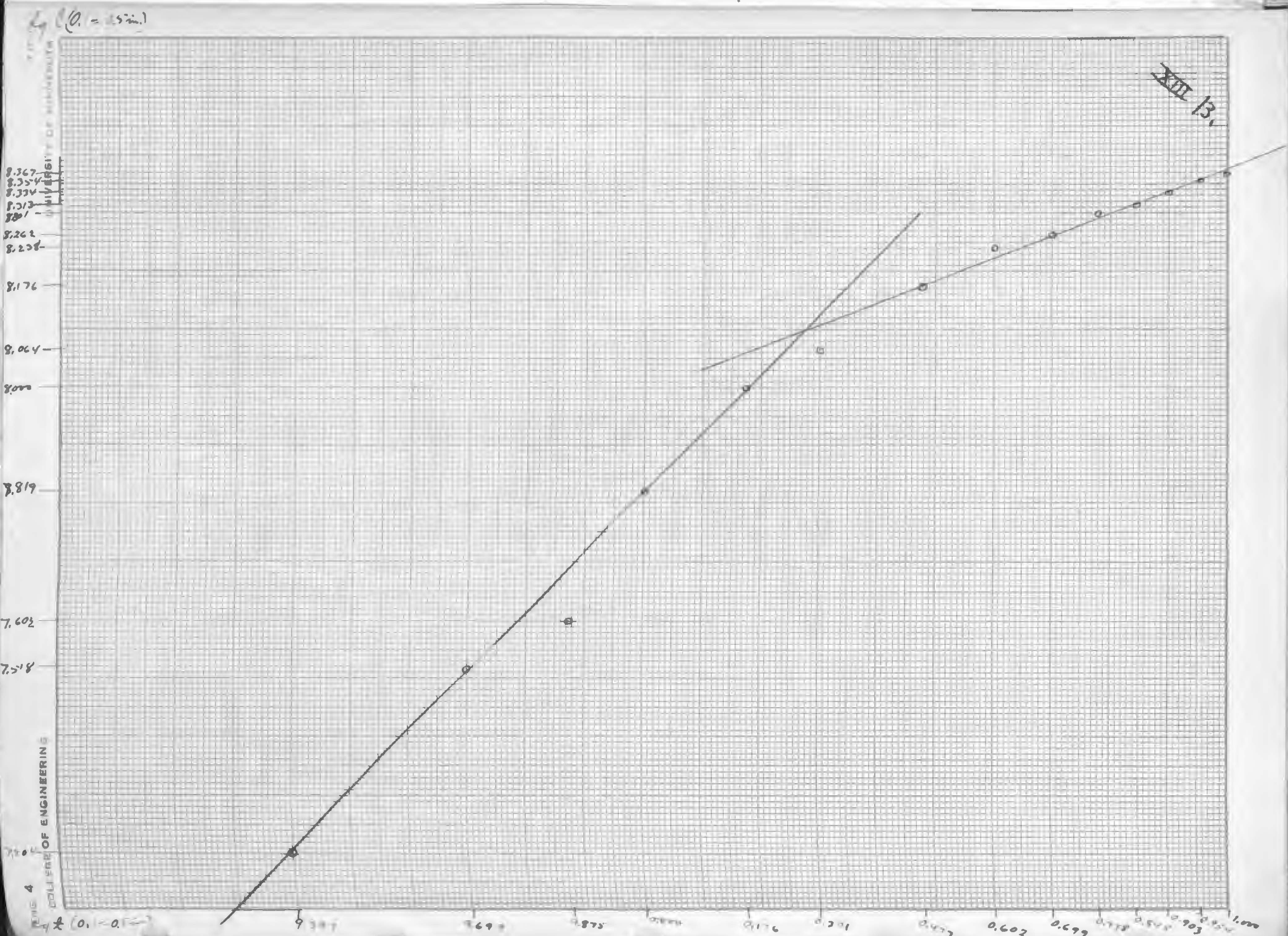
TABLE XIII A

Acetic Acid
Observations for one piece of rubber

Time minutes	Length cm.	Increase per cm. cm.
0.00	30.00	0.0000
.25	.05	.0016
.50	.10	.0033
.75	.15	.0050
1.00	.20	.0066
.50	.25	.0083
2.00	.30	.0100
.50	.32	.0106
3.00	.35	.0116
.50	.40	.0133
5.00	.43	.0143
6.00	.48	.0160
7.00	.50	.0166
8.00	.58	.0193
9.00	.60	.020
13.00	.65	.0216
37.00	.70	.0233
67.00	.70	.0233

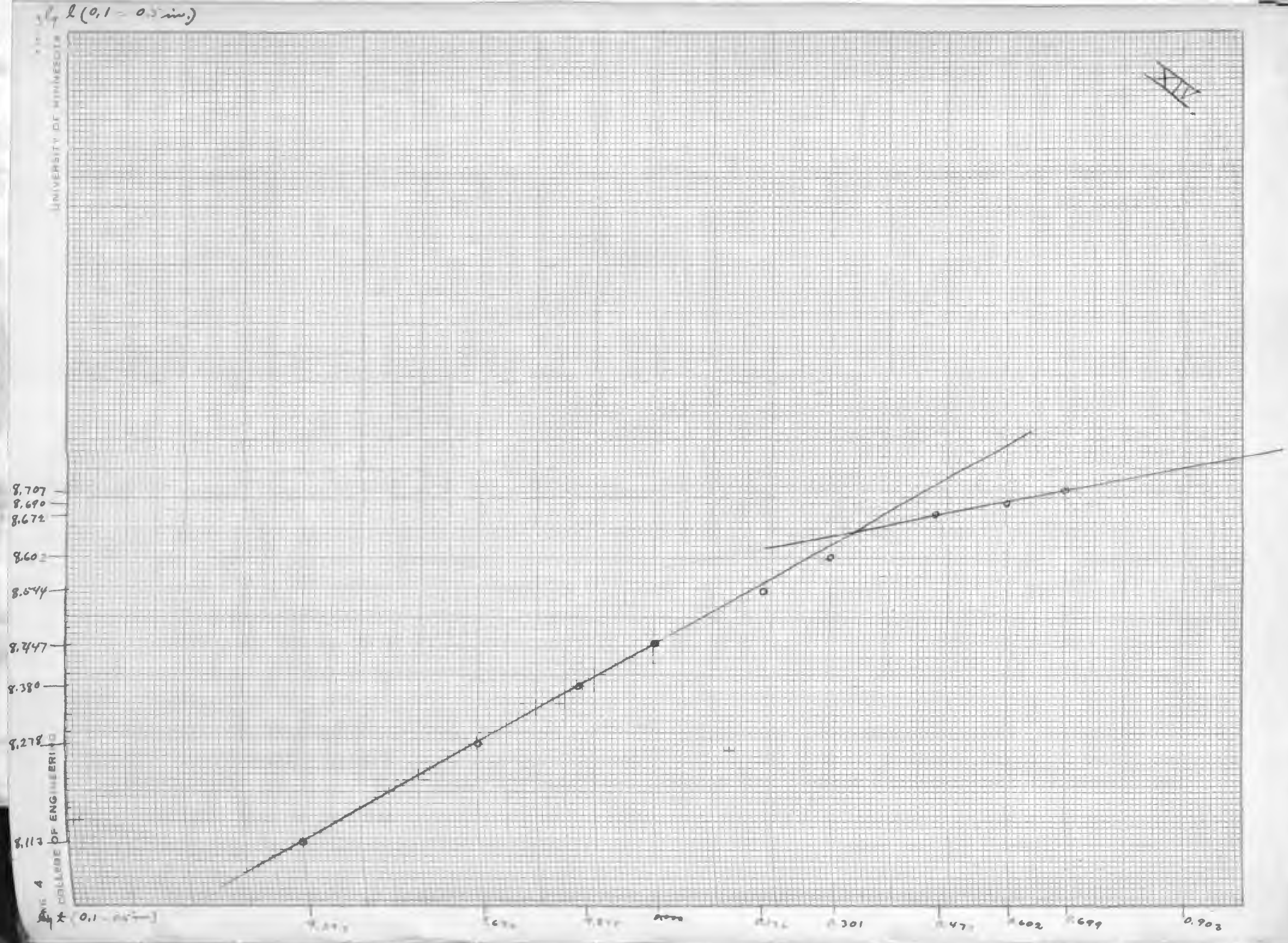


XIII B.
8.367
8.354
8.334
8.313
8.262
8.238
8.176
8.064
8.000
7.819
7.602
7.518
0.602
0.699
0.903
1.000

TABLE XIII B

Acetic Acid
Observations for one piece of rubber

Time minutes.	Length. cm.	Increase per cm. cm.
0.00	30.00	0.0000
.25	.05	.0016
.50	.10	.0033
.75	.12	.0040
1.00	.20	.0066
.25	.25	.0083
.50	.30	.0100
.75	.32	.0106
2.00	.35	.0116
.50	.40	.0133
3.00	.45	.0150
.50	.50	.0166
4.00	.52	.0173
5.00	.55	.0183
6.00	.60	.0200
7.00	.62	.0206
8.00	.65	.0216
9.00	.68	.0226
10.00	.70	.0233
15.00	.80	.0266
20.00	.85	.0283
25.00	.88	.0293
30.00	.88	.0293
35.00	.88	.0293



XIV
l (0.1 - 0.5 in.)
8.707
8.690
8.672
8.602
8.544
8.447
8.380
8.278
8.113
0.301
0.903
UNIVERSITY OF MINNESOTA
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TABLE XIV

Acetone
(Redistilled b.pt. 55-50)

An Average for three different pieces of rubber. The time for wetting t_x as calculated from graph XIX is 3 seconds.

Time	Increase in cm.	Increase per cm of rubber	t/l^2	$\frac{t - t_x}{l^2}$	t_x.
15 sec	0.40	0.013	881.00	710.00	
30 "	0.58	.019	831.	750.	1.73
45 "	0.72	.024	781.	730.	2.70
1 min	0.86	.028	765.	750.	2.94
15 "	0.97	.032	732.	712.	2.92
30 "	1.06	.035	726.	718.	3.70
45 "	1.13	.038	726.	710.	3.60
2 min	1.22	.040	750.	732.	2.72
15 "	1.28	.042	765.	750.	2.20
30 "	1.32	.044	774.	762.	2.04
45 "	1.35	.045		797.	
3 min	1.41	.047		805.	
15 "	1.43	.048			
30 "	1.45	.048			
45 "	1.47	.049			
4 min	1.49	.049	......	987.00	
15 "	1.51	.050			
30 "	1.52	.050			
45 "	1.53	.051			
5 min	1.54	.051	......	1370.00	
8 min	1.58	.0526	Complete Distension.		

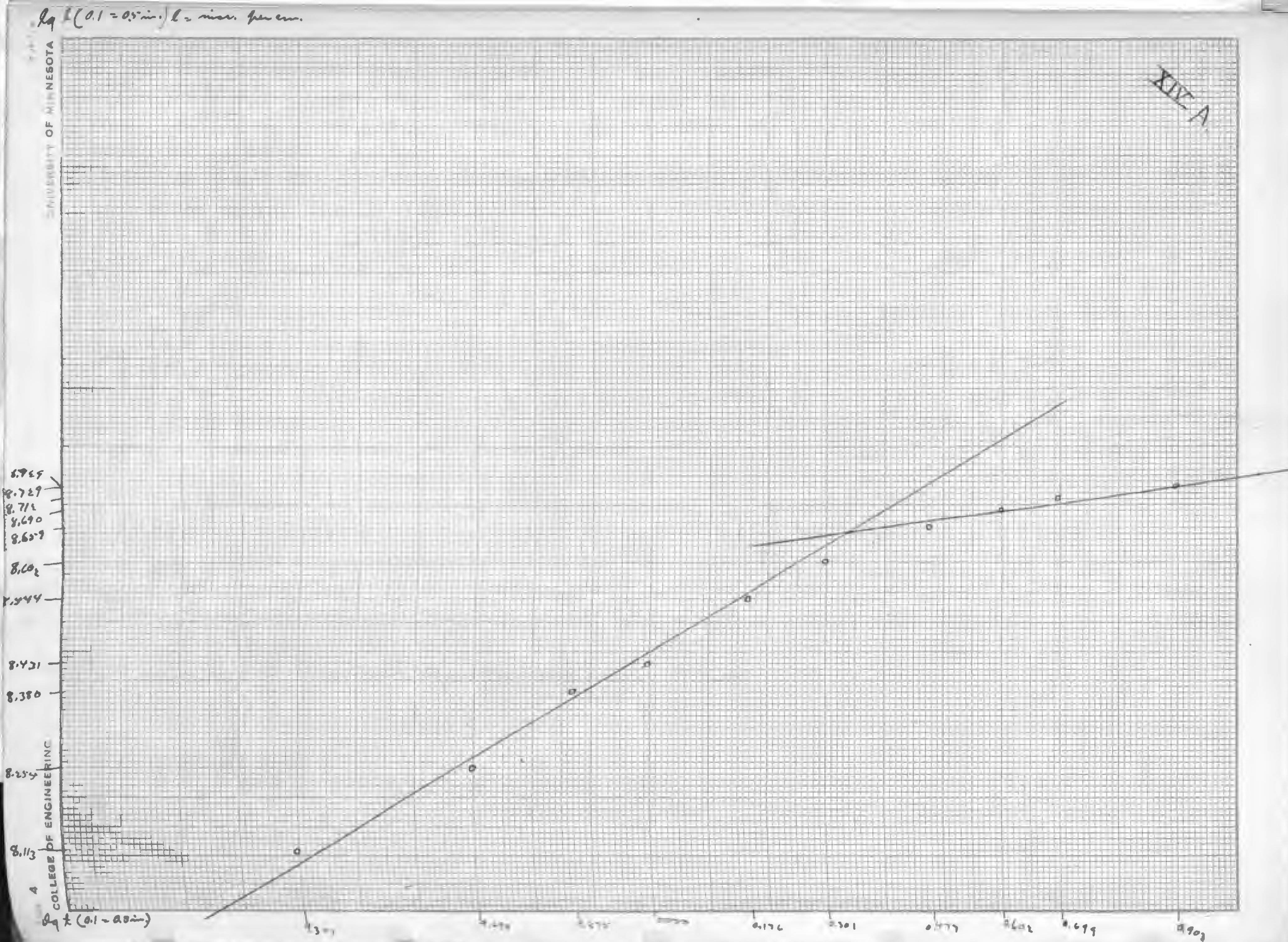

XIV A
UNIVERSITY OF MINNESOTA
COLLEGE OF ENGINEERING
8,929
8,729
8,712
8,690
8,659
8,602
8,380
8,254
8,113

TABLE XIV A

Acetone.
Observations for one piece of rubber.

Time minutes	Length cm.	Increase per cm. cm.
0.00	30.00	0.0000
.25	.40	.0133
.50	.55	.0183
.75	.72	.0240
1.00	.82	.0273
.25	.92	.0306
.50	31.05	.0350
.75	.10	.0366
2.00	.20	.0400
.25	.28	.0426
.50	.30	.0433
.75	.31	.0436
3.00	.37	.0456
.25	.40	.0466
.50	.40	.0466
.75	.43	.0476
4.00	.47	.0490
.25	.50	.0500
.50	.52	.0506
.75	.54	.0513
5.00	.55	.0516
.25	--	----
.50	.60	.0533
8.00	.61	.0536
10.00	.61	.0536
12.00	.61	.0536

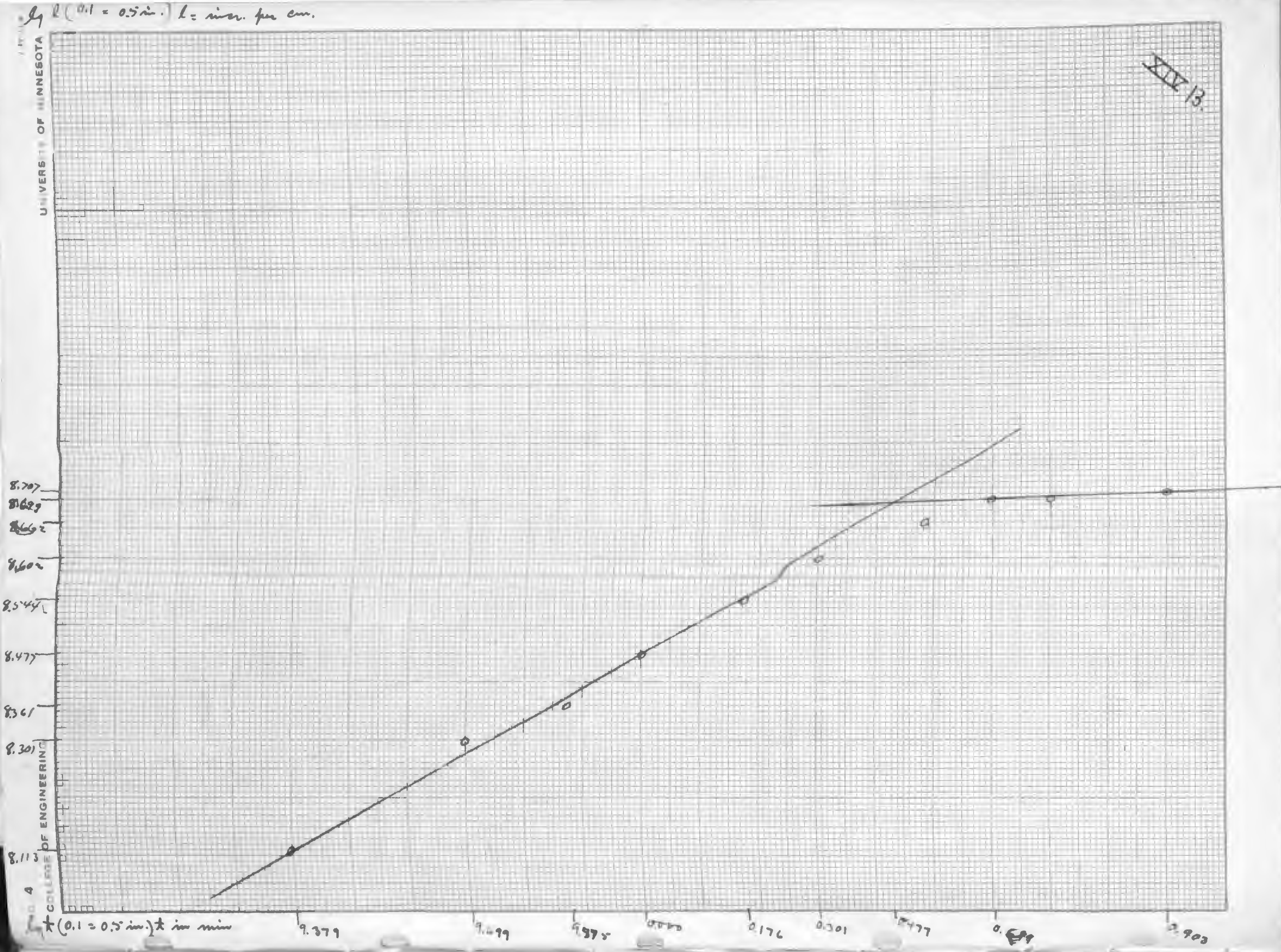
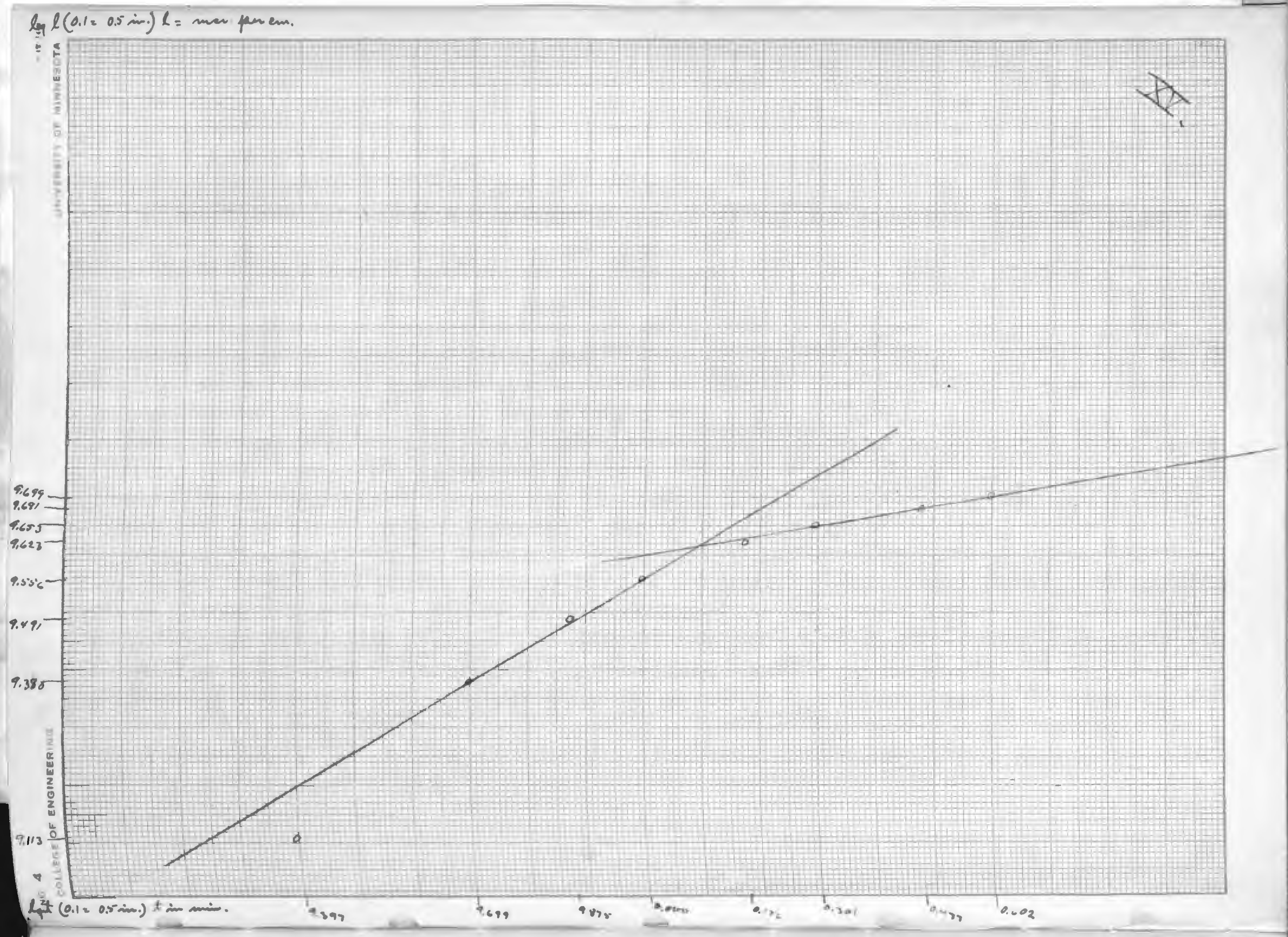

XIV/3.
log k (0.1 = 0.5 in.) k = incr. per cm.
log t (0.1 = 0.5 in.) t in min
UNIVERSITY OF MINNESOTA
COLLEGE OF ENGINEERING
8.707
8.629
8.602
8.544
8.477
8.361
8.301
8.113
9.379
9.699
9.875
0.000
0.176
0.301
0.477
0.903

TABLE XIV B

Acetone
Observations for one piece of rubber.

Time minutes	Length cm.	Increase per cm. cm.
0.00	30.00	0.0000
.25	.40	.0133
.50	.55	.0183
.75	.72	.0240
1.00	.82	.0273
.25	.92	.0306
.50	31.05	.0350
.75	.10	.0366
2.00	.20	.0400
.25	.28	.0426
.50	.30	.0433
.75	.31	.0436
3.00	.37	.0456
.25	.40	.0466
.50	.40	.0466
.75	.43	.0476
4.00	.47	.0490
.25	.50	.0500
.50	.52	.0506
.75	.54	.0513
5.00	.55	.0516
.25	--	----
.50	.60	.0533
8.00	.61	.0536
10.00	.61	.0536
12.00	.61	.0536



log l (0.1 = 0.5 in.) l = mer per cm.
XX
9.699
9.691
9.655
9.623
9.556
9.491
9.380
9.113
log t (0.1 = 0.5 in.) t in min.
9.397
9.699
9.875
0.000
0.176
0.301
0.477
0.602
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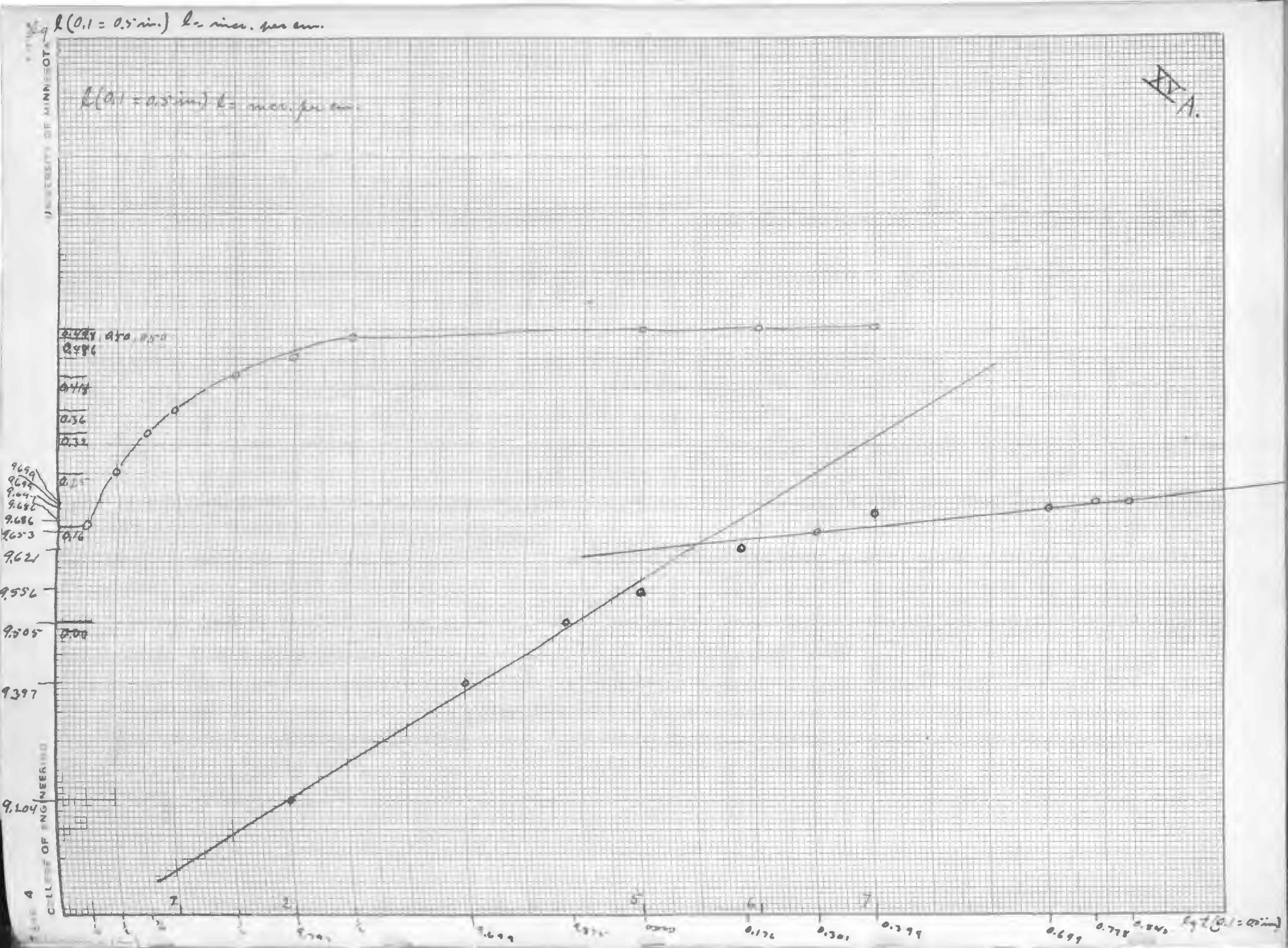
TABLE XV

Pentane.
(Commercial)

An average for three different pieces of rubber. The time for wetting t_x as calculated from graph XV is 8.3 seconds.

Time	Increase in cm.	Increase per cm of rubber	t/l^2	$\frac{t - t_x}{l^2}$	t_x.
15 sec	0.766	0.13	887.0	414.0	....
30 "	1.216	.24	520.8	382.	7.8
45 "	1.550	.31	468.7	385.	8.6
1 min	1.816	.36	463.2	402.	9.0
15 "	1.990	.40	468.8	418.	7.9
30 "	2.110	.42	510.2		
45 "	2.150	.43	567.0		
2 min	2.250	.45	566.0	544.	
15 "	2.310	.46	670.1		
30 "	2.340	.47	678.0		
45 "	2.380	.47	746.7		
3 min	2.410	.48			
15 "	2.430	.48	.....	747.	
30 "	2.450	.49		.	
45 "	2.480	.49			
4 min	2.490	.50	.....	927.	
6 min	2.490	.50	.....	927.	



XV A.
log l (0.1 = 0.5 in.) l = micr. per cm.
l (0.1 = 0.5 in.) l = micr. per cm.
9.699
9.694
9.686
9.653
9.621
9.556
9.505
9.397
9.204
0.16
0.25
0.32
0.36
0.486
0.50
0.00
2
5
6
7
0.176
0.301
0.399
0.699
0.778
0.845
log t (0.1 = 0.5 in.)
UNIVERSITY OF MINNESOTA
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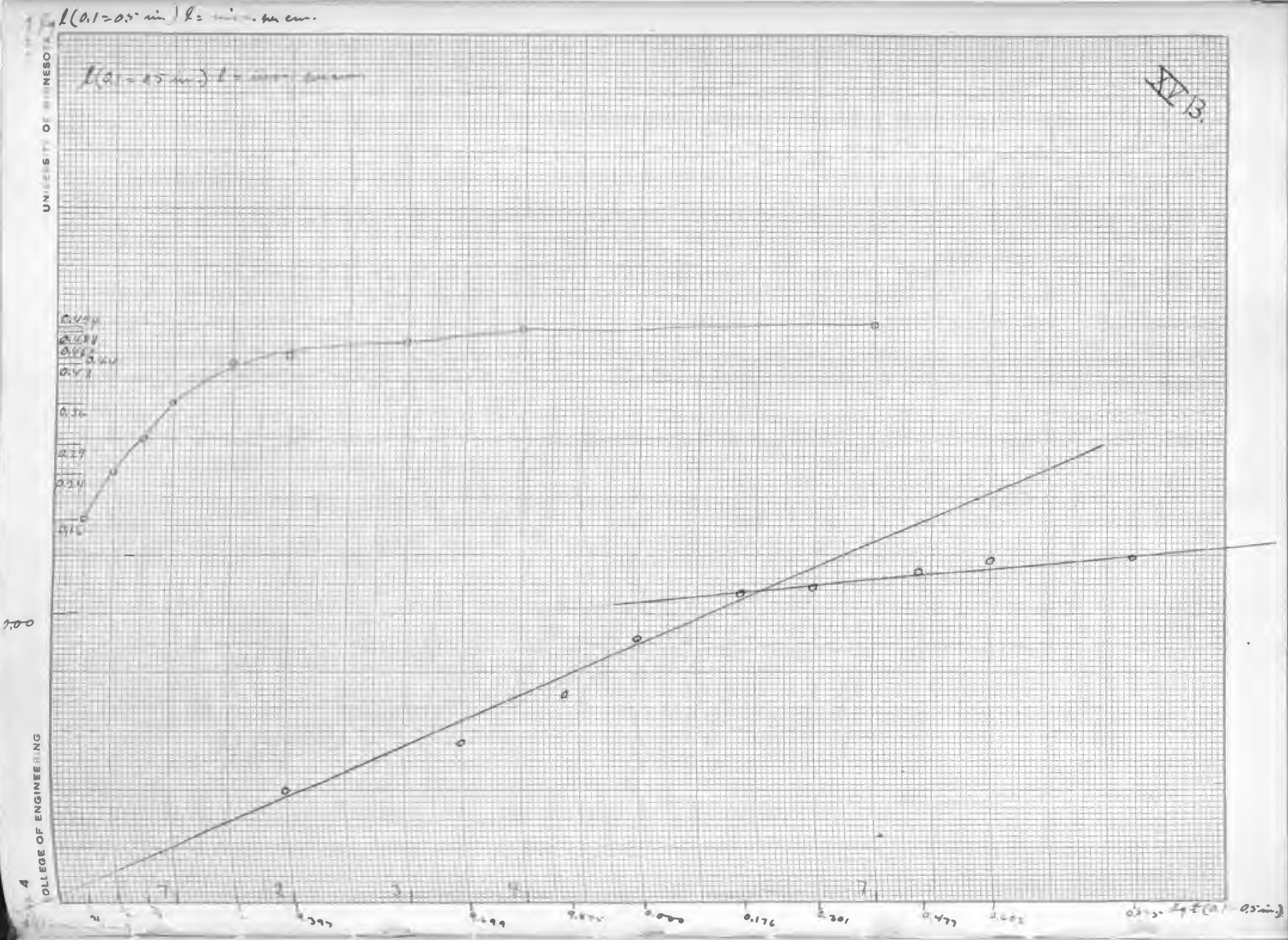
TABLE XV A

Pentane.
Observations from one piece of rubber

Time minutes	Length cm.	Increase per cm. cm.
0.00	5.00	0.00
.25	.80	.16
.50	6.25	.25
.75	.60	.32
1.00	.80	.36
.25	.97	.394
.50	7.09	.418
.75	.15	.43
2.00	.25	.45
.50	.43	.486
3.50	.43	.486
5.00	.49	.498
6.00	.50	.500
7.00	.50	.500


UNIVERSITY OF MINNESOTA
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XV 13.
0.176
0.301
0.477

TABLE XV B

Pentane.
Observations for one piece of rubber.

Time (minutes)	Length (cm.)	Increase per cm. (cm.)
0.00	5.00	0.00
.25	.80	.16
.50	6.20	.24
.75	.45	.29
1.00	.80	.36
.25	7.00	.40
.50	.15	.43
.75	--	--
2.00	.20	.44
.25	.28	.456
.50	.30	.46
.75	.32	.464
3.00	.35	.467
.25	--	--
.50	.40	.48
.75	.42	.484
4.00	.44	.488
7.00	.47	.494
8.00	.47	.494

TABLE XVI

Nitrobenzine.
(Redistilled b.Pt.20)

An average for two different pieces of rubber. The time for wetting t_x as calculated from graph XV is 19.7 sec.

Time	Increase in cm.	Increase per cm of rubber	t/l^2	$\frac{t - t_x}{l^2}$	t_x.
15 sec	0.65	0.022	3120.00	....	....
30 "	1.10	0.033	2750.00	918.0	21.5
45 "	1.35	0.045	2230.00	1240.0	20.0
1 min	1.52	0.050	2400.00	1600.0	22.2
15 "	1.80	0.060	2080.00		20.4

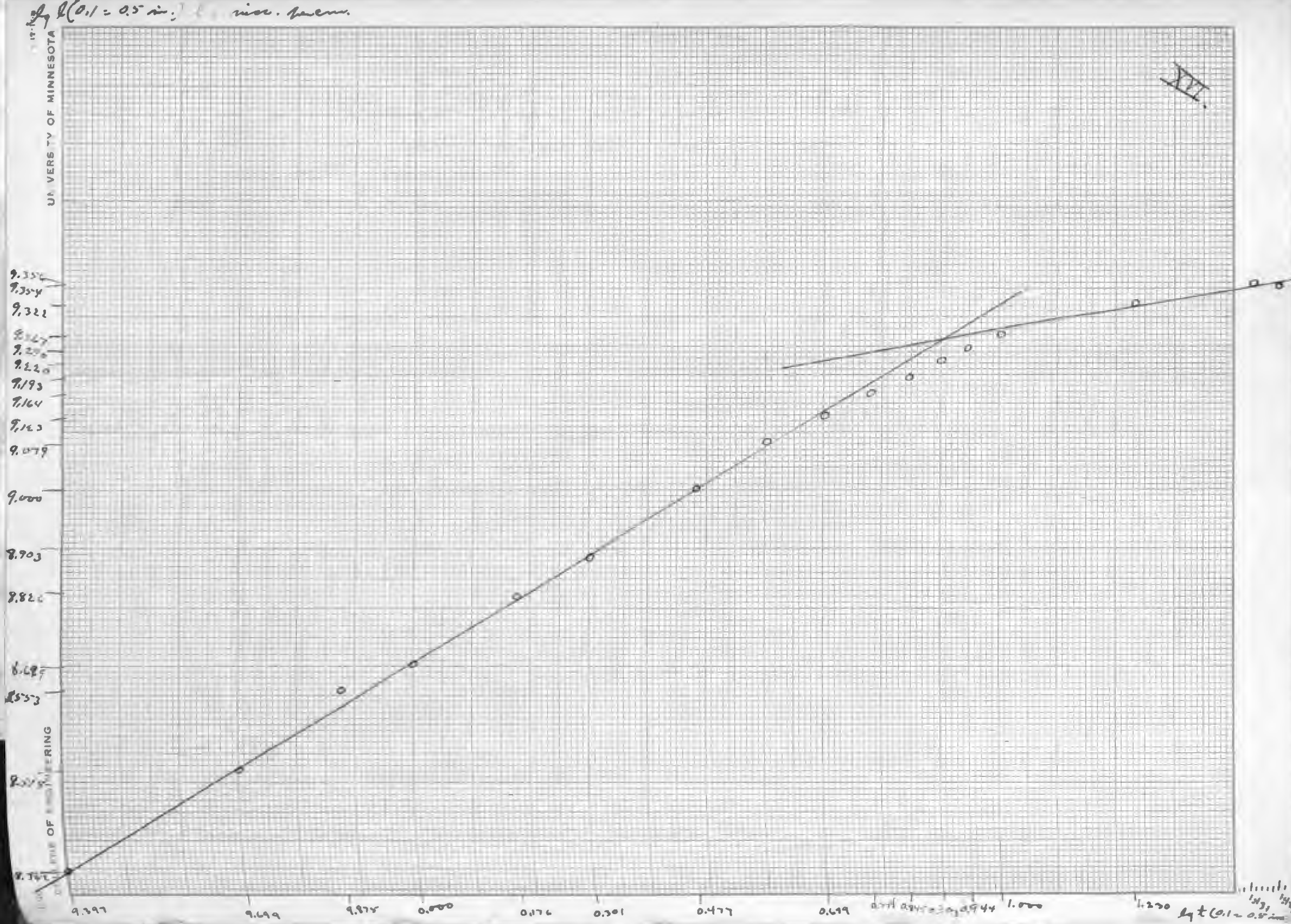
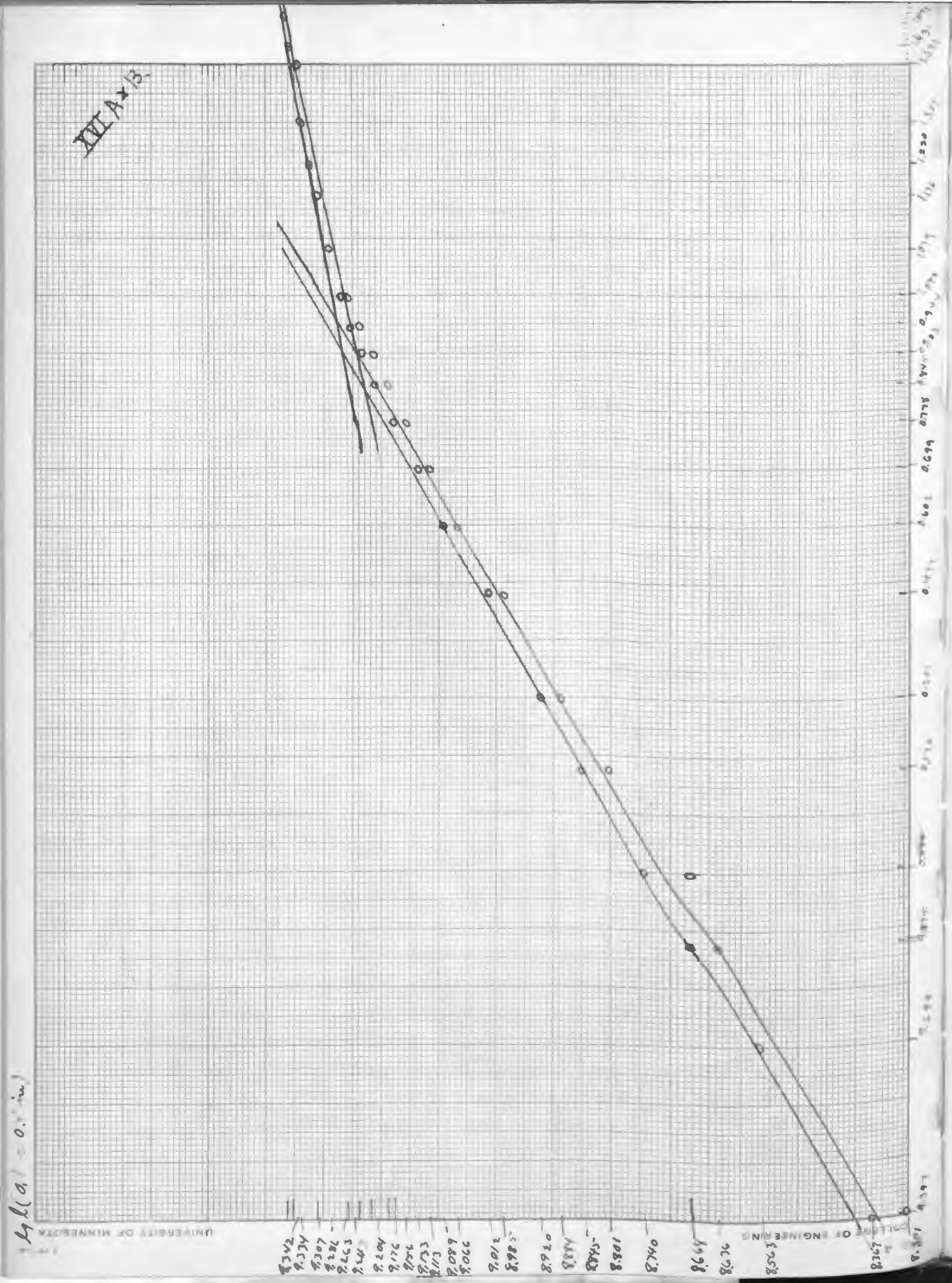

XVI.
UNIVERSITY OF MINNESOTA
9.356
9.354
9.322
9.267
9.220
9.193
9.164
9.079
9.000
8.903
8.820
9.398
9.699
9.875
0.000
0.176
0.301
0.477
0.699
1.000
1.230

TABLE XVI CONTINUED .

Nitrobenzine.

Time	Increase in cm.	Increase per cm. of rubber	t/l^2	$\frac{t - t_x}{l^2}$	t_x.
1 min 30 sec	2.00	0.067	2000.0	1560.0	20.2
45 "	2.20	.073	1960.0		18.8
2 min	2.40	.080	1870.0		18.0
15 "	2.57	.086	1820.0		16.6
30 "	2.75	.091	1810.0		
45 "	2.90	.097	1750.0		
3 min	3.00	.100	1800.0	1600.0	
15 "	3.15	.105	1730.0		
30 "	3.30	.110	1730.0		
45 "	3.45	.115	1610.0		
4 min	3.60	.120	1660.0	1530.0	
15 "	3.70	.123	1680.0		
30 "	3.80	.126	1700.0		
45 "	3.90	.130	1680.0		
5 min	4.00	.133	1650.0	1580.0	
15 "	4.10	.136	1700.0		
30 "	4.20	.140	1680.0		
45 "	4.30	.143	1700.0		
6 min	4.40	.146	1690.0	1590.0	
30 "	4.60	.153	1660.0		
7 min	4.70	.156	1720.0	1640.0	
30 "	4.82	.160	1750.0		
8 min	5.00	.166	1740.0	1670.0	
30 "	5.10	.170	1760.0		
9 min	5.22	.174	1780.0	1710.0	
30 "	5.45	.181	1690.0		
10 min	5.55	.185	1750.0	1690.0	
30 "	6.00	.200	1560.0		
17 min	6.30	.210			
27 min	6.72	.226			
30 min	6.80	.227			
45 hours	6.96	.232	(Complete Distension)		


XVI A × 13
9.342
9.334
9.307
9.204
9.176
9.066
9.012
8.920
8.801
8.740
8.664
8.636
8.563
8.367

Nitrobenzene
Observations for one piece (A)

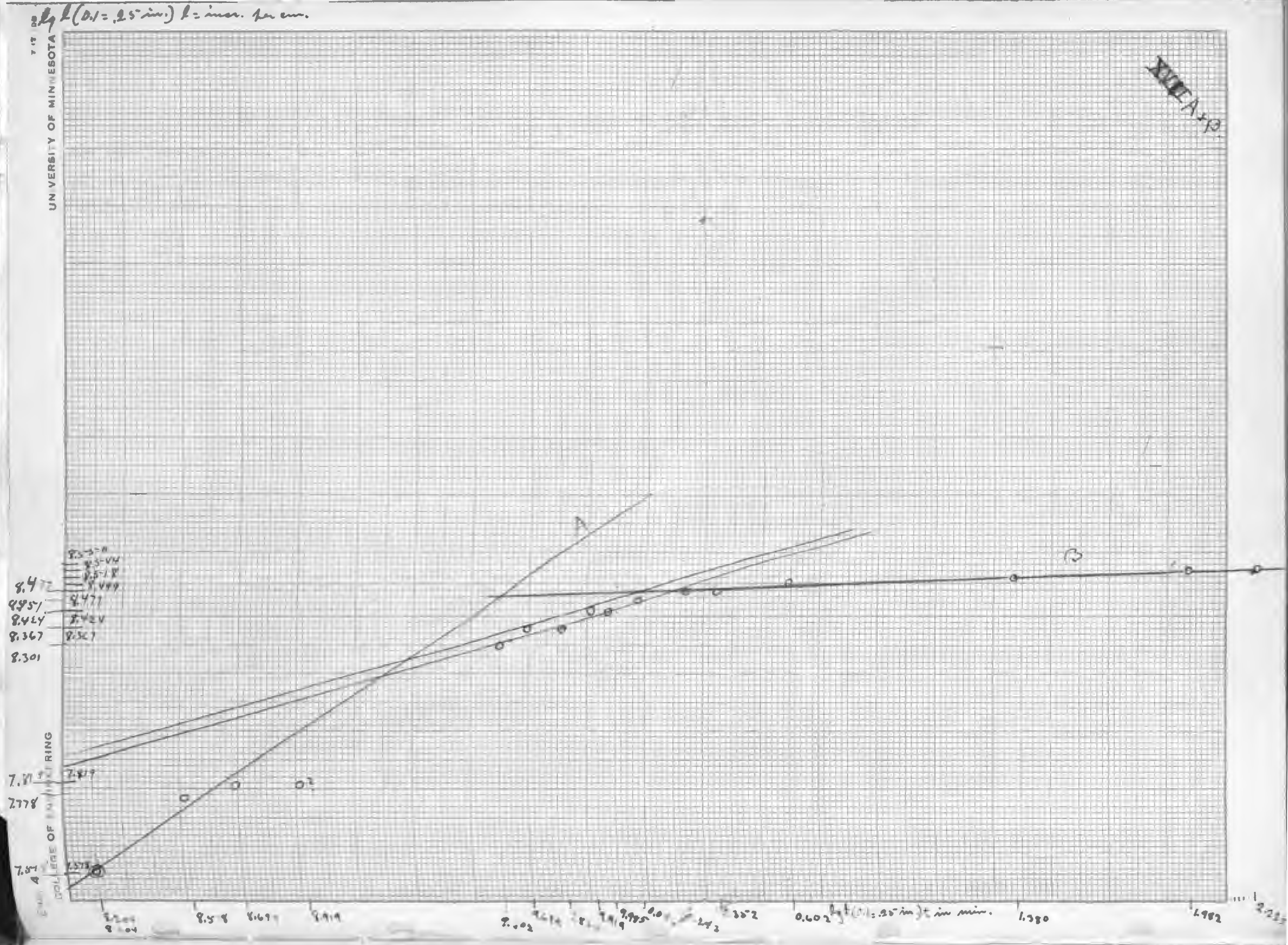
Time (minutes)	Length (cm.)	Increase per cm. (cm.)
0.00	30.00	0.0000
.25	.70	.0233
.50	31.10	.0366
.75	.30	.0433
1.00	.40	.0466
.25	---	----
.50	.90	.0633
.75	32.10	.0700
2.00	.30	.0766
.50	.70	.0900
3.00	.90	.0966
.50	33.20	.1066
4.00	.50	.1166
.50	.70	.1233
5 .00	.90	.1300
.50	34.10	.1366
6.00	.30	.1433
.50	.50	.1500
7.00	.60	.1533
.50	.75	.1586
8.00	.90	.1633
.50	35.00	.1666
9.00	.15	.1716
1 .50	.30	.1766
10.00	.40	.1800
.50	36.00	.2000
17.00	.30	.2100
27.00	.70	.2233
30.00	.90	.2300

Observations for one piece (B)

0.00	30.00	0.0000
.25	.60	.0200
.50	--	----

Observations for one piece (B) Continued.

Time (minutes)	Length (cm.)	Increase per cm. (cm.)
.75	31.40	.0466
1.00	.65	.0550
.25	.90	.0633
.50	32.10	.0700
.75	.30	.0766
2.00	.50	.0833
.25	.65	.0883
.50	.80	.0933
.75	33.00	.1000
3.00	.10	.1033
.25	.30	.1100
.50	.40	.1133
.75	.60	.1200
4.00	.70	.1233
.25	.80	.1266
.50	.90	.1300
.75	34.00	.1333
5.00	.10	.1366
.25	.20	.1400
.50	.30	.1433
.75	.40	.1466
6.00	.50	.1500
.50	.70	.1566
7.00	.80	.1600
.50	.90	.1633
8.00	35.10	.1700
.50	.20	.1733
9.00	.30	.1766
10.00	.50	.1833
11.00	.65	.1883
12.00	.80	.1933
13.00	.90	.1966
14.00	36.00	.2000
15.00	.10	.2033
20.00	.50	.2166
25.00	.60	.2200
30.00	.70	.2230
45 hours.	.97	.2320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A
B
1.380
1.982

TABLE XVII

Amyl Alcohol.
(sp.gr. 0.81 at 21.5 .b.pt. 127 - 132 C.)

Observations for the first piece of rubber (A)

Time	Increase in cm.	Increase per cm.	t/l^2	$\frac{t - t_x}{l^2}$	t_x (min)	t_x (sec
1 min	0.10	0.0033	550.10	318.10	....	.....
2 "	.18	.0060	333.10	264.10	0.56	33.6
3 "	.20	.0066	414.10	360.10	0.91	54.6
24 "	.60	.0200	360.10	356.10	0.60	36.0
40 "	.70	.0233	477.10	448.10	0.20	18.0
58 "	.80	.0266	514.10	486.10	0.10	6.0
75 "	.85	.0283	563.10	637.10	(-0.3)	
105 "	.90	.0300	700.10	700.10	(-0.3)	.....

Observations for the second piece of rubber (B).

Time	Increase in cm.	Increase per cm.	t/l^2	$\frac{t - t_x}{l^2}$	t_x (min)	t_x (sec.)
1 min	0.10	0.0033	550.10	354.10		
5 "	.20	.0066	690.10	648.10	-0.3	
30 "	.78	.0233	357.10	300.10	0.47	28.5
50 "	.8	.0266	427.10	393.10	0.20	12.0
135 "	.9	.0300	900.10	1111.10	-0.7	
4 hours	.95	0.0316				
1 day	.99	.0330				
4 "	1.05	.0350				
7 "	1.065	.0355				
11 "	1.10	.0366				
12 "	1.10	.0366				

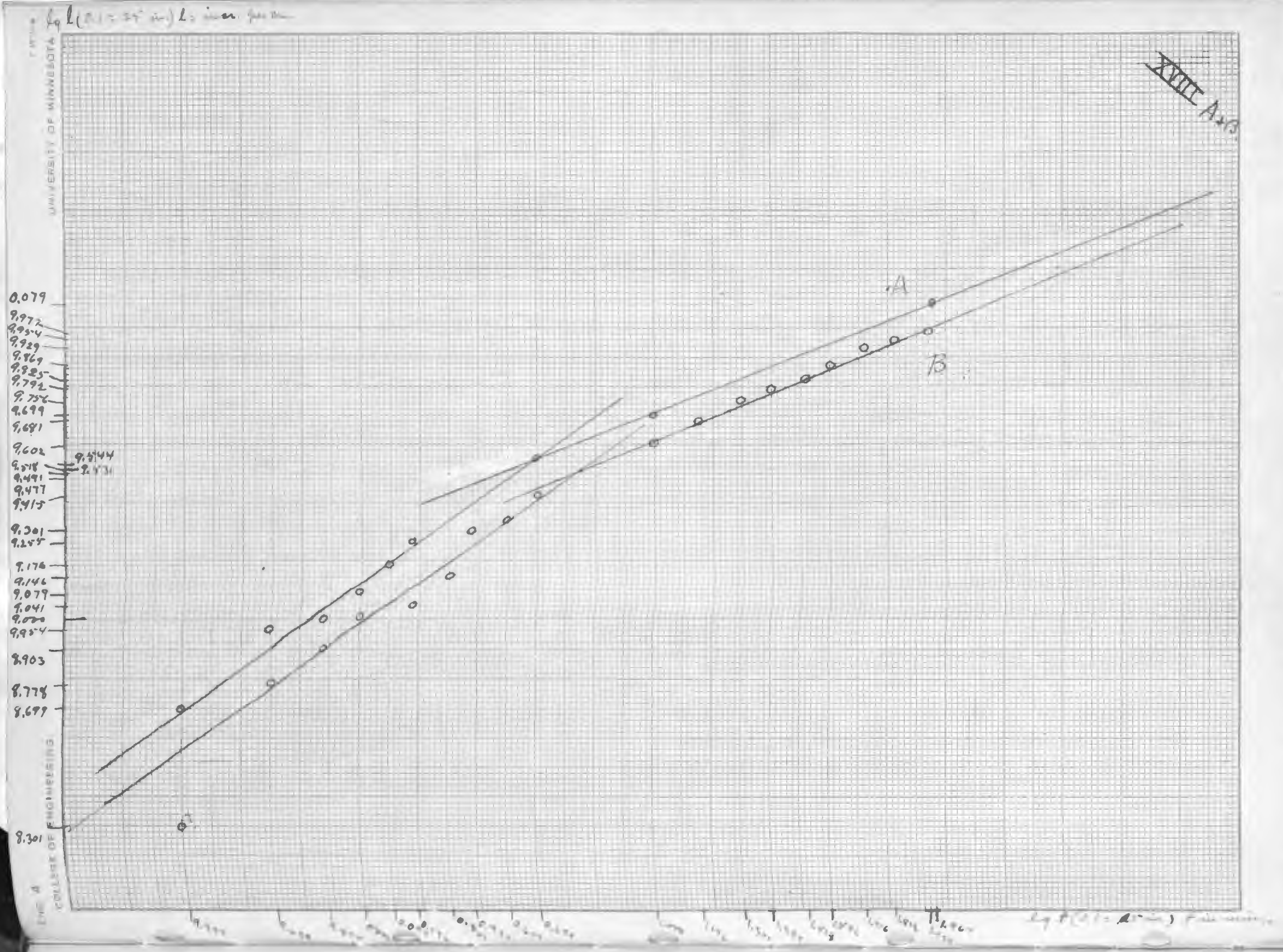
XVIII A+B
A
B
0,079
9,972
9,954
9,929
9,869
9,825
9,792
9,756
9,699
9,681
9,602
9,544
9,518
9,491
9,477
9,415
9,301
9,255
9,176
9,146
9,079
9,041
9,000
8,954
8,903
8,778
8,699
8,301
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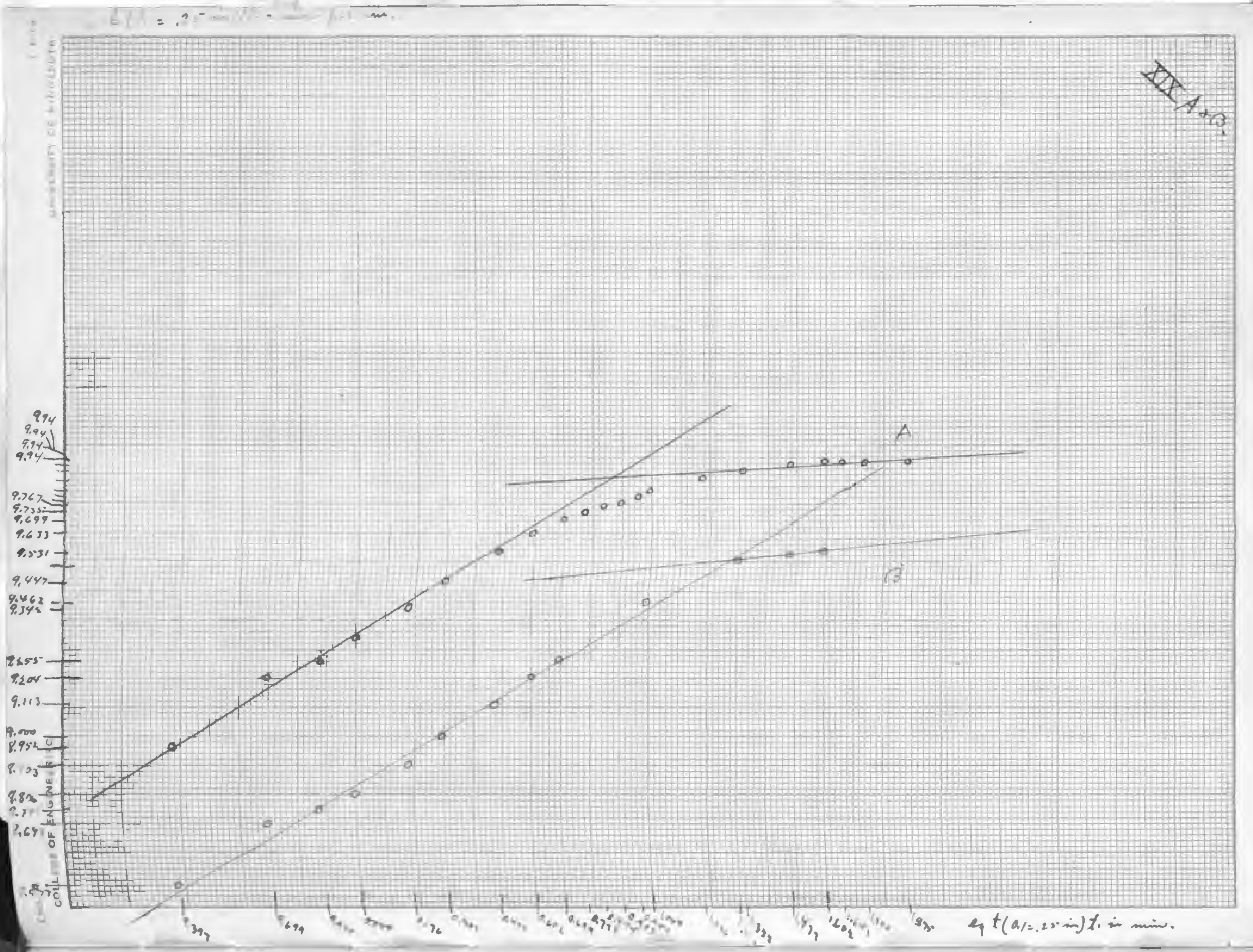
TABLE XVIII.

Methyl Alcohol.

Observations for two different pieces of rubber, in a gas burette.

Time	Increase in cm (A)	t/1	Increase in cm. (B)	t/1
15 sec.	0.05	6000	0.02	3750.0
30 "	0.09	3700	.06	833.0
45 "	0.10	4500	.08	703.0
1 min	0.12	4170	.10	600.0
15 "	0.15	3340		
30 "	0.18	2790	.11	745.0
45 "				
2 min			.14	613.0
3 "			.20	450.0
4 "			.22	487.0
5 "	0.35	2460	.26	445.0
10 "	0.50	2400	.40	375.0
15 "			.48	390.0
20 "			.57	370.0
25 "			.63	378.0
33 "			.70	405.0
39.5 min			.74	435.0
52 min			.85	433.0
65 "			.90	482.0
87 "			.95	514.0
92 "	1.20	....	....	....
23 hours	2.45			
48 "	3.02	3170	....	....



XIX A + B.
A
B
9.94
9.94
9.94
9.94
9.767
9.735
9.699
9.633
9.531
9.447
9.462
9.342
9.255
9.204
9.113
9.000
8.952
8.103
8.826
8.671
log t (a/=.25 in) t. in min.

TABLE XIX

Using a rubber band instead of dental rubber.
(5 x 1.95 x 0.01 cm.)
(A)
Carbondisulphite.

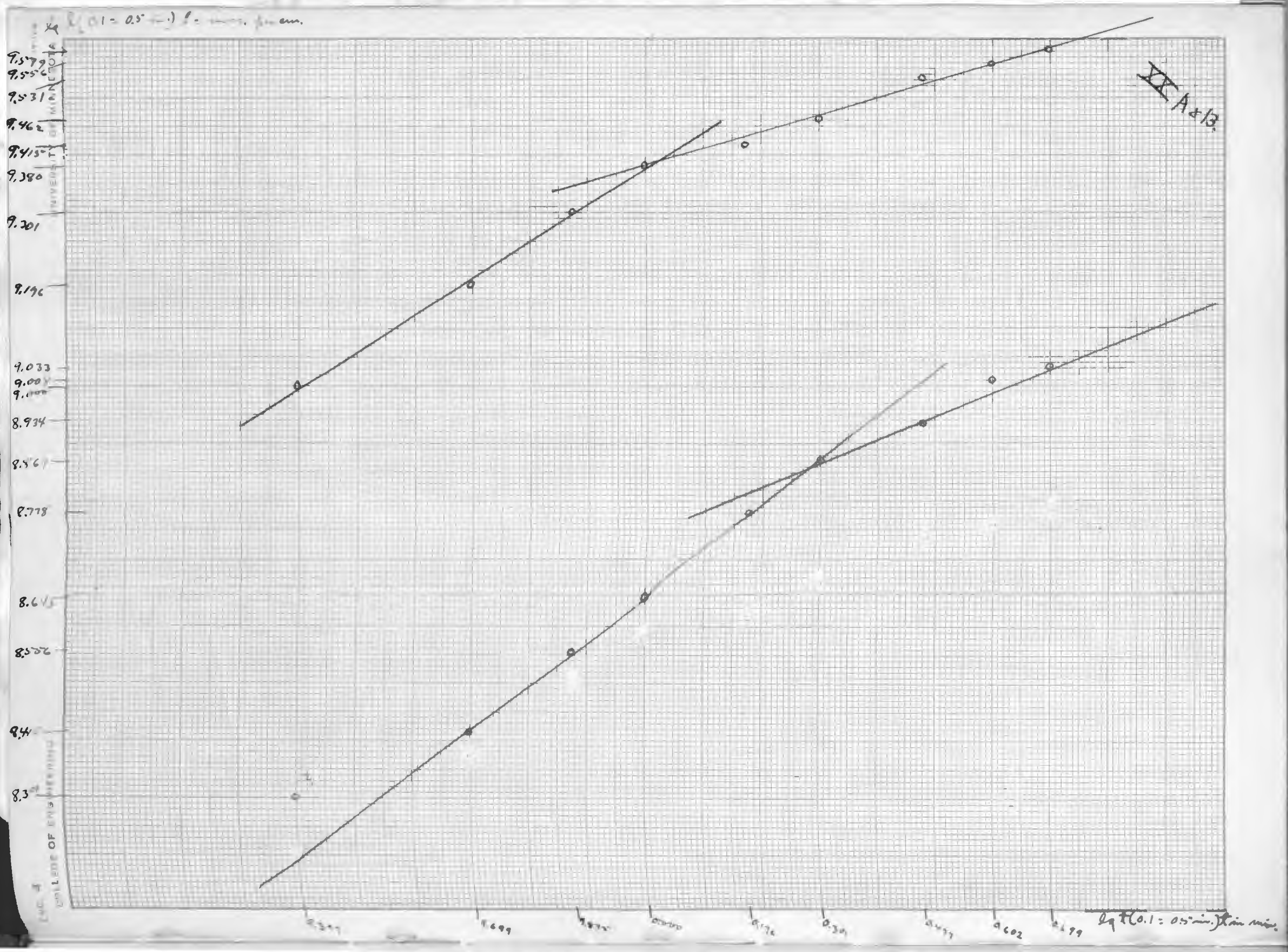
Time	Increase in cm.	Increase per cm.	$t/1^2$	Time	Increase in cm.	Increase per cm.	$t/1^2$
15 sec	0.45	0.09	1850	5½ min	2.72	0.544	1013
30 "	.70	.16	1170	15 sec	2.80	.56	
45 "	.90	.18	1390	30 "	2.85	.57	
1 min	1.10	.22	1240	45 "	2.90	.58	
15 "	.25	.25	1200	6 min	2.93	.586	1050
30 "	.40	.28	1150	30 "	3.02	.604	
45 "	.60	.32	1040	7 min	3.10	.62	1090
2 min	.70	.34	1040	30 "	3.15	.621	
15 "	.80	.36		8 min	3.20	.64	
30 "	.95	.39		9 min	3.35	.67	
45 "	2.05	.41		10 "	3.45	.69	
3 min	.15	.43	973	15 "	3.80	.76	
15 "	.23	.446		20 "			
30 "	.32	.464		21 "	4.07	.816	
45 "	.40	.48		30 "	4.23	.846	
4 min	.50	.50	960	40 "	4.33	.866	
15 "	.55	.51		45 "	4.35	.87	
30 "	.60	.52		55 "	4.40	.88	
45 "	.68	.534		75 "	4.40	.88	

TABLE XIX CONTINUED

Time	Increase in cm.	Increase per cm. (B)	t/l^2
15 sec	0.15	0.03	1660
30 "	.25	.05	1200
45 "	.28	.056	1290
1 min	.32	.064	1460
15 "	.374	.074	1360
30 "	.40	.080	1400
45 "	.45	.090	1300
2 min	.50	.100	1200
15 "	.55	.11	
30 "	.58	.116	1110
45 "	.62	.124	
3 min	.65	.130	1060
15 "	...	....	....
30 "	.70	.140	
45 "	...	....	....
4 min	.78	.156	980
15 "	.....	....	....
30 "	.85		
45 "	.....	....	....
5 min	.90	.180	920
15 "	.....	....	....
30 "			
45 "			
6 min	1.00		
7 "			
8 "	1.28		
9 "	.37		
10 "	.45	.290	710
15 "	.75		
20 "	.90	.380	830
21 "			
30 "	2.07	.414	1050
40 "	2.13	.426	1320

VI. MIXED LIQUIDS EXPERIMENTS.

The following tables show results that were obtained when caoutchouc was immersed in mixed liquids. When the liquids chosen are such that the one is imbibed very rapidly and the other is practically inactive we are really studying the action of the former going on at a lesser rate than when its concentration is one hundred per cent. At complete distension, the capillary action has decreased to zero, and the solubility process is under way. This is shown by the fact that if the results obtained for complete distention are substituted in $\frac{C_1}{C_2} = K$, the equation applied in calculating distribution coefficients, K is a constant. C_1 and C_2 are both expressed in volume concentration. C_1 is obtained as follows: To the increase of length per centimeter at complete distention add one centimeter which of course is the original length of rubber, which gives this amount of increase of length. Cube this sum and from this cube subtract one. The result, then, is the volume increase per unit volume of rubber, due to the imbibed liquid, This result, that is the volume increase due to the imbibed liquid, divided by the total volume of


XX A & B.
9.579
9.556
9.531
9.462
9.415
9.380
9.301
9.196
9.033
8.934
8.561
8.778
8.615
8.556
8.4
8.3
8.699
0.000
0.176
0.301
0.477
0.602
0.699
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the rubber and the imbibed liquid gives, when multiplied by 100, the per cent of the volume of the imbibed rubber and liquid which is due to the liquid itself.

TABLE XX

Mixtures of chloroform and absolute alcohol.

	60% Chloroform			30% Chloroform		
Time	Increase in cm. (A)	Increase per cm.	t/l^2	Increase in cm. (B)	Increase per cm.	t/l^2
15 sec	0.50	0.10	1500	0.10	0.020	37500
30 "	.75	.15	13333	.13	.026	44000
45 "	1.00	.20	1125	.18	.036	34000
1 min	.20	.24	1080	.22	.044	20900
15 "	.25	.25	1200	.27	.054	25600
30 "	.30	.26	1333	.30	.060	25000
45 "	.40	.28	1337	.35	.070	21400
2 min	.48	.29	1420	.37	.074	21900
15 "	.53	.30	1500	.39	.078	21100
30 "	.60	.32	1460	.40	.080	23400
45 "	.67	.33	1510			
3 min	.73	.34	1540	.43	.086	24400
15 "						
30 "	.75	.35	1680	.48	.096	22800
45 "	.78	.35				
4 min	.82	.36	1840	.51	.102	23100
15 "	.85	.37				
30 "	.87	.37		.53	.106	24100
5 min	.89	.38		.54	.108	25800
6 min						
30 "	.90	.38				
12 min				.54	.108	25800

Distribution ratio is 1.206. Distribution ratio is 1.121

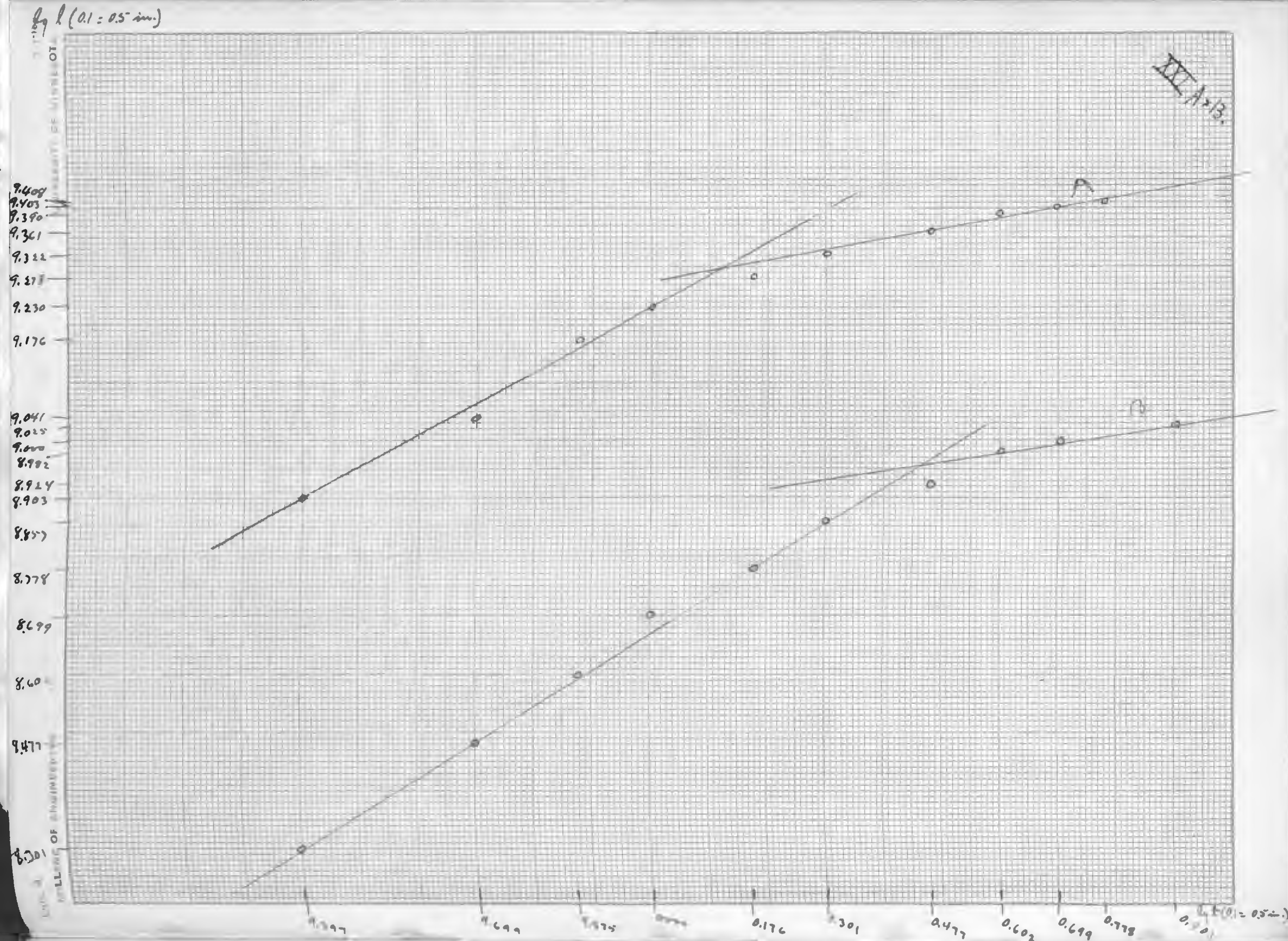

log l (0.1 : 0.5 in.)
XXI A + B.
A
B
9.408
9.403
9.390
9.361
9.322
9.230
9.176
9.041
9.025
9.000
8.982
8.924
8.903
8.778
8.699
0.176
0.477
0.602
0.699
0.778

TABLE XXI.

Mixtures of Chloroform and methyl alcohol.

Time	60% Chloroform			30% Chloroform		
	Increase in cm. (A)	Increase per cm.	t/l^2	Increase in cm. (B)	Increase per cm.	t/l^2
15 sec	0.40	0.08	2340	0.10	0.02	37500
30 "	.55	.11	2470	.15	.03	33333
45 "	.75	.15	2000	.20	.04	28100
1 min	.85	.17	2060	.25	.05	24000
15 "				.28	.056	23500
30 "	.95	.19	2050	.30	.060	25000
45 "	1.00	.20	2250	.32	.066	31000
2 min	.05	.21	2380	.36	.072	23000
15 "	.08	.216	2560	.38	.076	23000
30 "	.10	.220	2700	.39	.078	24000
45 "	.13	.226		.40	.080	25700
3 min	.15	.230		.42	.084	25500
15 "	.18	.236		.44	.084	25400
30 "	.19	.238		.45	.090	25900
45 "	.21	.242		.47	.094	25400
4 min	.23	.246		.48	.096	26000
15 "	.24	.248		.49	.098	26500
30 "	.25	.250				
45 "	.26	.252				
5 min				.50	.100	30000
15 "	.27	.254				
30 "						
45 "						
6 min	.28	.256				
7 min	.28	.256				
8 min	.28	.256		.53	.106	
10 min	.28	.256		.53	.106	

Distribution ratio is 0.996 Distribution ratio is 1.103

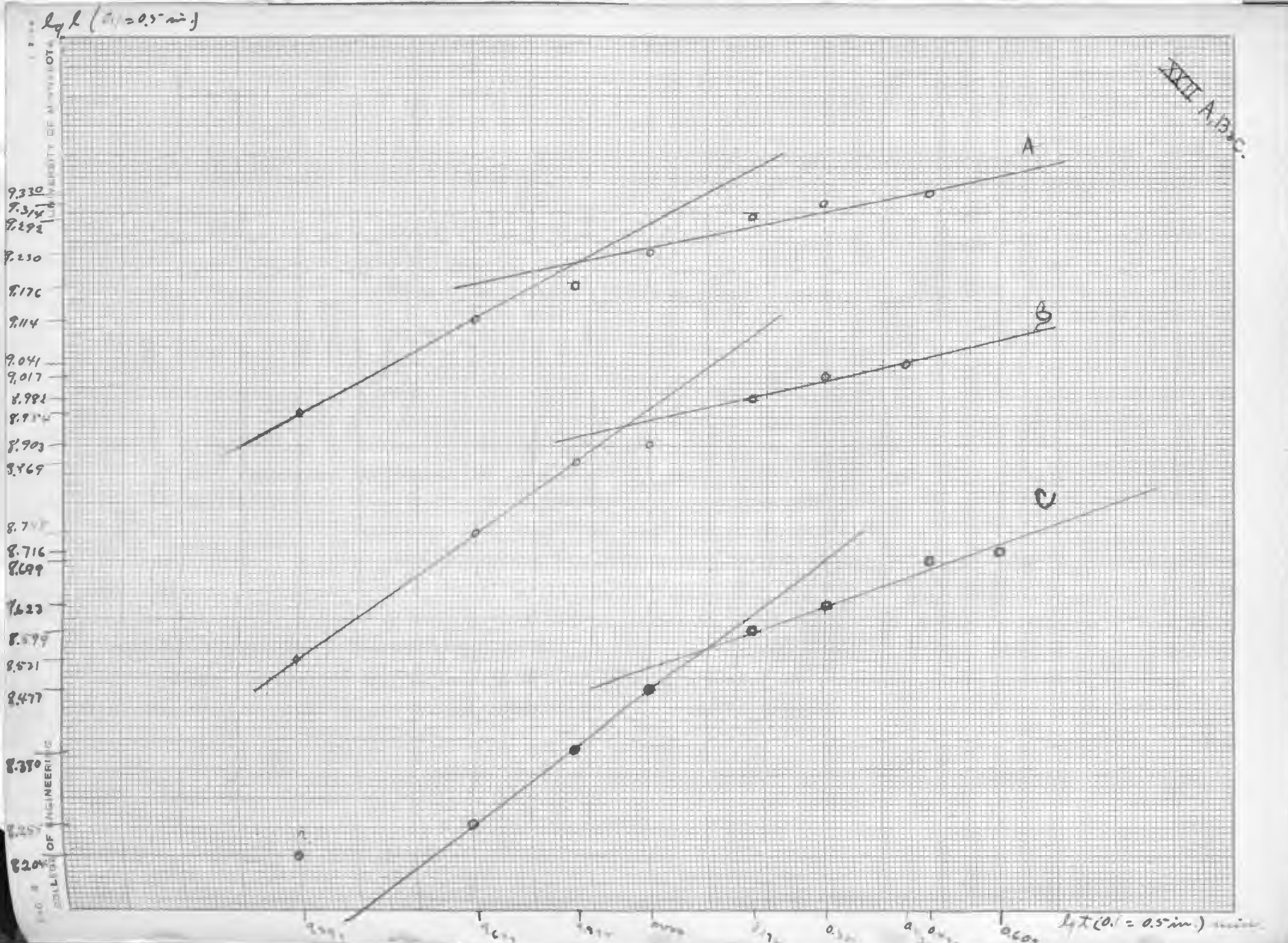

XXII A, B & C.
log l (0.1 = 0.5 in.)
A
B
C
9.330
9.314
9.292
9.230
9.176
9.114
9.041
9.017
8.981
8.903
8.716
8.699
8.623
8.599
8.571
8.477
8.350
8.204
0.602
log t (0.1 = 0.5 in.) min.

TABLE XXII.

Mixtures of absolute ether and methyl alcohol.

	80% Ether (A)			60% Ether (B)		
Time	Increase in cm.	Increase per cm.	t/l^2	Increase in cm.	Increase per cm.	t/l^2
15 sec	0.45	0.09	1850	0.17	0.034	12800
30 "	.65	.13	1780	.28	.056	9580
45 "	.75	.15	2000	.37	.074	8260
1 min	.85	.17	2150	.40	.080	9370
15 "	.936	.186	2180	.45	.090	9270
30 "	.98	.196	2280	.48	.096	9690
45 "	1.00	.201	2620	.50	.100	10500
2 min	.03	.206	2820	.52	.104	11100
15 "	.04	.208	3130	.50	.116	12100
30 "	.05	.210	3410	.54	.108	12900
45 "	.06	.212	3680	.55	.110	14900
3 min	.07	.214	3940	.55	.110	14900
30 "						
9 min	.07	.214	3940	....	....	....

Distribution ratio is 0.55. Distribution ratio is 0.44

30% Ether. (C)

Time	Increase in cm.	Increase per cm.	t/l^2
15 sec.	0.07	0.016	58600
30 "	.09	.018	92500
45 "	.12	.024	78200
1 min	.15	.030	66700
15 "	.18	.036	58000
30 "	.19	.038	63200
45 "	.20	.040	65600
2 min	.21	.042	68200
15 "	.22	.044	70000
30 "	.23	.046	
45 "	.24	.048	
3 min	.25	.050	
30 "	.25	.050	
9 min	....	....	....

Distribution ratio is 0.46.

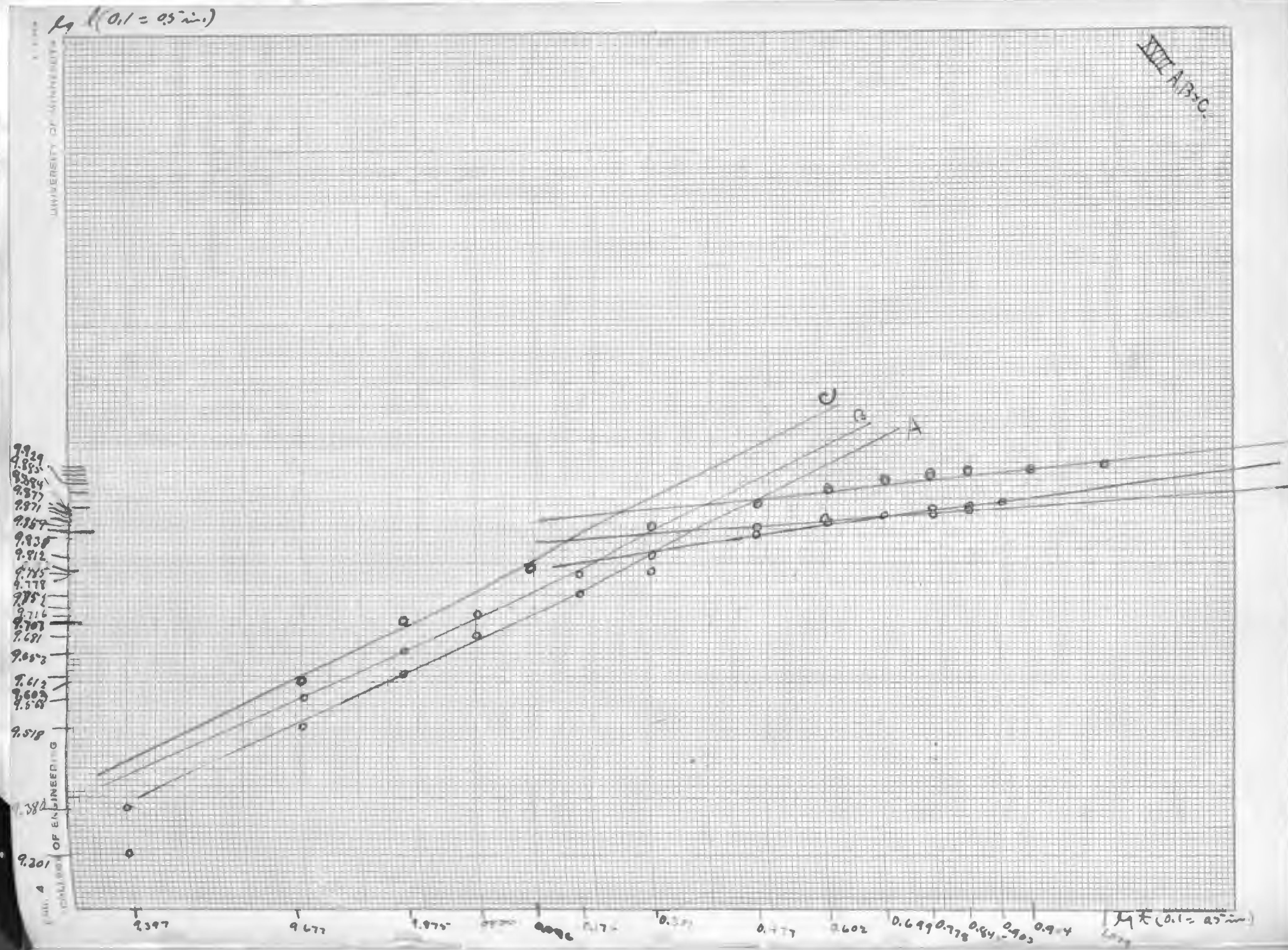

XVIII A,B,C.
(0.1 = 0.5 in.)
A
B
C
9.929
9.871
9.859
9.836
9.812
9.778
9.716
9.691
9.612
9.518
9.380
9.201
9.397
9.677
0.477
0.602
0.699
0.778
0.903
(0.1 = 0.5 in.)

TABLE XXIII

Fifty per cent mixtures.

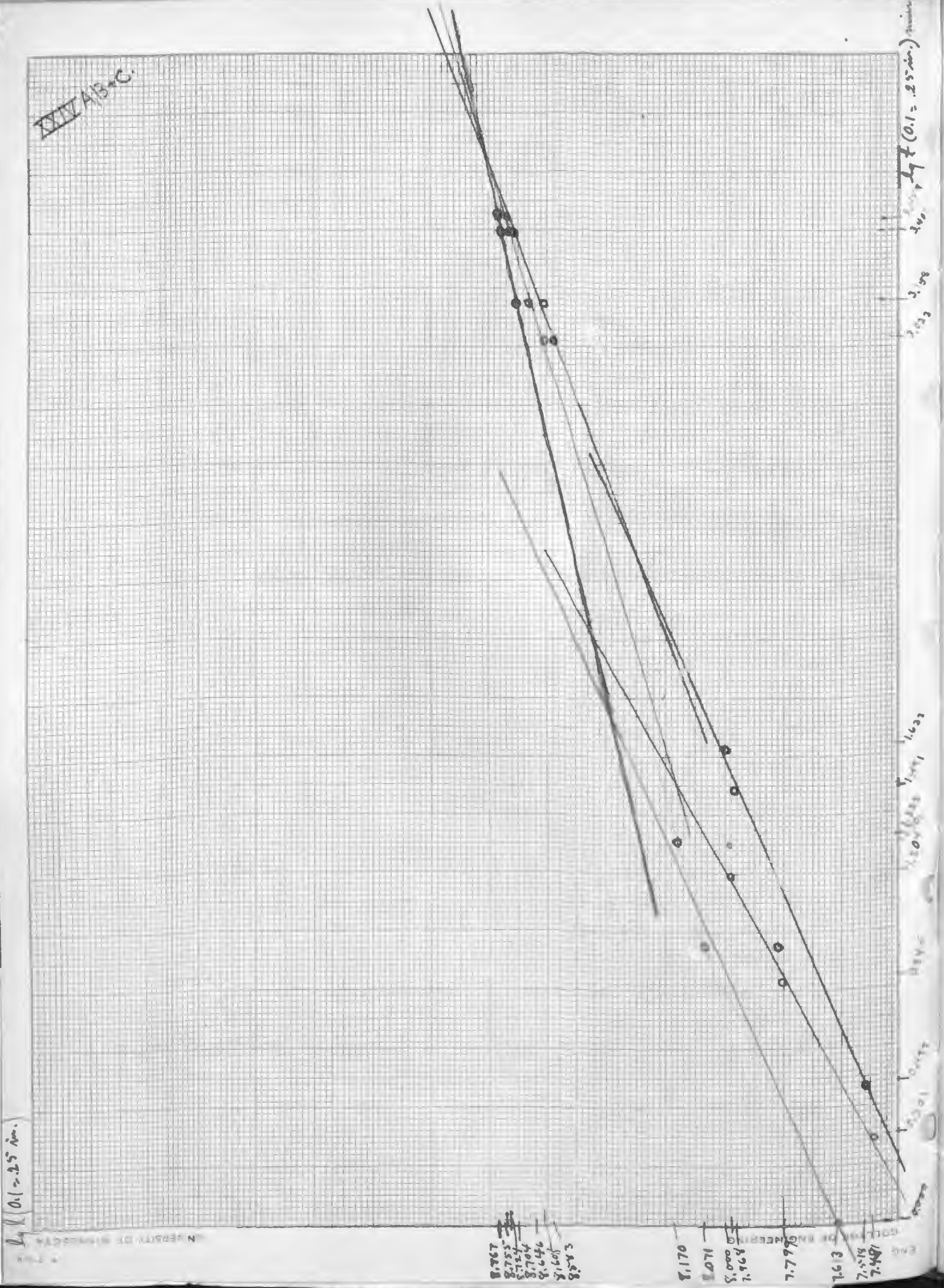
Time	Chloroform & Ether: Increase in cm. (A)	Increase per cm.	t/l²	Ether & Benzol: Increase in cm. (B)	Increase per cm.	t/l²
15 sec	1.00	0.20	375	1.20	0.24	269
30 "	1.65	.33	275	1.85	.37	219
45 "	2.05	.41	268	2.25	.45	223
1 min	2.40	.48	260	2.60	.52	222
15 "	2.65	.53	268			
30 "	2.83	.566	280	3.00	.60	250
45 "	3.00	.60	290	3.15	.63	264
2 min	3.10	.61	312	3.25	.65	284
15 "	3.20	.64	330	3.35	.67	
30 "	3.30	.66		3.40	.68	
45 "	3.38	.67		3.48	.696	
3 min	3.45	.69	379	3.53	.706	362
15 "	3.50	.70		3.58	.716	
30 "	3.55	.71		3.60	.710	
45 "	3.60	.72		3.64	.724	
4 min	3.62	.724	459	3.66	.732	449
15 "	3.64	.728		3.68	.736	
30 "	3.66	.732		3.70	.740	
45 "	3.70	.740				
5 min	3.72	.744				
30 "	3.75	.750				
6 min	3.79	.754		3.73	.746	647
30 "	3.80	.760		3.77	.754	
7 min	3.83	.766		3.80	.76	728
30 "	3.84	.768				
8 min	3.84	.768				
9 min	3.86	.771				
10 min	3.87	.774	545			
12 min	....	....	....	....	....	....
15 min				3.83	.766	
16 min	3.88	.776		....	....	....
19 min	....	....	....	....	....	....

TABLE XXIII

Fifty percent mixtures

(C) Benzol & Chloroform.

Time	Increase in cm.	Increase per cm.	t/l^2
15 sec.			
30 "	2.00	0.40	187
45 "	2.55	.51	173
1 min	2.40		
15 "	3.10	.62	195
30 "	3.30	.66	203
45 "	3.45	.69	221
2 min	3.55	.71	240
15 "	3.70	.74	247
30 "	3.80	.76	260
45 "	3.85	.77	279
3 min	3.90	.78	296
15 "	4.00	.80	
30 "	4.02	.804	
45 "	4.08	.816	
4 min	4.12	.824	353
15 "	4.15	.830	
30 "	4.20	.840	
45 "	4.22	.844	
5 min	4.25	.850	417
30 "	4.30	.860	
6 min	4.33	.866	480
30 "			
7 min	4.40	.880	
30 "			
8 min	4.45	.881	620
9 min	4.47	.894	
10 min	....	....	....
12 min	4.50	.900	890
15 min			
16 min	....	....	....
19 min	4.52	.904	



XXIV A|B+C.
log t (0.1 = .25 in.) min
log l (0.1 = .25 in.)
8.867
7.799
7.613

TABLE XXIV

Aqueous solutions of Ethyl Alcohol

Time	25% Solution (A) Increase in cm.	Increase per cm.	t/l²	50% Solution. (B) Increase in cm.	Increase per cm.	t/l²
1 min						
2 "	....	....	....	0.095	0.0031	125.10
3 "	0.10	0.0033	1650.10	....	....	....
7 "				0.190	0.0063	106.10
16 "	....	....	....	0.285	0.0095	167.10
20 "				0.285	0.0095	
21 "						
31 "	0.28	0.0093	2750.10	....	....	....
43 "	0.30	0.0100	2580.10			
18 hours	1.15	0.0383		1.220	0.0406	407.10
24 "	1.22	0.0406	5240.10	1.330	0.0443	
42 "	1.60	0.0530		1.610	0.0536	403.10
48 "	1.60	0.0530	6180.10	1.650	0.0550	
5 days	2.26	0.0753		2.300	0.0760	720.10
8 "	2.65	0.0883		3.640	0.1213	
12 "	2.65	0.0883		3.640	0.1213	
13 "	2.65	0.0883				

Distribution ratio 0.894. Distribution ratio 0.581

TABLE XXIV

Aqueous solutions of Ethyl Alcohol.

75% Solution.
(C)

Time	Increase in cm.	Increase per cm.	
1 min	0.123	0.0041	595.4
2 "			
3 "			
7 "	....	....	....
9 "	0.355	0.0118	388.10
16 "			
20 "			
21 "	0.444	0.0148	577.10
31 "			
43 "	....	....	....
18 hours		0.0406	407.10
24 "	1.520	0.0506	337.10
42 "	1.710	0.0570	
48 "	1.757	0.0585	505.10
5 days	2.456	0.0815	
8 "	4.440	0.1480	
12 "	4.440	0.1480	
13 "	....	....	....

Distribution ratio = 0.452.

VII. DISCUSSION OF RESULTS.

(a) Sources of Error.

The sources of error that were encountered with in this work differ with the different methods. In the experiments on the imbibition of vapor the greatest source of error is that the rubber at times touches the walls of the vessel and absorbs the adhering liquids. The results obtained, when the excess liquid adhering to the rubber is removed by blotting with filter paper, are found to be lower than those obtained by other methods. This is due to the fact that evaporation is going on while the rubber is handles and also that the filter paper absorbs some of the liquid imbibed by the rubber. When blotting with mercury there is the danger that a small particle of mercury may adhere to the rubber and thus cause an error in weight. An error which has just the opposite effect is liable to appear when weighing in mercury and that is that liquid may be carried down in the mercury and exert a bucyant affect. Somewhat erratic results are at times obtained by the distention method. These are due to the slight crumpling of the rubber or to the fact that the rubber may not slide uniformly along the bottom of the dish. Besides the source of error occasioned by the method employed there are those due to the temperature variations, the degree of purity of the liquid used, and the degree of uniformity of the thickness and the vulcanization of dental rubber.

(b). Comparison of results.

When the results obtained by the mercury displacement method and those from the distension method are calculated to the same units and then compared, it is seen that the former method yields higher results. This fact seems to show that mercury blotting leaves a thin film of liquid on the surface of the rubber.

The following tables show the results from experiments done by the mercury displacement and by the distention method both of benzol and ether, (A is benzol and B is ether). Imbibition is given in number of cc. of the liquid imbibed by a piece of rubber 10.0 x 5.0 x 0.02 cm.

TABLE XXV.

(A).

Time, min.	Imbibition by distention.	Imbibition by Hg displacement.
.25	0.699	1.12
.50	1.247	2.51
.75		3.19
1.00		4.04
.25	2.370	....
2.00	3.248	5.44
3.00	3.913	5.96
4.00	4.390	....

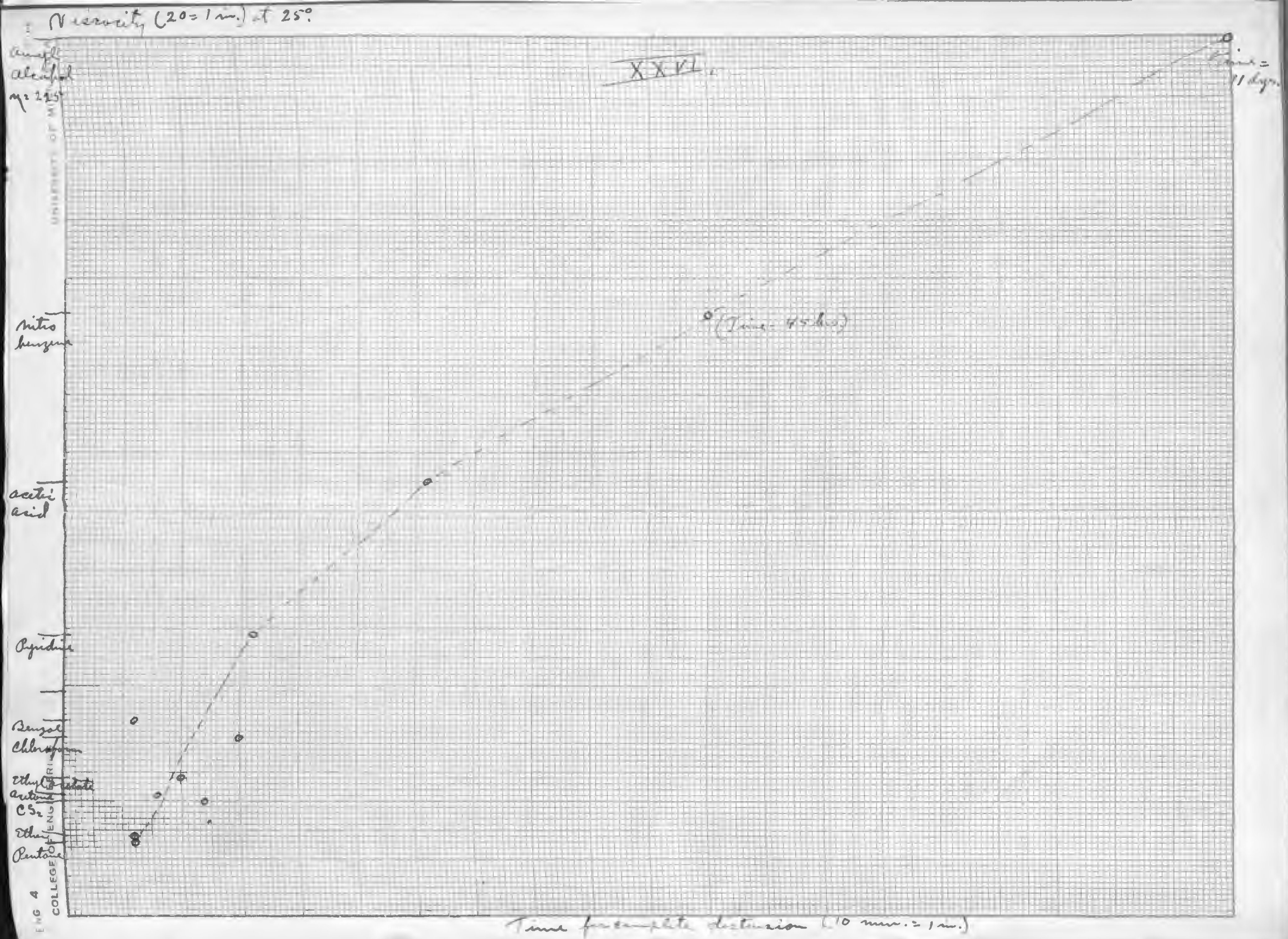
(B).

Time, min.	Imbibition by distention.	Imbibition by Hg displacement.
.25	0.699	0.84
.50	1.174	1.61
.75	1.460	2.11
1.00	1.724	2.16
.50	2.027	2.71
2.00	2.069	2.81
3.00	2.366	2.83
4.00	2.397	2.84
5.00	2.411	2.91
6.00	2.420	2.93

On the assumption that the distention is a correct expression of the imbibition the difference between these results composes the film adhering to the rubber when blotting with mercury. If the thickness of this adhering film is calculated from these results it proves to have a thickness of from 0.0031 to 0.009 cm. for benzol and from 0.0015 to 0.0029 cm. for ether. The thickness of the liquid films that adhere to glass were also determined and were found to be 0.00023 for ether and 0 0.00098 cm. for benzol. Since the viscosity of benzol is between two and three times as great as that of ether these results are in the order of the viscosity of the liquids.

(c) Conclusions.

The following table and accompanying graph show that the time for the complete distention, maximum swelling, of dental rubber is directly proportional to the viscosity of all the liquids experimented with, except one. These results support the theory that the flow of liquids into dental rubber is capillary action. Benzol



Viscosity (20 = 1 in.) at 25°
XXVI.
Amyl alcohol
Time = 11 days.
nitro benzene
(Time = 45 hrs.)
acetic acid
Pyridine
Benzol
Chloroform
Ethyl acetate
Acetone
CS2
Ether
Pentane
Time for complete distension (10 mm. = 1 in.)
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ENG 4

seemingly acts different on vulcanized dental rubber in this respect than the other ten liquids experimented with.

TABLE XXVI.

First period distention.	Liquids	Complete distention per cm. in cm.	Time for complete distention.	Relative viscosity at 25 C.	Time for initial period (in sec	t_x in sec.
0.400	Pentone	0.835	6 min.	12.9	74	8.3
0.440	Ether	0.524	6 "	13.8	90	2.5
0.720	C-disulphide	.900	12 min.	19.7	95	-3.7
0.044	Acetone	.0526	8 "	21.0	150	3.0
0.046	Ethylacetate	.178	9 "	23.6	144	3.5
0.720	Chloroform	.934	15 "	30.5	98	4.0
0.530	Benzol	.756	6 "	33.6	116	5.0
0.220	Pyridine	.372	16 "	49.6	213	3.0
0.010	Acetic Acid	.026	31 "	64.9	105	14.0
0.200	Nitrobenzene	.232	45 hrs.	103.8	630	19.7
0.030	Amylalcohol	.037	11 days	225.0	2 hr	27.0

CONCLUSIONS: Complete distention of dental rubber is directly proportional to the viscosity of the bathing liquid.

The flow of liquids into dental rubber is a capillary phenomena.

For the initial period the imbibition of liquids by dental rubber is in accordance with the formula $\frac{t - t_x}{l^2} = K$, a relation deduced from Poiseuille's law, in which l is the length of the space flowed through, t the time and t_x the time of wetting.

At complete distension imbibition changes to a solubility process as shown by results obtained from the experiments with mixed liquids.

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