TESTS TO DETERMINE THE EFFECT OF REVERSED STRESSES ON THE ELASTIC LIMIT AND THE ULTIMATE STRENGTH OF MEDIUM STEEL

BY

R. G. LAWRY AND A. H. JOHNSON.

Examples of repeated stresses occurring in practical work are numerous. In machinery the application of a load to a certain part rapidly and continuously, often occurs.

Repeated reversals of stress, alternate tension and compression, is less common. A familiar example is the reciprocating parts of an engine, piston rod and connecting rod.

The most important case of such stresses in structural work is in the end posts and end top and bottom chords of a draw span truss. For instance, the end posts are in tension when the span is swung, and in compression when the span is closed and a train passes over. Some of the best engineering authorities specify in the case of tension and compression occurring in the same member, that their sum shall be taken in obtaining the allowable working stress. Other engineers hold that the effect of alternate stresses of opposite sign is not equivalent to a stress in either direction equal to their sum, and such a rule involves an excess of material

Without discussing the case in question, or any of the many formulas used for obtaining the working stress; it is sufficient to say that the elastic limit and the ultimate strength are the bases of them all. The effect repeated tension and compression have in lowering the elastic limit or ultimate strength of the material must be determined by trial.

In this test the object has been to approach the conditions of the members in the truss of a draw span as nearly as possible. It is not practical to apply to a test specimen the number of repetitions of stress that would occur in the life of a bridge, so in this test a greater stress was applied with a fewer number of repetitions, thus working the metal as hard, or nearly so, as actual service would do.

We tried to bring the stress in tension as near as possible to the elastic limit without reaching it. And in order to apply a correspondingly heavy load in compression without bending the specimen, we used the ordinary compression formula for columns with pin ends;

$$C = \frac{T}{1 + \frac{l^2}{18000\ r^2}}$$

where C = repeated stress in compression
T = " " " tension
l = length in inches between centres of pins.
r = radius of gyration of bar in inches.

For our three-quarter inch bars C = 0.98 T, and in applying the load we never found it necessary to use the formula as other conditions stated below made it advisable to keep the compression load well under the load in tension.

The material used was structural steel of about 60,000 to 65,000 lbs. ultimate strength, 24,000 lbs., elastic limit, 25% elongation and 50% contraction at point of fracture, according to the tests made here. The test bars were one inch and a half square by sixteen inches long, turned in the centre for a distance of eight and a half inches, some to three-quarter inches, and some to seven-eighths inches diameter. One inch holes were bored and reamed in each end twelve and a half inches apart at right angles

to the axis of the bar. See Fig. 2. The jaws and pins for holding the test bars were designed by us especially for this test. The jaws BB are of low tool steel annealed. The pins AA of tool steel hardened and ground to a close fit. The wedges cc are of cast iron. All bearing parts were planed. See Fig. 1.

Fig. 2 shows the extensometer, and connection with battery and bell. Knobs EE are insulated from the clamp. The slightest touch of the micrometer on the points rings the bell. The readings were estimated to one ten-thousandth of an inch. Four readings were taken, two on each side of the specimen for each addition of from 250 to 500 lbs. to the load. The loads were applied by hand power when the readings were being taken, and near the highest point of each repeated load. Power was used the remainder of the time. The work was done as quickly as possible to avoid any rest between the applications of the different loads.

Readings were only taken in most cases near the elastic limit in both directions, so the resulting curves are short.

In all, twenty-four test bars were made. Number thirteen was not used. The first seven were tested in simple tension to obtain the properties of the material given above. The remainder were all tested in reversed stresses. Before giving results, we will mention some of the difficulties encountered that caused unreliable results to follow in some cases.

The jaws worked well, but were made for bars two inches square. As we could only get bars one inch and a half square, we used shims DD Fig. 1. No trouble was caused on this account

The testing machine used, (100000 lb. Riehle) will only register loads on the scale beam when the lower head is descending. In this test, tension loads could be measured in the ordinary manner. But when the machine was reversed to apply compression to the bar, the scale beam would not act, so another method was used to measure the load in compression. Two bars of each size were taken, three-quarter inch and seven-eighth inch, (Number 16 and 24), and the ends faced off true. They were then tested in flat end compression in the ordinary manner in the machine. The readings were taken at zero, and for each additional five-hundred pounds to near the elastic limit. The average difference gave the average elastic compression of the bar for each five-hundred pounds.

To apply this to the measurement of compression in the reversed stresses test, a bar was put in place and readings taken at zero load. Knowing the load we wished to apply in compression, we took the results of the flat end compression test above to obtain the amount the bar should shorten for the given load. This amount was subtracted from the zero reading and the micrometer set at this result. With the micrometers in place, compression was applied to the specimen until the micrometers touched and the bell rang. The machine was then reversed, and tension applied, which was of course measured on the scale beam. One micrometer always touched first, and for safety the load was always stopped at this point. This measurement was only approximate at the best. In the reversals, for which the machine is not well adapted, the personal equation effects results. The utmost care was required to prevent the stresses from running too high.

Much care was needed in making the specimens. A little variation of the holes from the axis of the specimens, or from the parallel with each other would cause it to buckle under a light load in compression. Most of the specimens were quite true. The results are all given on the accompanying test sheets.

The elastic limit was obtained from the stress-strain curve. On only a few of the specimens were enough readings taken below the elastic limit to compute the modulus of elasticity.

On both specimens number 1 and 2 no readings were taken until the elastic limit was passes. Numbers 3, 4, 6 and 7 gave average results. Number 5 is inexplainable, the first indication of elastic limit being at 41,730 lbs. The result could not have been caused by the machine being out of balance as the maximum load was average. The probable cause was some peculiarity in the steel.

In the reversed stress tests, the curves indicate a negative elongation after the repeated stresses. In some cases this may be due to passing the elastic limit in compression, but usually is caused by a slight buckling and also by not allowing the specimen time to recover before applying tension. Number 8 buckled enough to make it doubtful from the curve whether the bar was straightening or stretching. Number 9 buckled very slightly. Accidents happened to number 10 and 12 giving no result for the elastic limit. Number 11 buckled under too high a load; elastic limit doubtful. Numbers 14, 15 and 16 with a few reversals indicated a slightly lowered elastic limit. Number 17 was loaded too high in tension; elastic limit doubtful. The remainder of the specimens were all seven-eighths of an inch diameter. Numbers 18 and 19 were both subjected to loads above the elastic limit in tension; results high but not reliable. Numbers 20 and 21 were both good tests and showed no effect of repeated stresses. On numbers 22 and 23 the elastic limit was probably passes before readings were taken. Number 24 indicates a lowering of the elastic limit. However this specimen had been tested in flat end compression to near the elastic limit before this. The following tables compare the results of the simple tension test with those of the reversed stress test:

TABLE NO. I SIMPLE TENSION.

NO. SPECIMEN	ELASTIC LIMIT	MAXIMUM LOAD	% ELONGATION	% CONTRACTED AREA
1		61700	30.4	48.5
2		62010	24.9	50.5
3	24053	61273	25.6	54.2
4	24840	61582	23.1	51.7
5	?	62710	25.2	50.9
6	24020	60984	28.1	49.5
7	23730	61638	26.2	52.2
AVERAGE	24160	61700	26.21	51.07

TABLE NO. 2 REVERSED STRESSES.

NO. SPECIMEN	ELASTIC LIMIT	MAXIMUM LOAD	% ELONGATION	% CONTRACTED AREA
8	* 21810	61845	23.3	51.8
9	* 21850	62430	23.7	46.97
10		65270	23.5	52.5
11	* 21170	64730	23.8	52.9
12		66040	23.5	49.9
—	———	———	———	———
14	20880	61660	22.9	51.9
15	23710	61180	27.4	47.03
16	23410	61310	24.9	48.0
17	* 23020	63250	23.3	61.2
18	* 26610	61430	28.12	49.94
19	* 25780	61930	27.18	48.4
20	24050	61647	26.3	47.8
21	24940	61160	27.9	48.4
22	———	61360	28.9	48.4
23	———	61150	27.0	48.7
24	22400	61730	25.87	53.8
AVERAGE	23300	62380	25.47	50.47
AVERAGE OMITTING (*)	(23230)			

The results cannot be considered at all conclusive. The difference of the average in the two tables in both the percentages of elongation and contraction of section is less than one per cent.

For the reversed stress tests the ultimate strength is a few hundred pounds higher, and the elastic limit a few hundred pounds lower than the test in simple tension. If in table No. 2 we omit the results marked (*) on account of some of the reversals going beyond the elastic limit, we obtain the result given in parentheses, which is practically the same as given before.

In conclusion, it is certain that, with the number of

reversals of stress given any of the specimens the ultimate strength was not lowered.

The elastic limit seems to have been slightly lowered, but not enough tests were made to prove it. A greater number of repetitions should have been made, and a better means of measuring the load provided, in order to approach nearer the elastic limit with the reversed stresses. Tests made under such conditions should give reliable results.

(The steel was kindly furnished by the Phoenix Steel Company).

Finis.

FIGURE 1.

ATTACHMENT OF JAWS TO TESTING MACHINE.

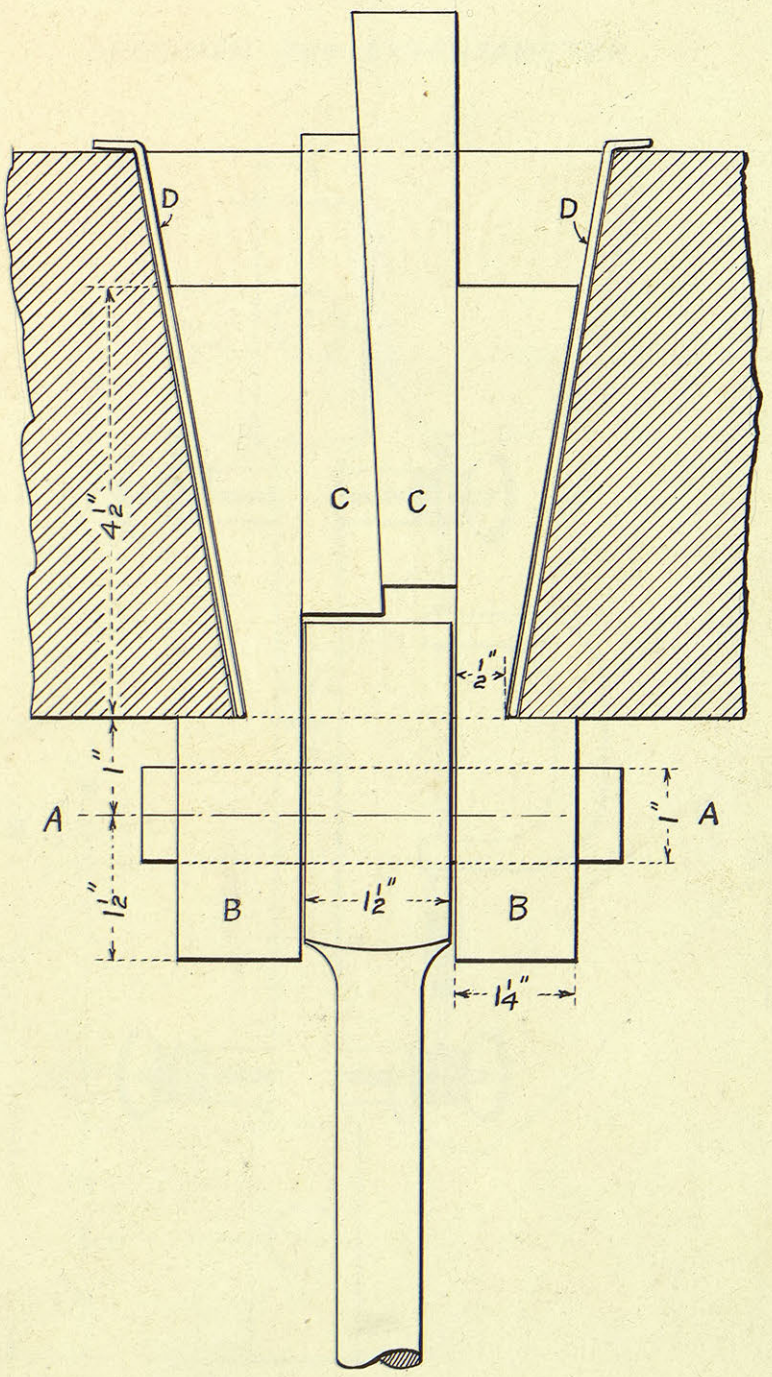
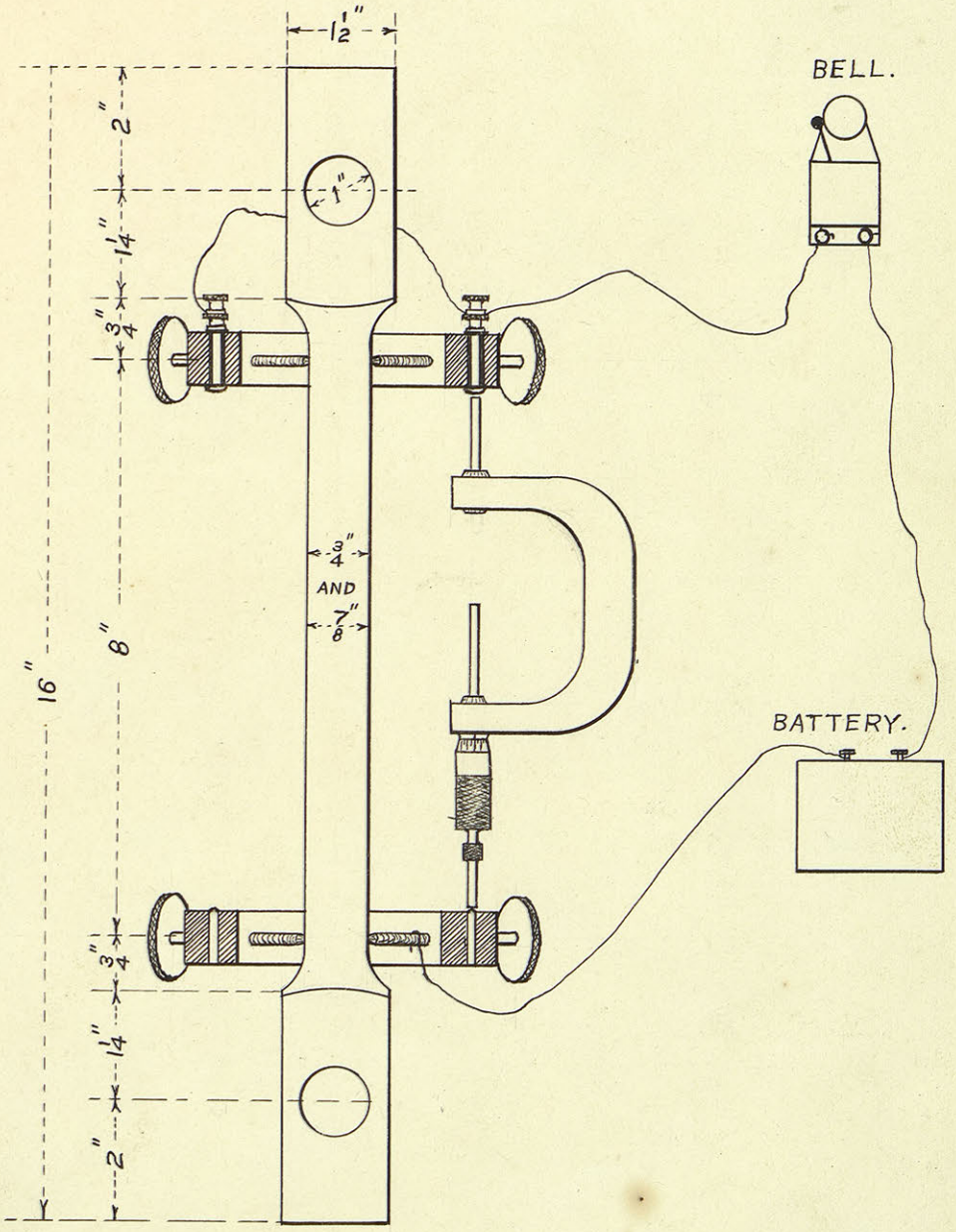
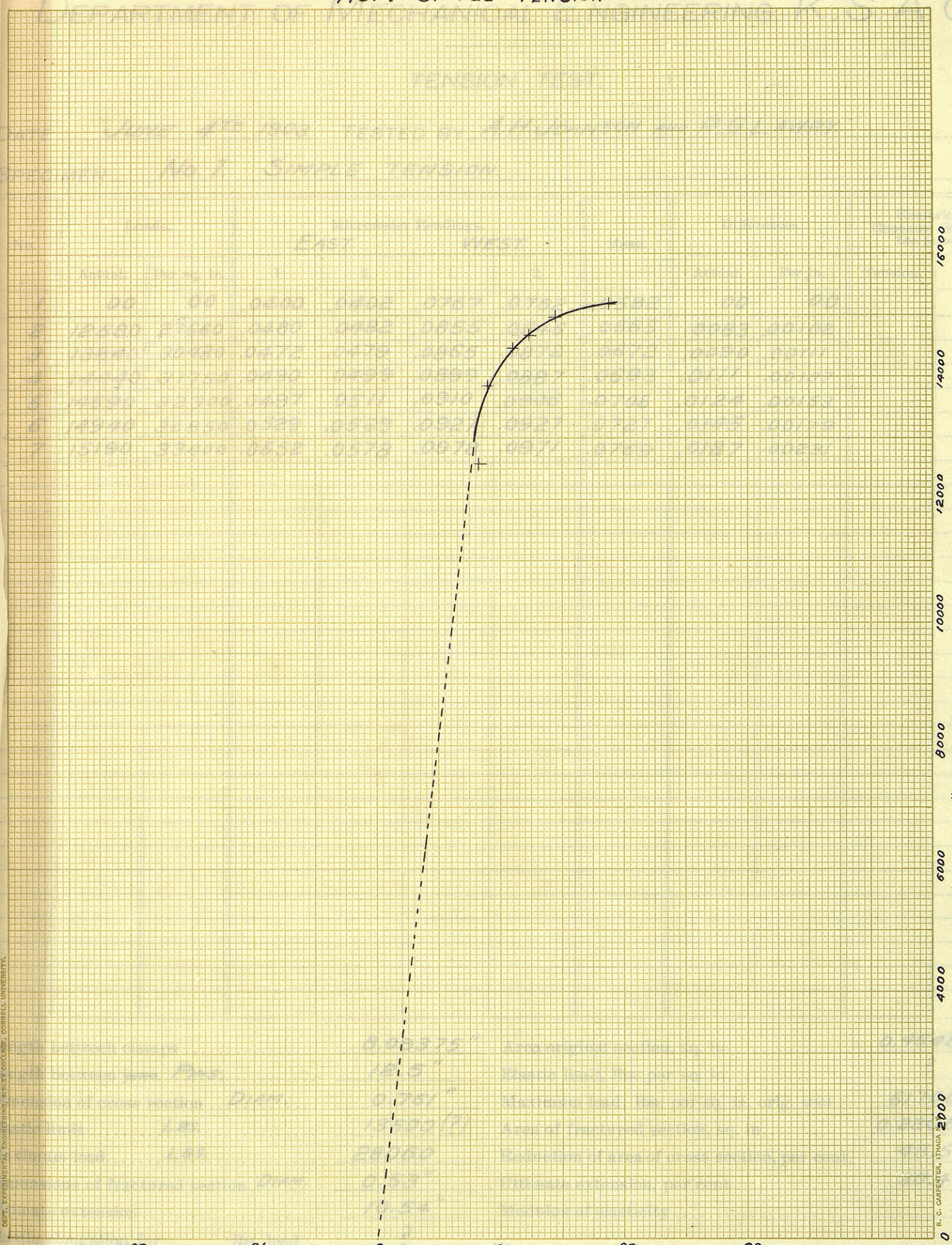


FIGURE 2.

SPECIMEN AND EXTENSOMETER.



No. 1 SIMPLE TENSION



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 4TH 1903 TESTED BY A.H.JOHNSON AND R.G.LAWRY.

SPECIMEN No. 1. SIMPLE TENSION.

No.	Loads.		Micrometer Readings. EAST.		WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00	00	.0400	.0402	.0767	.0762	.0582	00	00		
2	12580	27660	.0480	.0482	.0855	.0846	.0665	.0083	.00102		
3	13840	30480	.0472	.0479	.0865	.0872	.0672	.0090	.00111		
4	14440	31750	.0490	.0499	.0899	.0887	.0693	.0111	.00137		
5	14690	32300	.0497	.0511	.0910	.0906	.0706	.0124	.00153		
6	14940	32850	.0529	.0529	.0927	.0927	.0727	.0145	.00179		
7	15190	33400	.0552	.0578	.0978	.0971	.0769	.0187	.00231		

Length between clamps ..... 8.09375"

Length between ~~jaws~~ PINS ..... 12.5"

Dimension of cross section .. DIAM. .... 0.761"

Elastic limit ..... LBS. ..... 13500 (?)

Maximum load ..... LBS. 28060

Dimensions of fractured section .. DIAM. .. 0.53"

Ultimate extension ..... 10.54"

Elastic elongation for _____ lbs. load .. ?

Area original section, sq. in 0.4648

Elastic limit, lbs. per sq. in ..... ?

Maximum load; lbs. per sq. in. orig. sect .. 61700

Area of fractured section, sq. in 0.2206

Reduction of area of cross section, per cent, 48.5

Ultimate extension, per cent 30.4

Modulus of elasticity ..... ?

Plot stress-strain diagram and hand in with this sheet.

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TENSION TEST.

DATE JUNE 5TH 1903 TESTED BY A.H. JOHNSON AND R.G. LAWRY

SPECIMEN No. 2. SIMPLE TENSION

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00	00	.0270	.0270	.0460	.0470	.0367	00	00		
2	11000	25050	.0339	.0338	.0048	.0049	.0193	.0174	.000215		
3	11400	26090	.0365	.0366	.0014	.0011	.0189	.0178	.000219		
4	11800	27000	.0537	.0559	.0090	.0101	.0321(?)				

Length between clamps ..... 8.09375"

Length between ~~jaws~~ PINS ..... 12.5"

Dimension of cross section .. DIAM ..... 0.746"

Elastic limit ..... LBS. ..... ?

Maximum load ..... LBS. 27090

Dimensions of fractured section .. DIAM .. 0.53"

Ultimate extension ..... 10.114"

Elastic elongation for _____ lbs. load .. ?

Area original section, sq. in 0.4370

Elastic limit, lbs. per sq. in ..... ?

Maximum load; lbs. per sq. in. orig. sect .. 62010

Area of fractured section, sq. in 0.2206

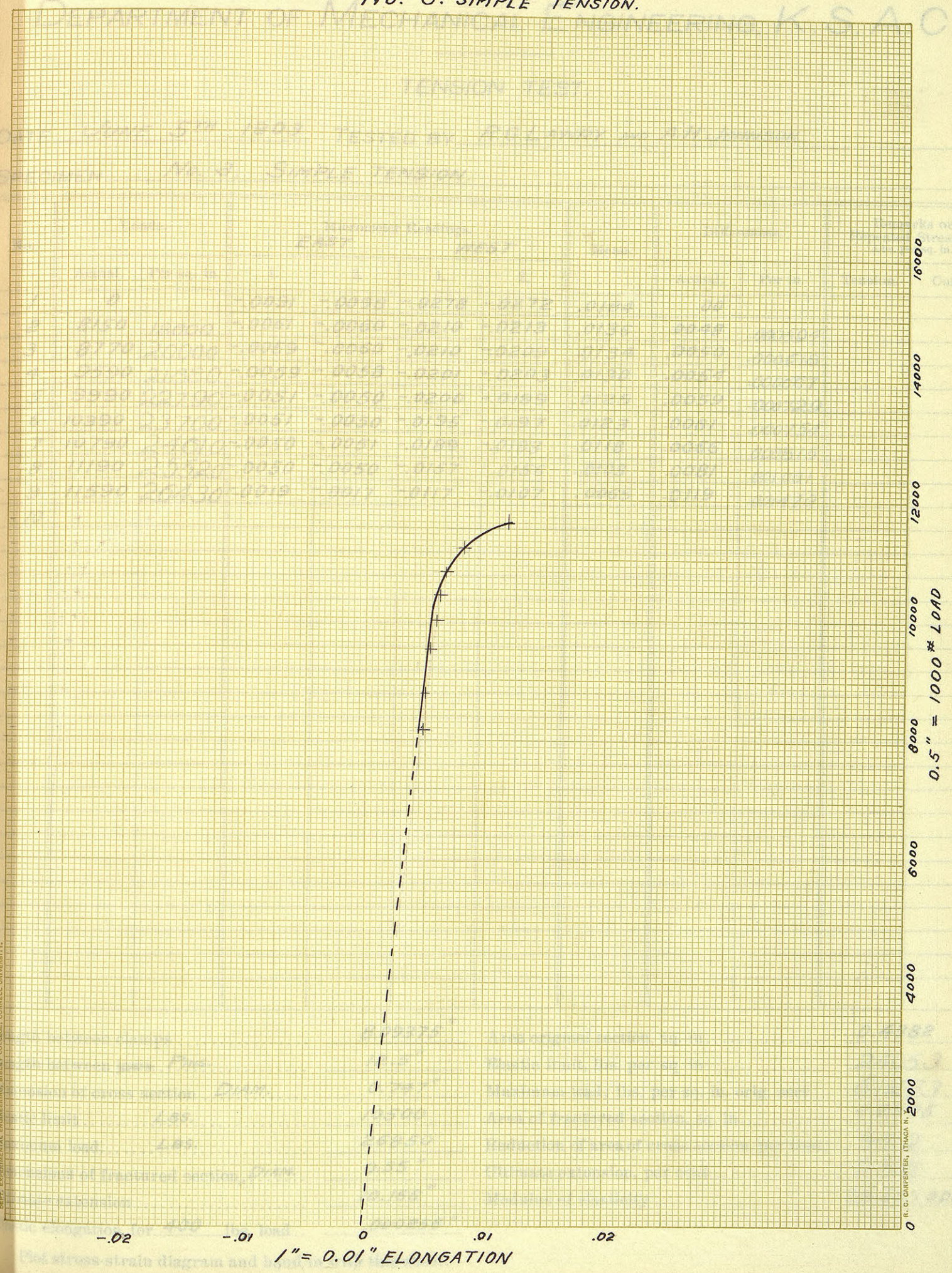
Reduction of area of cross section, per cent, 50.5

Ultimate extension, per cent 24.9

Modulus of elasticity ..... ?

Plot stress-strain diagram and hand in with this sheet.

No. 3. SIMPLE TENSION.



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TENSION TEST.

DATE JUNE 5TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON.

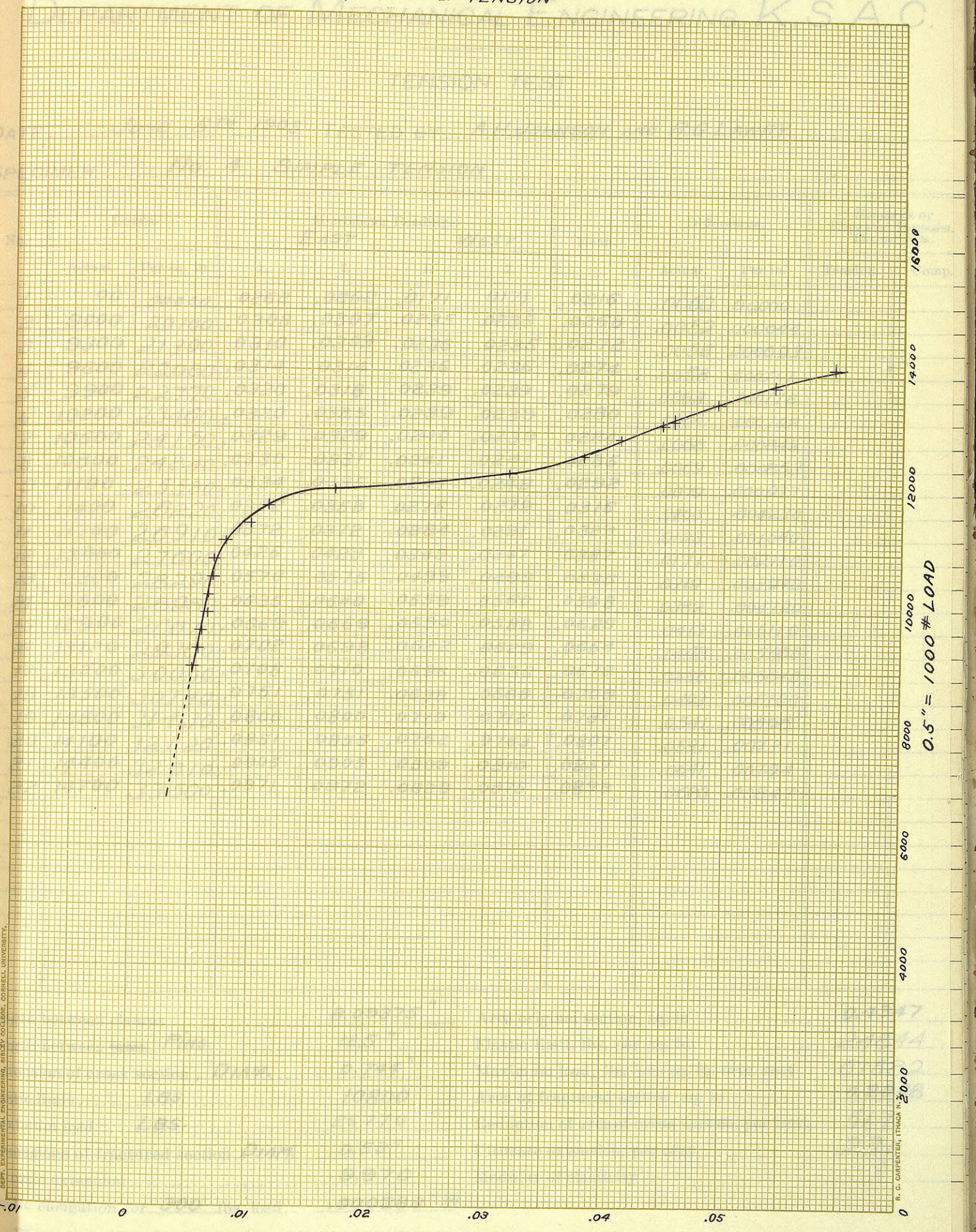
SPECIMEN No. 3, SIMPLE TENSION.

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0		-.0091	-.0098	-.0278	-.0272	.0184	00			
2	8150	18600	-.0061	-.0060	-.0210	-.0213	.0136	.0048	.000594		
3	8770	20000	-.0059	-.0060	-.0210	-.0209	.0134	.0050	.000618		
4	9590	21880	-.0059	-.0058	-.0201	-.0203	.0130	.0054	.000667		
5	9990	22790	-.0051	-.0050	-.0200	-.0199	.0125	.0059	.000729		
6	10390	23700	-.0051	-.0050	-.0195	-.0197	.0123	.0061	.000754		
7	10790	24610	-.0050	-.0051	-.0189	-.0183	.0118	.0066	.000815		
8	11190	2552O	-.0050	-.0050	-.0157	-.0156	.0103	.0081	.001001		
9	11590	26430	-.0019	-.0017	-.0117	-.0107	.0065	.0119	.001470		
10											

Length between clamps	8.09375"	Area original section, sq. in	0.4382
Length between ~~jaws.~~ PINS.	12.5"	Elastic limit, lbs. per sq. in	24053
Dimension of cross section DIAM.	0.747"	Maximum load; lbs. per sq. in. orig. sect	61273
Elastic limit LBS.	10500	Area of fractured section, sq. in	0.2375
Maximum load LBS.	26850	Reduction of area of cross section, per cent,	54.2
Dimensions of fractured section, DIAM.	0.55"	Ultimate extension, per cent	25.6
Ultimate extension	10.166"	Modulus of elasticity	28,647,000
Elastic elongation for 400 lbs. load	.000258"		

Plot stress-strain diagram and hand in with this sheet.

No. 4 SIMPLE TENSION



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R. C. CARPENTER, ITHACA N.Y.

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TENSION TEST.

DATE JUNE 5TH 1903 TESTED BY A.H.JOHNSON AND R.G.LAWRY.

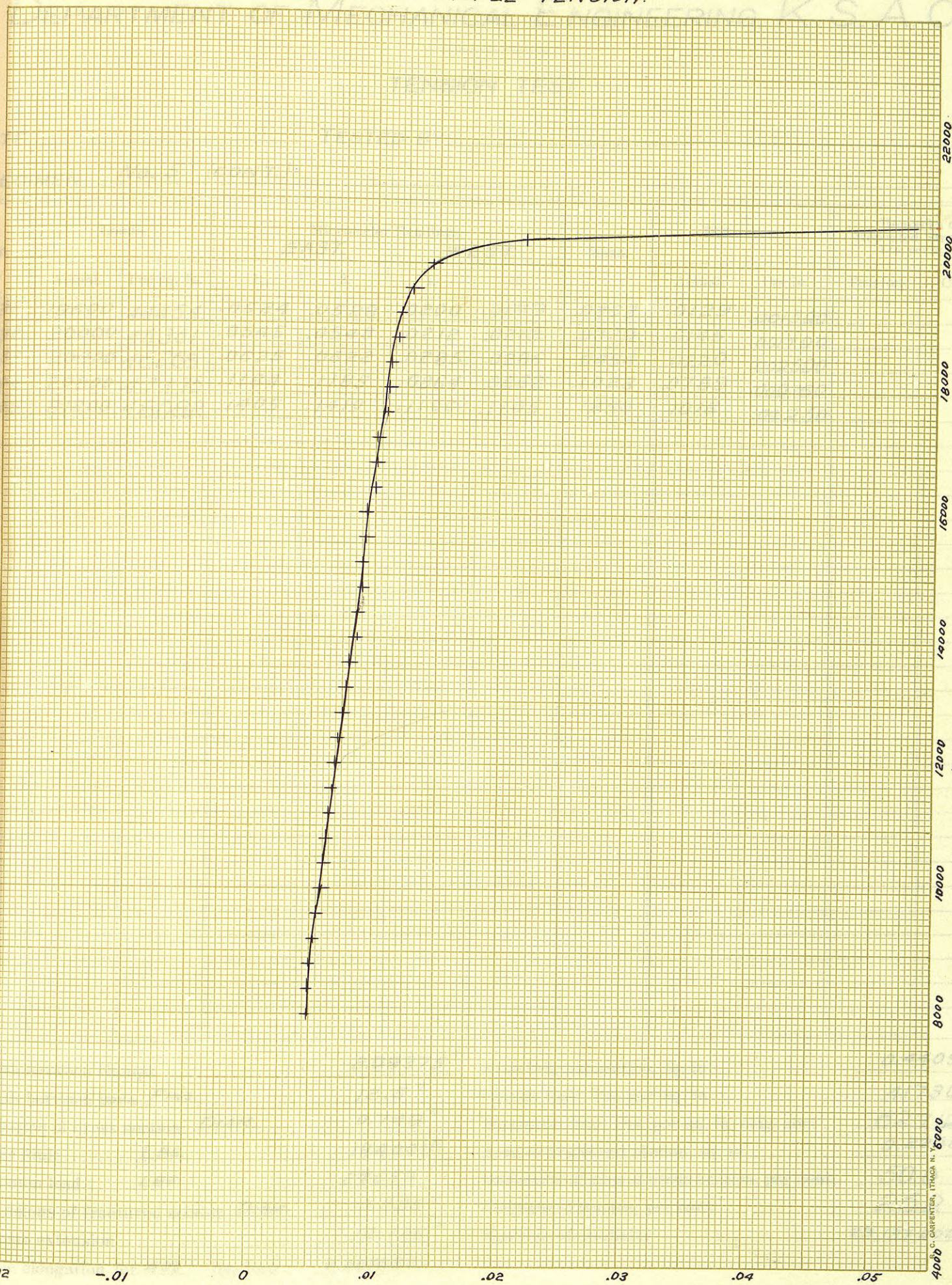
SPECIMEN No. 4, SIMPLE TENSION

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00	00000	.0262	.0262	.0171	.0171	.0216	.0000	.00000		
2	9000	20700	.0308	.0307	.0235	.0235	.0268	.0052	.000644		
3	9300	21390	.0310	.0309	.0236	.0235	.0272	.0056	.000693		
4	9600	22080	.0314	.0314	.0236	.0236	.0274	.0058	.000717		
5	9900	22770	.0320	.0318	.0239	.0239	.0279	.0063	.000778		
6	10200	23460	.0320	.0325	.0239	.0239	.0280	.0064	.000792		
7	10500	24150	.0329	.0329	.0240	.0239	.0284	.0068	.000842		
8	10800	24840	.0330	.0331	.0241	.0241	.0285	.0069	.000853		
9	11100	25530	.0334	.0335	.0247	.0248	.0292	.0079	.000977		
10	11400	26220	.0352	.0358	.0276	.0279	.0316	.0100	.000230		
11	11700	26910	.0372	.0372	.0284	.0291	.0329	.0123	.001540		
12	12000	27600	.0426	.0429	.0349	.0347	.0387	.0171	.002110		
13	12300	28290	.0570	.0575	.0499	.0499	.0535	.0319	.003940		
14	12600	28980	.0635	.0640	.0559	.0560	.0598	.0382	.004720		
15	12900	28670	.0669	.0669	.0590	.0588	.0629	.0413	.005110		
16	13120	29360	.0702	.0698	.0622	.0629	.0664	.0448	.005500		
17	13200	30050	.0708	.0710	.0636	.0636	.0672	.0456	.005640		
18	13500	30740	.0751	.0751	.0638	.0668	.0709	.0493	.006100		
19	13800	31430	.0800	.0800	.0719	.0712	.0757	.0541	.00696		
20	14100	32120	.0851	.0855	.0762	.0763	.0807	.0591	.00731		
21	14400	32810	.0905	.0905	.0809	.0810	.0857	.0641	.00794		
22	14700	33500	.0971	.0972	.0828	.0875	.0899	.0683	.00847		

Length between clamps	8.09375"	Area original section, sq. in	0.4347
Length between ~~jaws.~~ PINS.	12.5"	Elastic limit, lbs. per sq. in	24844
Dimension of cross section, DIAM.	0.744"	Maximum load; lbs. per sq. in. orig. sect	61582
Elastic limit LBS.	10800	Area of fractured section, sq. in	0.2248
Maximum load LBS.	26770	Reduction of area of cross section, per cent,	51.7
Dimensions of fractured section DIAM.	0.53"	Ultimate extension, per cent	23.1
Ultimate extension	9.970	Modulus of elasticity	?
Elastic elongation for 300 lbs. load	.000283" (?)		

Plot stress-strain diagram and hand in with this sheet.

No. 5 SIMPLE TENSION.



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TENSION TEST.

DATE *JUNE 9TH 1903* TESTED BY *R.G. LAWRY AND A.H. JOHNSON*

SPECIMEN *No. 5. SIMPLE TENSION*

No.	Loads.		Micrometer Readings. EAST.		WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	00000	.0379	.0379	.0091	.0091	.0234	00	.000000		
2	8000	18144	.0431	.0431	.0131	.0131	.0281	.0047	.000581		
3	8400	19051	.0432	.0431	.0130	.0131	.0281	.0047	.000581		
4	8800	19758	.0433	.0434	.0133	.0132	.0283	.0049	.000606		
5	9200	20665	.0437	.0436	.0136	.0135	.0286	.0052	.000643		
6	9600	21572	.0438	.0440	.0138	.0139	.0288	.0054	.000668		
7	10000	22479	.0443	.0443	.0141	.0141	.0292	.0058	.000717		
8	10400	23386	.0447	.0446	.0142	.0142	.0294	.0060	.000705		
9	10800	24293	.0449	.0449	.0145	.0144	.0296	.0062	.000766		
10	11200	25200	.0451	.0451	.0145	.0145	.0298	.0064	.000752		
11	11600	26107	.0453	.0454	.0146	.0148	.0300	.0066	.000815		
12	12000	27014	.0458	.0458	.0147	.0150	.0303	.0069	.000852		
13	12400	27921	.0458	.0458	.0152	.0150	.0305	.0071	.000878		
14	12800	28828	.0462	.0462	.0156	.0154	.0309	.0075	.000927		
15	13200	29735	.0464	.0464	.0159	.0159	.0311	.0077	.000952		
16	13600	30642	.0466	.0470	.0159	.0160	.0313	.0079	.000978		
17	14000	31549	.0469	.0472	.0160	.0161	.0320	.0086	.001060		
18	14400	32456	.0474	.0478	.0165	.0164	.0320	.0086	.001061		
19	14800	33363	.0482	.0480	.0168	.0167	.0324	.0090	.001110		
20	15200	34270	.0482	.0482	.0166	.0168	.0324	.0090	.001110		
21	15600	35177	.0484	.0486	.0169	.0169	.0327	.0093	.001150		
22	16000	36084	.0489	.0489	.0167	.0170	.0328	.0094	.001160		
22	16400	36991	.0493	.0494	.0174	.0176	.0334	.0100	.001230		
24	16800	37898	.0494	.0496	.0175	.0178	.0335	.0101	.001250		
25	17200	38805	.0490	.0500	.0175	.0178	.0335	.0101	.001250		
26	17600	39712	.0499	.0501	.0189	.0185	.0340	.0109	.001350		
27	18000	40619	.0501	.0502	.0187	.0189	.0344	.0110	.001360		
28	18400	41526	.0509	.0503	.0184	.0190	.0346	.0112	.001380		
29	18800	42433	.0507	.0509	.0194	.0194	.0351	.0117	.001440		
30	19200	43340	.0512	.0516	.0196	.0194	.0354	.0120	.001480		

Length between clamps ..... 8.09375"

Length between ~~jaws~~ PINS ..... 12.5"

Dimension of cross section .. DIAM. .... 0.749"

Elastic limit ..... LBS. ..... 18400 (?)

Maximum load... LBS. 27650

Dimensions of fractured section DIAM. 0.535

Ultimate extension ..... 10.136"

Elastic elongation for 400 lbs. load .. 0.000252"

Area original section, sq. in 0.4409

Elastic limit, lbs. per sq. in 41730

Maximum load; lbs. per sq. in. orig. sect .. 62712

Area of fractured section, sq. in 0.2248

Reduction of area of cross section, per cent, 50.9

Ultimate extension, per cent 25.2

Modulus of elasticity 29,137,000

Plot stress-strain diagram and hand in with this sheet.

DEPARTMENT OF MECHANICAL ENGINEERING, K. S. A. C.

TENSION TEST.

DATE _____ TESTED BY _____

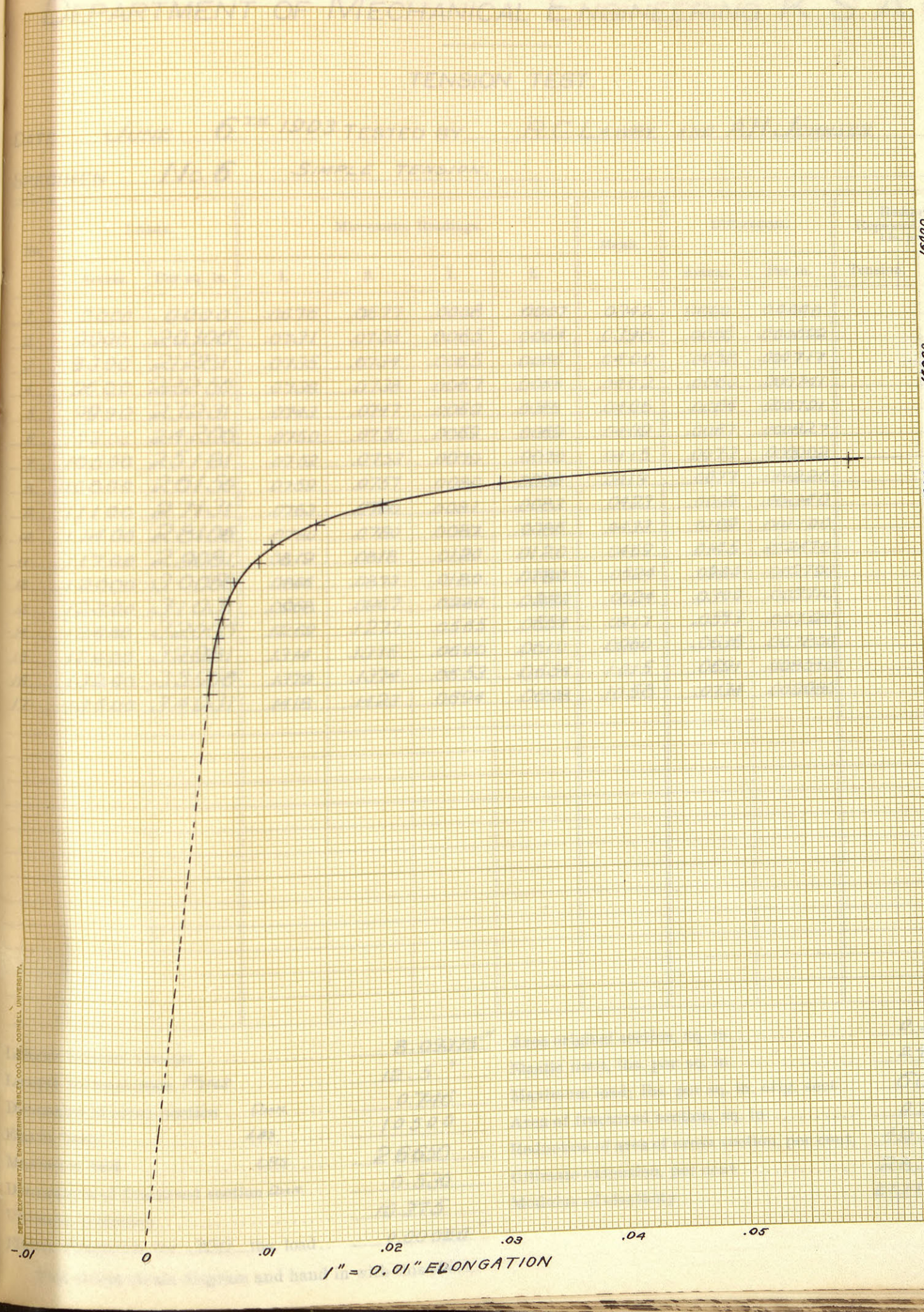
SPECIMEN No. 5 (CONT.)

No.	Loads.		Micrometer Readings. EAST.		WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
31	19600	44454	.0524	.0528	.0200	.0199	.0363	.0129	.001590		
32	20000	45361	.0545	.0548	.0212	.0212	.0379	.0145	.001790		
33	20400	46268	.0625	.0622	.0285	.0286	.0454	.0220	.002590		
34	20800	47175	.1184	.1185	.0864	.0862	.1023	.0789	.009760		
35	21200	48082	.1405	.1410	.1100	.1105	.1250	.1016	.01250		

Length between clamps	8.09375"	Area original section, sq. in	0.4409
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	41730
Dimension of cross section DIAM.	0.749"	Maximum load; lbs. per sq. in. orig. sect	62712
Elastic limit LBS.	18400 (?)	Area of fractured section, sq. in	0.2248
Maximum load LBS.	27650	Reduction of area of cross section, per cent,	50.9
Dimensions of fractured section DIAM.	0.535"	Ultimate extension, per cent	25.2
Ultimate extension	10.136"	Modulus of elasticity	29,137,000
Elastic elongation for 400 lbs. load	0.000252"		

Plot stress-strain diagram and hand in with this sheet.

No. 6 SIMPLE TENSION.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 6TH 1903 TESTED BY R.G. LAWRY AND A.H JOHNSON

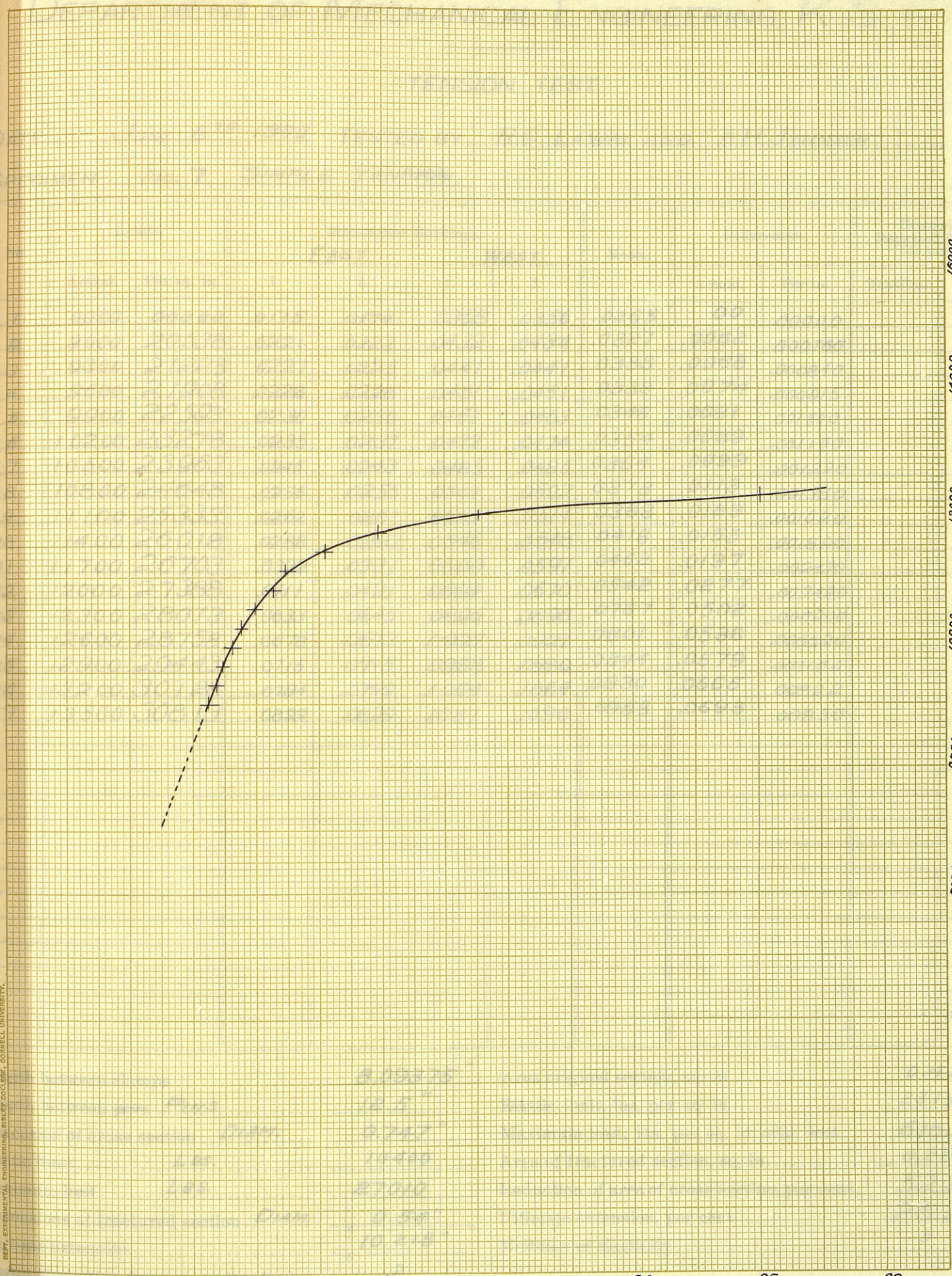
SPECIMEN No. 6 SIMPLE TENSION.

No.	Loads.		Micrometer Readings.				Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	0000	.0676	.0677	.0008	.0007	.0342	.0000	00000		
2	9000	20306	.0731	.0733	.0065	.0064	.0398	.0056	.000692		
3	9300	21281	.0735	.0734	.0065	.0066	.0400	.0058	.000717		
4	9600	22256	.0738	.0738	.0067	.0066	.0402	.0060	.000741		
5	9900	23231	.0743	.0747	.0069	.0066	.0406	.0064	.000791		
6	10200	24206	.0750	.0750	.0069	.0069	.0409	.0067	.000827		
7	10500	25181	.0752	.0753	.0079	.0078	.0415	.0073	.000902		
8	10800	26156	.0759	.0757	.0080	.0080	.0419	.0077	.001220		
9	11100	27131	.0763	.0766	.0081	.0083	.0423	.0099	.001340		
10	11400	28106	.0780	.0780	.0087	.0086	.0433	.0109	.001790		
11	11700	29081	.0819	.0818	.0120	.0120	.0469	.0145	.002470		
12	12000	30056	.0866	.0873	.0180	.0180	.0524	.0200	.002790		
13	12300	31031	.0968	.0967	.0280	.0282	.0624	.0300	.003710		
14	12600	32006	.1269	.1273	.0565	.0564	.0917	.0593	.007320		
15	12900	32981	.1314	.1316	.0600	.0610	.0960	.0636	.007850		
16	13200	33956	.1379	.1374	.0653	.0654	.1015	.0691	.008540		
17	13500	34931	.1418	.1423	.0694	.0698	.1058	.0734	.009080		

Length between clamps	8.09375"	Area original section, sq. in	0.4370
Length between ~~jaws~~. PINS	12.5"	Elastic limit, lbs. per sq. in	24020
Dimension of cross section ... DIAM.	0.746	Maximum load; lbs. per sq. in. orig. sect	60984
Elastic limit ... LBS.	10500	Area of fractured section, sq. in	0.2206
Maximum load ... LBS.	26650	Reduction of area of cross section, per cent,	49.5
Dimensions of fractured section DIAM.	0.530	Ultimate extension, per cent	28.1
Ultimate extension	10.375	Modulus of elasticity	27,777,000
Elastic elongation for 300 lbs. load	0.00020"		

Plot stress-strain diagram and hand in with this sheet.

No. 7. SIMPLE TENSION.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE June 6th 1903 TESTED BY R.G. Lawry and A.H. Johnson

SPECIMEN No. 7, Simple Tension.

No.	Loads.		Micrometer Readings. EAST		WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	00000	.0175	.0174	.0358	.0356	.0265	00	.00000		
2	9000	20538	.0221	.0223	.0432	.0434	.0327	.0062	.000766		
3	9300	21223	.0227	.0225	.0441	.0441	.0333	.0068	.000840		
4	9600	21908	.0228	.0228	.0451	.0451	.0339	.0074	.000915		
5	9900	22593	.0230	.0230	.0461	.0463	.0346	.0081	.001000		
6	10200	23278	.0235	.0237	.0472	.0474	.0354	.0089	.001100		
7	10500	23963	.0245	.0243	.0485	.0485	.0364	.0099	.001220		
8	10800	24648	.0256	.0255	.0501	.0502	.0378	.0113	.001380		
9	11100	25333	.0262	.0267	.0513	.0514	.0388	.0123	.001520		
10	11400	26018	.0288	.0292	.0546	.0548	.0418	.0153	.001890		
11	11700	26703	.0332	.0331	.0590	.0597	.0462	.0197	.002430		
12	12000	27388	.0411	.0421	.0669	.0670	.0542	.0277	.003420		
13	12300	28073	.0633	.0645	.0895	.0896	.0767	.0502	.006200		
14	12600	28758	.0678	.0673	.0927	.0927	.0801	.0536	.006620		
15	12900	29443	.0715	.0715	.0968	.0980	.0844	.0579	.007160		
16	13200	30128	.0794	.0799	.1064	.1064	.0930	.0665	.00822		
17	13500	30813	.0829	.0829	.1087	.1090	.0958	.0693	.00856		

Length between clamps ..... 8.09375"

Length between ~~jaws~~. PINS. ..... 12.5"

Dimension of cross section .. DIAM. .... 0.747"

Elastic limit ..... LBS. 10400

Maximum load ..... LBS. 27010

Dimensions of fractured section .. DIAM. 0.54"

Ultimate extension ..... 10.218"

Elastic elongation for _____ lbs. load .. ?

Area original section, sq. in 0.4382

Elastic limit, lbs. per sq. in 23730

Maximum load; lbs. per sq. in. orig. sect .. 61638

Area of fractured section, sq. in 0.2290

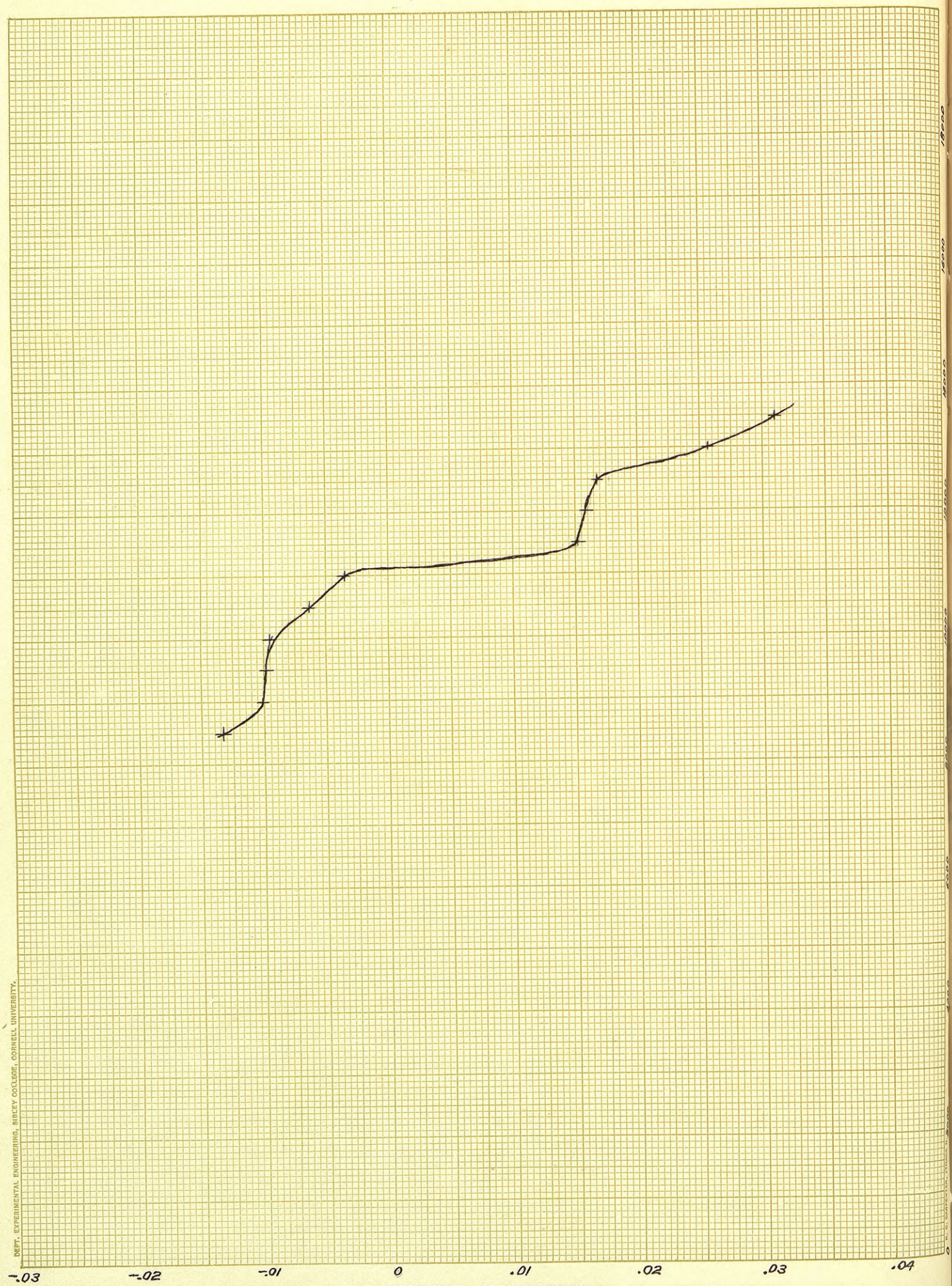
Reduction of area of cross section, per cent, 52.2

Ultimate extension, per cent 20.2

Modulus of elasticity ..... ?

Plot stress-strain diagram and hand in with this sheet.

No. 8, REVERSED STRESSES.



1" = 0.01" ELONGATION

DEPT. EXPERIMENTAL ENGINEERING, SIBLEY COLLEGE, CORNELL UNIVERSITY.

DEF

DATE 4

SPECIMEN

No.	Ac
1	
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DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 12TH 1903 TESTED BY R.G. LAWRY AND A.H. JOHNSON

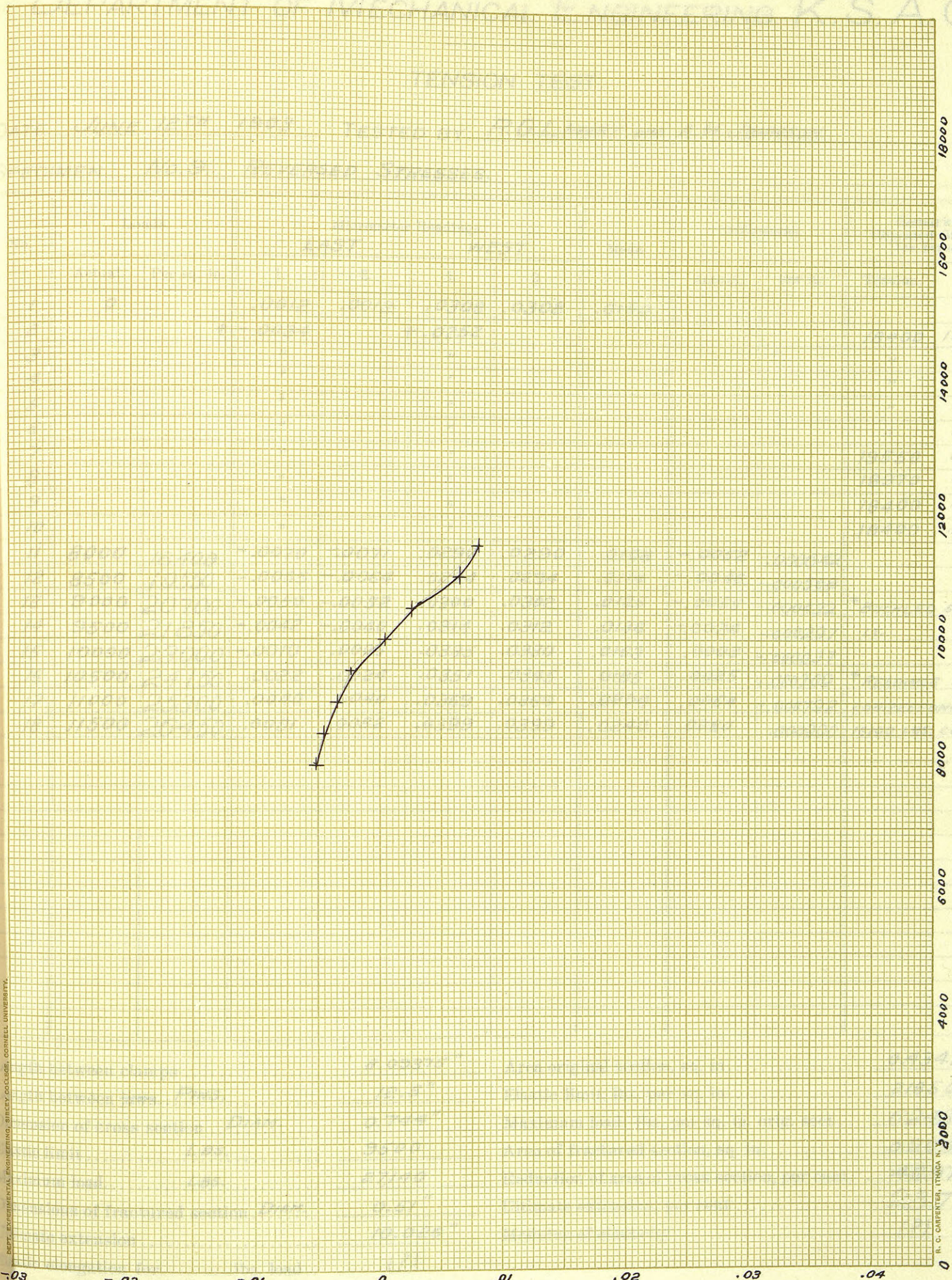
SPECIMEN No. 8 REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST.		Micrometer Readings. WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0		-.0016	-.0016	.0215	.0215	.0099				
2		*	-.0061		* .0170					17430	15200
3		*	-.0061		* .0170					21370	(?)+
4		*	-.0061		* .0170					17430	
5	8500	18542	-.0178		.0110		-.0034	-.0133	-.00164		
6	9000	19633	-.0160	-.0160	.0120	.0120	-.0020	-.0101	-.00125		
7	9500	20724	-.0142	-.0142	.0140	.0142	.0000	-.0099	-.00124	+ INDETERMINATE	
8	10000	21815	-.0113	-.0114	.0160	.0165	.00045	-.0095	-.00117	SPECIMAN BUCK-	
9	10500	22906	-.0110	-.0110	.0180	.0180	.0035	-.0064	-.00079	LED.	
10	11000	23997	-.0073	-.0075	.0202	.0204	.0064	-.0035	-.00043		
11	11670	24088	.0100	.0100	.0382	.0382	.0241	.0152	+.00185	* READING TO COR-	
12	12000	25179	.0101	.0102	.0390	.0392	.0246	.0157	+.00194	RESPOND TO	
13	12500	26270	.0123	.0124	.0408	.0412	.0266	.0167	+.00206	15200 LBS. COMP.	
14	13000	27361	.0196	.0201	.0495	.0490	.0345	.0256	+.00316		
15	13500	28452	.0271	.0272	.0565	.0566	.0418	.0319	+.00394		

Length between clamps	8.09375"	Area original section, sq. in	0.4584
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	21810
Dimension of cross section, DIAM.	0.764"	Maximum load; lbs. per sq. in. orig. sect	61845
Elastic limit LBS.	10000	Area of fractured section, sq. in	0.2375
Maximum load LBS.	28350	Reduction of area of cross section, per cent,	51.8
Dimensions of fractured section, DIAM.	0.55"	Ultimate extension, per cent	23.3
Ultimate extension	9.979"	Modulus of elasticity	?
Elastic elongation for ____ lbs. load	?		

Plot stress-strain diagram and hand in with this sheet.

No. 9, REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 12TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON.

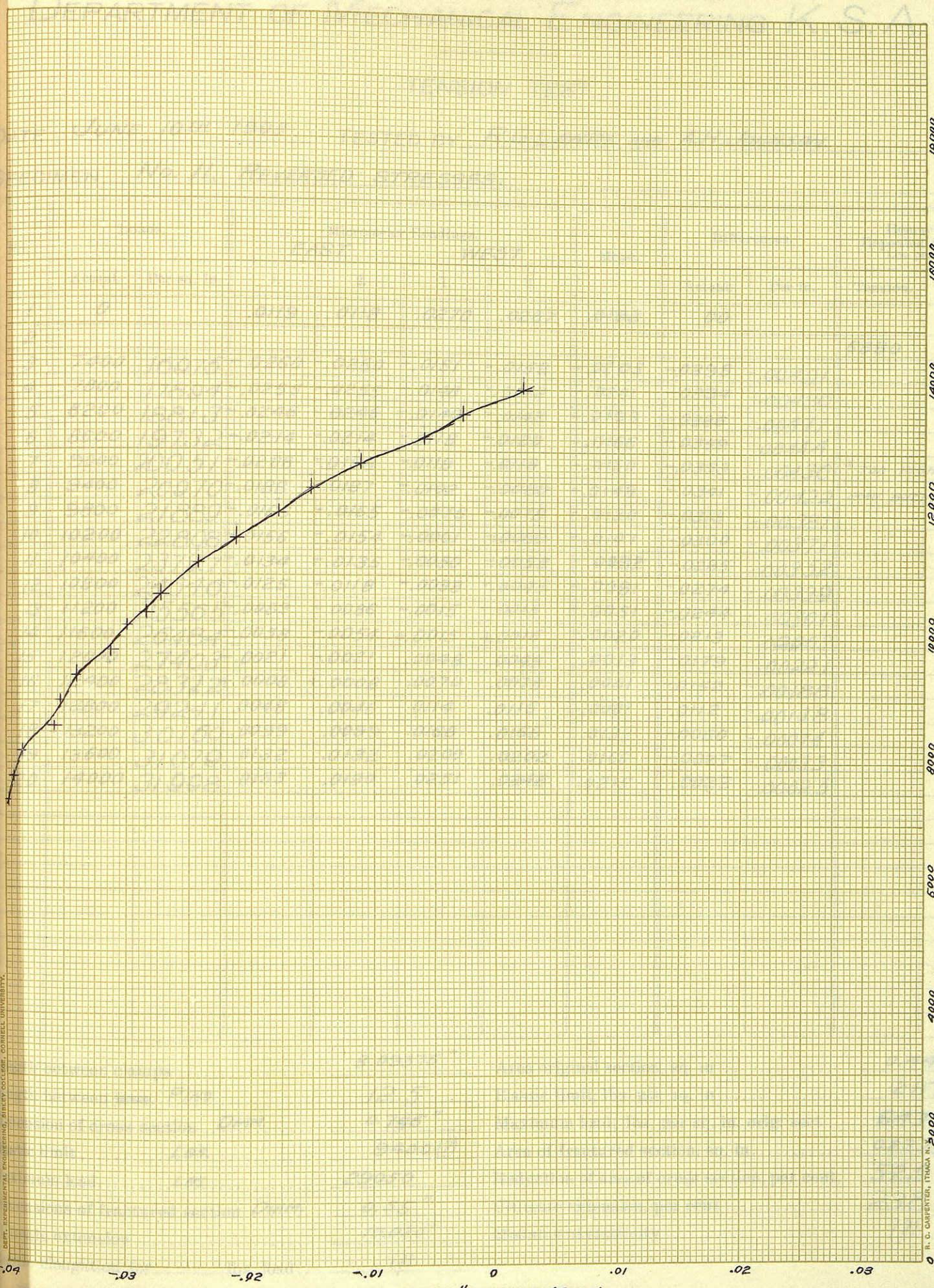
SPECIMEN No.9, REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0		.0012	.0012	.0308	.0308	.0160				
2		+	-.0034		+.0252					18400	16100+ *
3			"		"					"	" (?)
4			"		"					"	"
5			"		"					"	"
6			"		"					"	"
7			"		"					19550	"
8			"		"					18970	"
9			"		"					18400	"
10			"		"					18400	"
11	8000	18408	-.0070	-.0071	.0290	.0290	.0108	-.0052	-.000642		
12	8500	19550	-.0065	-.0064	.0294	.0294	.0114	-.0046	-.000568		
13	9000	20700	-.0050	-.0052	.0300	.0302	.0125	-.0035	-.000432	* BUCKLED SLIGHT-	
14	9500	21850	-.0042	-.0040	.0314	.0312	.0136	-.0024	-.000297	LY.	
15	10000	23000	-.0010	.0000	.0335	.0330	.0163	.0003	+.000037		
16	10500	24150	.0022	.0024	.0351	.0345	.0185	.0025	+.000309	+ READINGS TO	
17	11000	25300	.0040	.0040	.0369	.0369	.0204	.0064	+.000792	CORRESPOND TO	
18	11500	26450	.0081	.0082	.0399	.0399	.0240	.0080	.000990	16100 LBS. COMP.	

Length between clamps	8.09375"	Area original section, sq. in	0.4347
Length between ~~jaws~~ PINS.	12.5"	Elastic limit, lbs. per sq. in	21850
Dimension of cross section DIAM.	0.744"	Maximum load; lbs. per sq. in. orig. sect	62434
Elastic limit LBS.	9500	Area of fractured section, sq. in	0.2042
Maximum load LBS.	27140	Reduction of area of cross section, per cent,	46.97
Dimensions of fractured section DIAM.	0.51"	Ultimate extension, per cent	23.7
Ultimate extension	10.026"	Modulus of elasticity	(?)
Elastic elongation for ____ lbs. load	(?)		

Plot stress-strain diagram and hand in with this sheet.

No. 11 REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 10TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON.

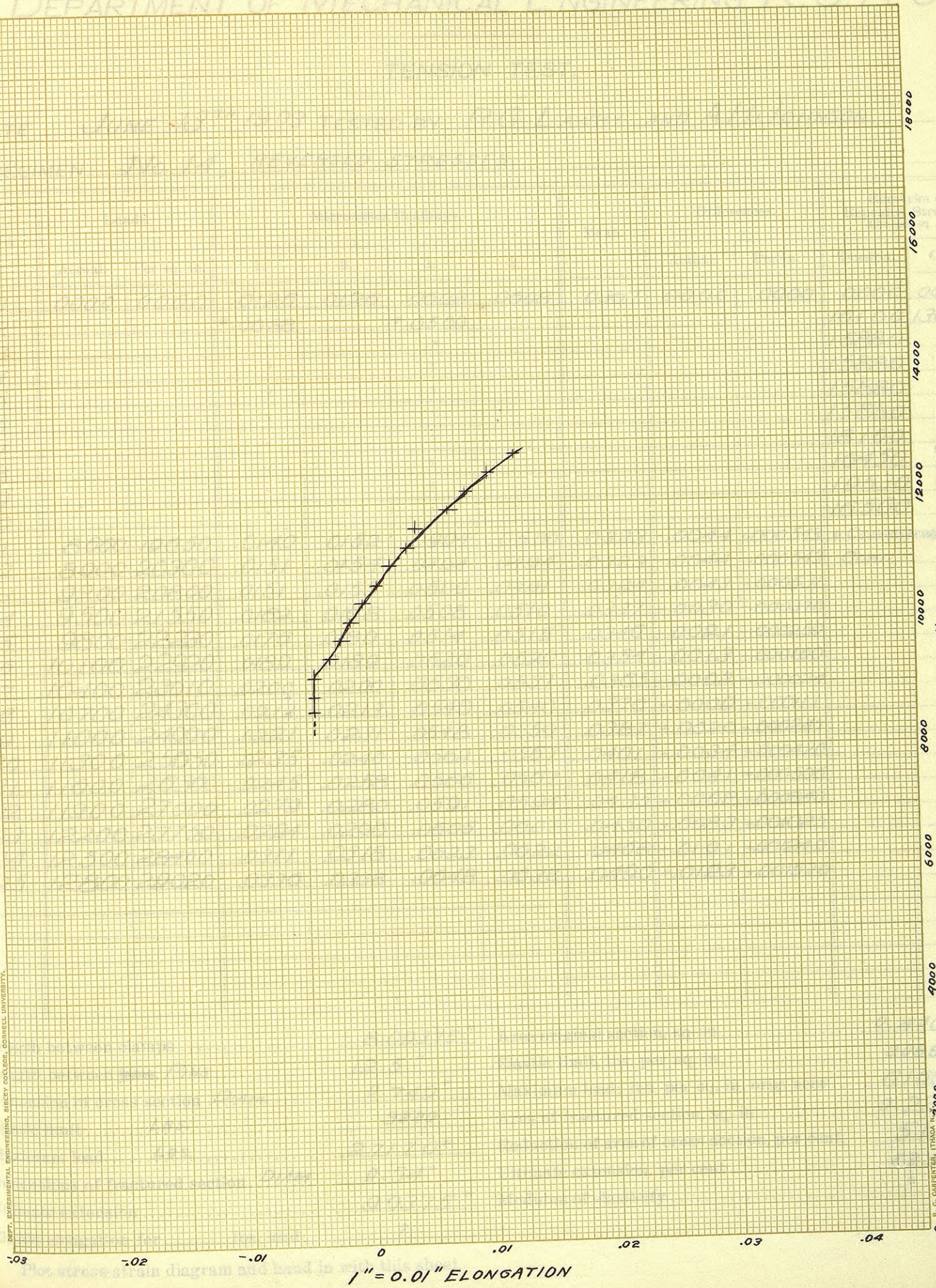
SPECIMEN No. 11, REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST.		WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0		.0119	.0118	.0270	.0267	.0193	00			
2										6880	(?) *
3	7400	16975	-.0260	-.0260	-.0151	-.0152	-.0205	-.0398	-.00491		
4	7800	17894	-.0255	-.0255	-.0148	-.0148	-.0201	-.0394	-.00486		
5	8200	18813	-.0246	-.0246	-.0140	-.0143	-.0193	-.0386	-.00477		
6	8600	19732	-.0214	-.0214	-.0118	-.0120	-.0166	-.0359	-.00444		
7	9000	20051	-.0208	-.0198	-.0118	-.0118	-.0160	-.0353	-.00436	* TOO HIGH, SPEC-	
8	9400	20970	-.0188	-.0187	-.0102	-.0089	-.0148	-.0341	-.00422	IMAN BUCKLED.	
9	9800	21889	-.0165	-.0165	-.0075	-.0078	-.0120	-.0313	-.00387		
10	10200	22808	-.0156	-.0154	-.0061	-.0060	-.0107	-.0300	-.00371		
11	10400	23727	-.0134	-.0135	-.0050	-.0052	-.0092	-.0285	-.00352		
12	10800	24646	-.0125	-.0118	-.0038	-.0045	-.0081	-.0274	-.00339		
13	11200	25565	-.0089	-.0086	-.0015	-.0015	-.0051	-.0244	-.00301		
14	11600	26484	-.0058	-.0054	+.0015	+.0016	-.0020	-.0213	-.00263		
15	12000	27403	-.0021	-.0021	.0048	.0049	.0013	-.0179	-.00221		
16	12400	28322	+.0008	+.0008	.0070	.0078	.0041	-.0152	-.00188		
17	12800	29241	.0048	.0046	.0114	.0116	.0081	-.0112	-.00138		
18	13200	30160	.0099	.0099	.0168	.0168	.0133	-.0060	-.00074		
19	13600	31079	.0132	.0132	.0200	.0202	.0166	-.0027	-.00033		
20	14000	31998	.0183	.0180	.0251	.0248	.0215	.0022	.00025		

Length between clamps	8.09375"	Area original section, sq. in	0.4488
Length between ~~jaws~~ PINS	12.5	Elastic limit, lbs. per sq. in	21170 (?)
Dimension of cross section DIAM.	0.756"	Maximum load; lbs. per sq. in. orig. sect	64730
Elastic limit LBS.	9400 (?)	Area of fractured section, sq. in	0.2375
Maximum load LBS.	29050	Reduction of area of cross section, per cent,	52.9
Dimensions of fractured section DIAM.	0.55"	Ultimate extension, per cent	23.8
Ultimate extension	10.020"	Modulus of elasticity	(?)
Elastic elongation for ____ lbs. load	(?)		

Plot stress-strain diagram and hand in with this sheet.

No. 14 REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 13TH 1903 TESTED BY R.G. LAWRY AND A.H. JOHNSON

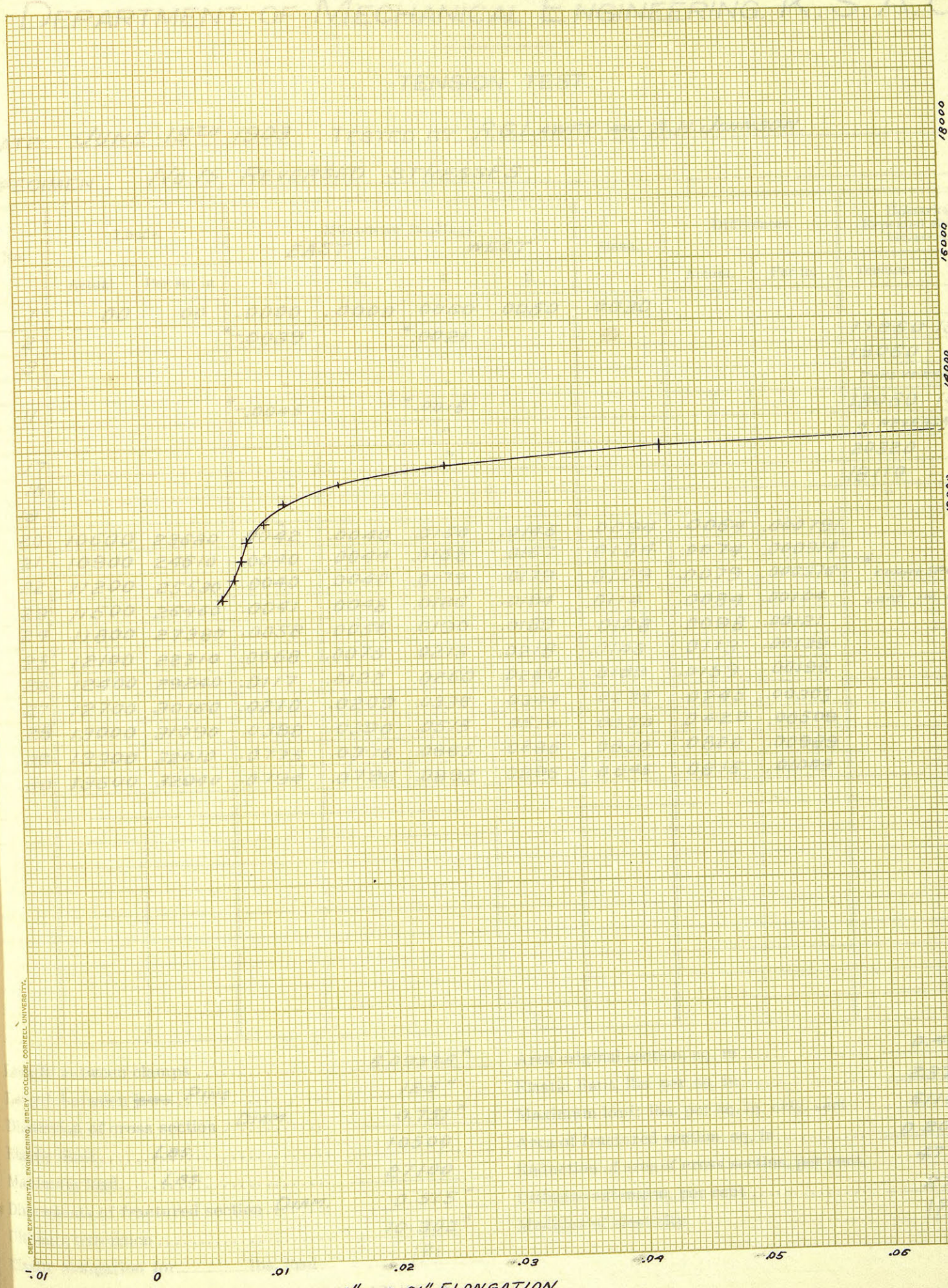
SPECIMEN No. 14, REVERSED STRESSES.

No.	Loads.		Micrometer Readings.				Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	0000	.0126	.0126	.0608	.0608	.0367	0000	.0000	0000	0000
2			*.0088		*.0569					16100	13618
3			"		"					15880	"
4			"		"					15880	"
5			"		"					15880	CONSTANT
6			"		"					15880	
7			"		"					18160	
8			"		"					16450	
9			"		"					19530	
10			"		"					16560	
11	8660	19650	.0140	.0152	.0994	.0500	.0323	-.0044	-.000543	* CORRESPONDS TO	
12	8900	20300	.0151	.0154	.0494	.0494	.0323	-.0044	-.000543	COMP.	
13	9200	20800	.0151	.0155	.0500	.0491	.0324	-.0043	-.000531		
14	9500	21550	.0162	.0168	.0508	.0510	.0337	-.0030	-.000370		
15	9800	22230	.0176	.0180	.0514	.0515	.0346	-.0021	-.000259		
16	10100	22920	.0189	.0189	.0520	.0520	.0354	-.0013	-.000160		
17	10400	23610	.0200	.0200	.0530	.0531	.0365	-.0002	-.000024		
18	10700	24300	.0212	.0213	.0540	.0540	.0376	+.0009	+.000111		
19	11000	24990	.0221	.0231	.0548	.0550	.0387	+.0020	+.000247		
20	11300	25650	.0235	.0240	.0562	.0567	.0401	+.0034	+.000420		
21	11600	26300	.0245	.0258	.0566	.0567	.0418	+.0041	+.000506		
22	11900	27000	.0279	.0280	.0591	.0594	.0435	+.0068	+.000840		
23	12200	27750	.0294	.0296	.0605	.0607	.0450	+.0083	+.001025		
24	12500	28400	.0311	.0318	.0623	.0622	.0468	+.0101	+.001249		
25	12800	29020	.0336	.0338	.0648	.0638	.0490	+.0123	+.001520		

Length between clamps	8.09375"	Area original section, sq. in	0.4406
Length between ~~jaws~~. PINS	12.5"	Elastic limit, lbs. per sq. in	20880
Dimension of cross section DIAM.	0.740"	Maximum load; lbs. per sq. in. orig. sect	61666
Elastic limit LBS.	9200	Area of fractured section, sq. in	0.2290
Maximum load LBS.	27170#	Reduction of area of cross section, per cent,	51.9
Dimensions of fractured section DIAM.	0.54"	Ultimate extension, per cent	22.9
Ultimate extension	9.9375"	Modulus of elasticity	?
Elastic elongation for ____ lbs. load	?		

Plot stress-strain diagram and hand in with this sheet.

No. 15 REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 15TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON.

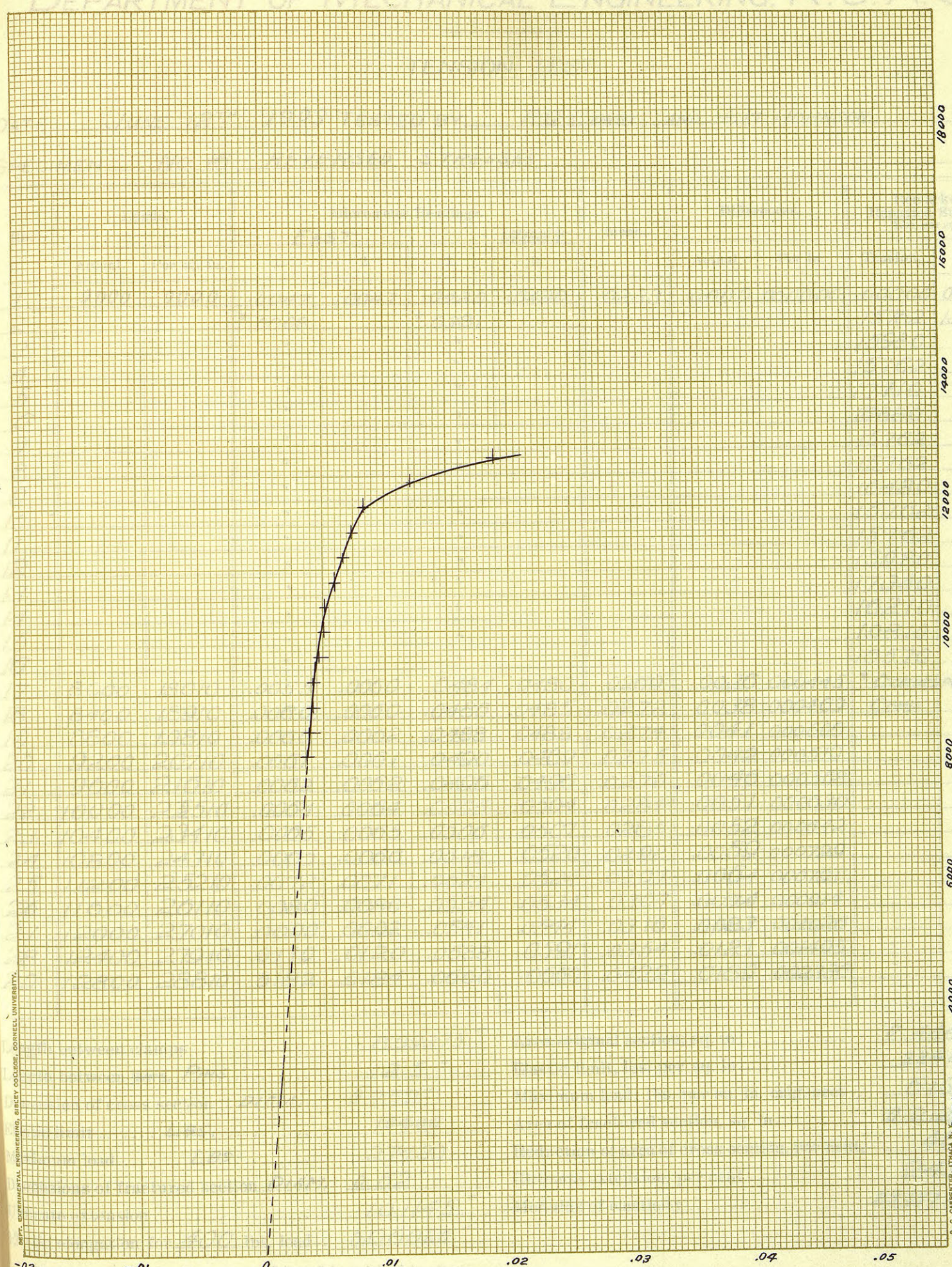
SPECIMEN No. 15, REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00	00	.0000	.0000	.0060	.0060	.0030				
2			*-.0039		*.0021					17250	13520
3			"		"					18060	"
			"		"					7-REVERSALS.	
11			*-.0045		*.0015					18060	15580
			"		"					5-REVERSALS.	
17			"		"					20320	"
18			"		"					18110	"
19			"		"					"	"
20	10600	23680	.0042	.0040	.0150	.0145	.0094	.0064	.00791		
21	10900	24610	.0040	.0044	.0168	.0167	.0104	.0074	.000914		
22	11200	25530	.0040	.0040	.0179	.0179	.0109	.0079	.000976	* CORRESPONDS TO	
23	11500	26460	.0041	.0048	.0186	.0184	.0114	.0084	.00104	LOAD IN COMP.	
24	11800	27380	.0058	.0056	.0190	.0189	.0128	.0098	.00121		
25	12100	28310	.0068	.0075	.0213	.0218	.0143	.0113	.00139		
26	12400	29240	.0117	.0122	.0260	.0260	.0189	.0159	.00196		
27	12700	30160	.0210	.0209	.0338	.0344	.0275	.0245	.00303		
28	13000	31090	.0388	.0390	.0515	.0510	.0450	.0420	.00509		
29	13300	32010	.0775	.0776	.0885	.0886	.0830	.0800	.00989		
30	13600	32940	.0794	.0796	.0892	.0896	.0845	.0815	.01009		

Length between clamps	8.09375"	Area original section, sq. in	0.4429
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	23710
Dimension of cross section DIAM.	0.751"	Maximum load; lbs. per sq. in. orig. sect	61180
Elastic limit LBS.	10500	Area of fractured section, sq. in	0.2083
Maximum load LBS.	27100	Reduction of area of cross section, per cent,	47.03
Dimensions of fractured section DIAM.	0.515"	Ultimate extension, per cent	27.4
Ultimate extension	10.302"	Modulus of elasticity	(?)
Elastic elongation for ____ lbs. load	(?)		

Plot stress-strain diagram and hand in with this sheet.

No. 16 REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 12TH 1903 TESTED BY R.G. LAWRY AND A.H. JOHNSON

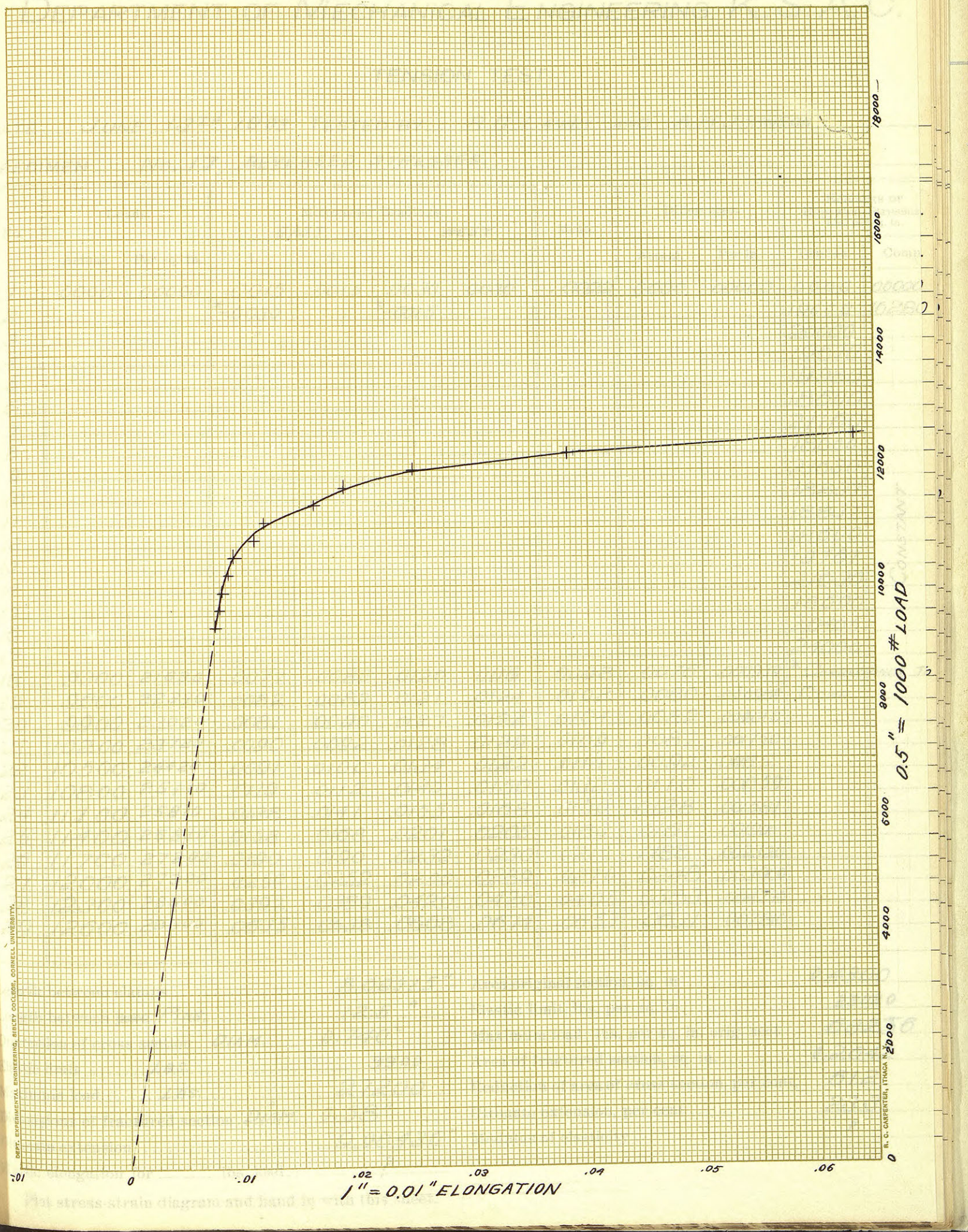
SPECIMEN NO. 16, REVERSED STRESSES

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	0000	.0047	.0047	.0420	.0420	.0233	.0000	.000000	00000	00000
2			*.0008		*.0381					15762	13520
3			"		"					15980	
4			"		"					15762	
5			"		"					17110	
6			"		"					16880	
7			"		"					15762	
8			"		"					15762	
9			"		"					16430	CONSTANT
10			"		"					15762	
11			"		"					15762	
12			"		"					15980	
13			"		"					17340	
14			"		"					16210	
15			"		"					19810	
16			"		"					16570	
17	8000	18010	.0055	.0060	.0484	.0480	.0269	.0036	.000445	* CORRESPONDS TO	
18	8400	18910	.0060	.0060	.0486	.0485	.0272	.0038	.000469	COMP.	
19	8800	19810	.0060	.0062	.0488	.0488	.0274	.0041	.000506		
20	9200	20710	.0061	.0061	.0490	.0489	.0275	.0042	.000519		
21	9600	21610	.0062	.0062	.0496	.0496	.0279	.0046	.000568		
22	10000	22510	.0064	.0064	.0505	.0504	.0284	.0051	.000630		
23	10400	23410	.0065	.0065	.0506	.0507	.0285	.0052	.000642		
24	10800	24310	.0065	.0066	.0518	.0520	.0292	.0059	.000729		
25	11200	25210	.0072	.0071	.0524	.0524	.0297	.0064	.000791		
26	11600	26110	.0080	.0080	.0534	.0534	.0307	.0074	.000914		
27	12000	27010	.0090	.0092	.0541	.0544	.0316	.0083	.001020		
28	12400	27910	.0119	.0120	.0588	.0591	.0354	.0121	.001495		
29	12800	28810	.0182	.0184	.0660	.0660	.0422	.0189	.002336		

Length between clamps	8.09375"	Area original section, sq. in	0.4441
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	23410
Dimension of cross section .. DIAM.	0.752"	Maximum load; lbs. per sq. in. orig. sect	61310
Elastic limit ..... LBS.	10400	Area of fractured section, sq. in	0.2123
Maximum load ..... LBS.	27430	Reduction of area of cross section, per cent,	48.
Dimensions of fractured section DIAM.	0.52"	Ultimate extension, per cent	24.9
Ultimate extension	10.1145"	Modulus of elasticity	29,157,000
Elastic elongation for 400 lbs. load	0.00025"		

Plot stress-strain diagram and hand in with this sheet.

No. 17, REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 13TH 1903 TESTED BY R.G. LAWRY AND A.H JOHNSON

SPECIMEN No. 17, REVERSED STRESSES.

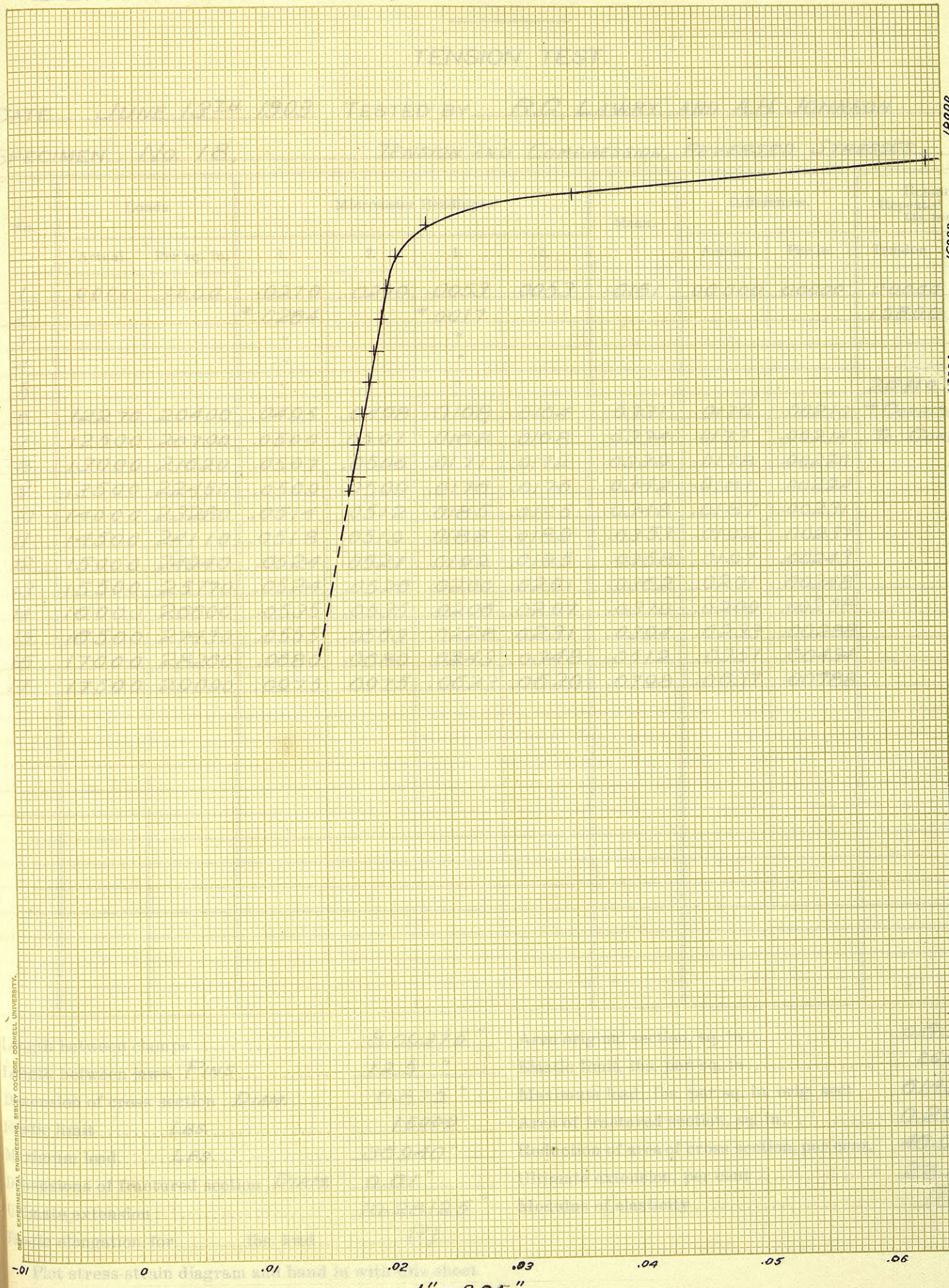
No.	Loads.		Micrometer Readings. EAST.		Micrometer Readings. WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	00000	.0015	.0015	.0030	.0030	.0022	0000	00000	0000	00000
2			*-.0030		*-.0015					19000	16280
3			"		"					20000	
4			"		"					19670	
5			"		"					19980	
6			"		"					18600	
7			"		"					21160	
8			"		"					18600	
9			"		"					21630	
10			"		"					18837	
11			"		"					18837	
12			"		"					18600	
13			"		"					19767	
14			"		"					21630	
15			"		"					18600	
16			"		"					20465	
17			"		"					24000	
18	9300	21630	.0077	.0080	.0120	.0116	.0098	.0076	.000939	*Corresponds To	
19	9600	22330	.0082	.0082	.0121	.0124	.0102	.0080	.000989	Comp	
20	9900	23020	.0081	.0090	.0127	.0122	.0104	.0082	.001010		
21	10200	23720	.0090	.0092	.0128	.0129	.0109	.0087	.001750		
22	10500	24420	.0091	.0100	.0134	.0122	.0114	.0092	.001135		
23	10800	25110	.0119	.0112	.0140	.0150	.0132	.0110	.001359		
24	11100	25810	.0138	.0141	.0155	.0168	.0150	.0128	.001581		
25	11400	26510	.0158	.0168	.0201	.0205	.0183	.0161	.001990		
26	11700	27200	.0190	.0190	.0232	.0230	.0210	.0188	.002320		
27	12000	27900	.0250	.0252	.0290	.0289	.0270	.0248	.003060		
28	12300	28600	.0392	.0389	.0420	.0420	.0405	.0383	.004730		
29	12600	29300	.0635	.0638	.0668	.0674	.0653	.0631	.007810		

CONSTANT

Length between clamps	8.09375"	Area original section, sq. in	0.4300
Length between ~~jaws~~. PINS	12.5 "	Elastic limit, lbs. per sq. in	23020
Dimension of cross section ..DIAM.	0.740"	Maximum load; lbs. per sq. in. orig. sect ..	63256
Elastic limit ..... LBS.	9900	Area of fractured section, sq. in	0.2642
Maximum load..... LBS.	27200	Reduction of area of cross section, per cent,	61.2
Dimensions of fractured section .DIAM.	0.58"	Ultimate extension, per cent	23.3
Ultimate extension	9.98436"	Modulus of elasticity	?
Elastic elongation for _____ lbs. load..	?		

Plot stress-strain diagram and hand in with this sheet.

No. 18, REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 13TH 1903 TESTED BY R.G. LAWRY AND A.H. JOHNSON

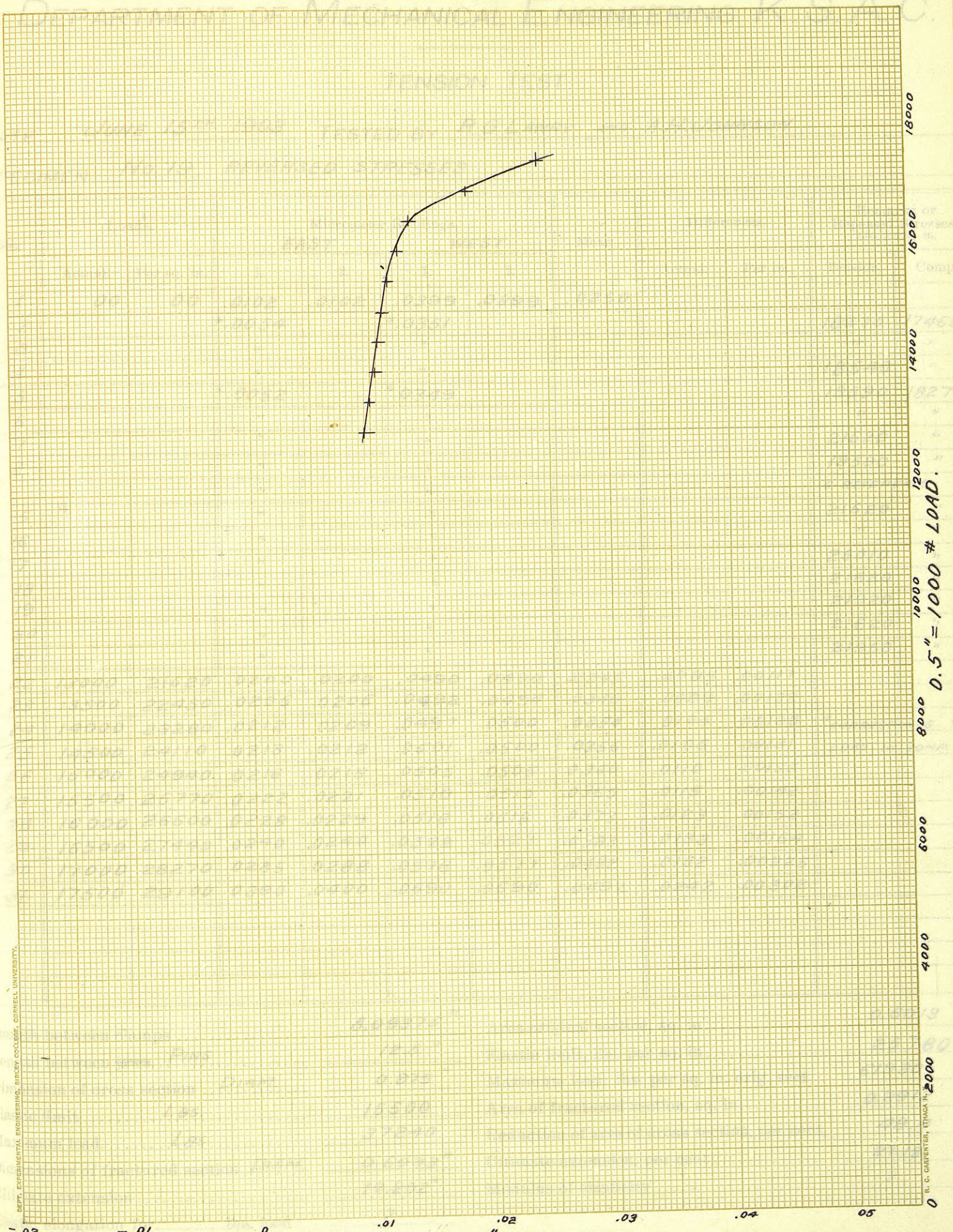
SPECIMEN No. 18, TENSION AND COMPRESSION, REVERSED STRESSES.

No.	Loads.		Micrometer Readings.				Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	0000	.0270	.0270	.0053	.0053	.0161	00000	00000	00000	00000
2			*.0264		*.0017					15800	13470
3			"		"					"	"
4			"		"					"	"
5			"		"					26110	"
6	12270	20400	.0495	.0498	.0168	.0164	.0331	.0170	.00210	*CORRESPONDS	
7	12500	20780	.0500	.0501	.0168	.0168	.0334	.0173	.00214	TO COMP	
8	13000	21620	.0507	.0506	.0171	.0172	.0339	.0178	.00220		
9	13500	22450	.0509	.0509	.0176	.0176	.0342	.0181	.00224		
10	14000	23280	.0514	.0512	.0185	.0185	.0348	.0187	.00231		
11	14500	24110	.0518	.0519	.0188	.0189	.0353	.0192	.00237		
12	15000	24940	.0524	.0521	.0192	.0195	.0358	.0197	.00243		
13	15500	25770	.0524	.0526	.0200	.0201	.0362	.0201	.00248		
14	16000	26600	.0535	.0535	.0206	.0207	.0370	.0209	.00258		
15	16500	27430	.0555	.0563	.0228	.0231	.0394	.0233	.00288		
16	17000	28260	.0680	.0680	.0243	.0348	.0512	.0351	.00434		
17	17500	29090	.0975	.0975	.0623	.0620	.0798	.0637	.00788		

Length between clamps	8.09375"	Area original section, sq. in	0.6013
Length between ~~jaws.~~ PINS.	12.5 "	Elastic limit, lbs. per sq. in	26610
Dimension of cross section . DIAM.	0.875"	Maximum load; lbs. per sq. in. orig. sect	61430
Elastic limit ..... LBS.	16000	Area of fractured section, sq. in	0.2022
Maximum load ..... LBS.	36940"	Reduction of area of cross section, per cent,	40.04
Dimensions of fractured section . DIAM.	0.51"	Ultimate extension, per cent	28.12
Ultimate extension	10.28125"	Modulus of elasticity	(?)
Elastic elongation for ____ lbs. load	(?)		

Plot stress-strain diagram and hand in with this sheet.

No. 19, REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 15TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON

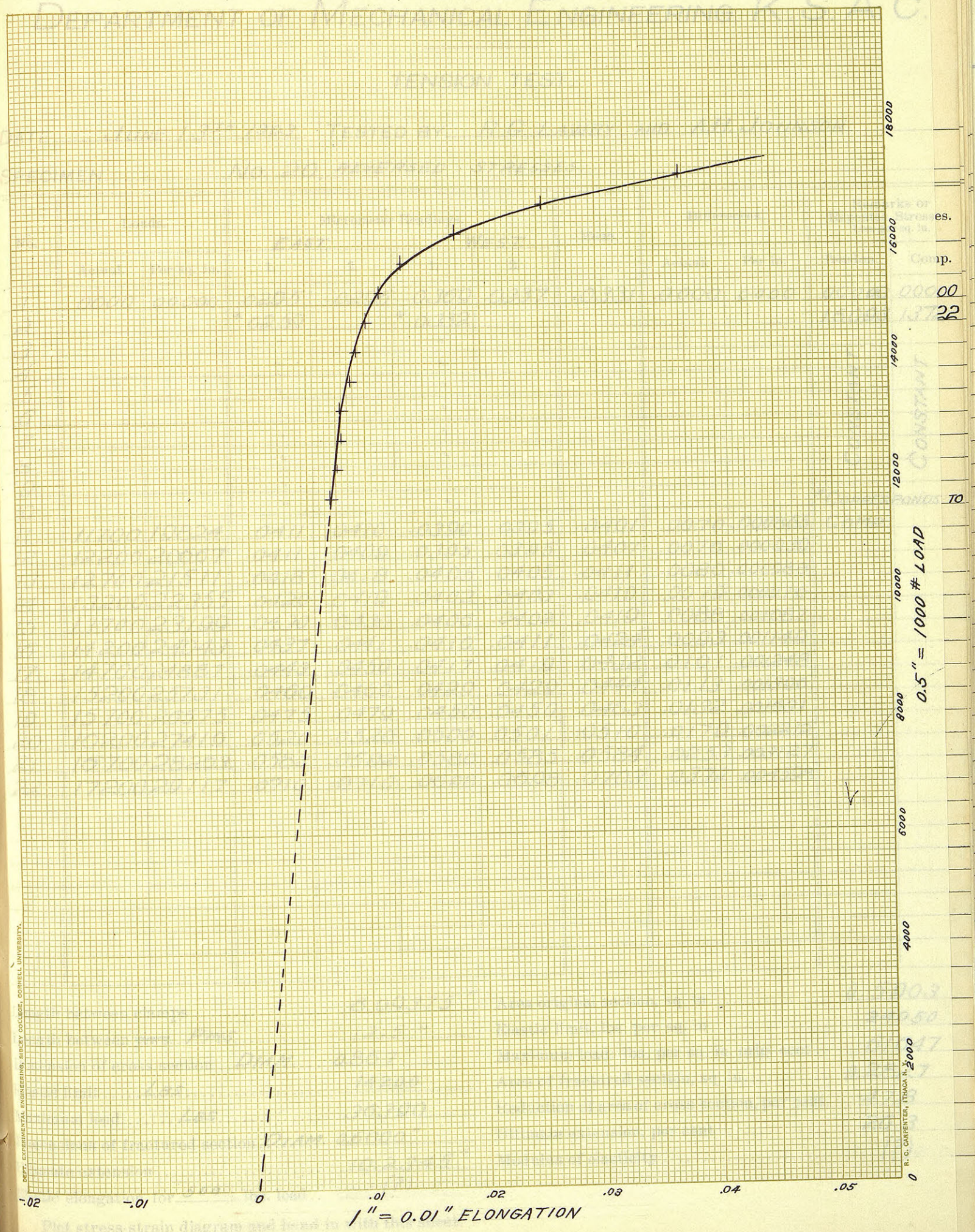
SPECIMEN No. 19, REVERSED STRESSES

No.	Loads. Actual.	Loads. Per sq. in.	Micrometer Readings. EAST 1.	EAST 2.	WEST 1.	WEST 2.	Mean.	Differences. Actual.	Differences. Per in.	Remarks or Repeated Stresses. Lbs. per sq. in. Tension.	Comp.
1	00	00	.0102	.0102	.0399	.0399	.0250				
2			*.0054		*.0351					18270	17460
3			"		"					"	"
4			"		"					18540	"
5			*.0052		*.0349					19590	18270
6			"		"					"	"
7			"		"					21620	"
8			"		"					19590	"
			"		"					6-REVERSALS	
15			"		"					21620	"
16			"		"					"	"
17			"		"					26010	"
18			"		"					21620	"
19			"		"					21920	"
20			"		"					21620	"
21			"		"					21950	"
22	13000	21620	.0200	.0200	.0490	.0490	.0345	.0095	.00117		
23	13500	22450	.0206	.0206	.0492	.0494	.0349	.0099	.00122		
24	14000	23280	.0212	.0209	.0497	.0500	.0354	.0104	.00128	*CORRESPONDS TO	
25	14500	24110	.0213	.0212	.0501	.0500	.0356	.0106	.00131	LOAD IN COMP.	
26	15000	24940	.0216	.0216	.0505	.0506	.0360	.0110	.00136		
27	15500	25770	.0222	.0221	.0510	.0510	.0365	.0115	.00142		
28	16000	26600	.0228	.0229	.0518	.0518	.0373	.0123	.00152		
29	16500	27440	.0240	.0240	.0528	.0527	.0383	.0133	.00164		
30	17000	28270	.0285	.0288	.0578	.0577	.0432	.0182	.00225		
31	17500	29100	.0390	.0400	.0690	.0690	.0492	.0242	.00302		

Length between clamps	8.09375"	Area original section, sq. in	0.6013
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	25780
Dimension of cross section DIAM.	0.875"	Maximum load; lbs. per sq. in. orig. sect	61930
Elastic limit LBS.	15500	Area of fractured section, sq. in	0.2912
Maximum load LBS	37240	Reduction of area of cross section, per cent,	48.4
Dimensions of fractured section DIAM.	0.6093"	Ultimate extension, per cent	27.18
Ultimate extension	10.292"	Modulus of elasticity	?
Elastic elongation for ____ lbs. load	?		

Plot stress-strain diagram and hand in with this sheet.

No. 20, REVERSED STRESSES



DEPT. EXPERIMENTAL ENGINEERING, SIBLEY COLLEGE, CORNELL UNIVERSITY.

R. C. CARPENTER, ITHACA N.Y.

DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 13TH 1903 TESTED BY R.G. LAWRY AND A.H. JOHNSON

SPECIMEN No. 20, REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST.		WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	0000	00000	.0295	.0295	.0369	.0337	.0331	.0000	.0000	.00000	.00000
2			*.0259		*.0332					16093	13722
3			"		"					CONSTANT	CONSTANT
4			"		"						
5			"		"						
6			"		"						
7			"		"						
8			"		"						
9			"		"						
10			"		"					*CORRESPONDS TO	
11	11700	10824	.0411	.0410	.0390	.0395	.0401	.0070	.000865	COMP.	
12	12200	20667	.0411	.0409	.0395	.0395	.0407	.0076	.000939		
13	12700	21511	.0418	.0418	.0405	.0405	.0411	.0080	.000988		
14	13200	22355	.0420	.0419	.0402	.0403	.0410	.0079	.000976		
15	13700	23199	.0430	.0430	.0406	.0402	.0419	.0088	.001087		
16	14200	24043	.0437	.0441	.0410	.0411	.0424	.0093	.001149		
17	14700	24887	.0443	.0450	.0417	.0419	.0432	.0101	.001248		
18	15200	25731	.0460	.0460	.0429	.0429	.0444	.0113	.001396		
19	15700	26575	.0475	.0479	.0450	.0450	.0463	.0132	.001631		
20	16200	27419	.0520	.0520	.0500	.0501	.0510	.0170	.002212		
21	16700	28263	.0583	.0592	.0580	.0585	.0584	.0253	.003127		
22	17200	29117	.0710	.0710	.0698	.0698	.0703	.0372	.004598		

Length between clamps ..... 8.09375"

Length between ~~jaws~~ PINS ..... 12.5"

Dimension of cross section .. DIAM. .... 0.867"

Elastic limit ..... LBS. 14200

Maximum load ..... LBS. 30390

Dimensions of fractured section DIAM. 0.6000"

Ultimate extension ..... 10.2345"

Elastic elongation for 500 lbs. load .. (?)

Area original section, sq. in 0.5903

Elastic limit, lbs. per sq. in 24050

Maximum load; lbs. per sq. in. orig. sect .. 61647

Area of fractured section, sq. in 0.2827

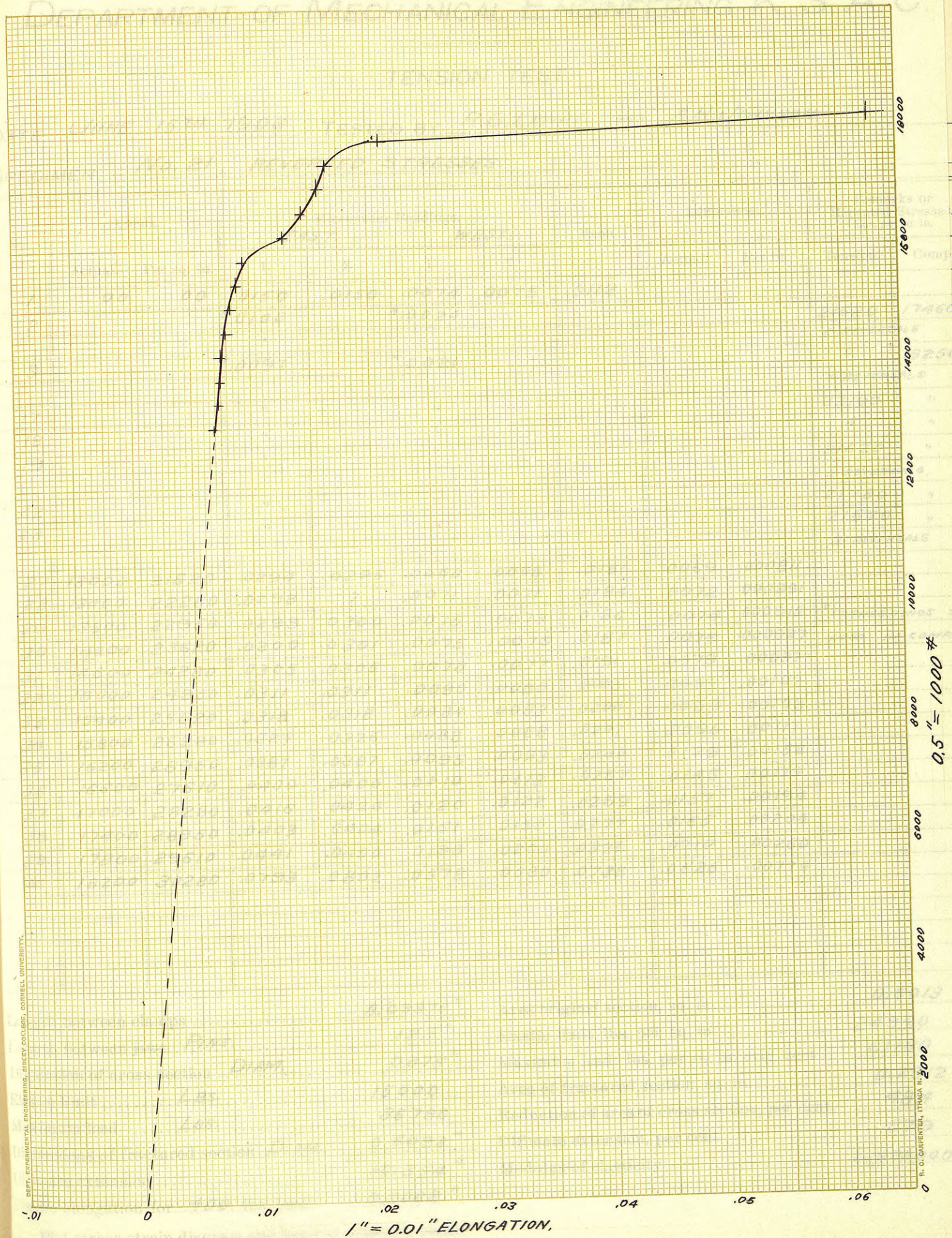
Reduction of area of cross section, per cent, 47.8

Ultimate extension, per cent 26.3

Modulus of elasticity ..... (?)

Plot stress-strain diagram and hand in with this sheet.

No. 21, REVERSED STRESSES.



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 15TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON

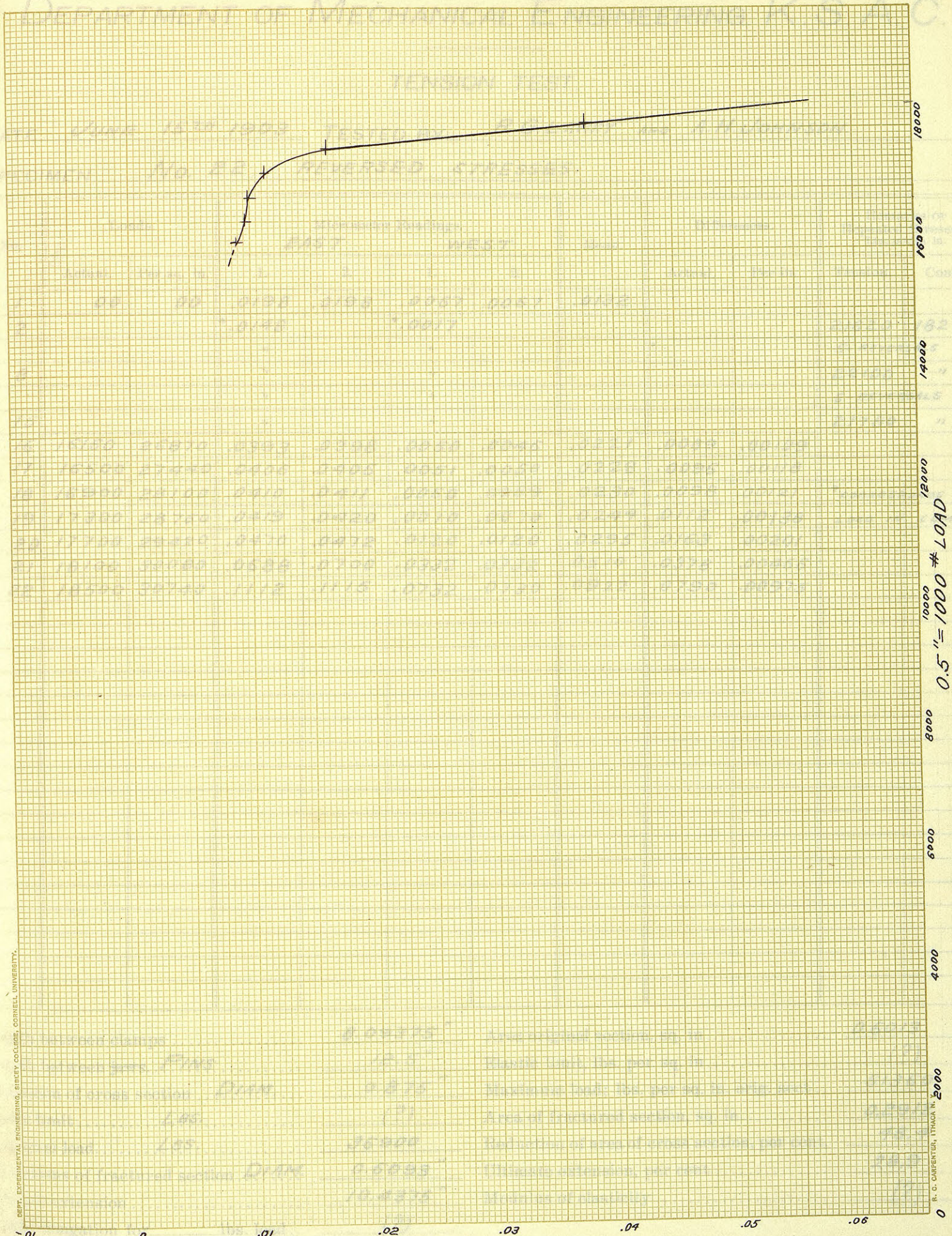
SPECIMEN No. 21, REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST.		WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00	00	.0150	.0150	.0074	.0075	.0112				
2			*.0100		*.0024					21620	17460
			"							6-REVERSALS	
9			*.0097		*.0021					"	19250
										7-REVERSALS	
17			"		"					22100	"
18			"		"					"	"
19			"		"					21620	"
										2-REVERSALS	
22			"		"					21780	"
23			"		"					21620	"
										3-REVERSALS	
27	13000	21620	.0294	.0296	.0068	.0068	.0181	.0069	.000811		
28	13400	22280	.0298	?	.0071	.0071	.0184	.0072	.000891		
29	13800	22950	.0299	.0300	.0075	.0073	.0186	.0074	.000915	*CORRESPONDS TO	
30	14200	23620	.0300	.0301	.0075	.0075	.0187	.0075	.000927	LOAD IN COMP.	
31	14600	24280	.0305	.0306	.0078	.0077	.0191	.0079	.000977		
32	15000	24950	.0311	.0311	.0080	.0080	.0195	.0083	.00102		
33	15400	25620	.0318	.0318	.0084	.0083	.0200	.0088	.00108		
34	15800	26280	.0327	.0326	.0088	.0088	.0207	.0095	.00117		
35	16200	26950	.0387	.0387	.0095	.0093	.0240	.0128	.00158		
36	16600	27610	.0400	.0400	.0110	.0113	.0257	.0145	.00179		
37	17000	28280	.0416	.0420	.0120	.0122	.0269	.0157	.00194		
38	17400	28950	.0403	.0404	.0151	.0150	.0277	.0165	.00204		
39	17800	29610	.0441	.0450	.0198	.0200	.0321	.0210	.00260		
40	18200	30280	.0793	.0802	.0578	.0580	.0738	.0626	.00774		

Length between clamps	8.09375"	Area original section, sq. in	0.6013
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	24940
Dimension of cross section DIAM.	0.875"	Maximum load; lbs. per sq. in. orig. sect	61160
Elastic limit LBS.	15000	Area of fractured section, sq. in	0.2912
Maximum load LBS.	36780	Reduction of area of cross section, per cent,	48.4
Dimensions of fractured section DIAM.	0.6093"	Ultimate extension, per cent	27.9
Ultimate extension	10.354"	Modulus of elasticity	26,928,000
Elastic elongation for 400 lbs. load	0.0002"		

Plot stress-strain diagram and hand in with this sheet.

No. 22, REVERSED STRESSES



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 15TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON.

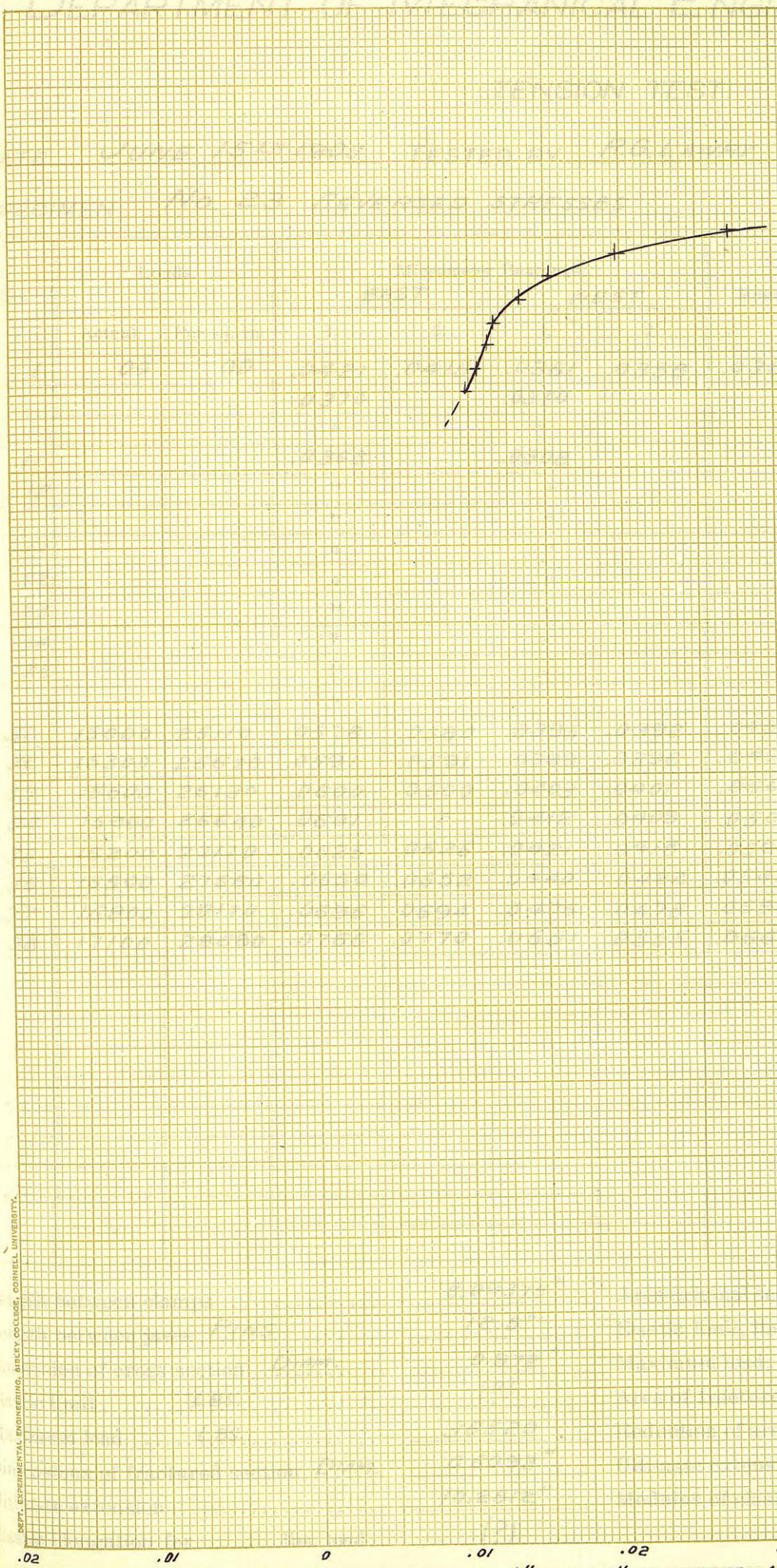
SPECIMEN No. 22, REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00	00	.0198	.0198	.0067	.0067	.0132				
2			*.0148		*.0017					21620	18270
			"		"					5- REVERSALS	
8			"		"					22100	"
			"		"					6- REVERSALS	
15			"		"					21780	"
16	16160	26870	.0393	.0398	.0050	.0046	.0221	.0089	.00109		
17	16500	27440	.0406	.0406	.0051	.0050	.0228	.0096	.00118		
18	16900	28100	.0410	.0411	.0060	.0059	.0230	.0098	.00121	*CORRESPONDS TO	
19	17300	28760	.0419	.0420	.0070	.0070	.0244	.0112	.00138	LOAD IN COMP.	
20	17700	29420	.0470	.0472	.0120	.0120	.0295	.0163	.00201		
21	18100	30080	.0688	.0700	.0332	.0332	.0510	.0378	.00466		
22	18500	30740	.1112	.1115	.0732	.0730	.0922	.0790	.00975		

Length between clamps	8.09375"	Area original section, sq. in	0.6013
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	(?)
Dimension of cross section DIAM.	0.875"	Maximum load; lbs. per sq. in. orig. sect	61360
Elastic limit LBS.	(?)	Area of fractured section, sq. in	0.2912
Maximum load LBS.	36900	Reduction of area of cross section, per cent,	48.4
Dimensions of fractured section DIAM.	0.6093"	Ultimate extension, per cent	28.9
Ultimate extension	10.4375"	Modulus of elasticity	(?)
Elastic elongation for ____ lbs. load	(?)		

Plot stress-strain diagram and hand in with this sheet.

No. 23, REVERSED STRESSES



DEPT. EXPERIMENTAL ENGINEERING, SIBLEY COLLEGE, CORNELL UNIVERSITY.

R. C. CARPENTER, ITHACA N. Y.

DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 15TH 1903 TESTED BY R.G. LAWRY AND A.H. JOHNSON

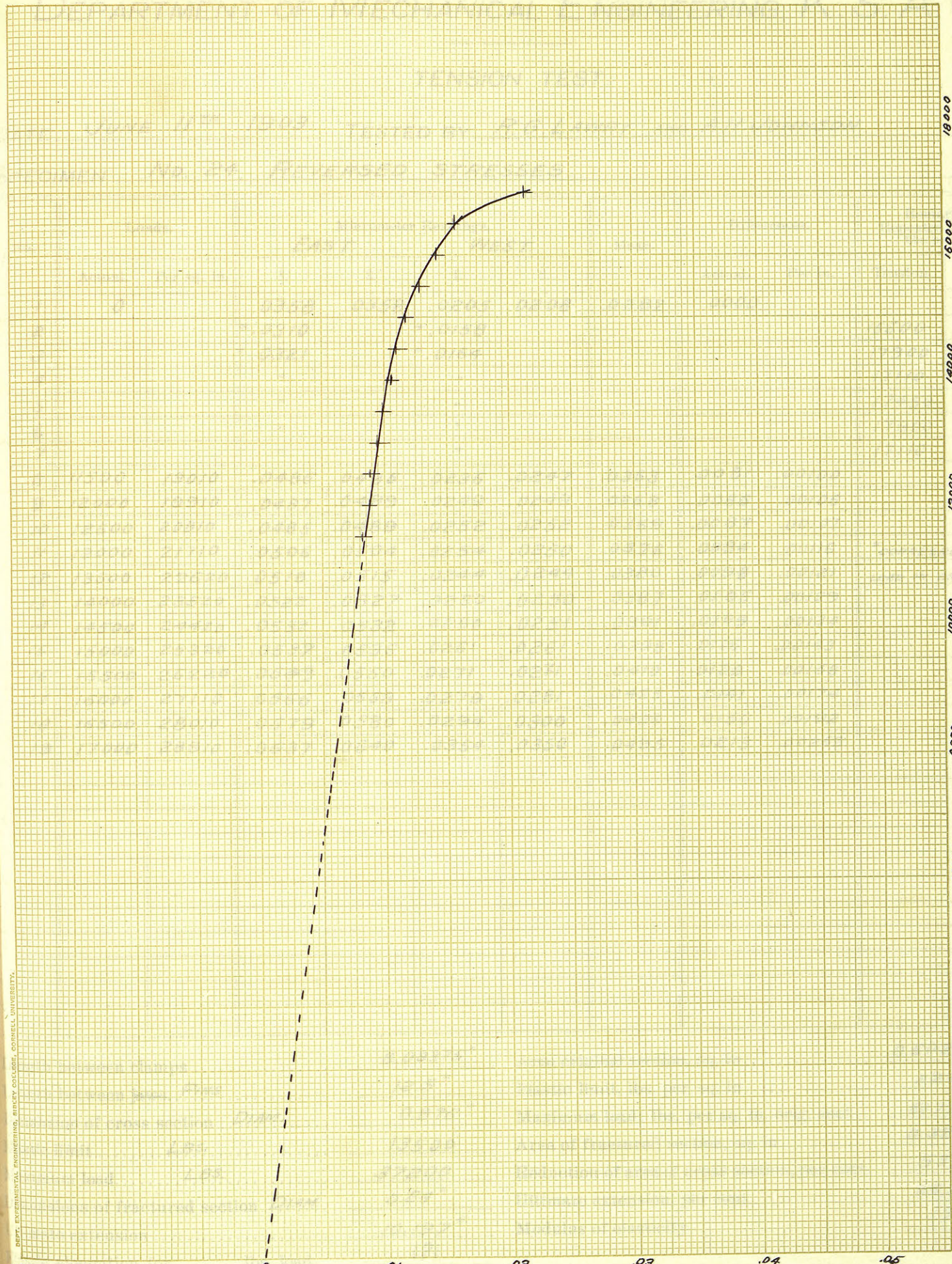
SPECIMEN No. 23, REVERSED STRESSES

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00	00	.0421	.0418	.0361	.0358	.0389				
			.0370		.0310					21750	18420
			"		"					9-REVERSALS	
11			.0368		.0308					21750	19260
12			"		"					"	20100
			"		"					8-REVERSALS	
21			"		"					22420	"
22			"		"					21750	"
23			"		"					"	"
24			"		"					22730	"
25			"		"					21750	"
			"		"					5-REVERSALS	
31	15000	25110	.0578	.0580	.0395	.0392	.0486	.0097	.00119		
32	15300	25620	.0591	.0591	.0399	.0396	.0494	.0105	.00129		
33	15600	26130	.0600	.0600	.0403	.0401	.0501	.0112	.00138		
34	15900	26640	.0601	?	.0412	.0409	.0505	.0116	.00143		
35	16200	27110	.0625	.0626	.0421	.0418	.0522	.0133	.00164		
36	16500	27660	.0650	.0652	.0440	.0422	.0541	.0152	.00187		
37	16800	28170	.0696	.0694	.0476	.0478	.0586	.0197	.00243		
38	17100	28680	.0766	.0770	.0551	.0555	.0660	.0271	.00334		

Length between clamps	8.09375"	Area original section, sq. in	0.5972
Length between ~~jaws~~ PINS	12.5"	Elastic limit, lbs. per sq. in	(?)
Dimension of cross section DIAM.	0.872"	Maximum load; lbs. per sq. in. orig. sect	61150
Elastic limit LBS.	(?)	Area of fractured section, sq. in	0.2912
Maximum load LBS.	36520	Reduction of area of cross section, per cent,	48.7
Dimensions of fractured section DIAM.	0.6093"	Ultimate extension, per cent	27.0
Ultimate extension	10.2812"	Modulus of elasticity	(?)
Elastic elongation for ____ lbs. load	(?)		

Plot stress-strain diagram and hand in with this sheet.

No. 24 REVERSED STRESSES,



DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

TENSION TEST.

DATE JUNE 11TH 1903 TESTED BY R.G.LAWRY AND A.H.JOHNSON.

SPECIMEN No. 24, REVERSED STRESSES.

No.	Loads.		Micrometer Readings. EAST		WEST		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1.	0		.0358	.0358	.0205	.0208	.0282	0000			
2			*.0310		*.0158					16600	16600
3			*.0321		*.0164					17900	13270
4			"		"					17110	"
5			"		"					17450	"
6			"		"					17900	"
7			"		"					17110	"
8	11500	19010	.0486	.0486	.0236	.0247	.0363	.0081	.00100		
9	12000	19910	.0487	.0489	.0249	.0249	.0368	.0086	.00106		
10	12500	20810	.0485	.0489	.0252	.0252	.0369	.0087	.00107		
11	13000	21710	.0506	.0504	.0254	.0250	.0376	.0094	.00116	*CORRESPONDS TO	
12	13500	22620	.0518	.0515	.0244	.0244	.0380	.0098	.00121	LOAD IN COMP.	
13	14000	23520	.0522	.0527	.0250	.0250	.0387	.0105	.00129		
14	14500	24420	.0532	.0532	.0250	.0251	.0391	.0109	.00134		
15	15000	25320	.0537	.0536	.0261	.0261	.0398	.0116	.00143		
16	15500	26220	.0549	.0550	.0271	.0271	.0410	.0128	.00158		
17	16000	27110	.0566	.0568	.0279	.0281	.0423	.0141	.00174		
18	16500	28010	.0579	.0580	.0294	.0300	.0438	0156	.00192		
19	17000	28910	.0637	.0640	.0354	.0350	.0495	.0213	.00263		

Length between clamps	8.09375"	Area original section, sq. in	0.6026
Length between ~~jaws~~. PINS	12.5"	Elastic limit, lbs. per sq. in	22400
Dimension of cross section ..DIAM.	0.876"	Maximum load; lbs. per sq. in. orig. sect ..	61730
Elastic limit ..LBS.	13500	Area of fractured section, sq. in	0.3216
Maximum load..LBS.	37200	Reduction of area of cross section, per cent,	53.8
Dimensions of fractured section..DIAM..	0.64"	Ultimate extension, per cent	25.87
Ultimate extension	10.197"	Modulus of elasticity	(?)
Elastic elongation for_____lbs. load..	(?)		

Plot stress-strain diagram and hand in with this sheet.

DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

~~TENSION~~ TEST.

DATE JUNE 11TH 1903 TESTED BY R.G. LAWRY

SPECIMEN No. 16, COMPRESSION, FLAT ENDS.

No.	Loads.		Micrometer Readings. EAST.		Micrometer Readings. WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00		.0285		.0300		.0292				
2	500		.0245		.0330		.0287				
3	1200		.0228		.0333		.0280				
4	1500		.0222		.0334		.0278				
5	2000		.0216		.0332		.0274				
6	2500		.0211		.0331		.0271				
7	3000		.0209		.0328		.0268				
8	3500		.0202		.0315		.0258				
9	4000		.0200		.0324		.0262				
10	4500		.0198		.0323		.0260				
11	5000		.0194		.0318		.0256				
12	5500		.0192		.0313		.0252				
13	6000		.0189		.0311		.0250				
14	6500		.0185		.0310		.0247				
15	7000		.0182		.0307		.0244				
16	7500		.0179		.0305		.0242				
17	8000		.0175		.0304		.0237				
18	8500		.0172		.0301		.0236				
19	9000		.0170		.0297		.0233				
20	9500		.0169		.0292		.0230				

Length between clamps .....

Length between jaws.....

Dimension of cross section, DIAM.... 0.752"

Elastic limit .....

Maximum load.....

Dimensions of fractured section.....

Ultimate extension .....

Elastic ~~elongation~~ COMPRESSION for 500 lbs. load.. 0.000326"

Area original section, sq. in .....

Elastic limit, lbs. per sq. in.....

Maximum load; lbs. per sq. in. orig. sect ..

Area of fractured section, sq. in.....

Reduction of area of cross section, per cent,

Ultimate extension, per cent .....

Modulus of elasticity .....

Plot stress-strain diagram and hand in with this sheet.

DEPARTMENT OF MECHANICAL ENGINEERING, K.S.A.C.

~~TENSION~~ TEST.

DATE JUNE 11TH 1903 TESTED BY R.G. LAWRY

SPECIMEN No. 24, COMPRESSION, FLAT ENDS.

No.	Loads.		Micrometer Readings. EAST.		Micrometer Readings. WEST.		Mean.	Differences.		Remarks or Repeated Stresses. Lbs. per sq. in.	
	Actual.	Per sq. in.	1.	2.	1.	2.		Actual.	Per in.	Tension.	Comp.
1	00		.0409		.0159		.0284				
2	500		.0420		.0140		.0280				
3	1000		.0432		.0127		.0279				
4	1500		.0432		.0124		.0278				
5	2000		.0433		.0114		.0272				
6	2500		.0434		.0107		.0270				
7	3000		.0434		.0103		.0268				
8	3500		.0432		.0100		.0266				
9	4000		.0429		.0099		.0264				
10	4500		.0429		.0099		.0264				
11	5000		.0427		.0092		.0259				
12	5500		.0424		.0093		.0258				
13	6000		.0420		.0090		.0255				
14	6500		.0419		.0088		.0253				
15	7000		.0418		.0085		.0251				
16	7500		.0414		.0085		.0249				
17	8000		.0413		.0082		.0247				
18	8500		.0409		.0079		.0244				
19	9000		.0409		.0075		.0241				
20	9500		.0406		.0075		.0240				
21	10000		.0403		.0072		.0237				
22	10500		.0400		.0070		.0235				
23	11000		.0398		.0067		.0232				
24	11500		.0398		.0064		.0231				
25	12000		.0395		.0063		.0229				
26	12500		.0395		.0060		.0227				
27	13000		.0392		.0058		.0225				
28											
29											

Length between clamps .....

Length between jaws.....

Dimension of cross section DIAM..... 0.876 "

Elastic limit.....

Maximum load.....

Dimensions of fractured section.....

Ultimate extension.....

Elastic ~~elongation~~ COMPRESSION for 500 lbs. load.. 0.000229 "

Plot stress-strain diagram and hand in with this sheet.

Area original section, sq. in.....

Elastic limit, lbs. per sq. in.....

Maximum load; lbs. per sq. in. orig. sect ..

Area of fractured section, sq. in.....

Reduction of area of cross section, per cent,

Ultimate extension, per cent .....

Modulus of elasticity .....