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FLEXURAL PROPERTIES OF CONOLON 506 AT ROOM TEMPERATURE, -320°F AND -423°F

REPORT NO. 55E 522

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REVISIONS

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FLEXURAL PROPERTIES OF CONOLON 506 AT ROOM TEMPERATURE, -320°F AND -423°F

OBJECTIVE:

The object of this test was to determine the flexural properties of three thicknesses of Conolon 506, glass fiber laminate material, at room temperature, -320°F and -423°F

CONCLUSIONS:

1. Fiber strength was apparently maximum at -320°F since ultimate stress values were highest at this temperature in all but one instance. The single exception occurred in 0.062 inch material with longitudinal warp, where maximum strength was attained at -423°F. (See Figures 2 and 3)

2. Specimens with longitudinal warp possessed greater strength than specimens of the same thickness with transverse warp. The single exception to this occurred in 0.062 Conolon at room temperature (See Figure 2).

3. No other trends or general statements are justified due to the irregularity of the data obtained in this investigation.

4. The quality control problem is a big obstacle to the use of Conolon 506.

RECOMMENDATIONS:

1. That attention be given to improve the quality of Conolon 506.

2. That other laminated materials be used in lieu of Conolon 506.

SPECIMENS:

Test specimens were cut from panels of Conolon 506 glass fiber laminate in such a way as to have the warp of the panel either parallel or perpendicular to length of the specimen. Half of the specimens of each thickness of material possessed parallel (longitudinal) warp and half possessed perpendicular (tranverse) warp.

Dimensions of the specimens were: 0.094 x 1 x 3-3/4 inches; 0.062 x 1 x 2 inches, and 0.022 x 1 x 3-1/2 inches.

PROCEDURE:

This investigation was requested by Structures, Department 597-3, and was conducted in accordance with Federal Specification L-P-406b, Method 1031.

The test consisted of bending specimens to their point of failure, while the specimens were at either room temperature, -320°F or -423°F.

To achieve loading of specimens at -423°F a special bending apparatus was designed. Figure 46 shows the bending fixture with cryostat removed. The pin supports at each end of the lower portion of the bending fixture were adjustable, so that span length could be varied. The center pin was raised to bend the specimen; thus bending curvature was upward.

Figure 47 shows a specimen positioned in the bending fixture. The rod in the foreground connected a knife-edge bar (shown resting on top of the specimen) to a dial indicator which measured beam deflection.

Figure 48 shows the cryostat in place and the dial indicator in position to measure deflection. Also shown, is the force gage employed to measure load in pounds.

Figure 49 is a view of the cryostat after filling with liquid hydrogen. The flexible metal hose connected to the top of the cryostat allowed hydrogen boil-off to escape to atmosphere.

The fiew in Figure 50 shows two copper tubes going to the loading rod and to the dial indicator rod. These tubes delivered heated helium to purge areas around the two rods; thus preventing frost formation and binding of the rods. Note; helium purge was not in progress when photograph was made; hence the presence of frost on the rods.

Figure 51 is an over all view of the test apparatus. The balanced beam was used to apply loadings to specimens. The loading was increased by flowing water into the barrel at the end of the beam.

RESULTS:

Data for Conolon specimens 0.094 inches thick is presented in Figure 1. Of these specimens, numbers 4, 5 and 6 yielded results which did not fit the usual pattern. Namely, the proportional limit for these specimens coincided with their ultimate loading.

Figures 2 and 3 present data for Conolon specimens 0.062 inches thick. Of these, specimens 1, 13, 14 and 15 had unusual load deflection curves. Specimen 1 had a completely linear curve. Specimens 13, 14 and 15 had load deflection curves which had two regions of linearity in each curve. Thus it was difficult to determine the bending modulus.

Specimens 17 and 18, Figure 3, appeared to have high ultimate stress values; in view of the fact that other specimens attained their maximum, ultimate stress values at -320°F, not at -423°F.

Figures 4 and 5 pertain to 0.022 inch thick Conolon. Of these specimens number 1 was the only one to have a linear load-deflection curve, and corresponding coincidence of proportional limit and ultimate load.

DISCUSSION:

Some of the specimens presented for testing produced strength values below the minimums required by material specifications. The unsatisfactory performance of these specimens was attributed to lack of quality control in manufacture and was not thought to be typical of properly made Conolon. Therefore, data from the substandard specimens was omitted from this report. This accounts for the lack of data on 0.094 inch thick material at -423°F, and for the occasional presence in the tables of data pertaining to single specimens.

The fact that some test data was disregarded because of sub-standard test values is evidence that all of the material submitted for testing was of doubtful quality. Therefore, even the data presented in this report is suspect, and should be regarded as presenting the maximum property values of the material submitted for testing; not as necessarily representing the properties of good quality Conolon.

NOTE: The test data from which this report was prepared are recorded in Astronautics Engineering Laboratories Notebooks Numbered 7502, pages 61-67 and 7530, pages 24-27 and 29-38.

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TABLE 1

FLEXURE DATA FOR .094 CONDITION AT ROOM TEMP. AND -320°F

SPECIMEN NUMBER	THICKNESS (in.)	WIDTH (in.)	SPAN (in.)	DIRECTION OF WARP	PROP. LIMIT (lb)	PROP. LIMIT (ksi)	ULTIMATE LOAD (lbs)	ULTIMATE STRESS (ksi)	BENDING MODULUS PSI x 10^-6	MAXIMUM DEFLECTION (in.)
				ROOM TEMPERATURE						
2	0.093	1.000	1.58	L	180	49.4	226	62.0	2.90	0.100
3	0.092	0.999	1.58	L	168	47.0	218	61.3	2.98	0.103
AVERAGE	0.0925	0.9995	1.58		174	48.2	222	61.6	2.93	0.1015
11	0.093	0.996	1.58	T	142	39.2	176	48.5	2.67	0.092
12	0.094	1.002	1.58	T	134	35.9	174	46.8	2.76	0.083
13	0.094	1.006	1.58	T	144	38.0	193	50.9	2.88	0.089
AVERAGE	0.094	1.001	1.58		140	37.7	181	48.7	2.77	0.088
					-320°F					
4	0.095	1.004	1.58	L	364	96.0	364	96.0	3.76	0.103
5	0.093	1.000	1.58	L	366	100.2	366	100.2	3.89	0.101
6	0.093	1.005	1.58	L	230	63.2	230	63.2	3.00	0.095
AVERAGE	0.0936	1.003	1.58		320	86.3	320	86.3	3.55	0.0996
14	0.093	1.000	1.58	T	180	49.3	276	75.5	4.46	0.078

PREPARED BY [illegible] DATE 5-25-61 | CHECKED BY DATE | REVISED BY DATE

Figure 1

TABLE 2

FLEXURE DATA FOR 0.062 CONOLON AT ROOM TEMP. AND -320°F

SPECIMEN NUMBER	THICKNESS (in.)	WIDTH (in.)	SPAN (in.)	DIRECTION OF WARP	PROP. LOAD (lbs)	PROP. LIMIT (ksi)	ULTIMATE LOAD (lbs)	ULTIMATE STRESS (ksi)	BENDING MODULUS (psi x 10⁶)	MAXIMUM DEFLECTION (in.)
ROOM TEMPERATURE										
1	0.060	1.000	1.58	T	82.0	54.0	82.0	54.0	2.28	0.157
2	0.060	1.000	1.58	T	52.0	34.2	75.0	49.4	2.63	0.154
AVERAGE	0.060	1.000	1.58		67.0	44.1	78.5	51.7	2.46	0.156
11	0.065	0.988	1.58	L	62.0	35.2	85.0	48.3	3.03	0.124
12	0.065	1.000	1.58	L	75.0	42.0	95.0	53.2	2.99	0.132
AVERAGE	0.065	0.994	1.58		68.5	38.6	90.0	50.8	3.01	0.127
-320°F										
3	0.059	1.000	1.00	T	80.0	34.5	169.0	72.7	3.24	0.092
4	0.059	1.000	1.00	T	54.0	23.2	175.0	74.5	3.20	0.093
5	0.059	1.000	1.00	T	90.0	33.8	166.0	71.5	3.13	0.079
6	0.063	1.000	1.00	T	90.0	35.9	182.0	68.5	2.74	0.083
AVERAGE	0.060	1.000	1.00		78.5	32.8	172.0	71.8	3.08	0.084
13	0.065	1.000	1.00	L	78.0	27.7	217.0	77.0	4.28	0.061
14	0.064	1.000	1.00	L	60.0	22.0	204.0	74.6	5.05	0.056
15	0.063	1.000	1.00	L	80.0	30.2	210.0	79.4	3.64	0.067
AVERAGE	0.064	1.000	1.00		72.6	26.7	210.3	77.0	4.32	0.061

PREPARED BY H. A. Lucas DATE 5-23-61 | CHECKED BY DATE | REVISED BY DATE

Figure 2

TABLE 3

FLEXURE DATA FOR 0.062 CONOLON AT -423°F

SPECIMEN NUMBER	THICKNESS (in.)	WIDTH (in.)	SPAN (in.)	DIRECTION OF WEAVE	FPOP LIMIT (lbs)	FPOP LIMIT (KS)	ULTIMATE LOAD (lbs)	ULTIMATE STRESS (KS)	BENDING MODULUS ($\times 10^6$)	MAXIMUM DEFLECTION (in.)
				-423°F						
7	0.063	1.000	1.00	T	64	24.2	150	58.0	3.58	0.077
8	0.062	1.000	1.00	T	60	23.4	175	68.2	3.66	0.084
9	0.063	1.000	1.00	T	68	25.7	185	69.9	3.49	0.074
10	0.063	1.000	1.00	T	52	19.7	170	64.3	3.55	0.073
AVERAGE	0.0628	1.000	1.00		61	23.2	175	66.6	3.57	0.077
17	0.062	1.000	1.00	L	62	24.2	210	81.7	3.80	0.065
18	0.061	1.000	1.00	L	58	23.4	210	84.5	4.33	0.066
AVERAGE	0.0615	1.000	1.00		60	23.8	210	83.1	4.06	0.0655

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Figure 3

TABLE 4

FLEXURE DATA FOR 0.0217 CONOLON AT ROOM TEMP AND -320°F

SPECIMEN NUMBER	THICKNESS (in)	WIDTH (in)	SPAN (in)	DIRECTION OF WARP	PROP. LIMIT (lb)	PROP. LIMIT (KSI)	ULTIMATE LOAD (lbs)	ULTIMATE STRESS (KSI)	BENDING MODULUS (PSI x 10^6)	MAXIMUM DEFLECTION (in)
ROOM TEMPERATURE										
1	0.0220	0.9980	1.00	T	10.75	33.4	10.75	33.4	1.19	0.225
2	0.0216	0.9940	1.00	T	3.4	11.0	8.5	27.5	1.22	0.238
AVERAGE	0.0218	0.9960	1.00		7.07	22.2	9.63	30.5	1.205	0.232
11	0.0213	0.9980	1.00	L	12.0	39.8	19.1	63.3	1.34	0.210
12	0.0217	0.9985	1.00	L	11.2	35.9	17.9	57.4	1.38	0.180
AVERAGE	0.0215	0.9983	1.00		11.6	37.8	18.5	60.3	1.36	0.195
-320°F										
4	0.0214	0.9955	1.00	T	9.5	31.2	12.25	40.3	1.99	0.385
5	0.0217	0.9980	1.00	T	7.5	24.0	11.50	36.7	1.29	0.275
6	0.0210	0.9985	1.00	T	8.5	27.3	12.75	46.9	1.35	0.375
AVERAGE	0.0214	0.9973	1.00		8.3	27.5	12.5	41.3	1.21	0.345
13	0.0215	0.9985	1.00	L	20.4	66.1	32.75	105.0	5.20	0.540
14	0.0214	0.9980	1.00	L	16.4	54.1	27.50	90.0	3.14	0.278
16	0.0213	0.9970	1.00	L	18	59.6	26.0	86.1	2.50	0.276
AVERAGE	0.0214	0.9978	1.00		18.3	59.9	28.75	94.0	3.61	0.298

PREPARED BY H. H. [illegible] DATE 6-1-[illegible] | CHECKED BY DATE | REVISED BY DATE

Figure 4

TABLE 5

FLEXURE DATA FOR 0.0217 CONOLON AT -423 °F

SPECIMEN NUMBER	THICKNESS (in.)	WIDTH (in.)	SPAN (in.)	DIRECTION OF WARP	PROP. LIMIT (lbs)	PROP. LIMIT (ksi)	ULTIMATE LOAD (lbs)	ULTIMATE STRESS (ksi)	BENDING MODULUS (psi × 10^{-6})	MAXIMUM DEFLECTION (in)
					-423 °F					
7	0.0220	0.9985	1.00	T	9.5	29.4	12.5	38.7	1.18	0.245
8	0.0215	0.9985	1.00	T	11.5	37.3	13.75	44.5	1.24	0.340
9	0.0216	0.9975	1.00	T	8.0	26.0	10.00	32.5	1.04	0.278
AVERAGE	0.0217	0.9982	1.00		9.7	30.9	12.0[illegible]	38.6	1.15	0.287
17	0.0219	0.9970	1.00	L	23.4	73.4	29.0	91.0	2.86	0.278

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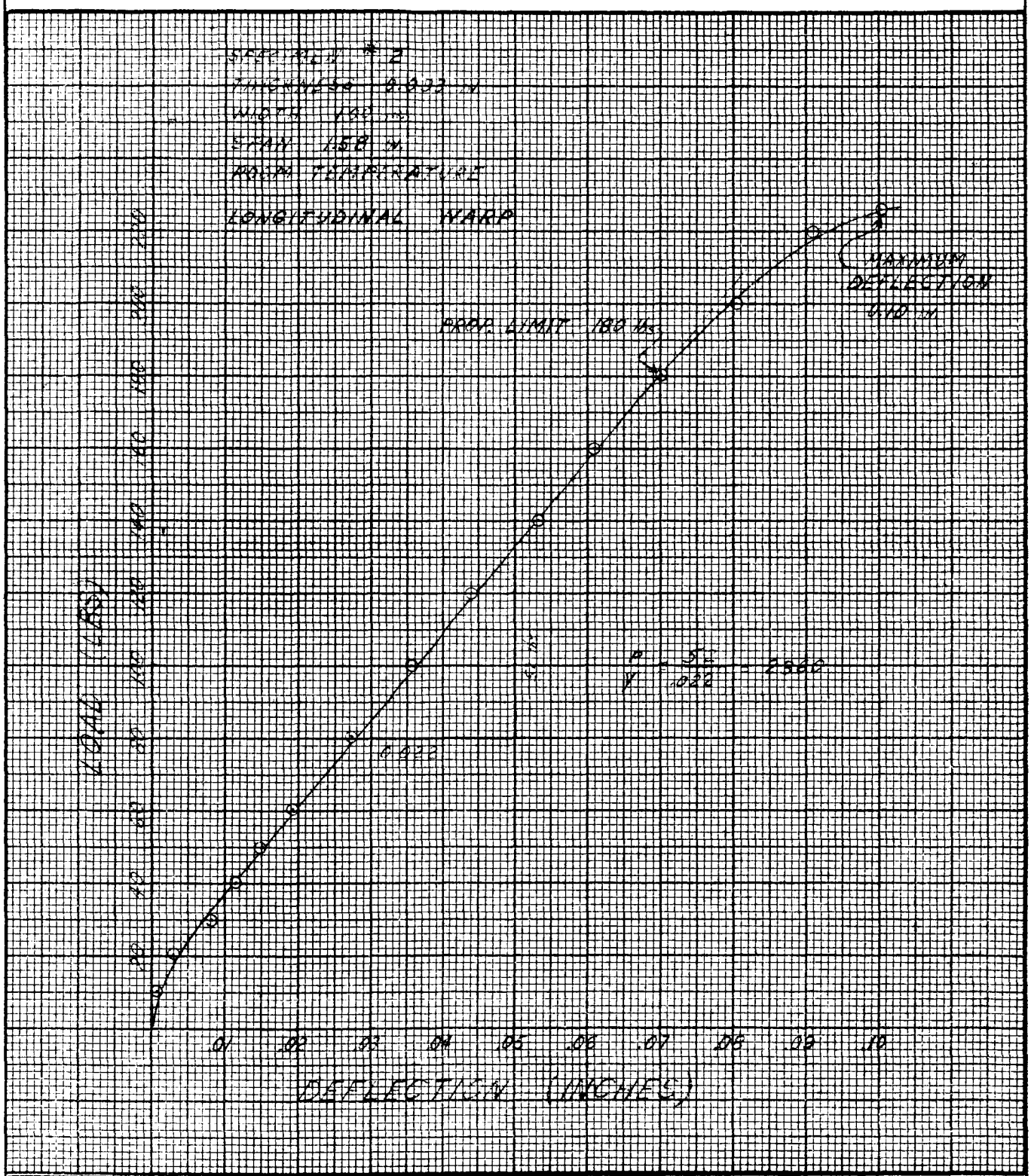
H. H. [illegible]	6-1-61				

Figure 5

CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



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[illegible]	5-25-61				

Figure 6

CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE

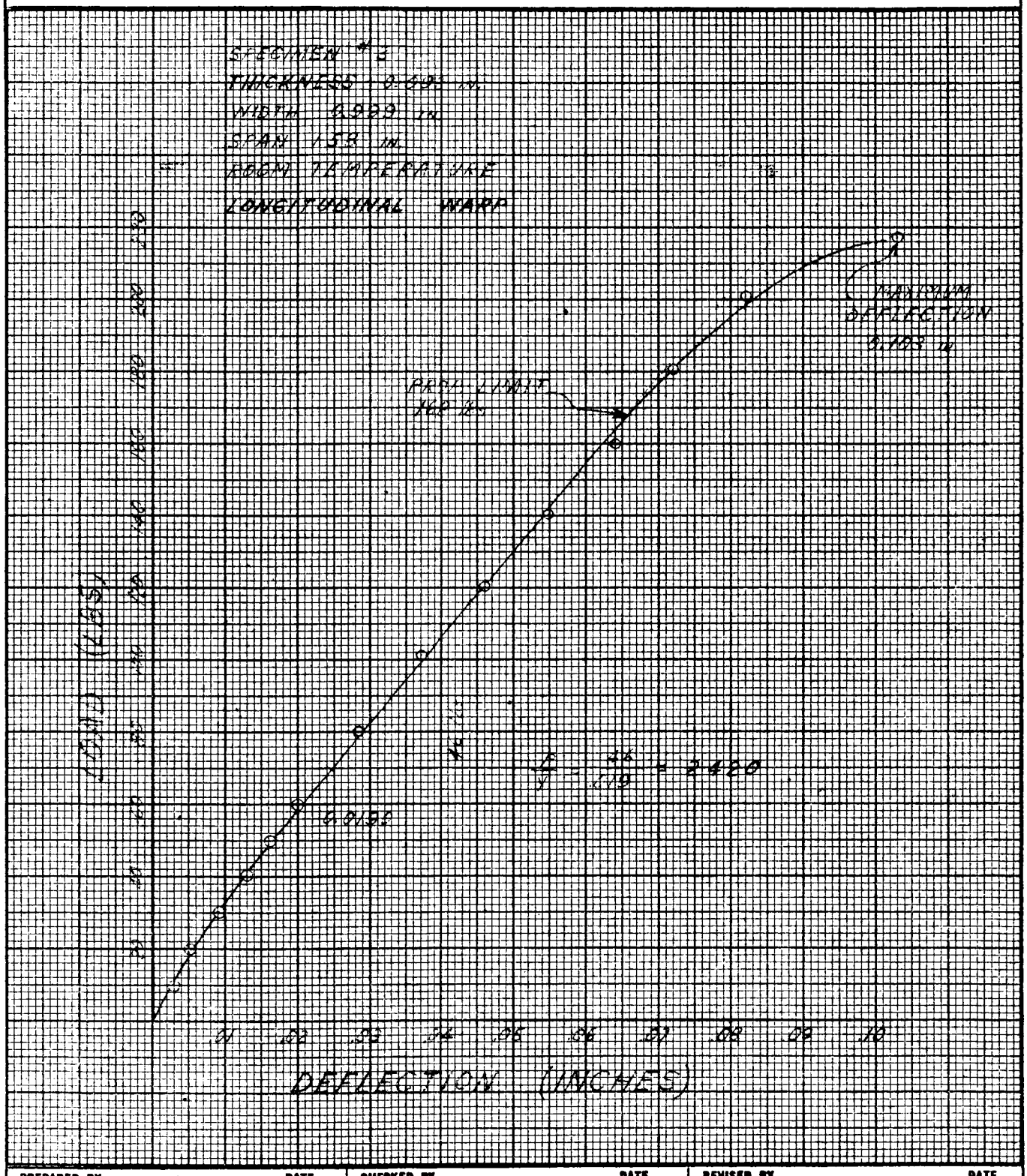

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Figure 7

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE

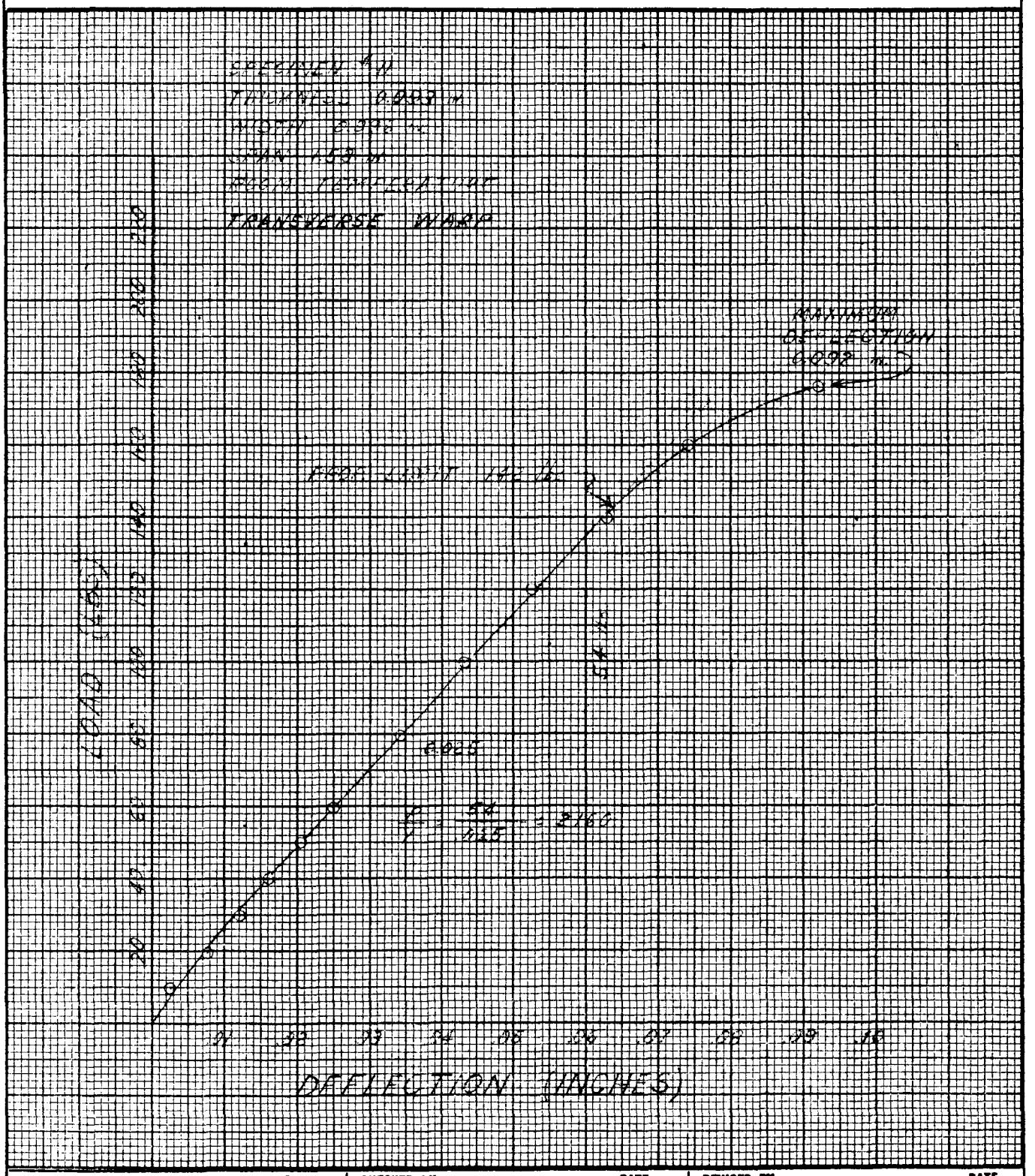

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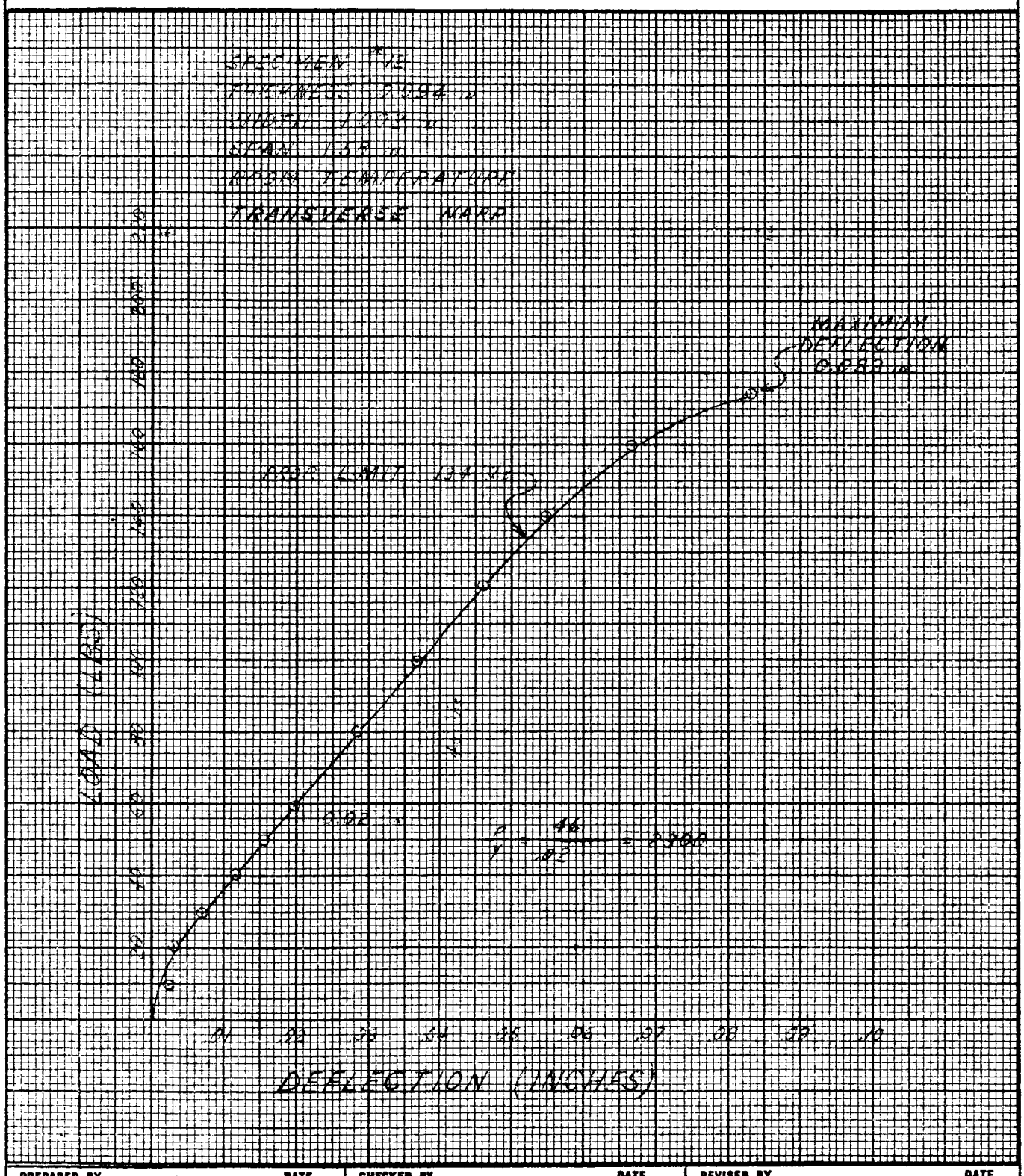
Figure 8

CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



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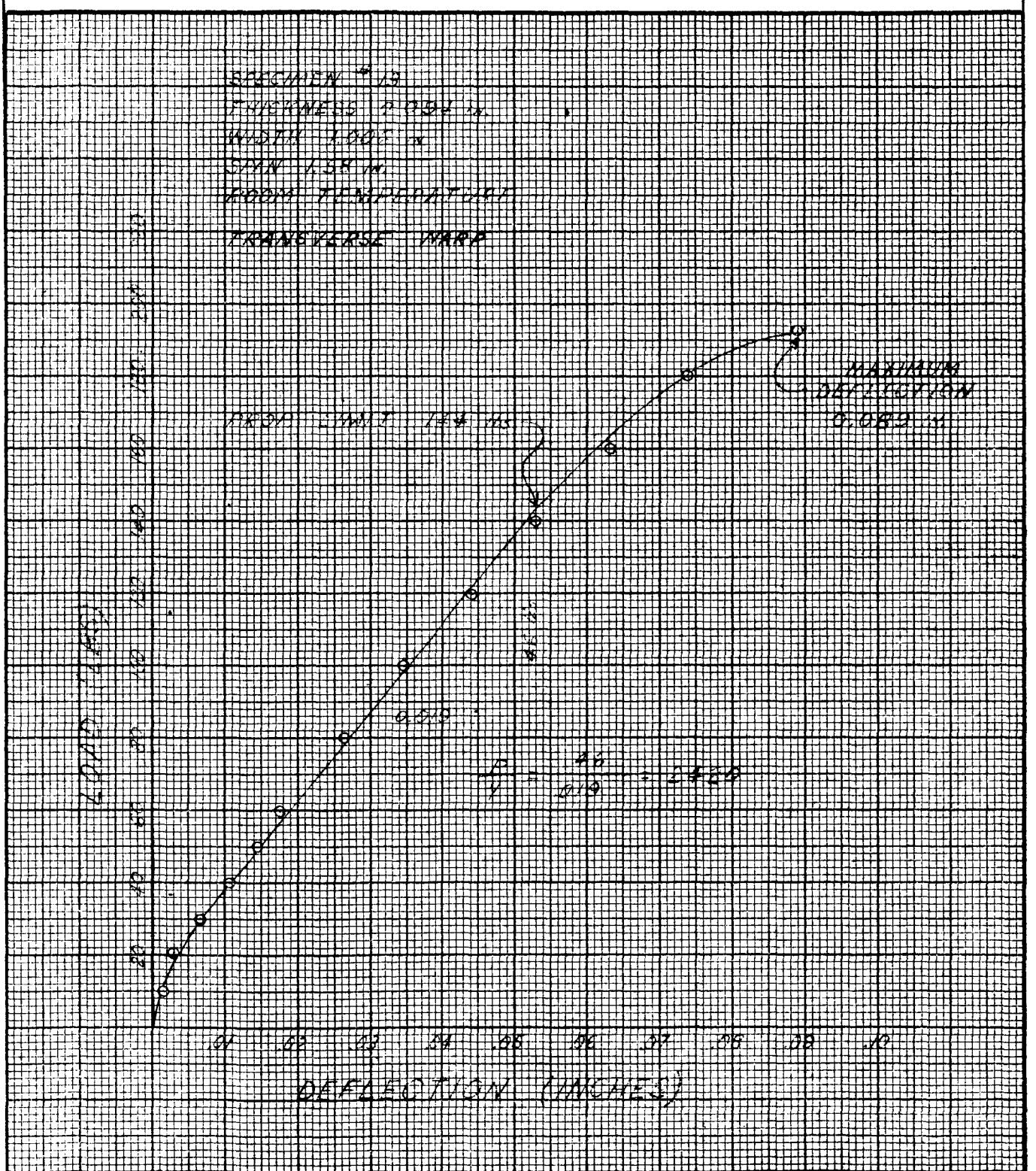
[illegible]	5-25-61				

Figure 9

CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



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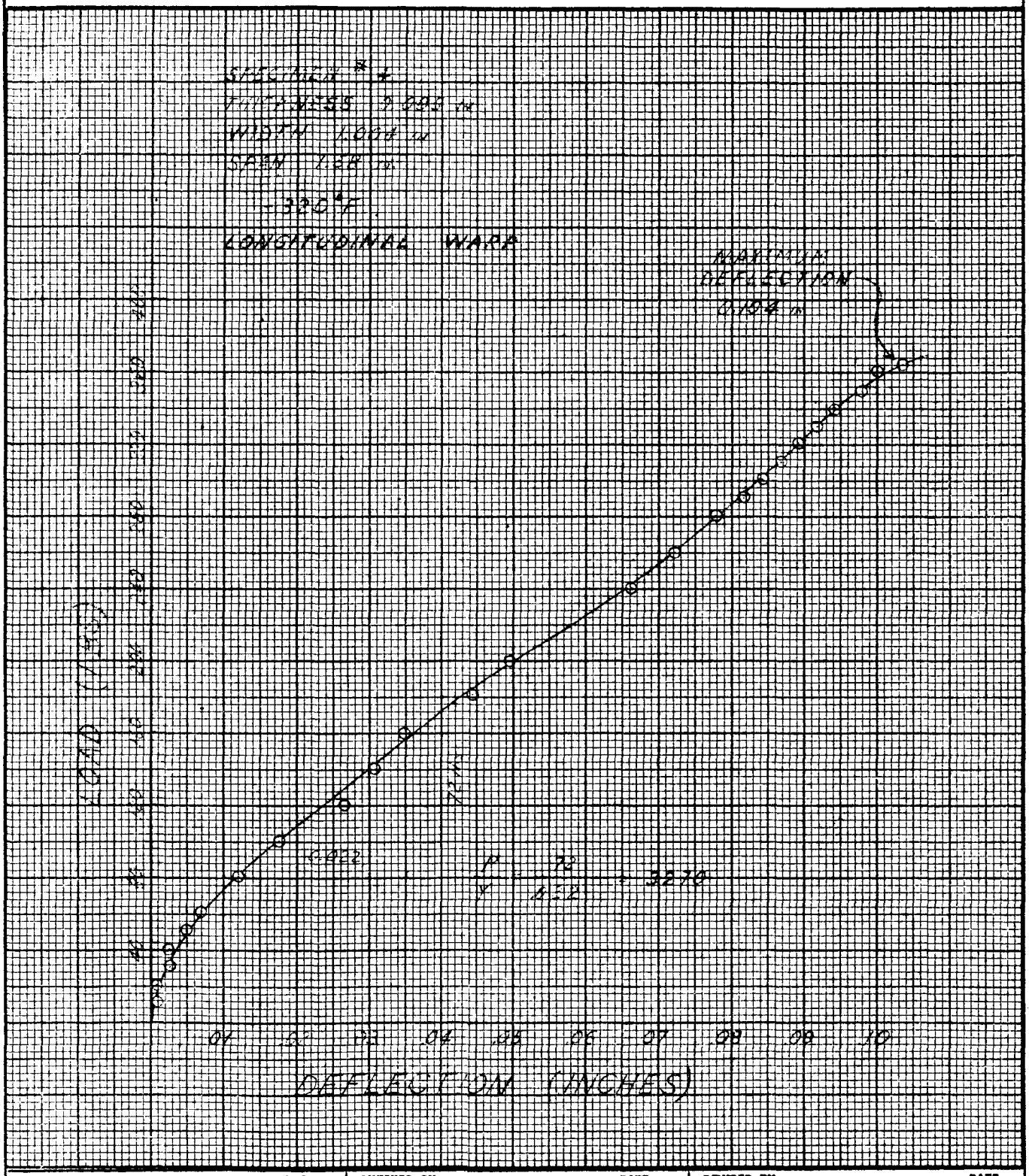
[illegible]	[illegible]				

Figure 10

CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



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	5-26-61				

Figure 11

CONSOLIDATED 506 FLEXURAL LOAD - DEFLECTION CURVE

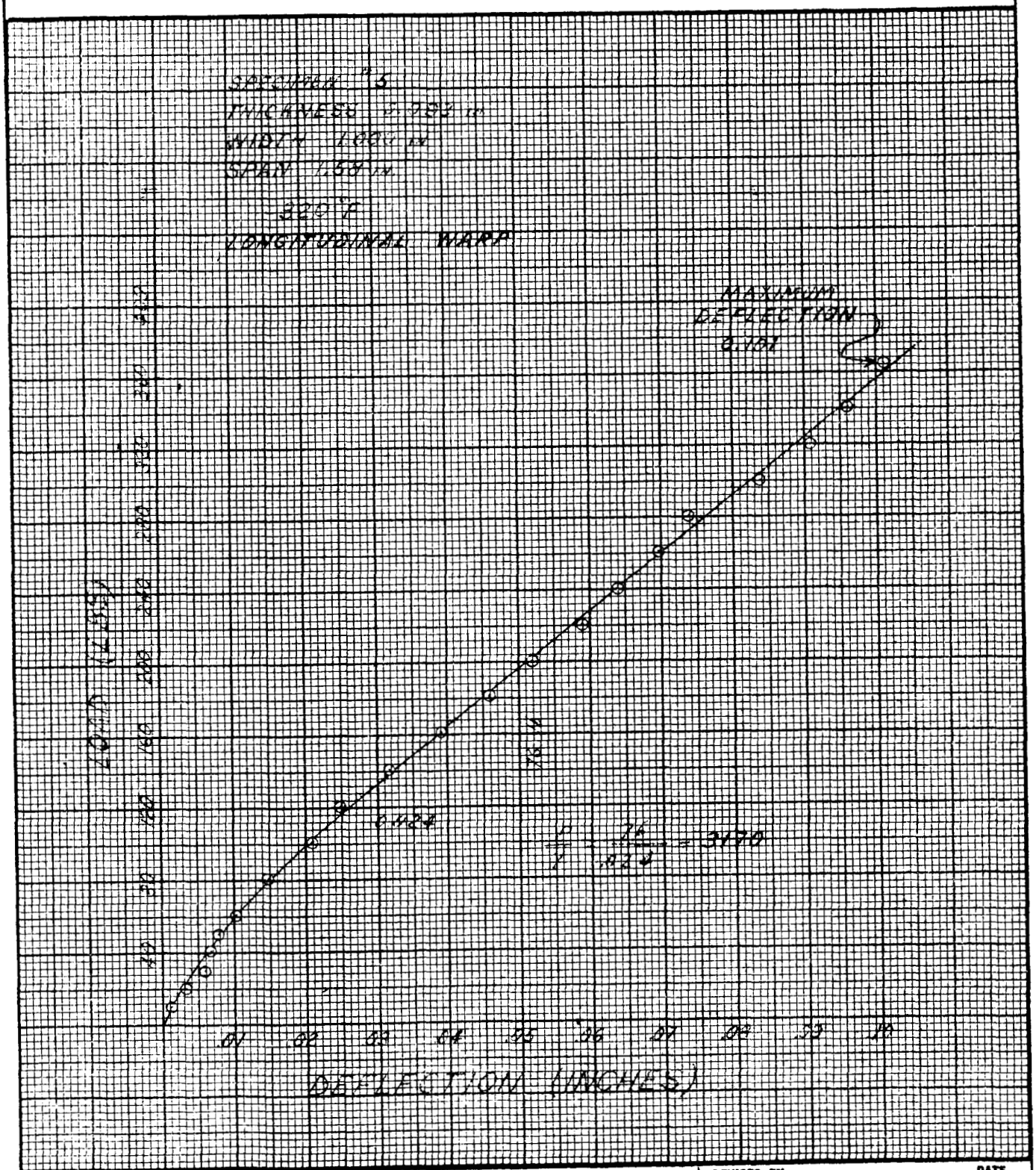

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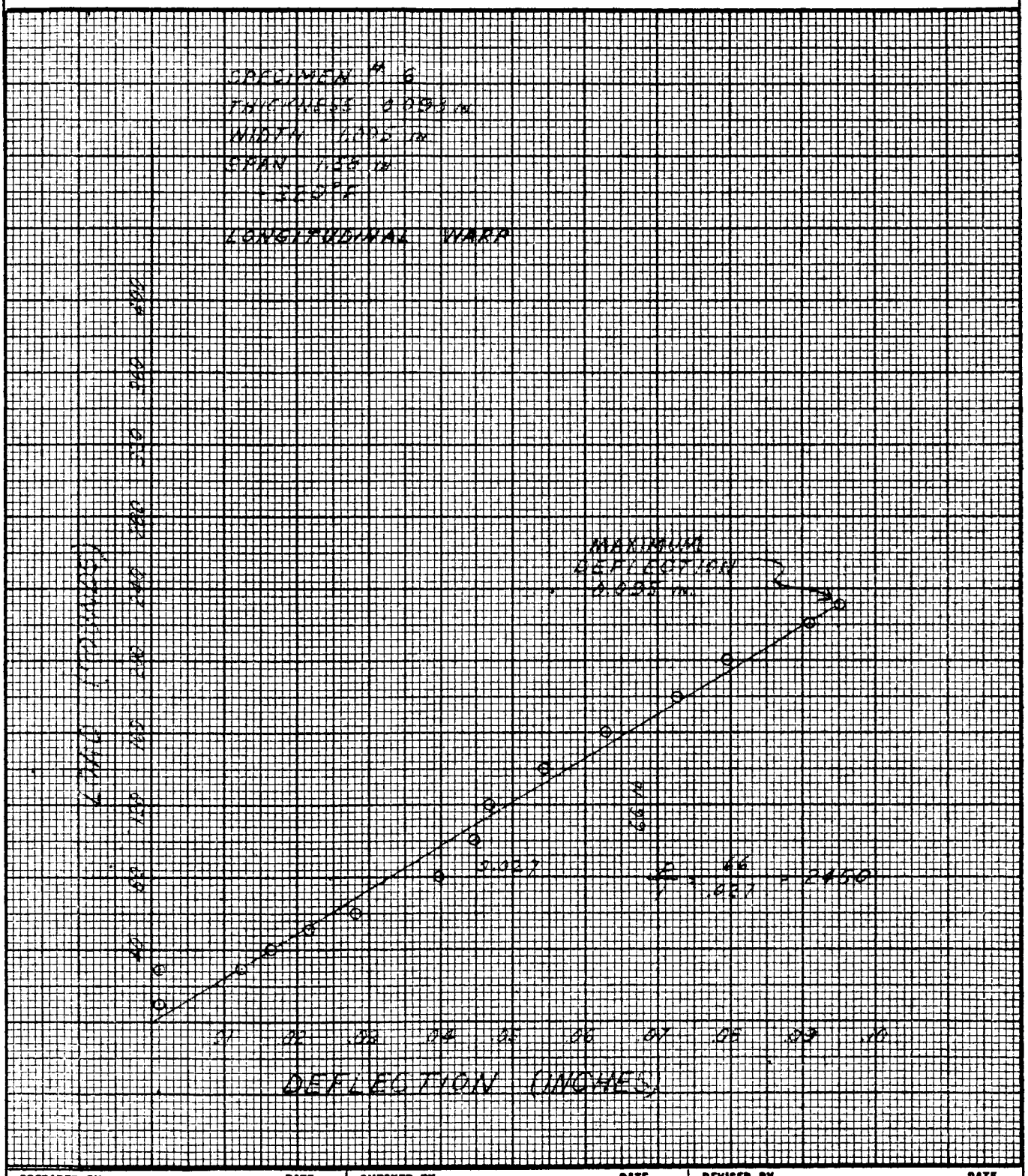
Figure 12

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



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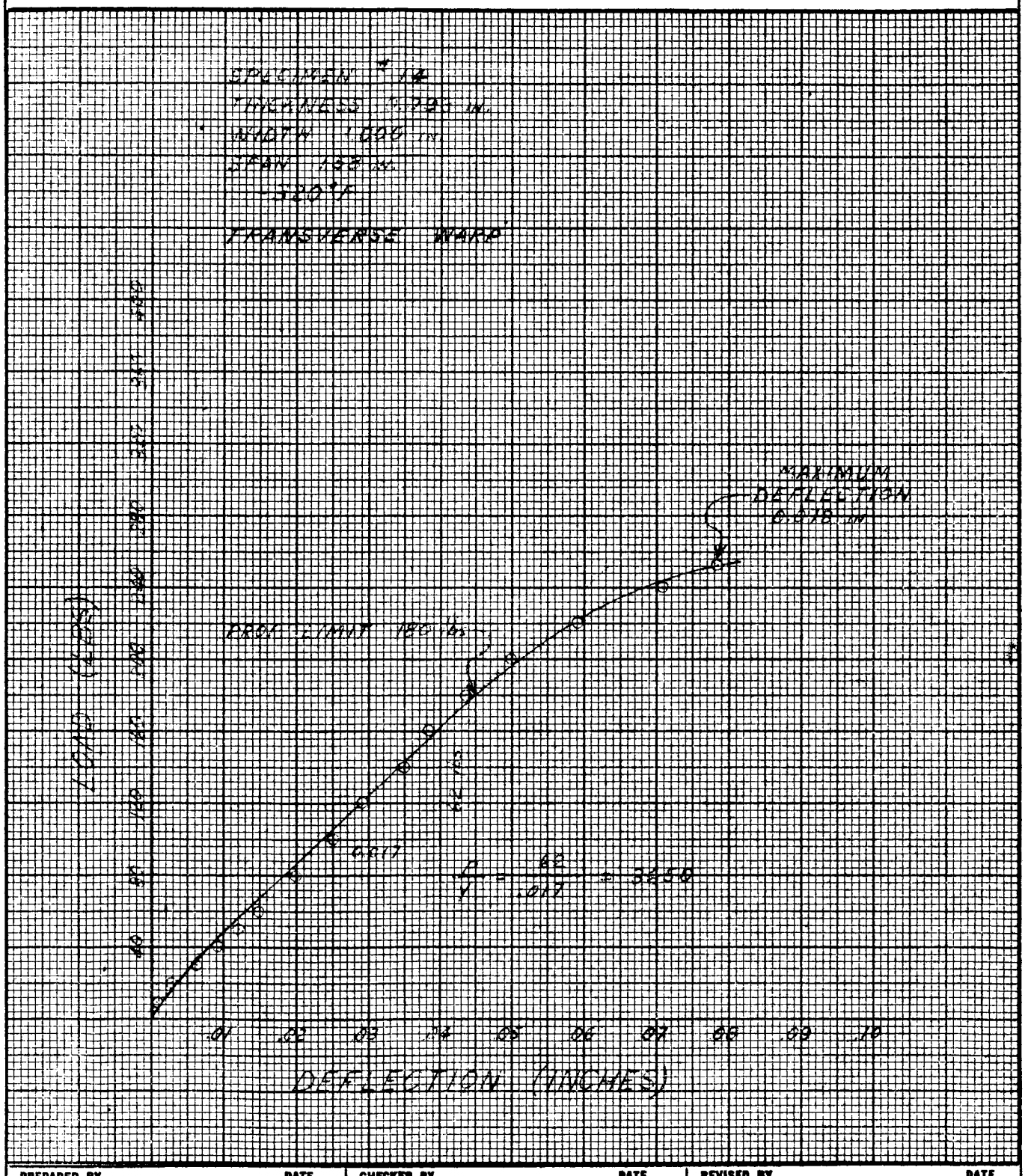
[illegible]	5-26-61				

Figure 13

CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



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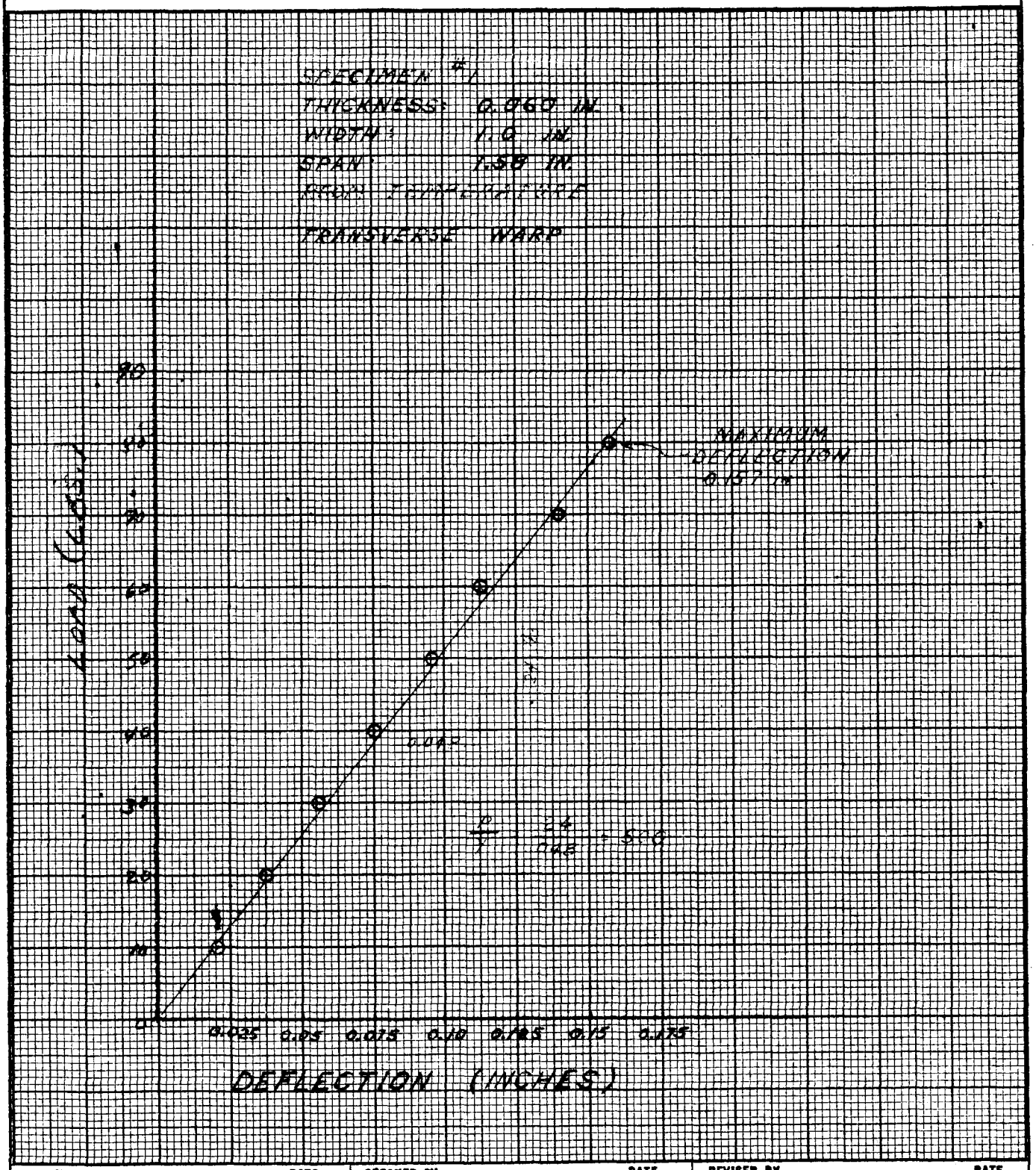
H. B. Brown	5-22-61				

Figure 14

CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



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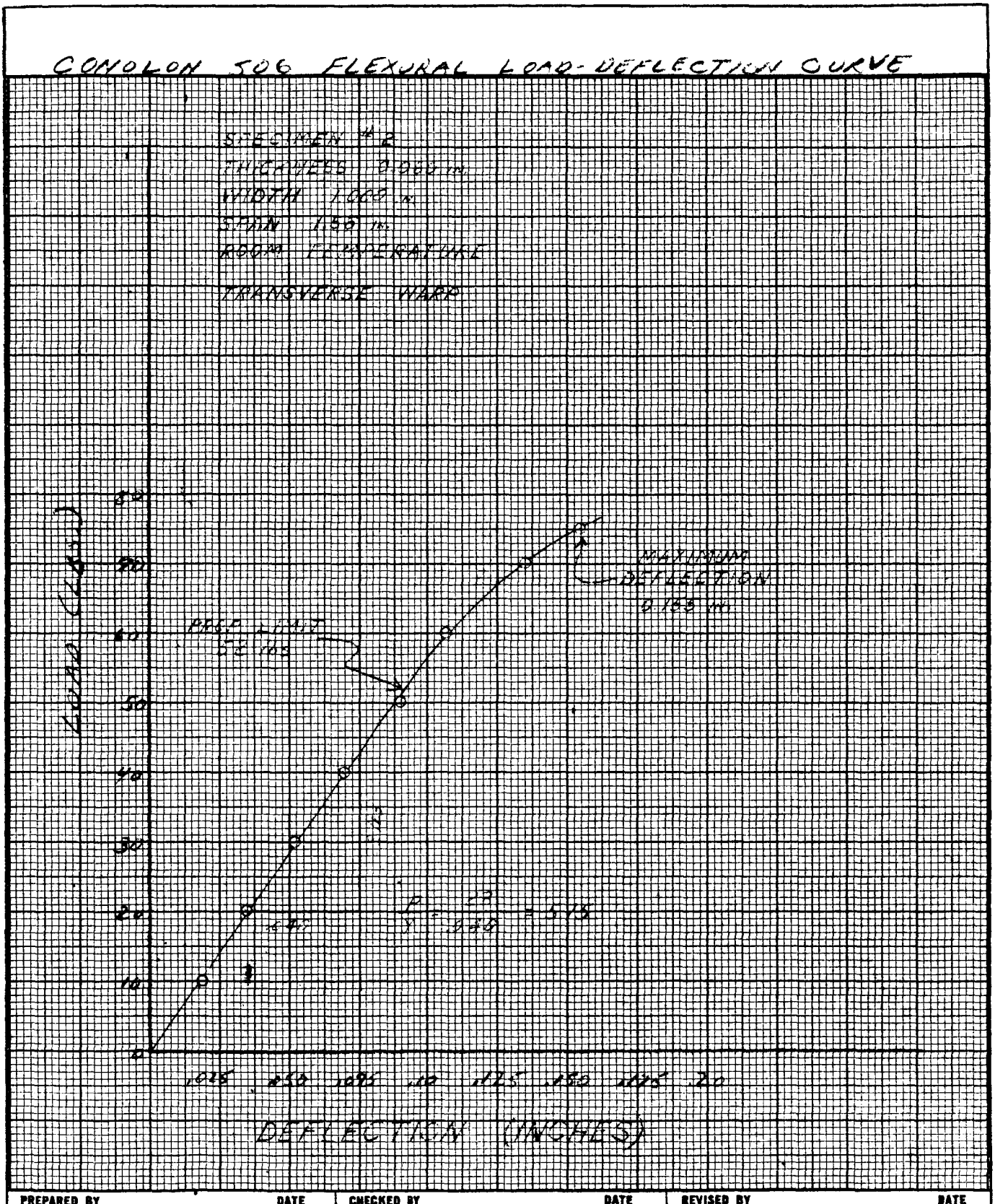
S. ROTH	1-31-61				

Figure 15



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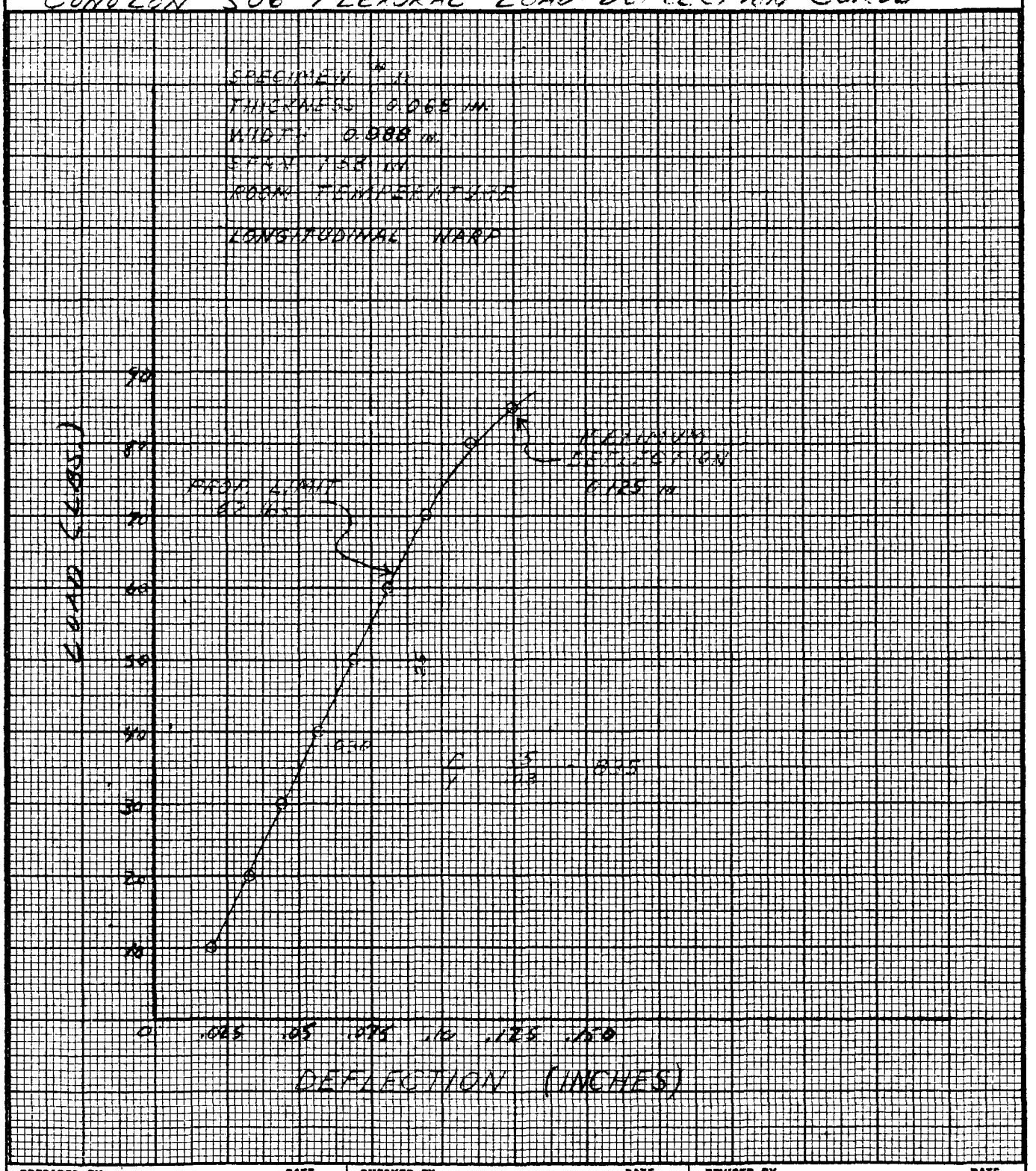
S. ROTH	1-31-61				

Figure 16

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



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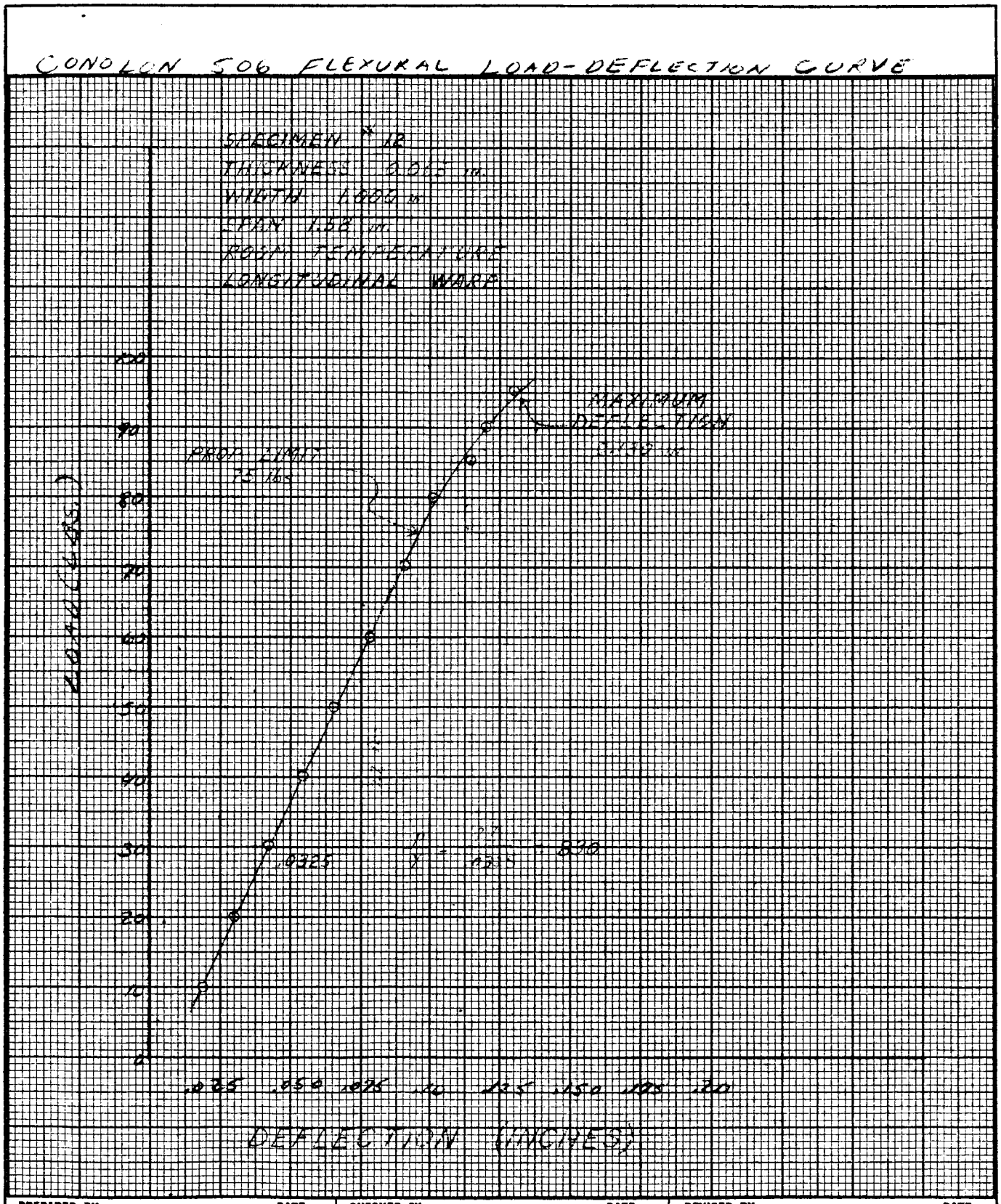
S. ROTH	1-31-61				

Figure 17



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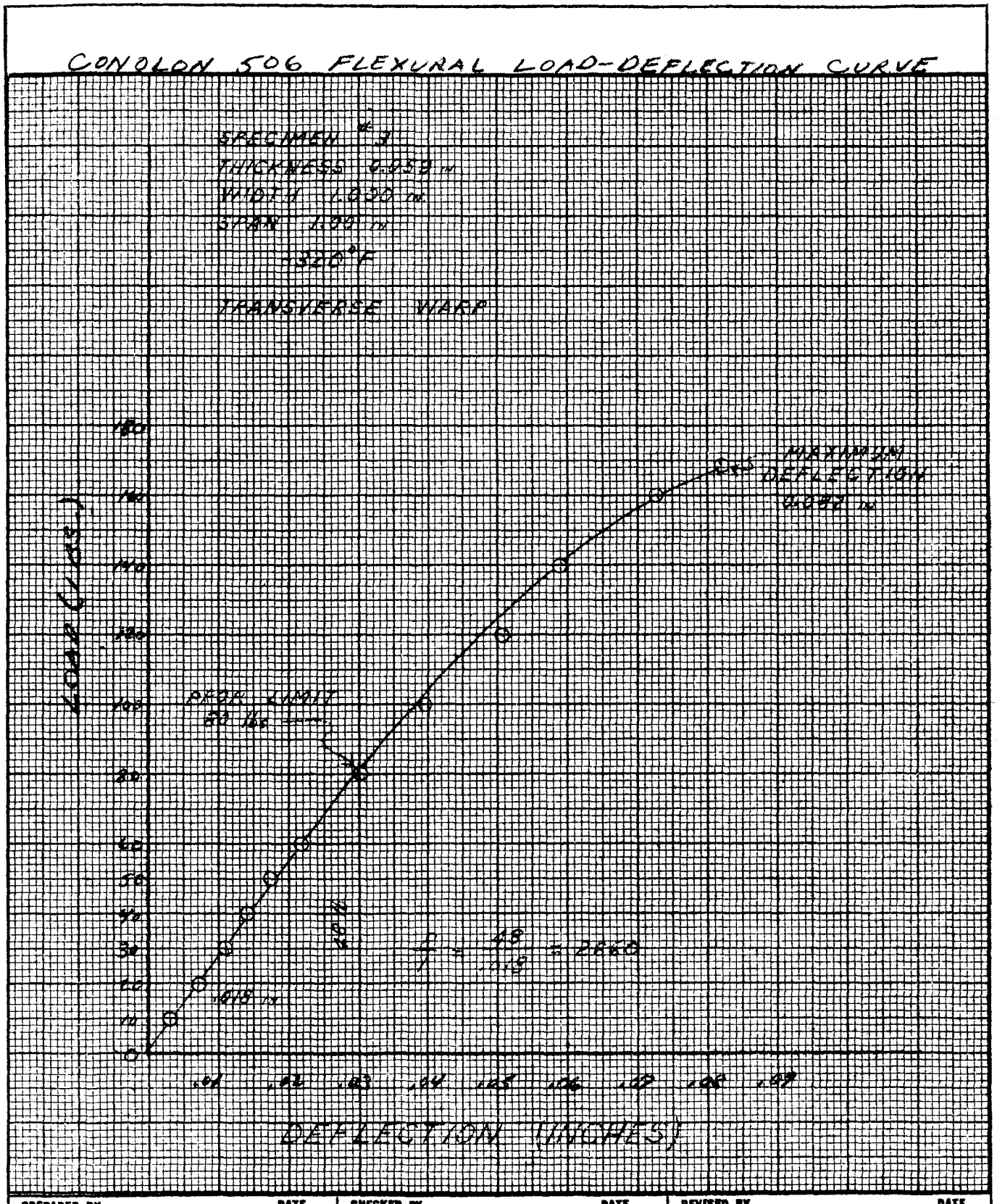
S. ROTH	1-31-61				

Figure 18



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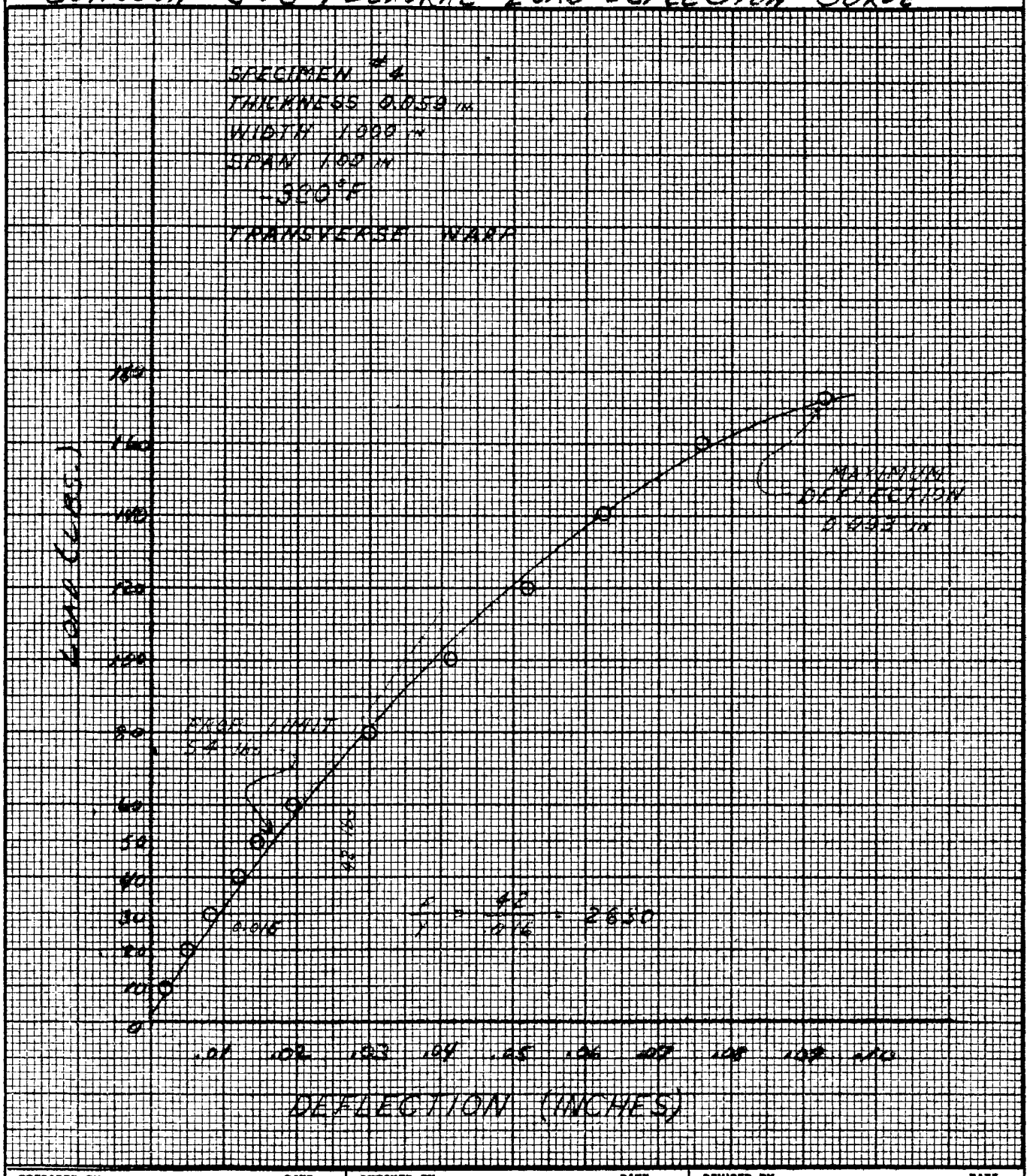
S. ROTH	2-1-61				

Figure 19

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



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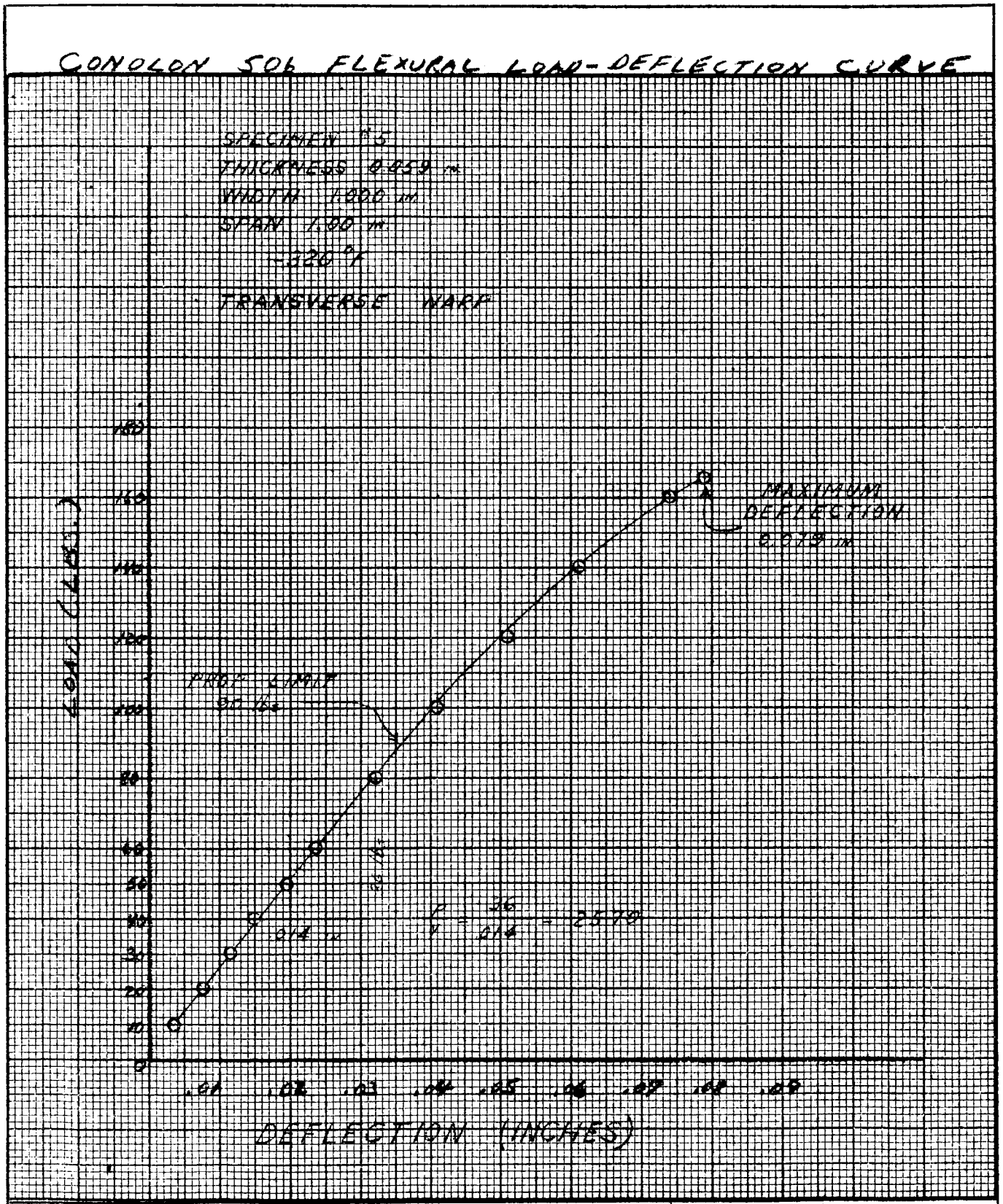
S. ROTH	2-1-61				

Figure 20



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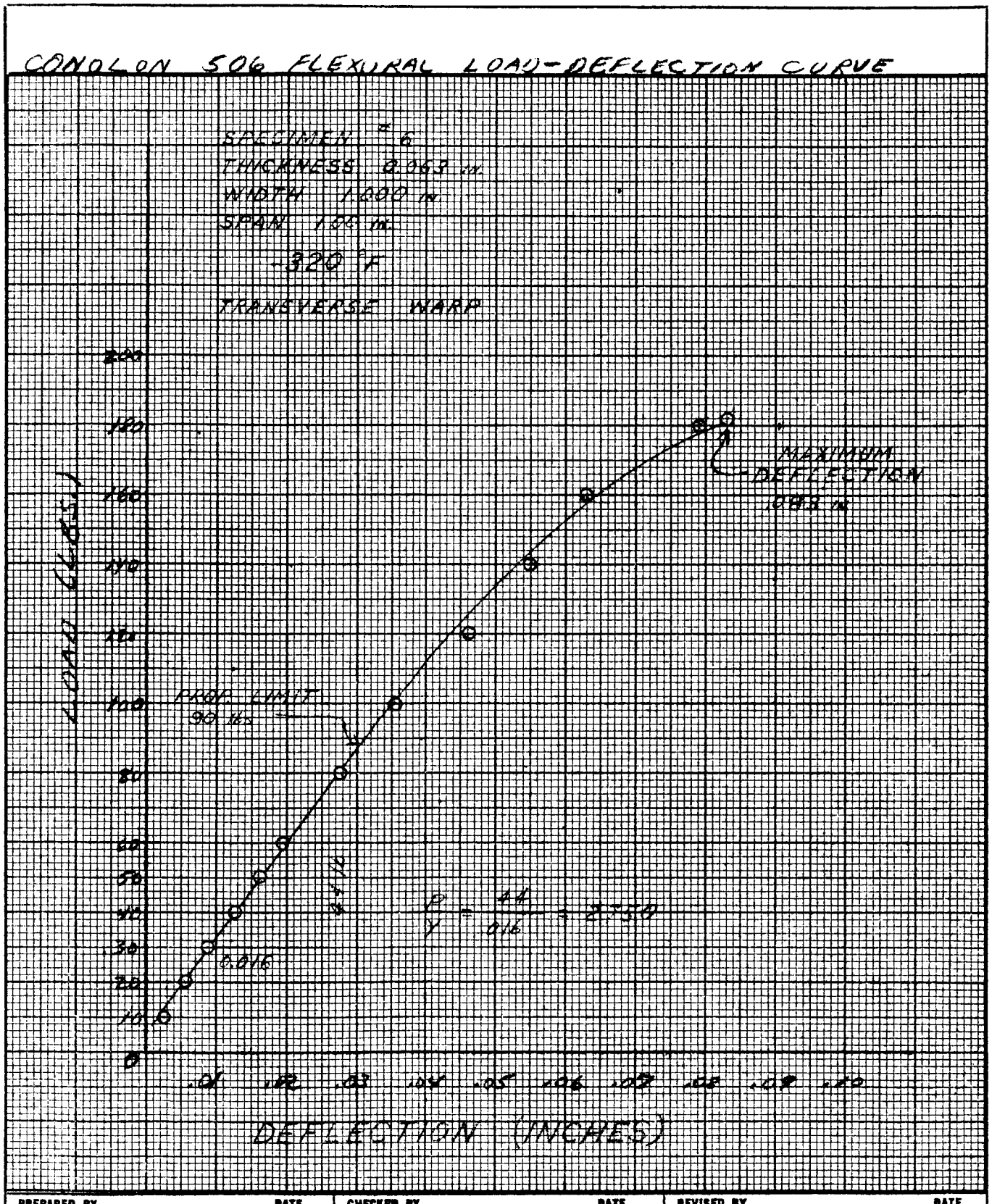
S. ROTH	2-2-61				

Figure 21



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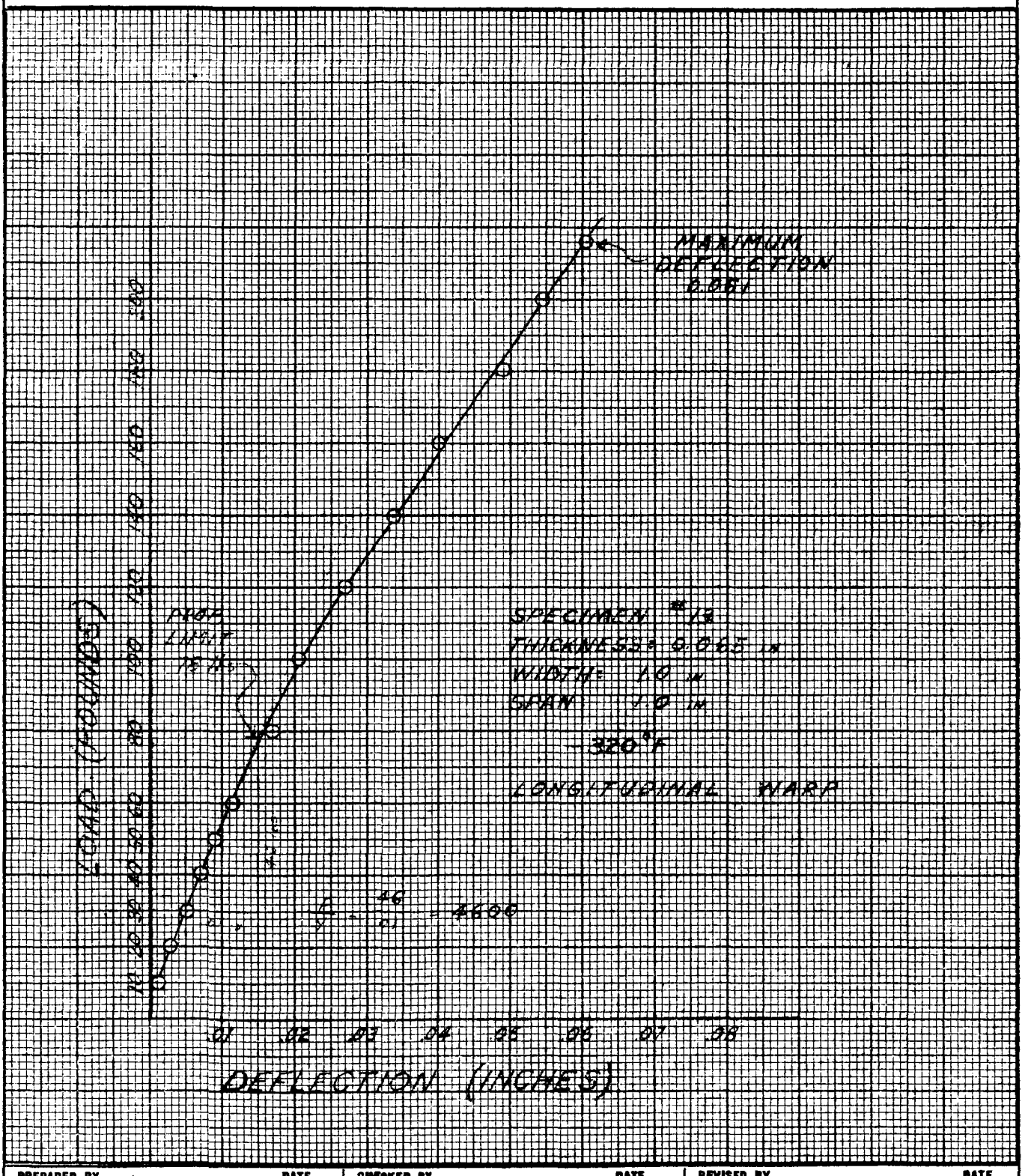
S. ROTH	2-3-61				

Figure 22

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



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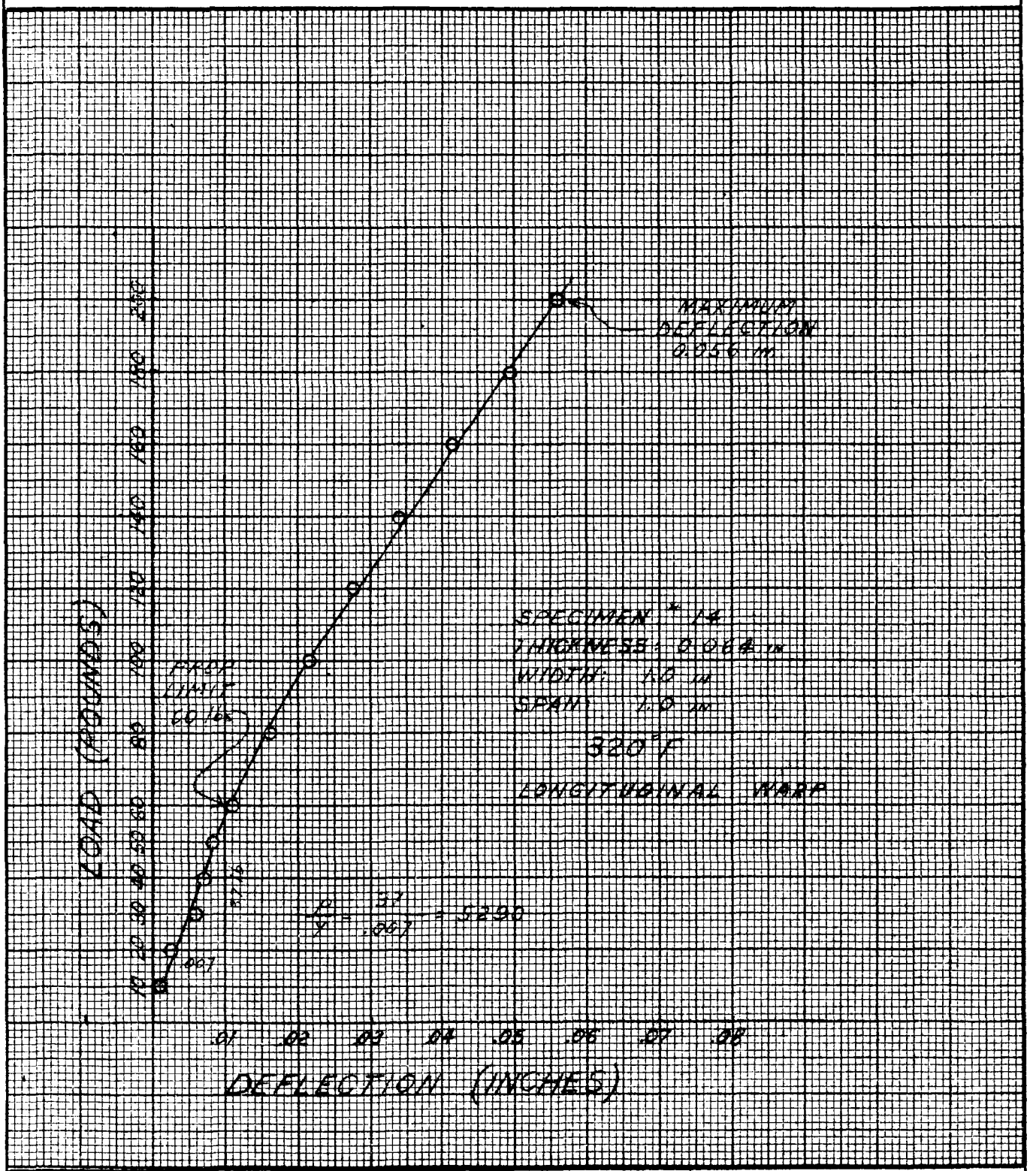
H. F. [illegible]	20 Mar 61				

Figure 23

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



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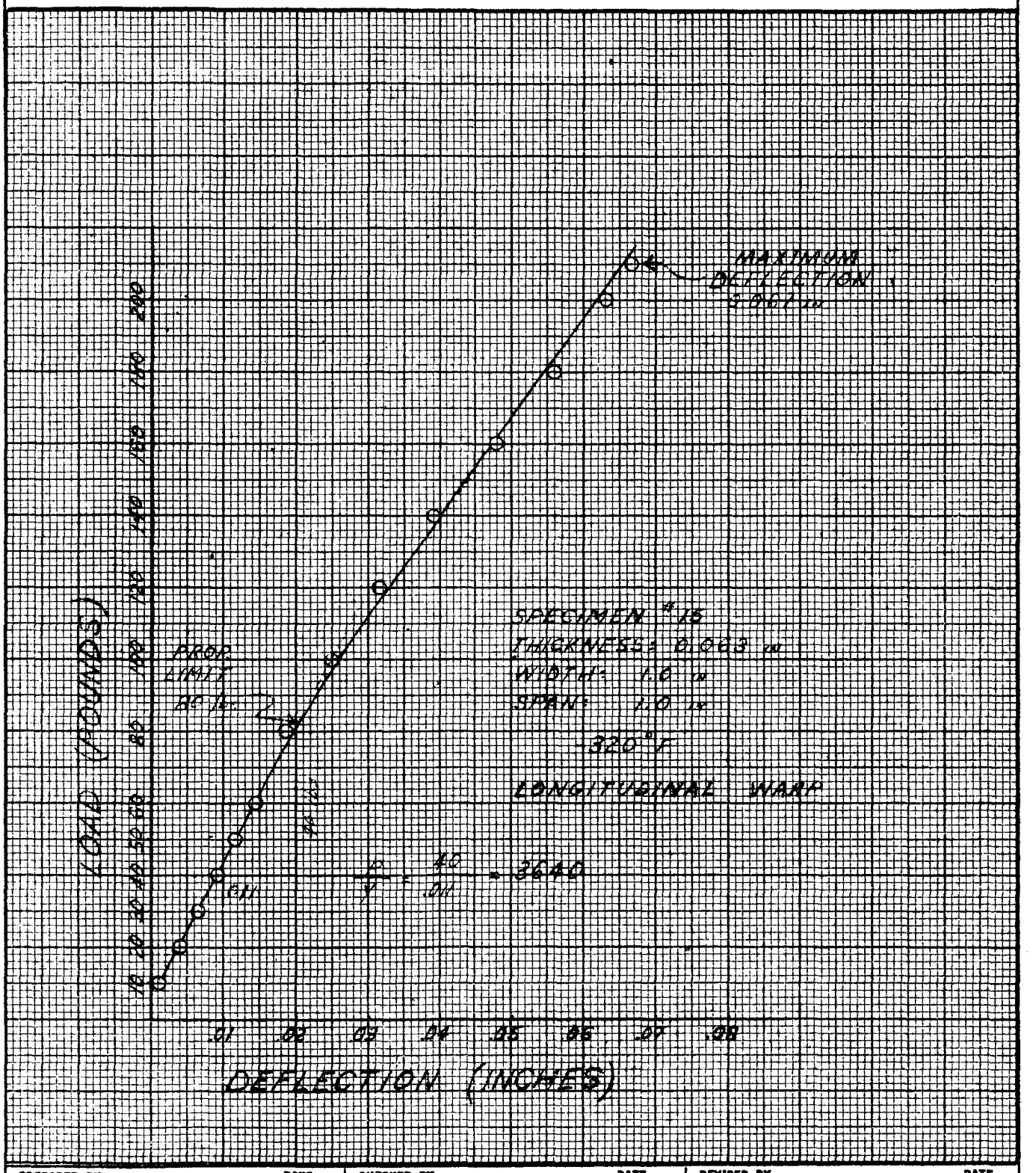
H. F. [illegible]	20 Mar '61				

Figure 24

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



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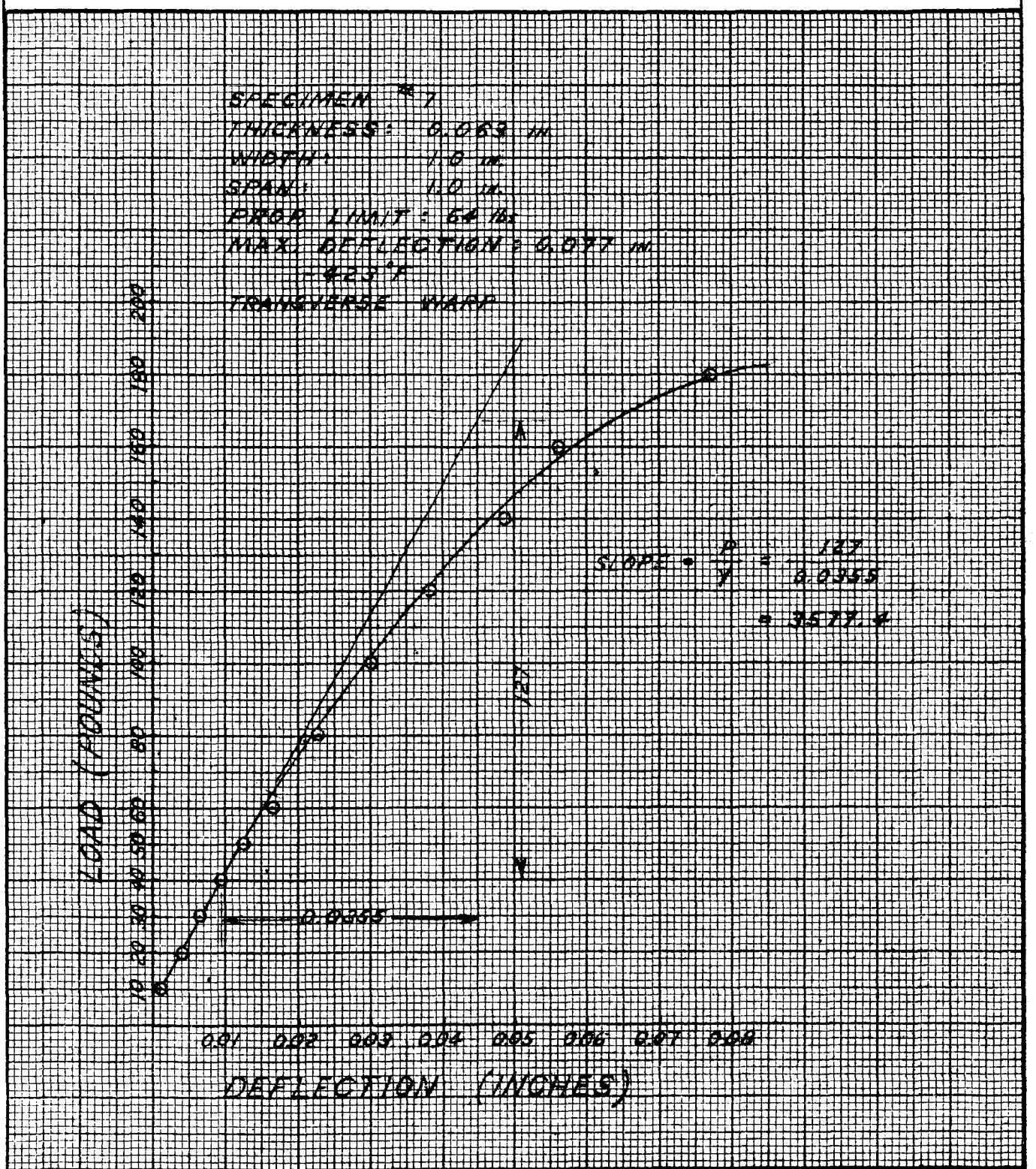
H J Greer	20 MAR '61				

Figure 25

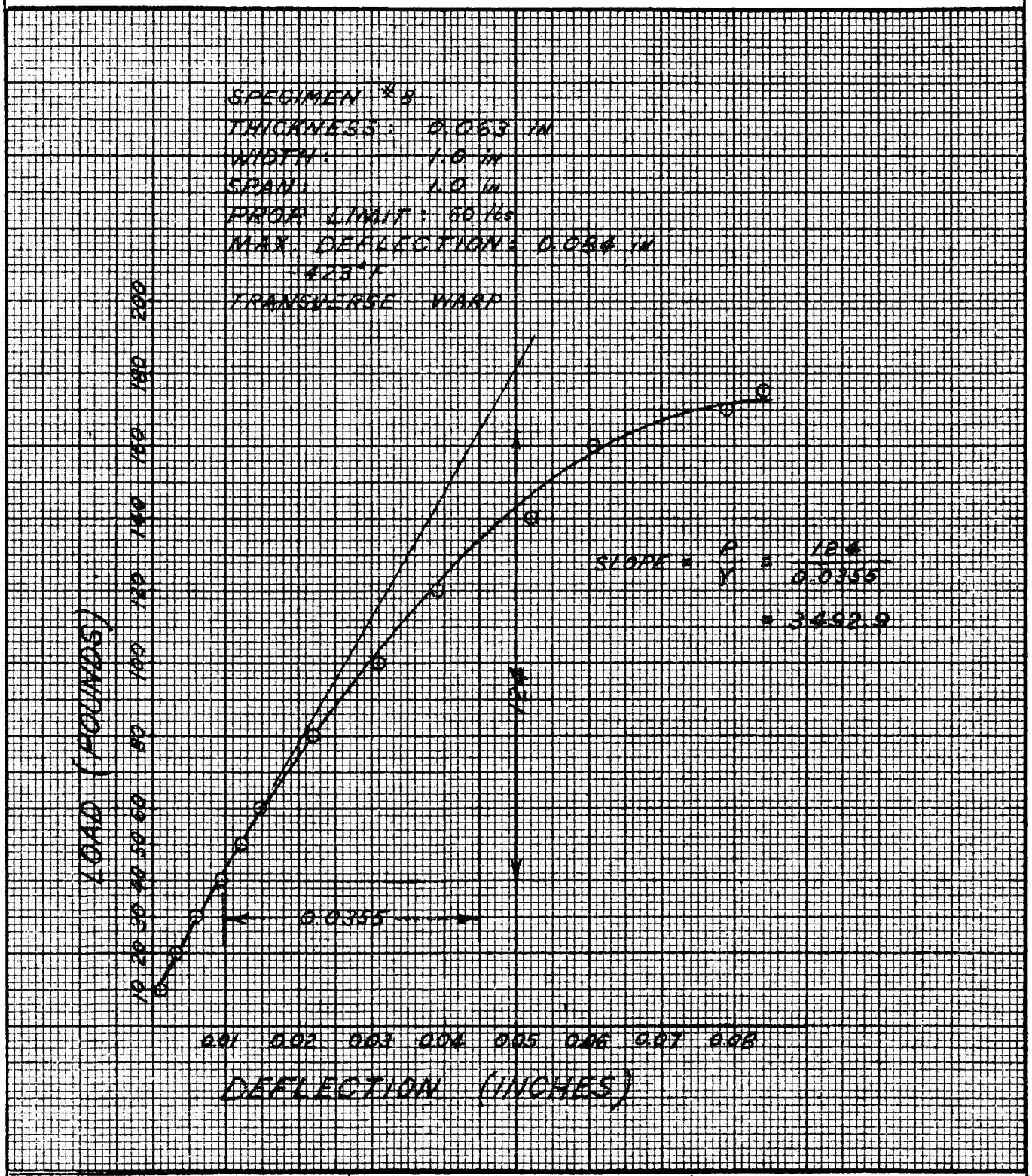
CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
H. F. Grier	3-10-61				

Figure 26

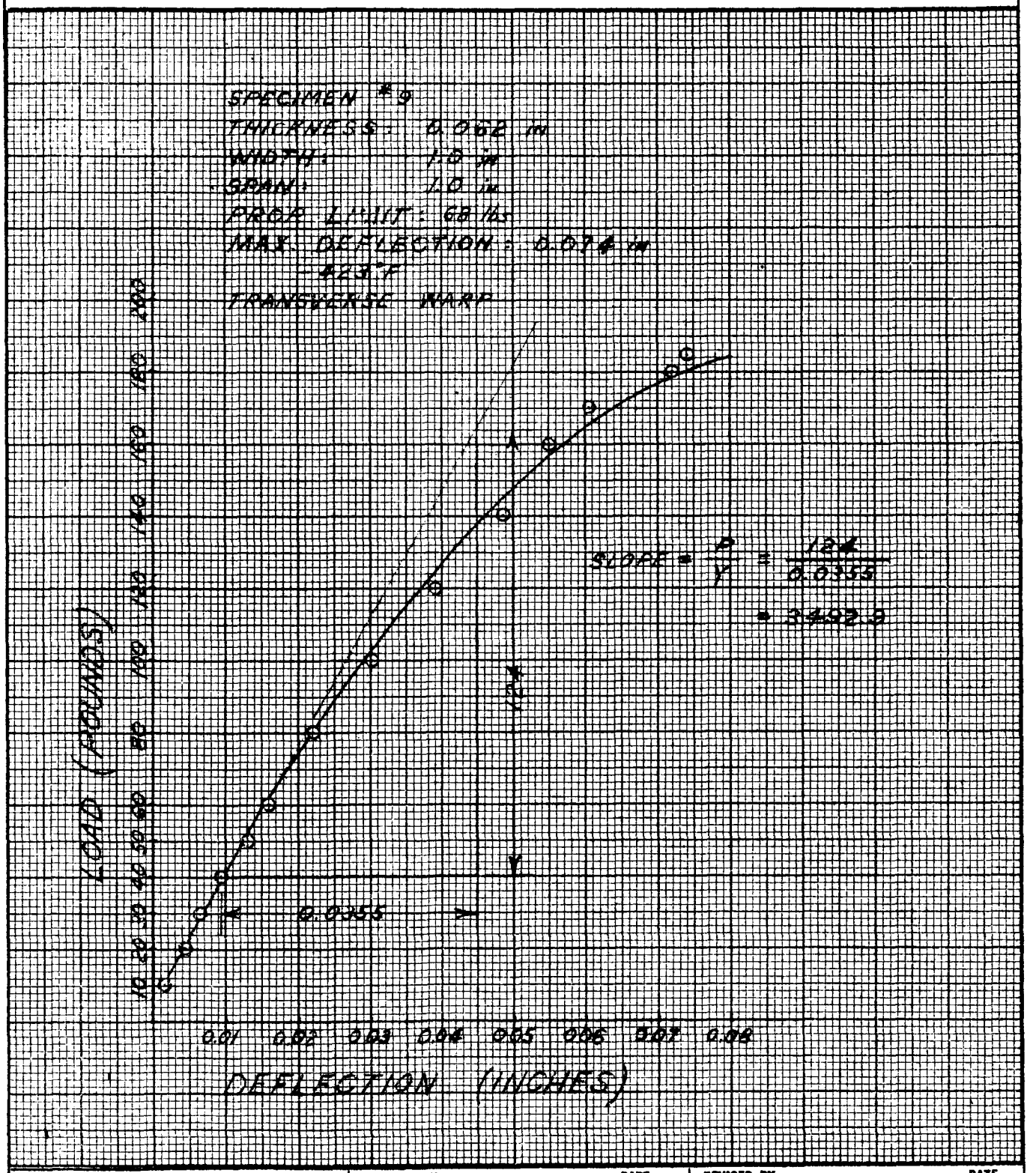
CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
H. A. Gruen	3-10-'61				

Figure 27

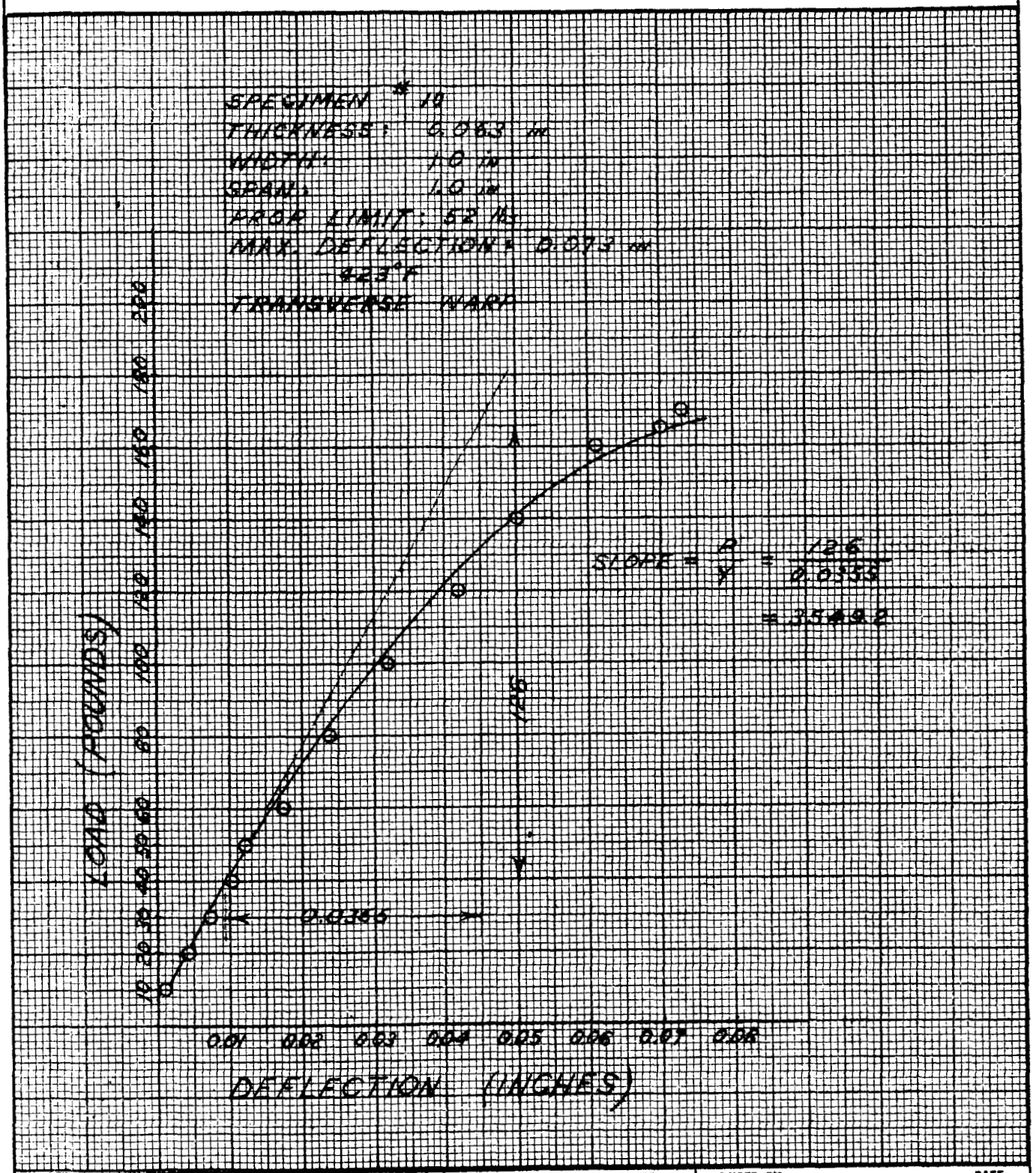
CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
H. F. Brau	3-10-61				

Figure 28

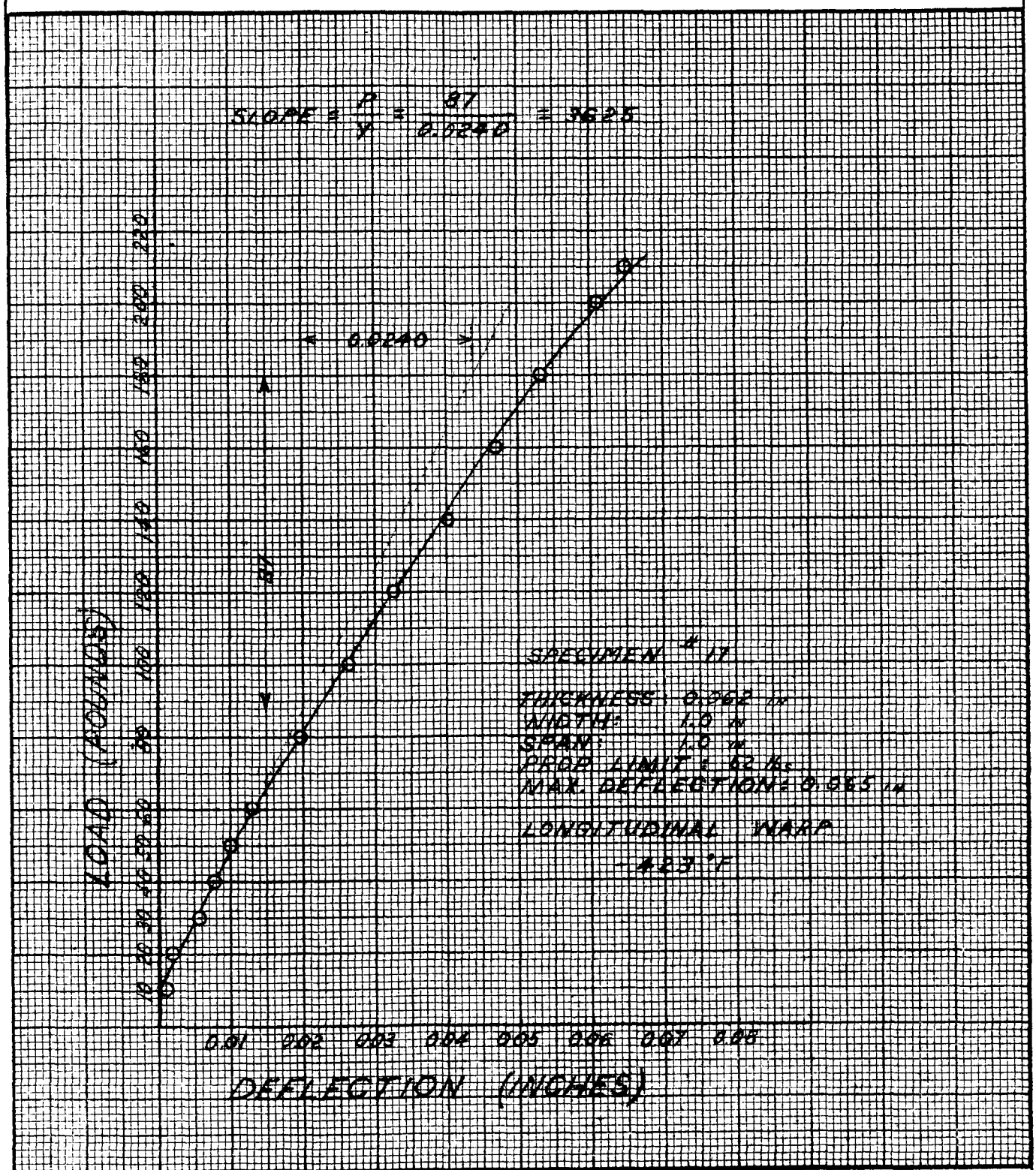
CONOLON 506 FLEXURAL LOAD - DEFLECTION CURVE



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
H. A. [illegible]	3-16-61				

Figure 29

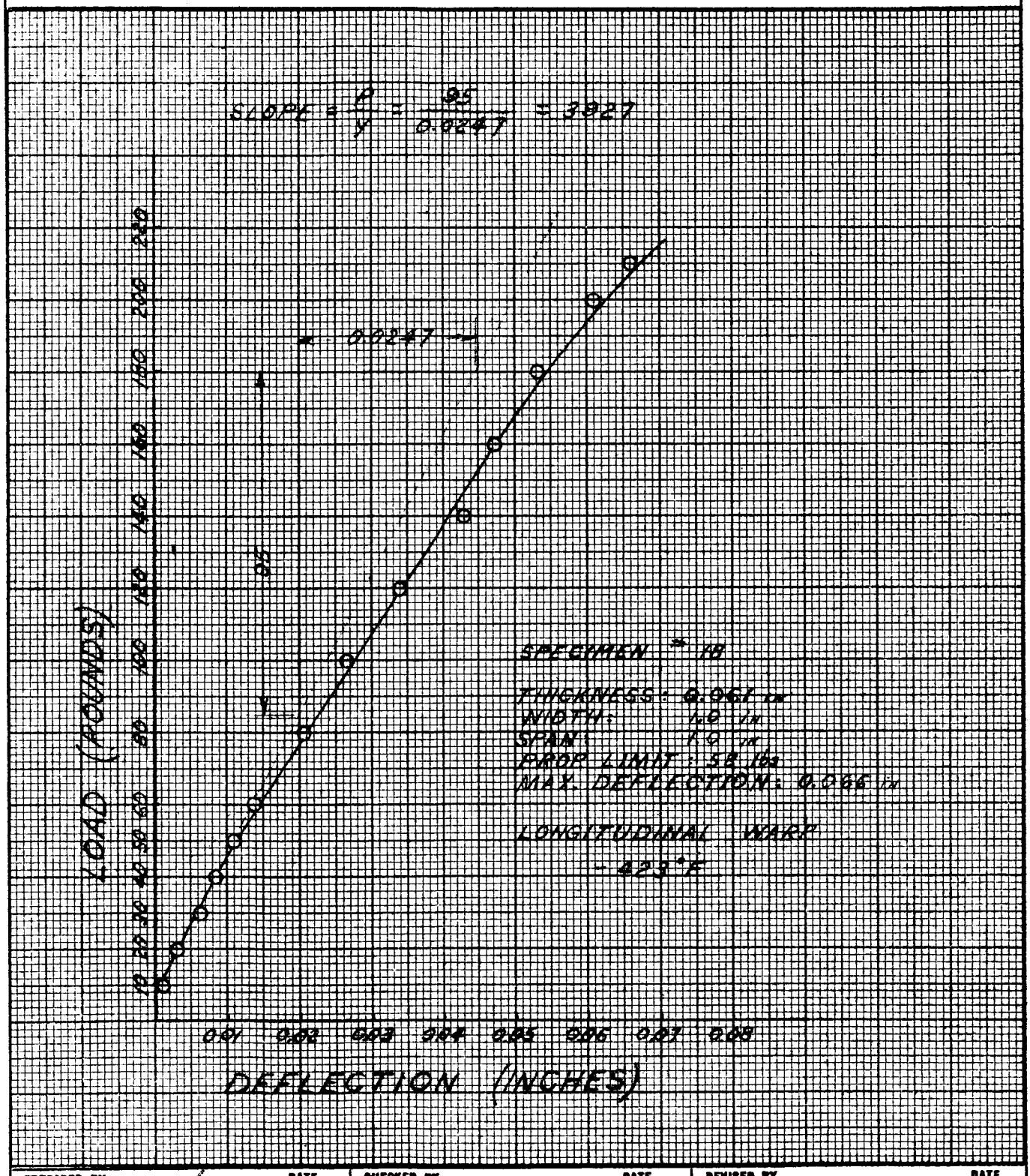
CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
H. J. Green	3-10-61				

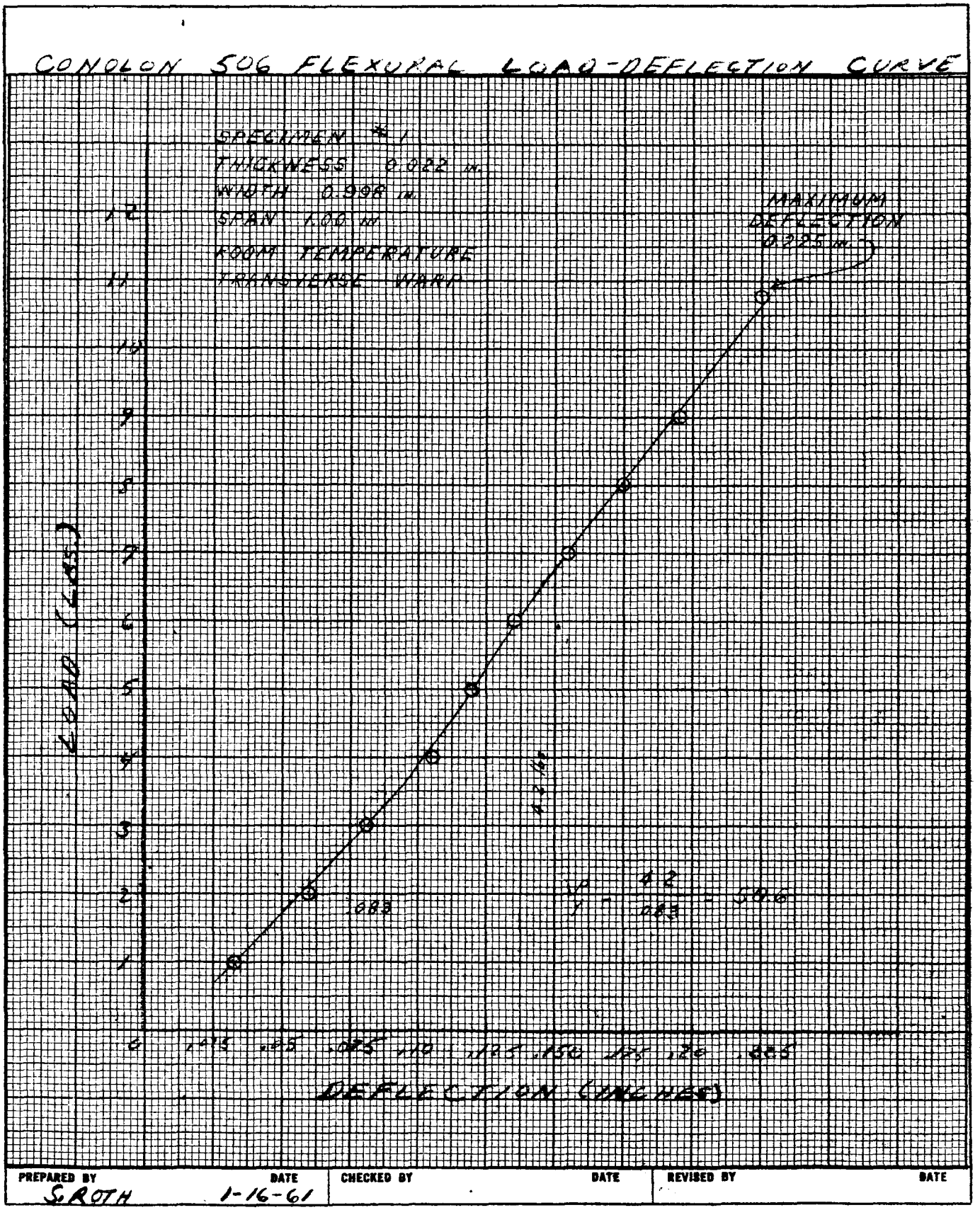
Figure 30

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



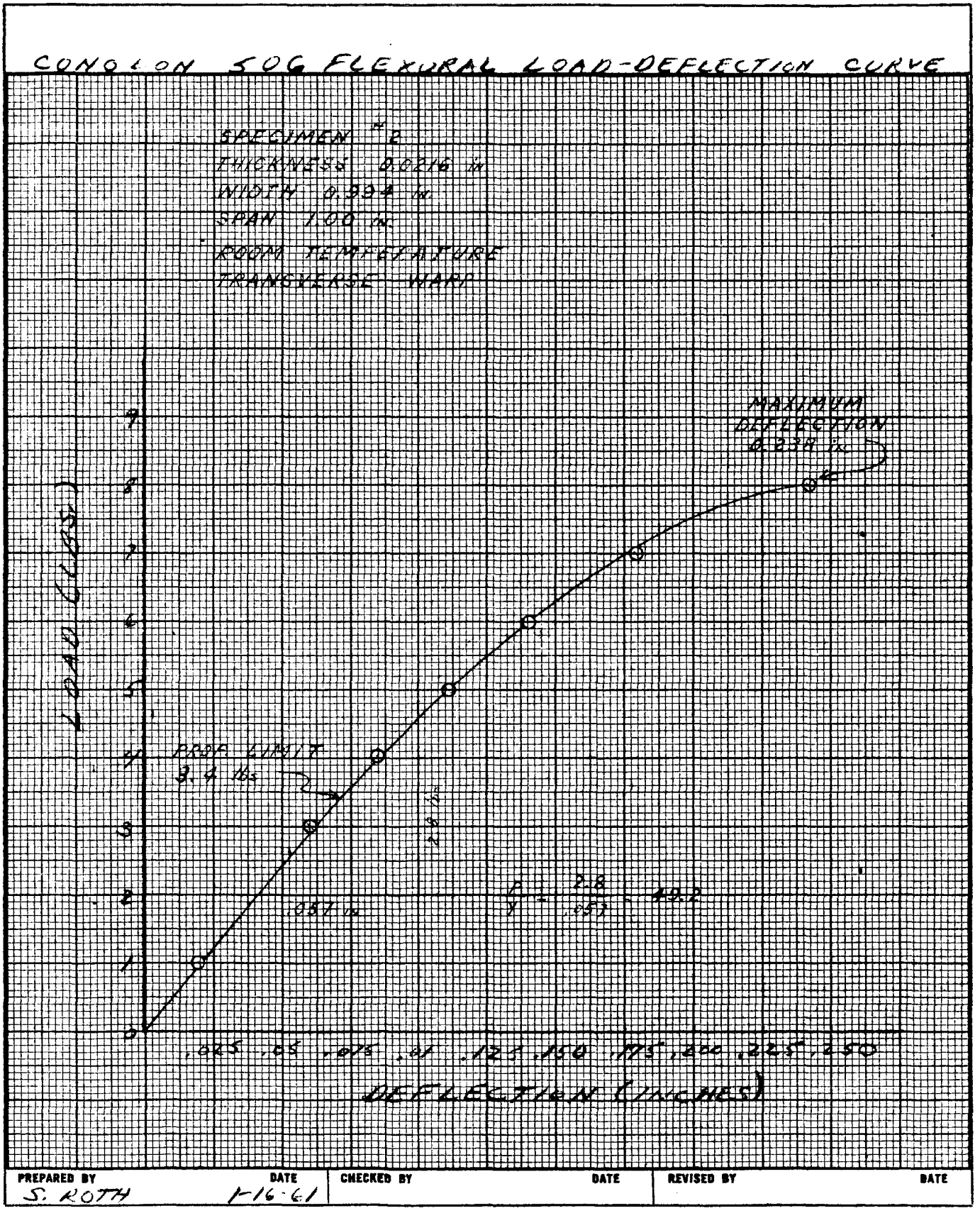
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
H. A. Green	3-10-61				

Figure 31



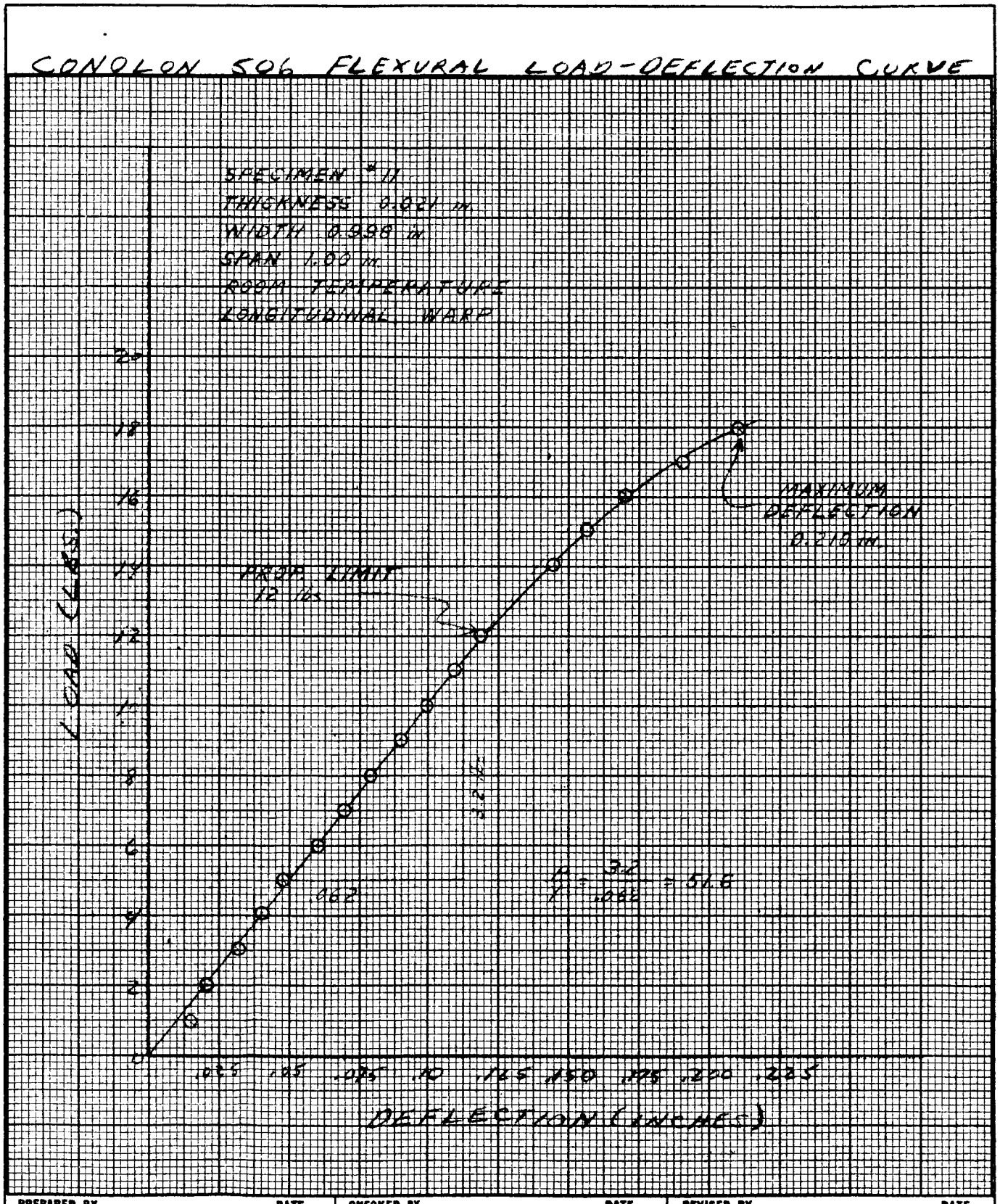
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-61				

Figure 32



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-61				

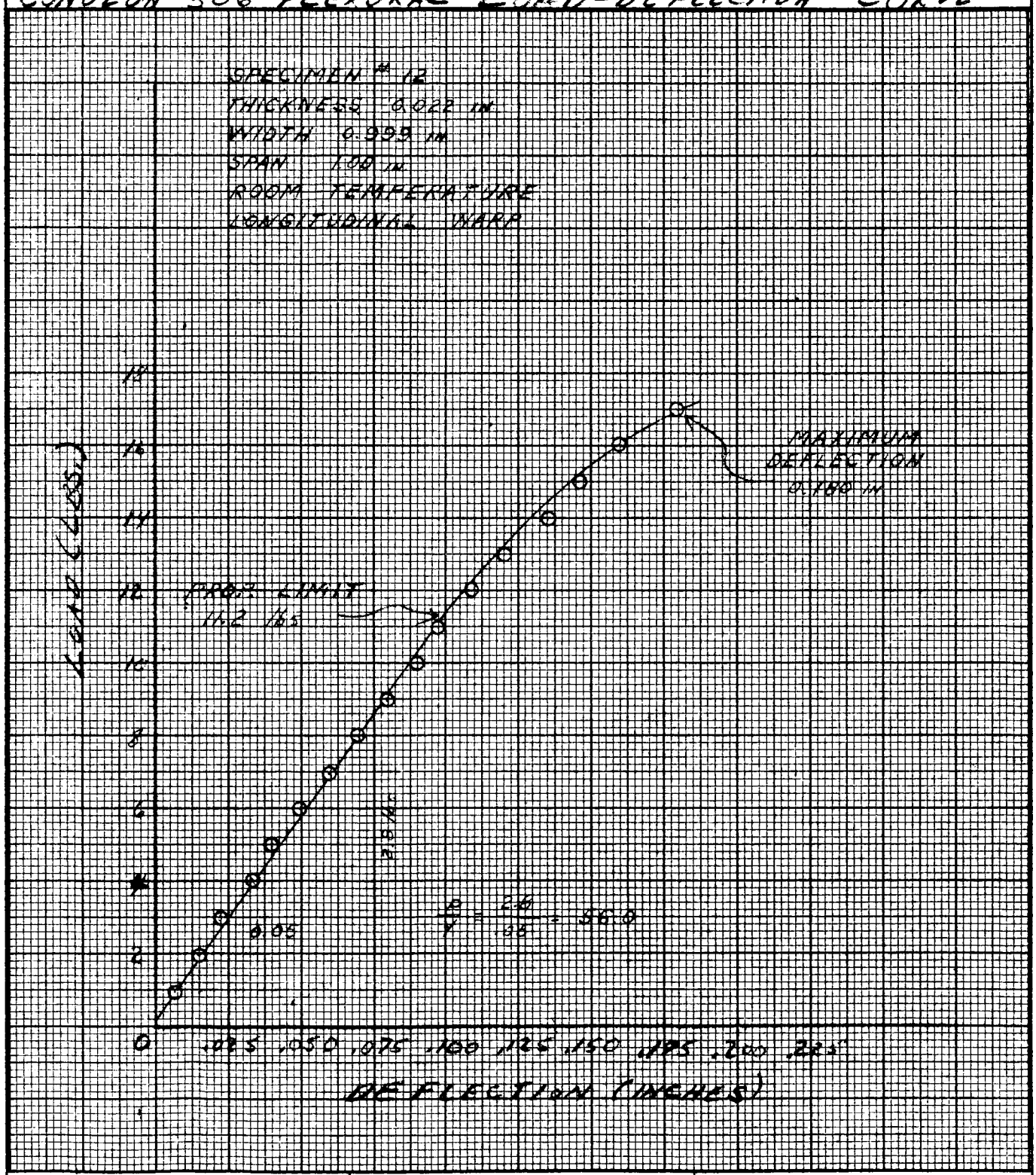
Figure 33



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-61				

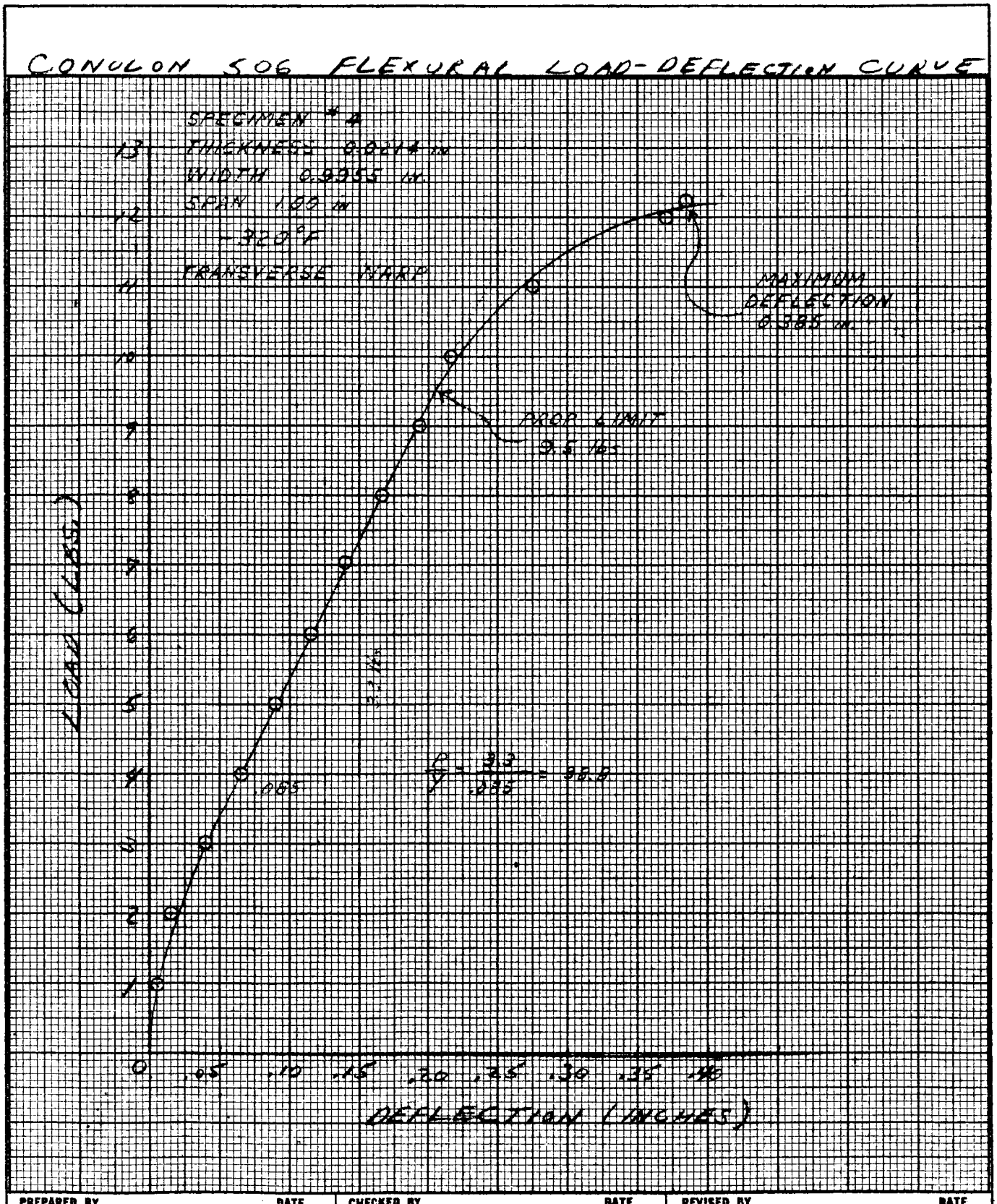
Figure 34

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



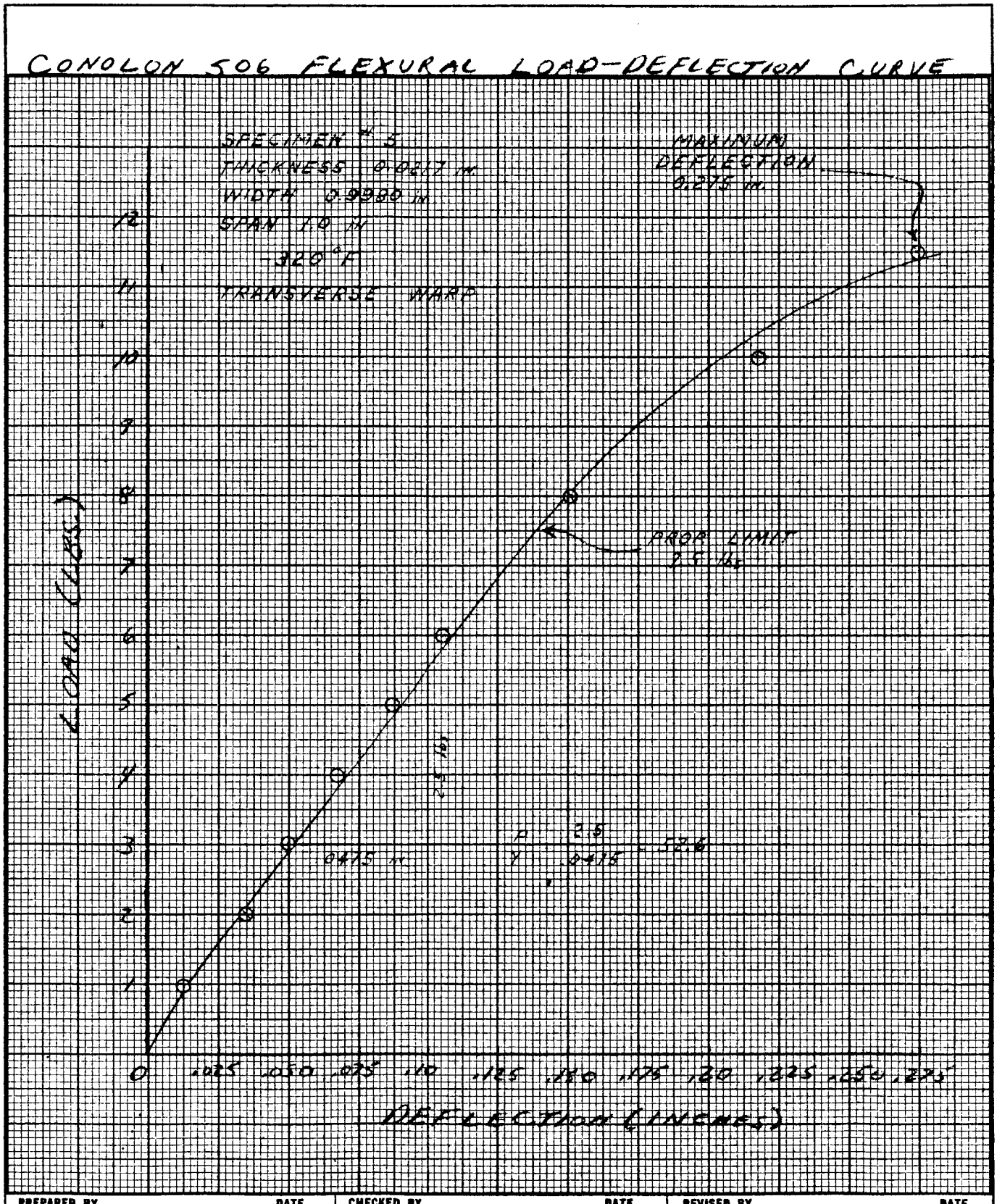
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-61				

Figure 35



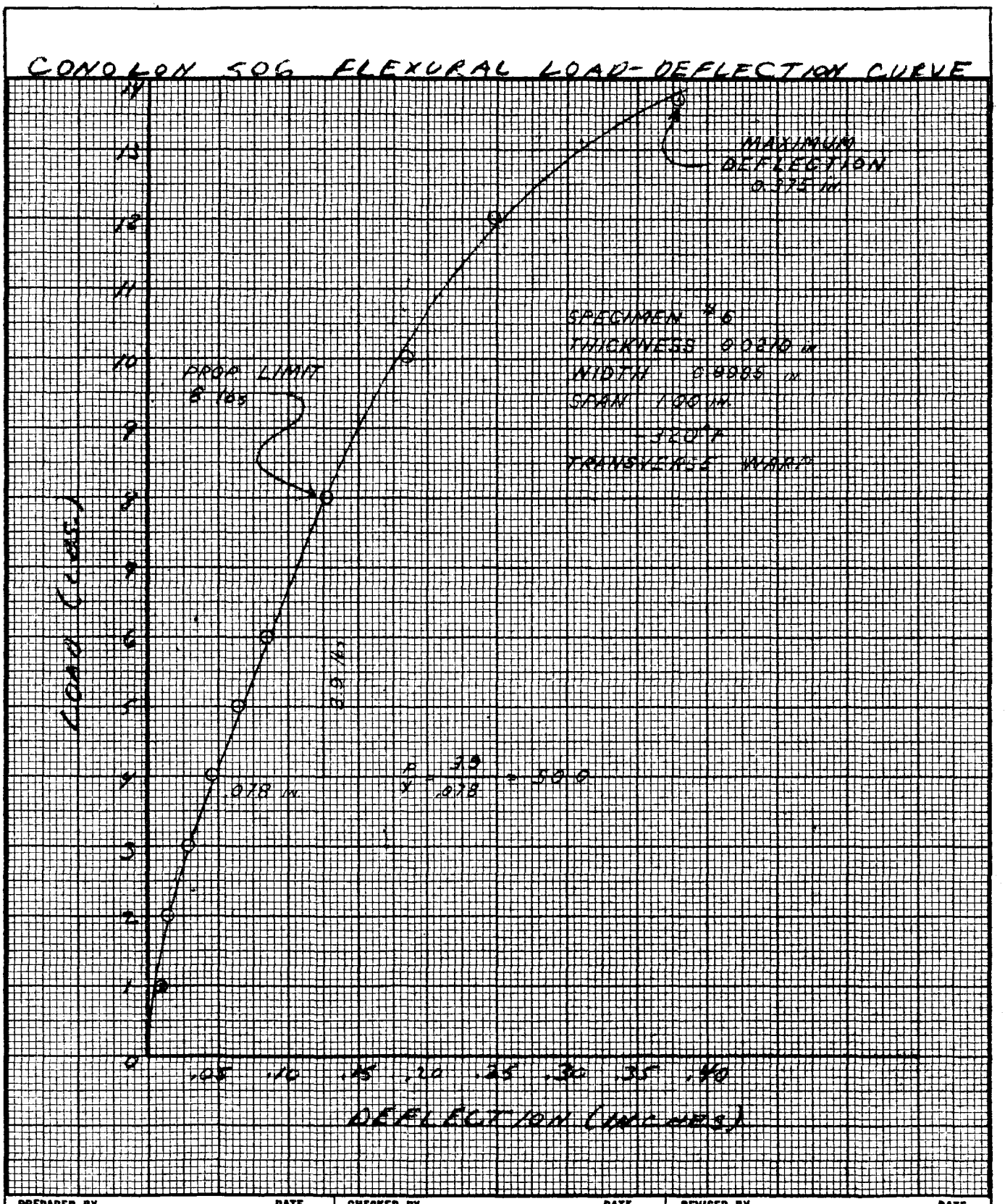
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-60				

Figure 36



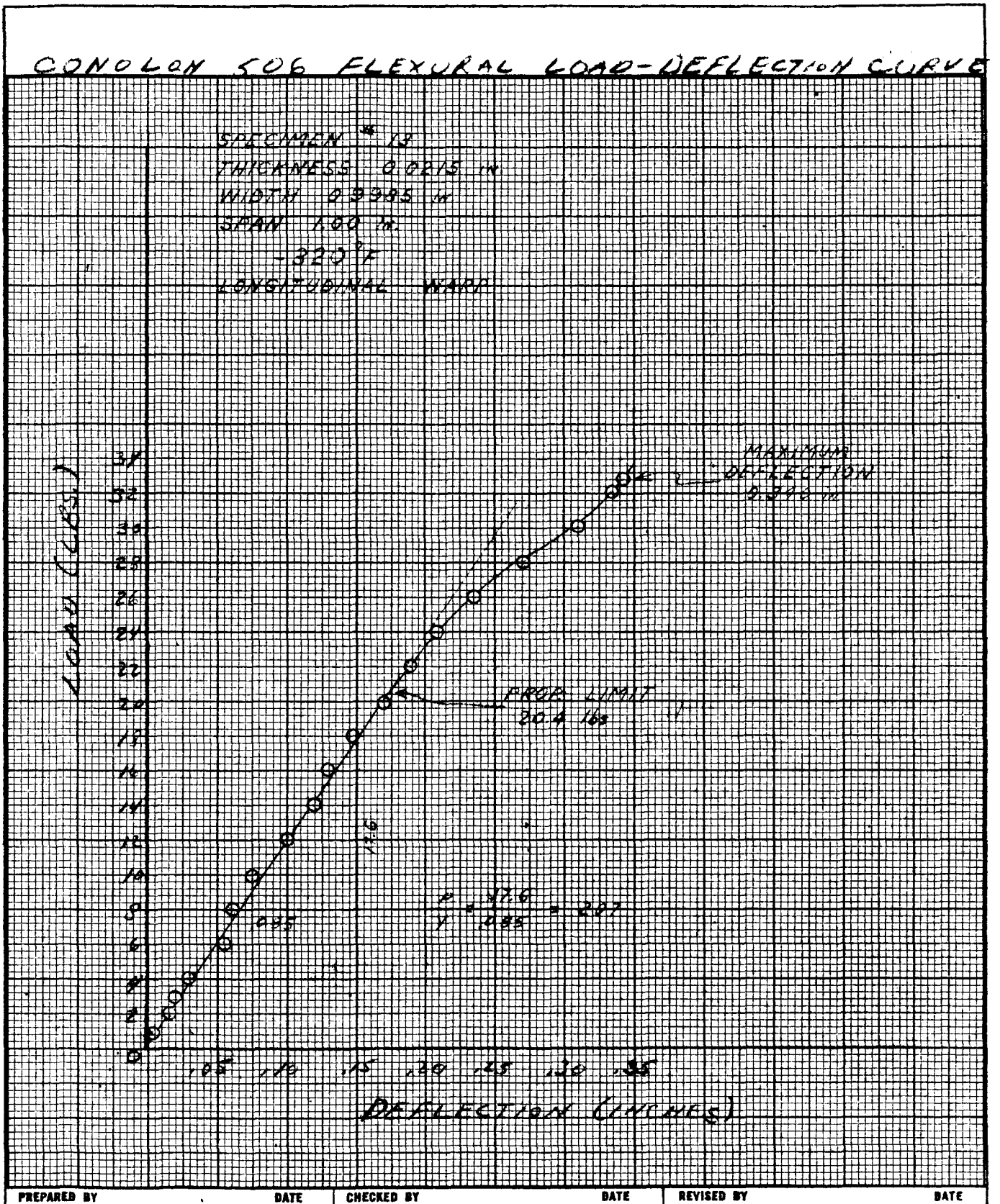
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-61				

Figure 37



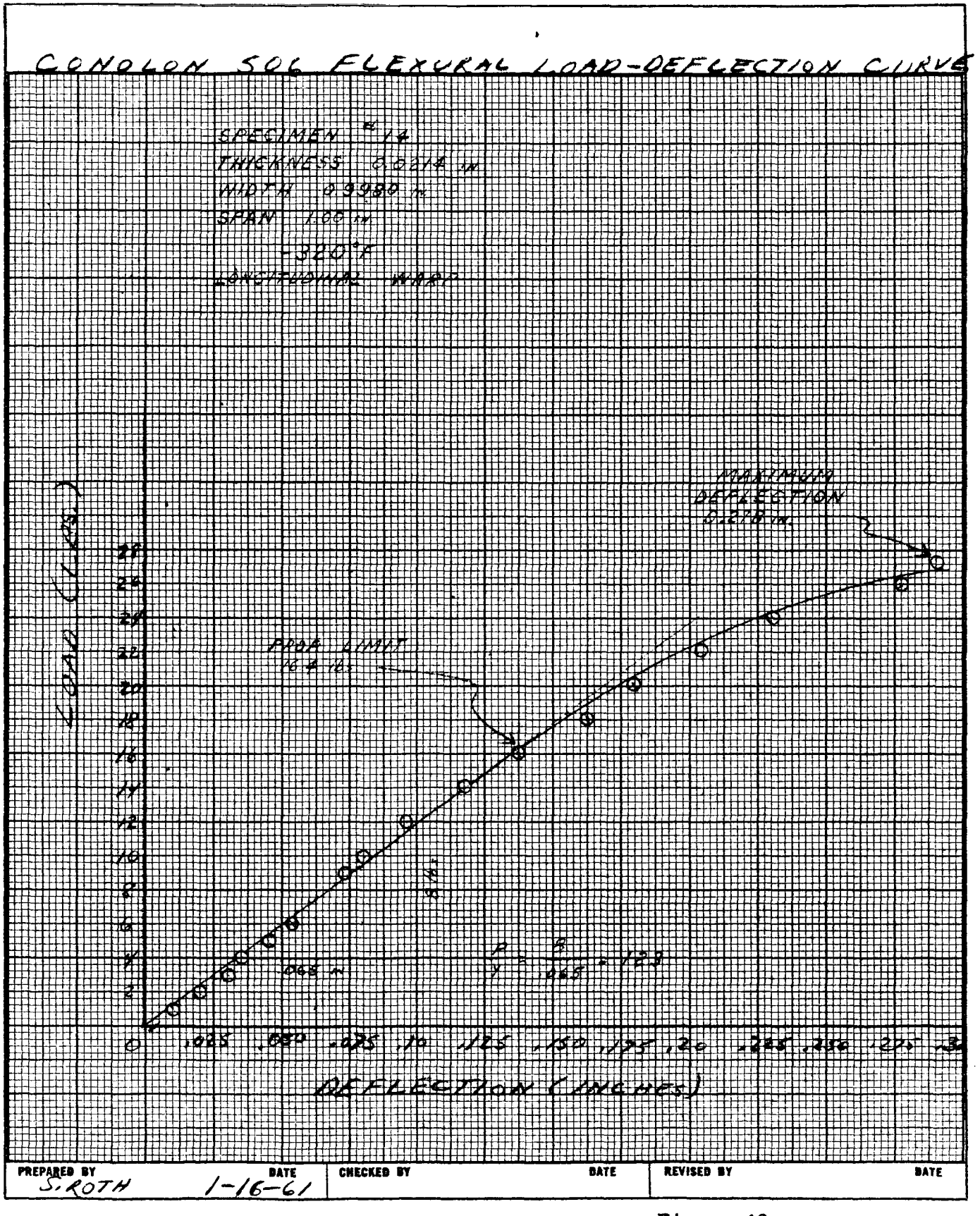
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-17-61				

Figure 38



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-61				

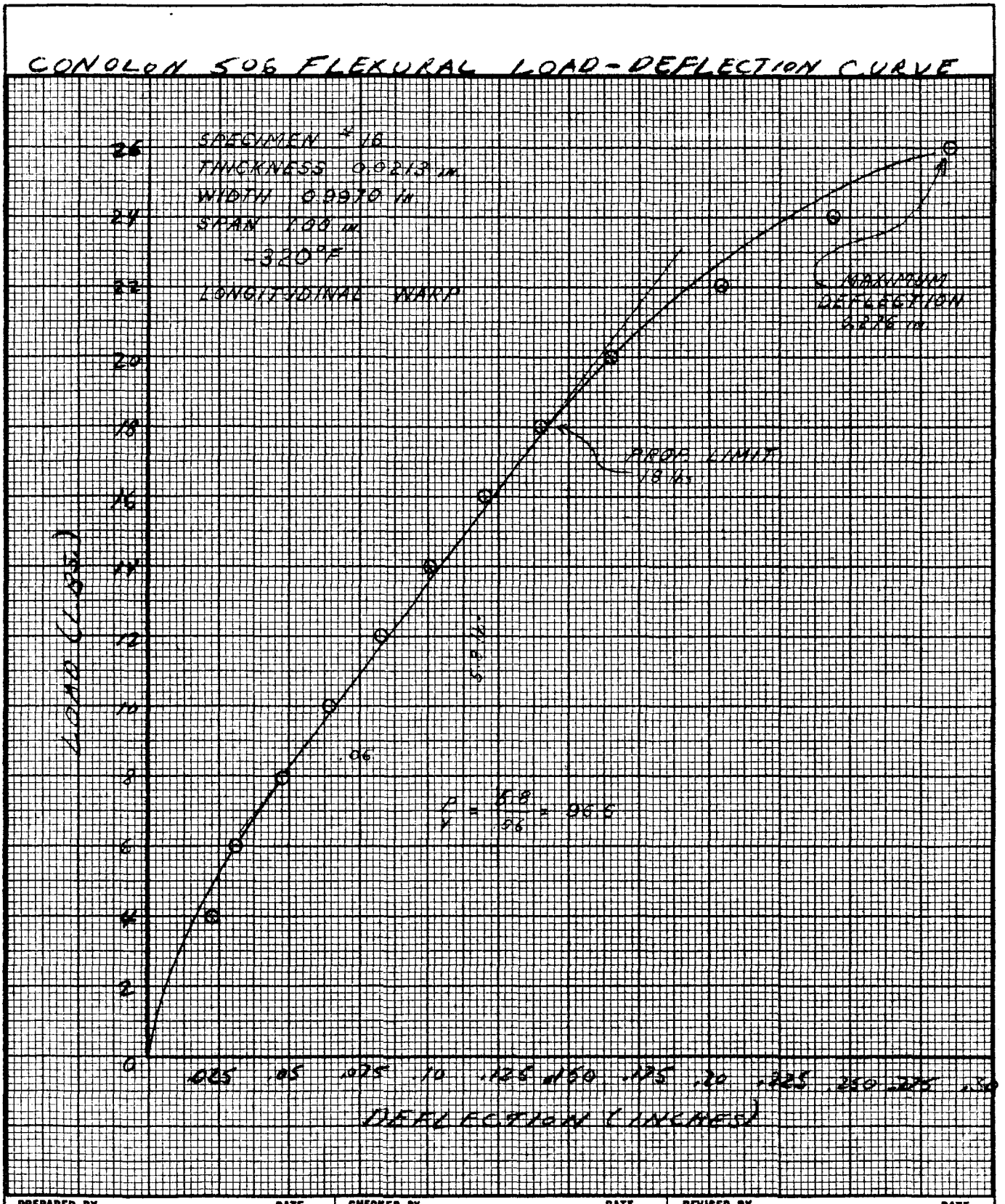
Figure 39



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-16-61				

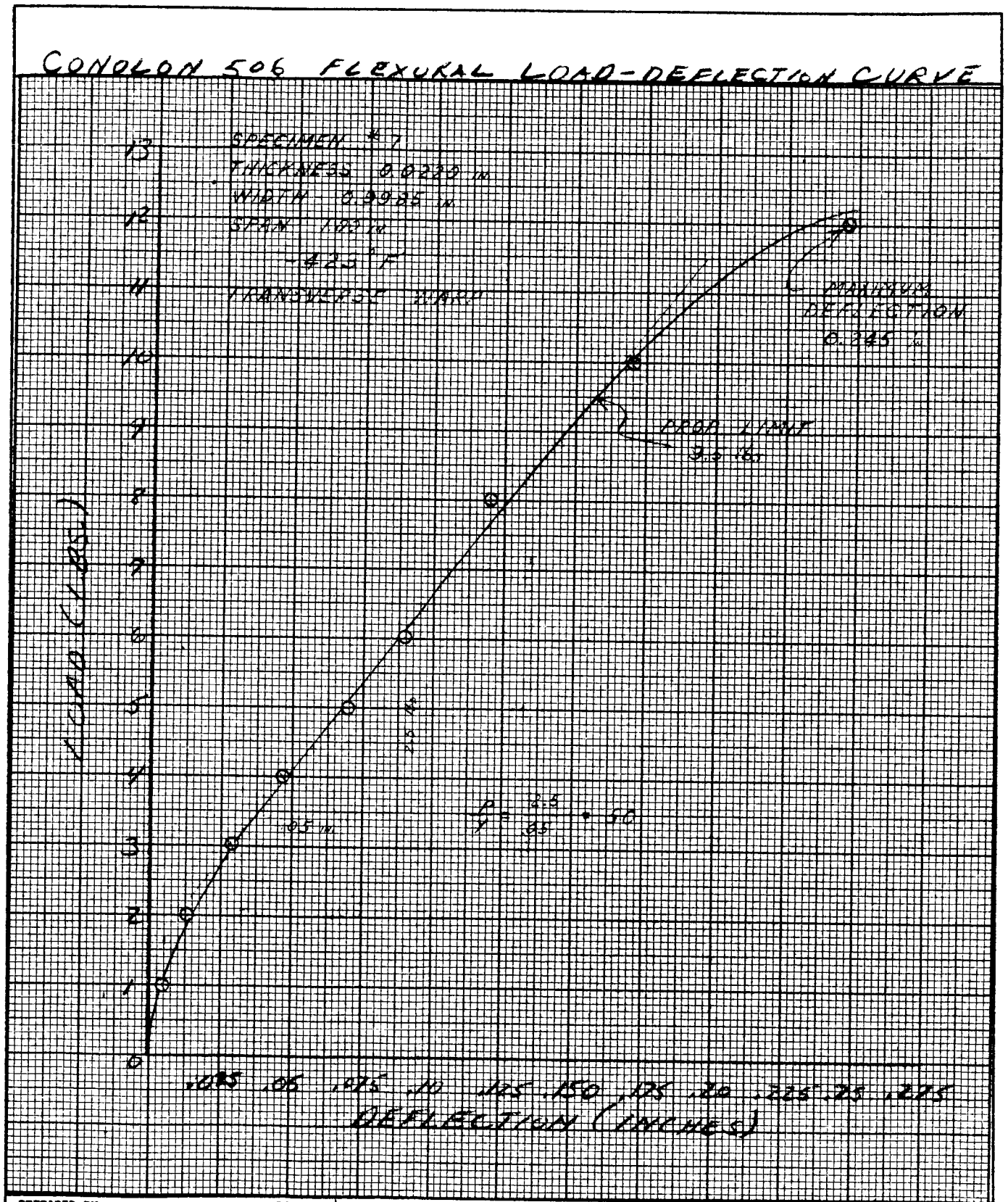
Figure 40

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE



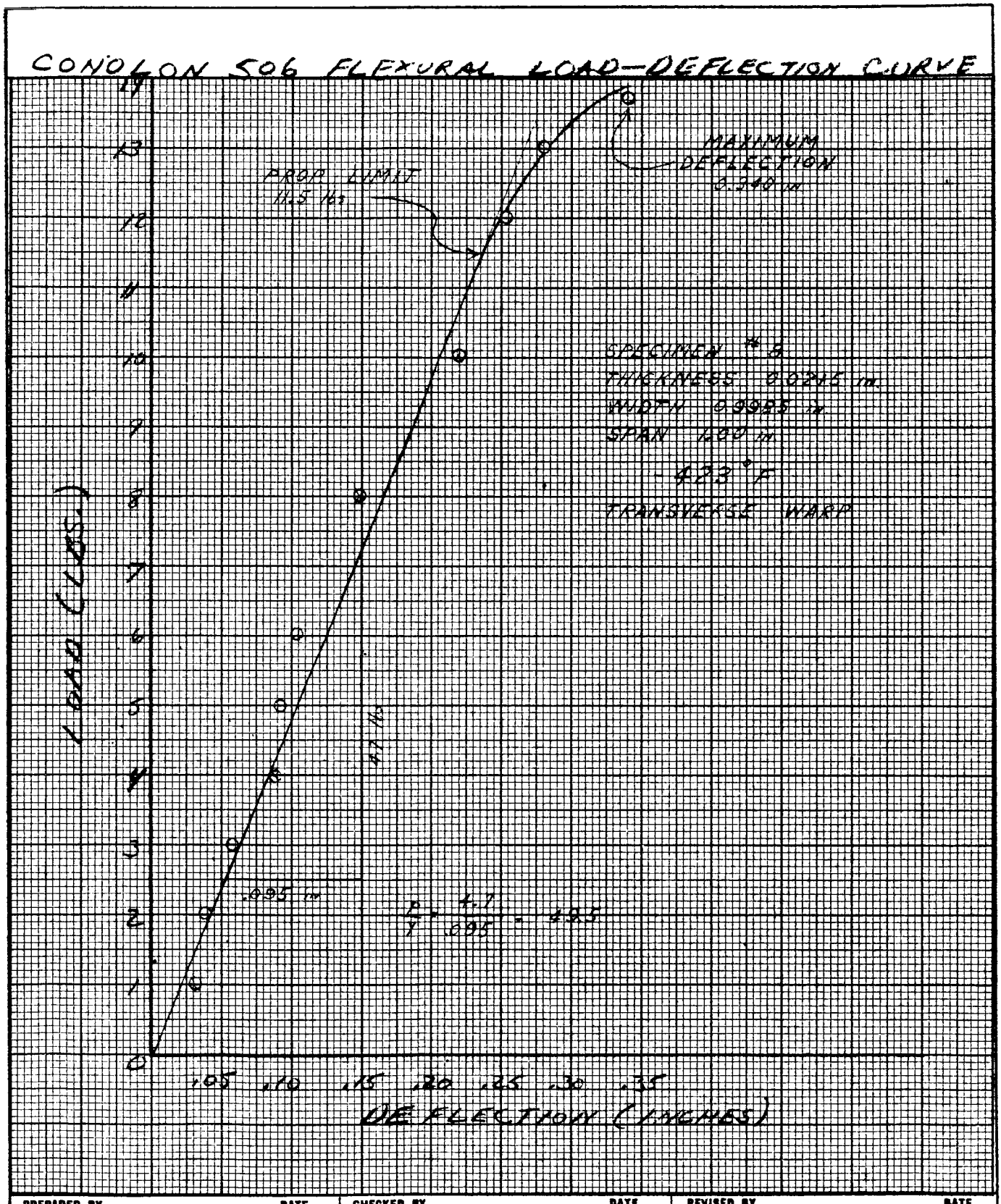
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-17-61				

Figure 41



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-17-61				

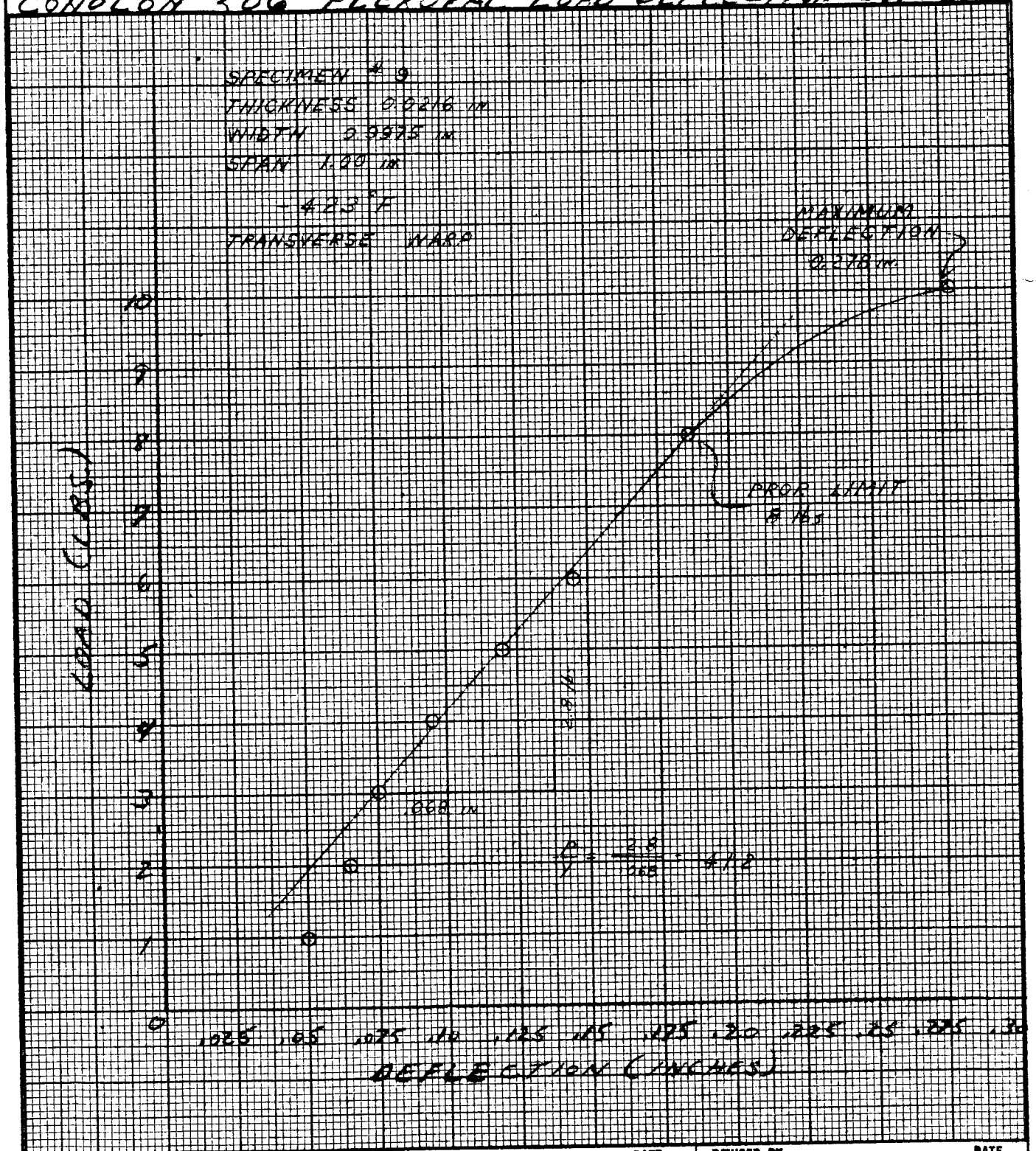
Figure 42



PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-17-61				

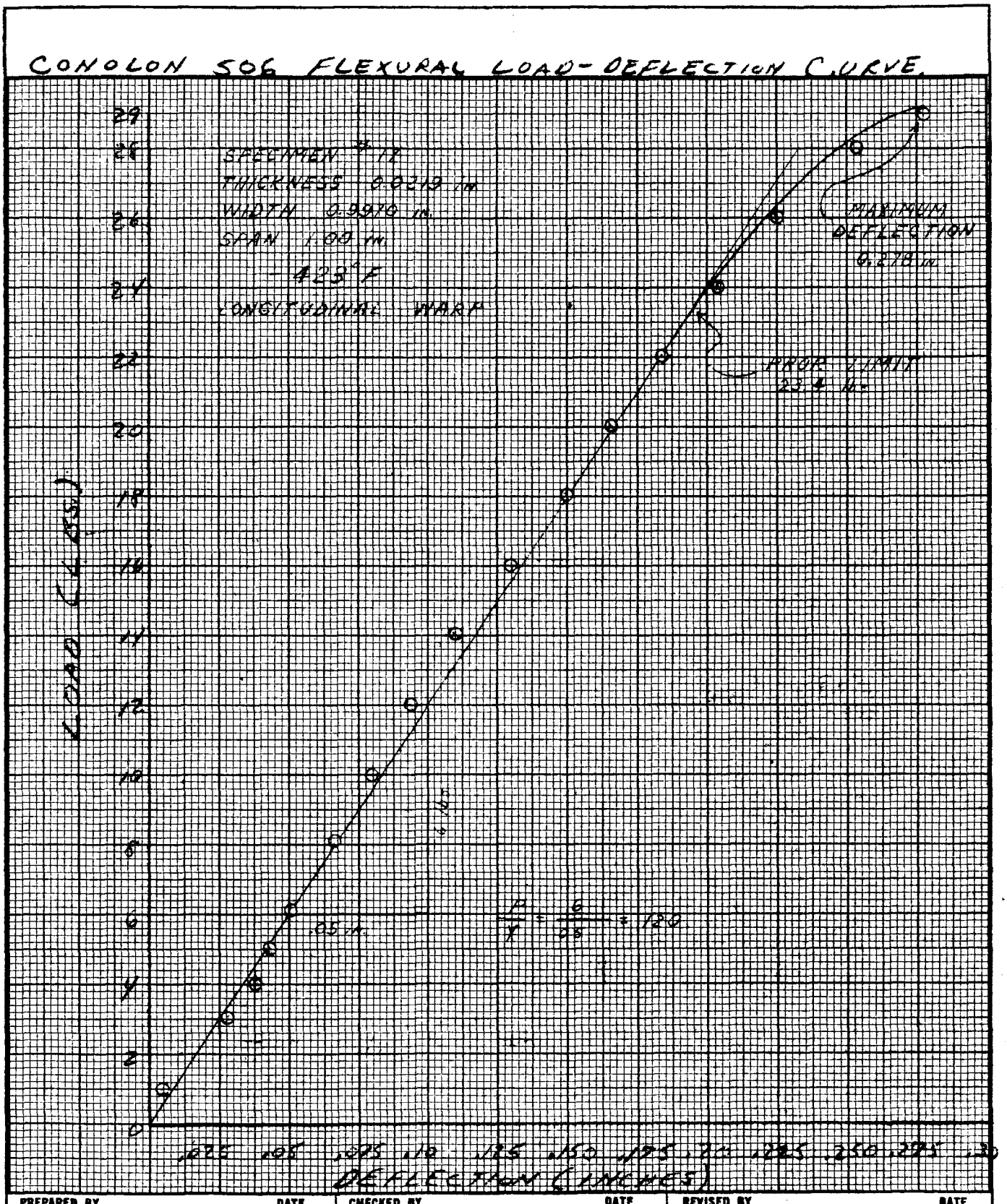
Figure 43

CONOLON 506 FLEXURAL LOAD-DEFLECTION CURVE.



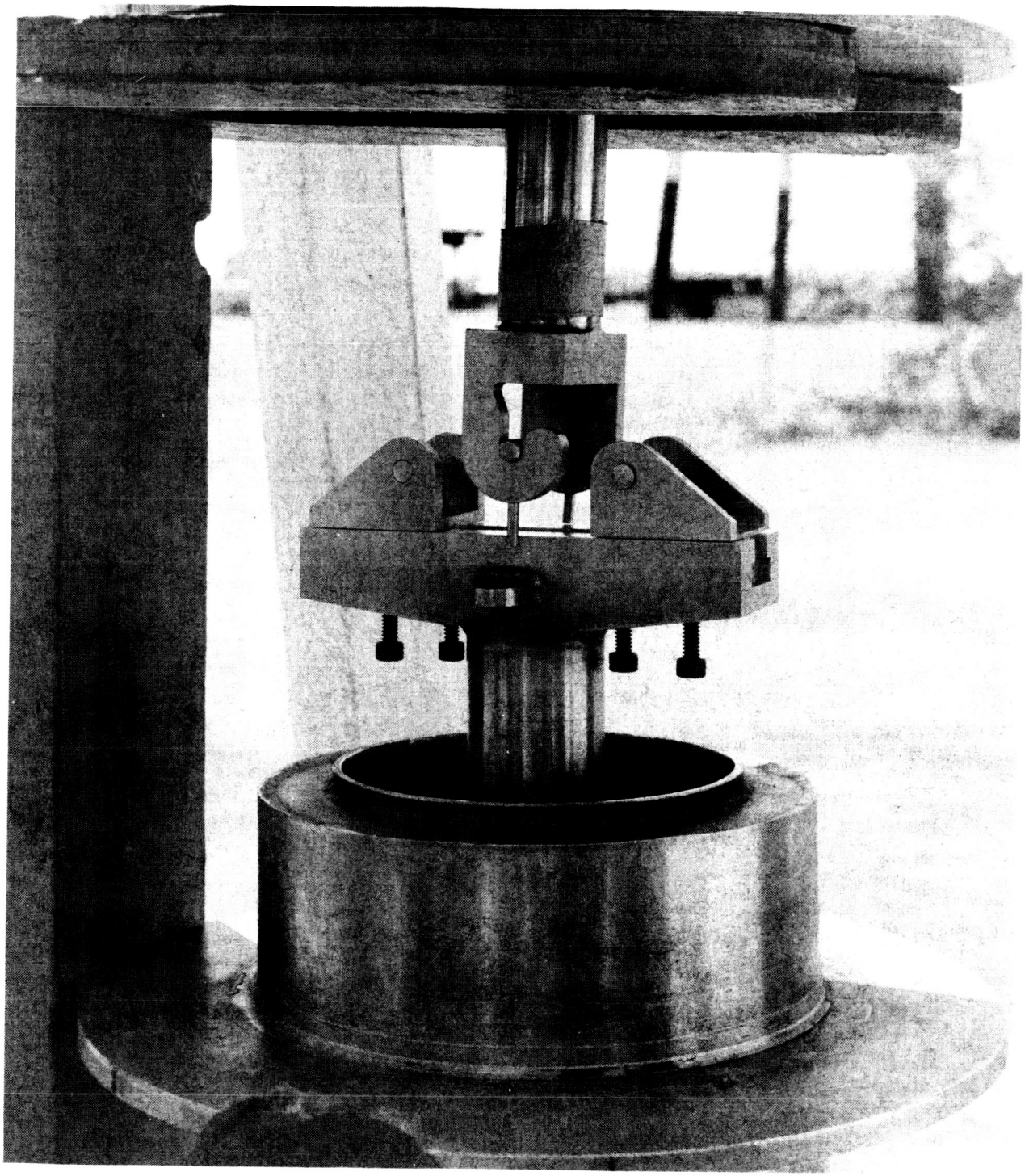
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-17-61				

Figure 44

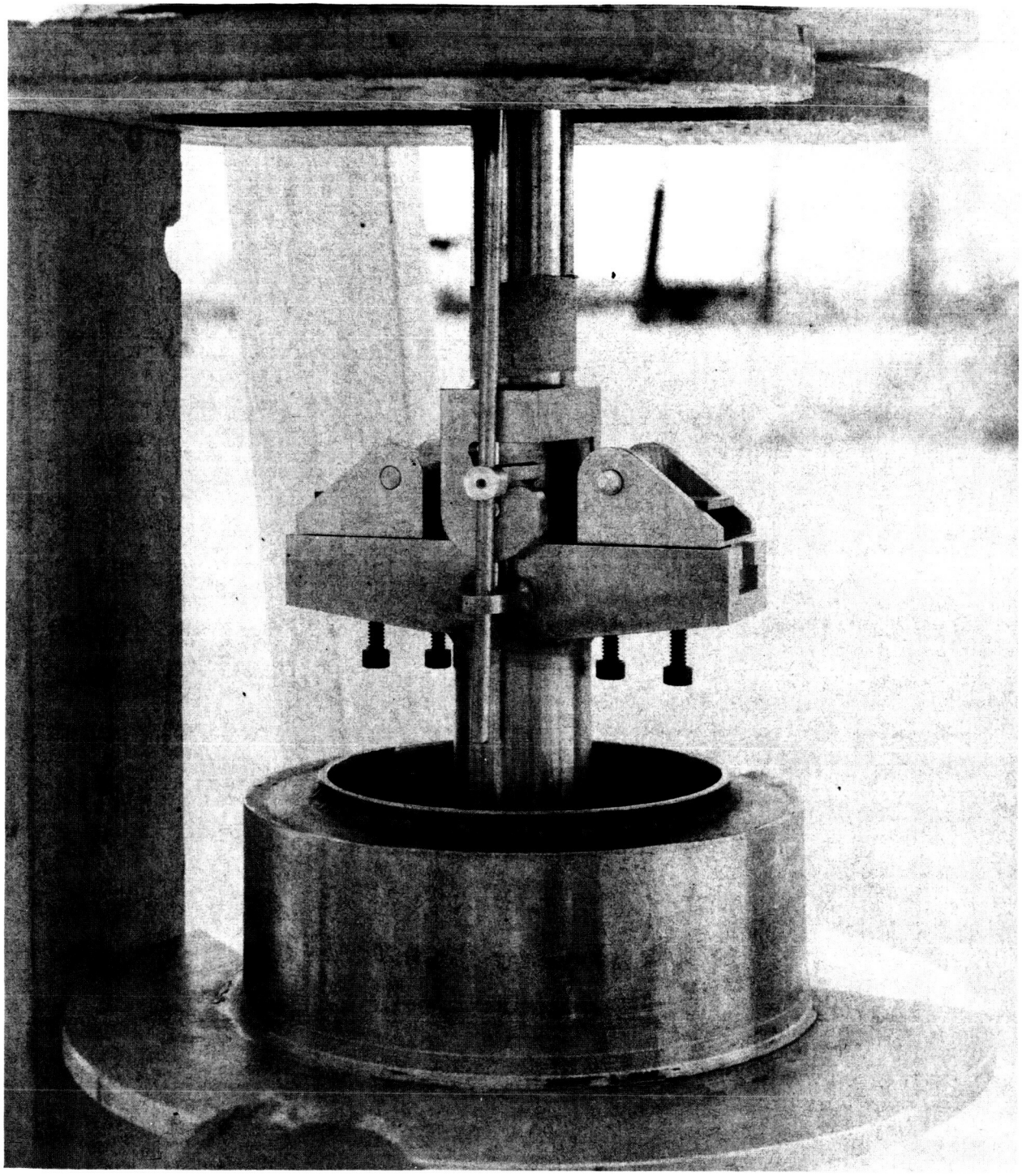


PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
S. ROTH	1-17-61				

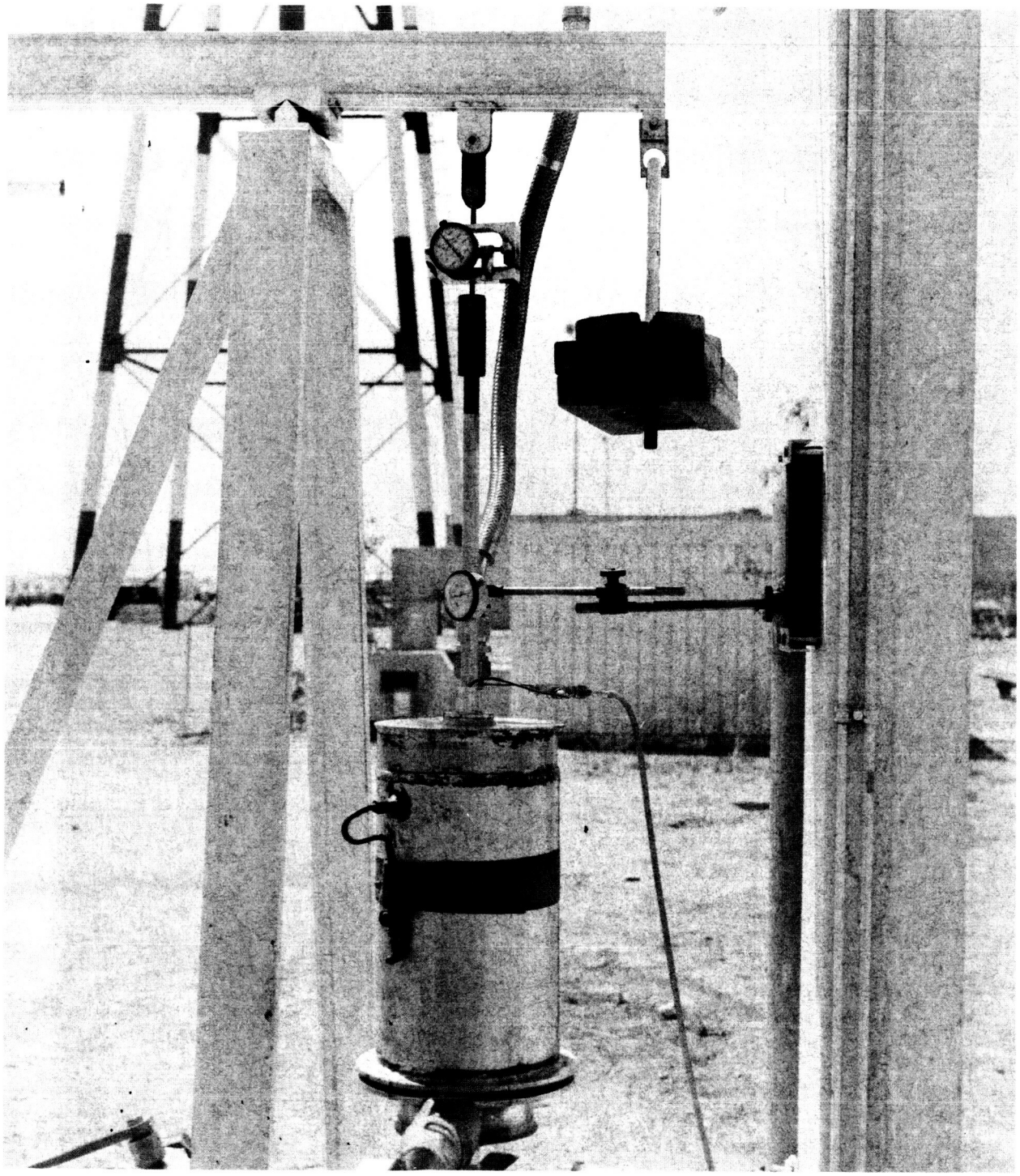
Figure 43



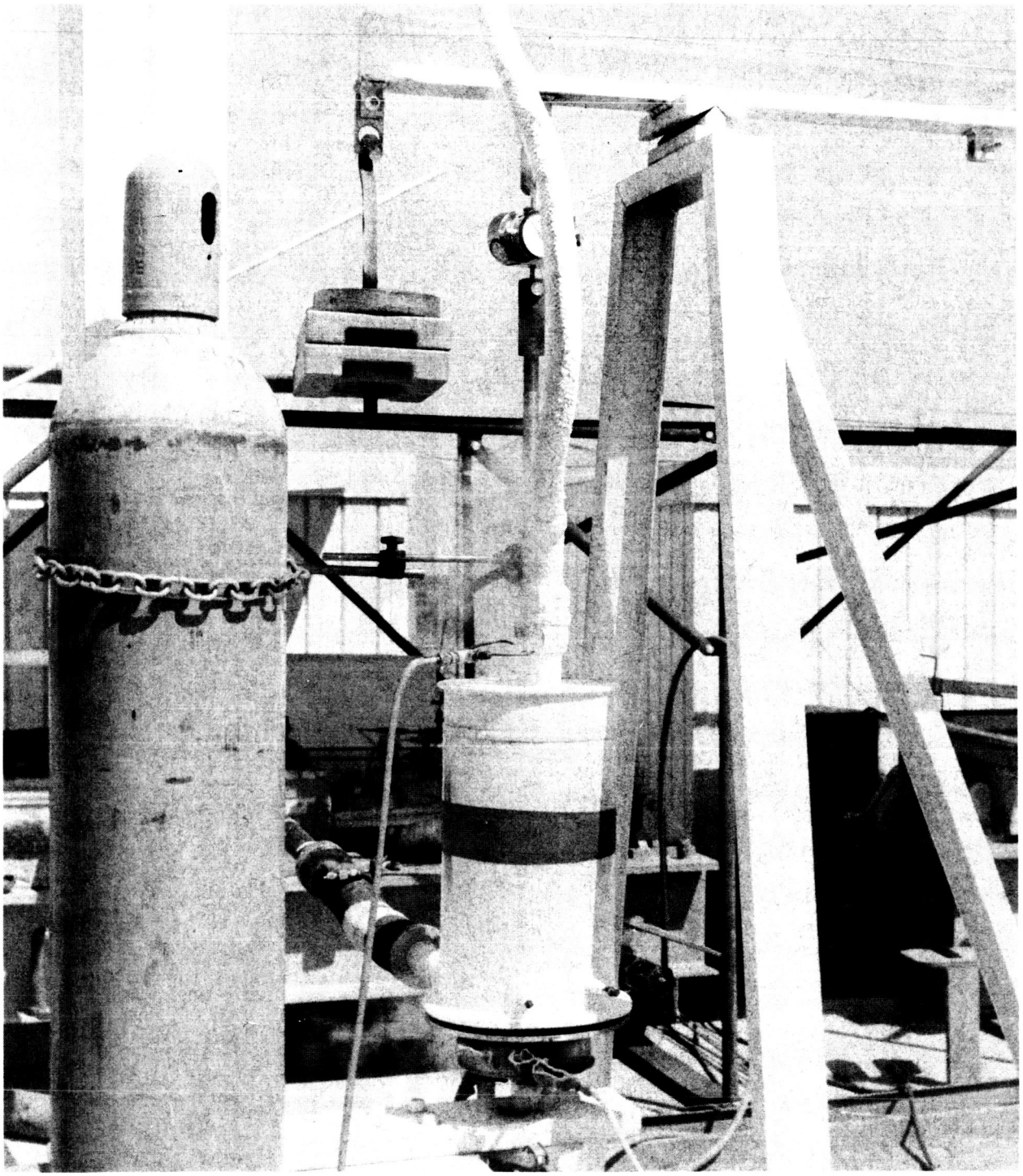
VIEW OF BENDING FIXTURE (CRYOSTAT REMOVED)
FIGURE NO. 46



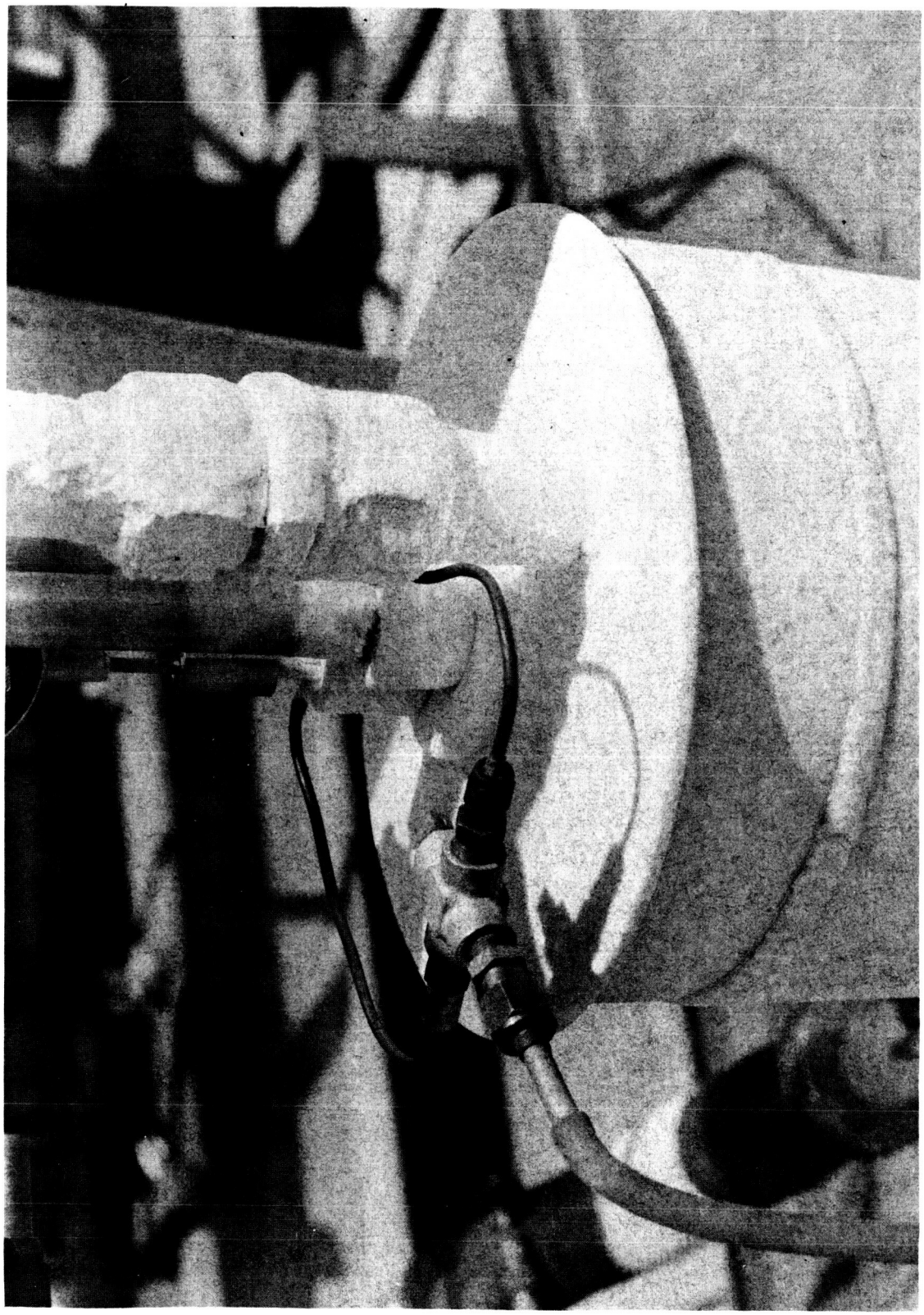
VIEW OF BENDING FIXTURE WITH SPECIMEN IN POSITION
FIGURE NO. 47



VIEW OF CRYOSTAT IN POSITION WITH DIAL
INDICATORS LOCATED TO MEASURE DEFLECTION AND LOAD
FIGURE NO. 46

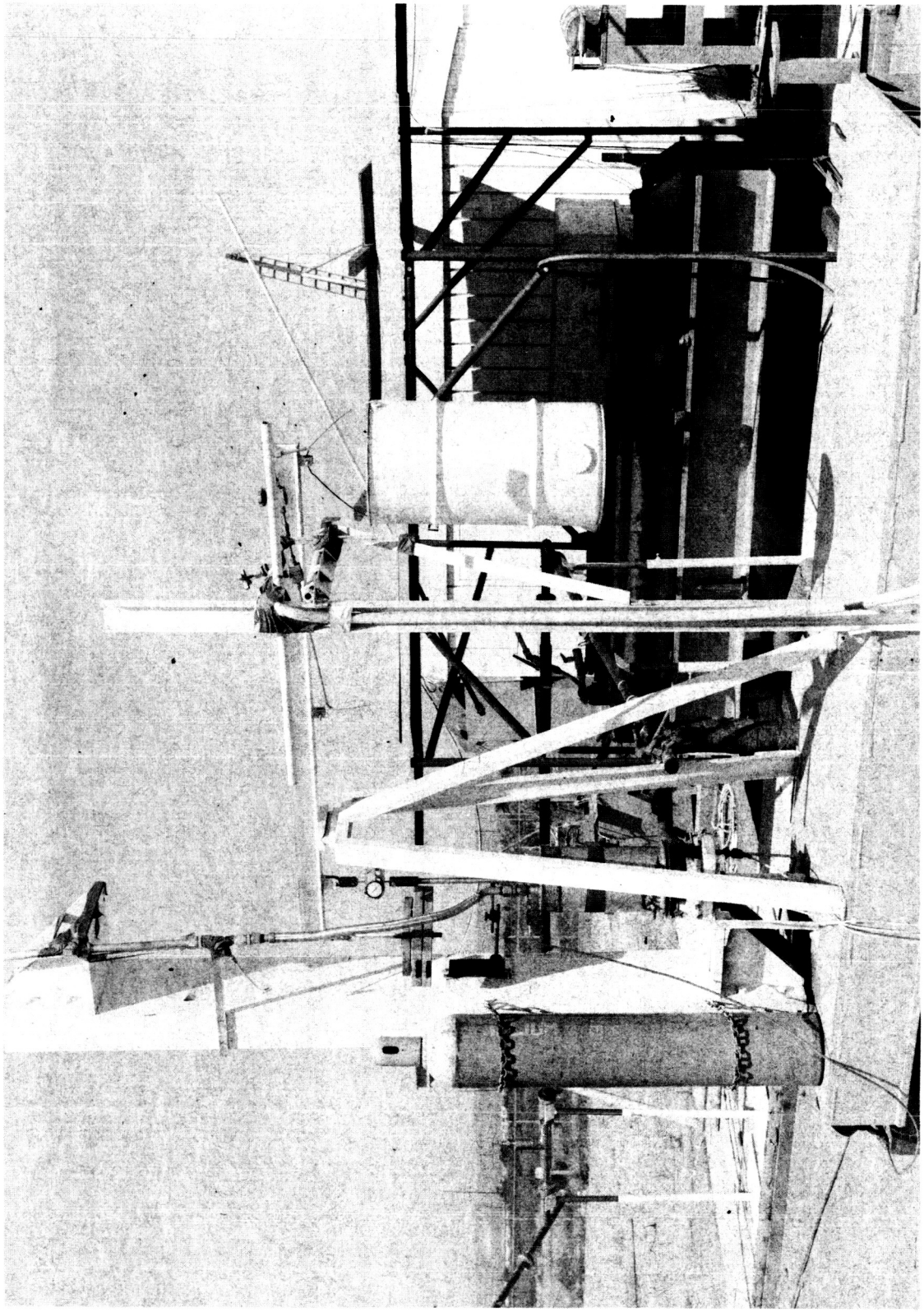


VIEW OF CRYOSTAT AFTER FILLING WITH LIQUID HYDROGEN
FIGURE NO. 49



VIEW OF COPPER TUBING USED TO DELIVER HEATED HELIUM TO AREAS AROUND PULL ROD AND DEFLECTION ROD

FIGURE NO. 50



OVERALL VIEW OF TEST SPPARATUS SHOWING BEAM AND WATER BARREL USED TO LOAD SPECIMENS
FIGURE NO. 51