

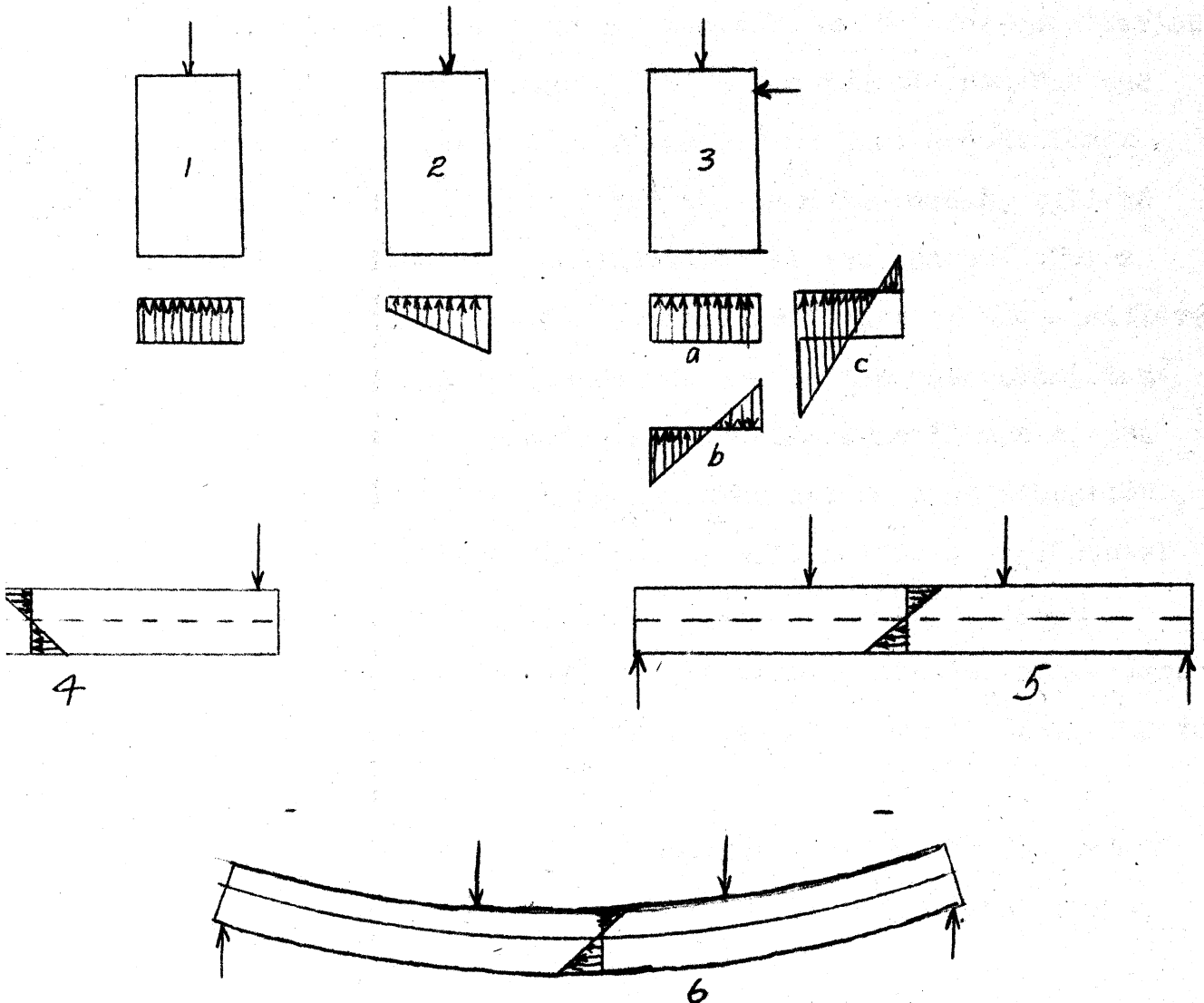
AN INVESTIGATION OF THE STRESS DISTRIBUTION
IN A TIMBER BEAM

Thesis for the degree of Mechanical Engineer

Submitted by H.B. Bennett, B.S.

**AN INVESTIGATION OF THE STRESS DISTRIBUTION
IN A TIMBER BEAM**

In the theoretical treatment of beams, columns, and other structural members, Navier's Principle is assumed. This principle states that the deformation of the fibers of any stressed member varies as a straight line from the point of maximum deformation to the point of minimum deformation. Some of the cases to which this principle is applied are shown below.



For a short strut loaded at the center of gravity of the section all the fibers are shortened an equal amount, and the diagram showing ~~showing~~ the deformation of the fibers is rectangular as shown in figure 1. When the strut is loaded eccentrically as in figure 2, the outermost fibers of the side nearest the load will be shortened more than those on the opposite side and the diagram will be trapezoidal. For a strut subjected to direct (or simple) compression and a couple (or moment) the deformation of a fiber between two consecutive sections that were parallel before loading is the resultant of the two component deformations, diagram (a) for compression and diagram (b) for flexure, (c) being the diagram for the resultant deformation. In figure 4, we have a cantilever beam the fibers of which, when the beam is loaded, will be elongated at the top and shortened at the bottom. For a simple beam the strain is reversed from that of the cantilever. The top fibers are shortened and the bottom ones elongated. For a curved beam supported and loaded as in figure 6, the top fibers will be shortened and the bottom ones elongated but the point of zero deformation will not be at the center of gravity of the section,

According to Navier's Principle, the law of variation of the deformation of the fibers in all cases is according to a straight line.

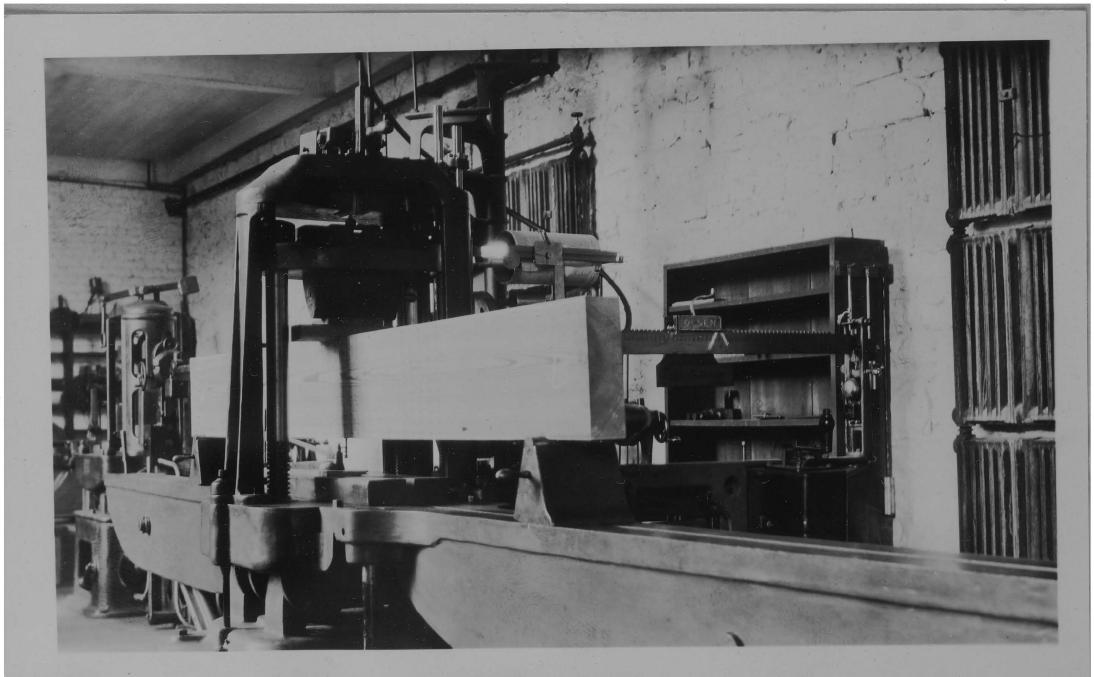
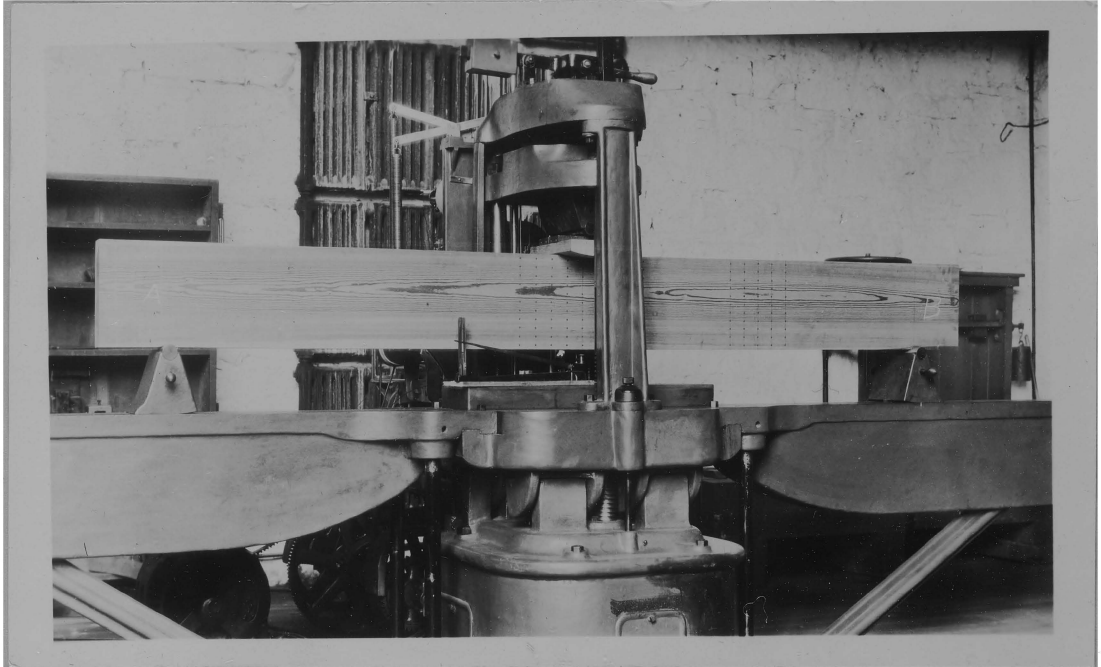
The object of this investigation was to determine whether the deformation of fibers of a loaded beam vary in accordance with Navier's assumption.

Procedure

A timber (pine) beam, three and one quarter inches wide, eleven and one sixteenth inches deep, and eight feet between supports was used in this investigation. A portion of the length near the center was divided into 2-inch spaces longitudinally and one-inch transversely and on both sides. This gave a portion of the beam sixteen inches long marked off at two-inch intervals horizontally, and one-inch intervals vertically. At the intersections of these lines tacks were driven, thereby providing for center punch marks for use with the strain gage.

A similar portion of the beam near the quarter point was also experimented upon. The position of the beam and the manner in which it was marked and loaded are shown on page 5.

A Berry strain gage was used in this investigation and a deflectometer was also used for recording transverse deflections in order that the elastic limit of the beam might be found.



Tabulated Results

In the following tables the average deformation of the fibers is given . It was originally planned to show the deformation of each 2-inch length of the fibers, but due to the inherent inaccuracies of the gage the readings were very irregular, and for this reason only the averages for the whole sixteen-inch portion of the beam are given. The first reading in each table is the average unit compression for the upper row of tacks, the second reading is the average along the second row of tacks , and so on. The numbers with the minus sign before them denote contraction of the fibers and the numbers with no sign before them denote elongation.

Center Section 4,000 lb.load

No.	Front View unit strain in./in.	Back View unit strain in./in.
1	-.000600	-.000600
2	-.000537	-.000375
3	-.000283	-.000225
4	-.000083	-.000138
5	.000100	-.000025
6	.000067	.000050
7	.000167	.000175
8	.000317	.000237
9	.000467	.000375
10	.000500	.000437
11	.000650	.000625

Center Section

8,000 lb.load

No.	Front View unit strain in./in.	Back View unit strain in./in.
1	-.001300	-.00100
2	-.001183	-.000763
3	-.000900	-.000475
4	-.000300	-.000362
5	-.000200	.000000
6	.000000	.000163
7	.000250	.000413
8	.000500	.000500
9	.000717	.000675
10	.000850	.000737
11	.000950	.001075

12,000 lb.load

1	-.002167	-.001300
2	-.001650	-.001267
3	-.000933	-.000917
4	-.000417	-.000537
5	-.000233	-.000200
6	.000067	.000125
7	.000400	.000425
8	.000733	.000525
9	.001150	.000937
10	.001417	.001262
11	.001633	.001625

Center Section
16,000lb. load

No.	Front View unit strain in./in.	Back View unit strain in./in.
1	-.002750	-.002863
2	-.001967	-.001925
3	-.001400	-.001150
4	-.000783	-.000875
5	-.000483	-.000313
6	-.000050	.000100
7	.000483	.000437
8	.000900	.000737
9	.001533	.001187
10	.001967	.001737
11	.002317	.002150

20,000 lb. load

1	-.002800	-.002663
2	-.003150	-.002525
3	-.001833	-.001638
4	-.001017	-.000987
5	-.000350	-.000363
6	.000050	.000050
7	.000467	.000600
8	.001233	.000975
9	.001850	.001587
10	.002383	.002163
11	.003050	.002863

Quarter Point
4,000 lb. load

No.	Front View unit strain	Back View unit strain
1	-.000175	-.000350
2	-.000075	-.000175
3	-.000150	-.000175
4	-.000200	-.000200
5	-.000175	-.000050
6	-.000050	.000125
7	.000050	.000225
8	.000075	.000125
9	.000175	.000100
10	.000275	.000250
11	.000500	.000275

8,000 lb. load

1	-.000575	-.000475
2	-.000450	-.000450
3	-.000450	-.000175
4	-.000350	-.000375
5	-.000250	-.000150
6	.000025	.000025
7	.000125	.000050
8	.000225	.000175
9	.000275	.000225
10	.000225	.000450
11	.000625	.000500

Quarter Point
12,000 lb. load

Front View

Back View

No.	unit strain
1	-.000750
2	-.000500
3	-.000300
4	-.000475
5	-.000150
6	-.000050
7	.000100
8	.000275
9	.000500
10	.000650
11	.000775

unit strain
-.000675
-.000725
-.000425
-.000250
-.000275
-.000025
.000100
.000225
.000350
.000475
.000575
.000675

12,000 lb. load

1	-.000975
2	-.000650
3	-.000625
4	-.000625
5	-.000175
6	-.000050
7	.000175
8	.000425
9	.000650
10	.000775
11	.001175

-.000975
-.000975
-.000650
-.000550
-.000550
-.000400
.000000
.000250
.000425
.000700
.000950
.001175

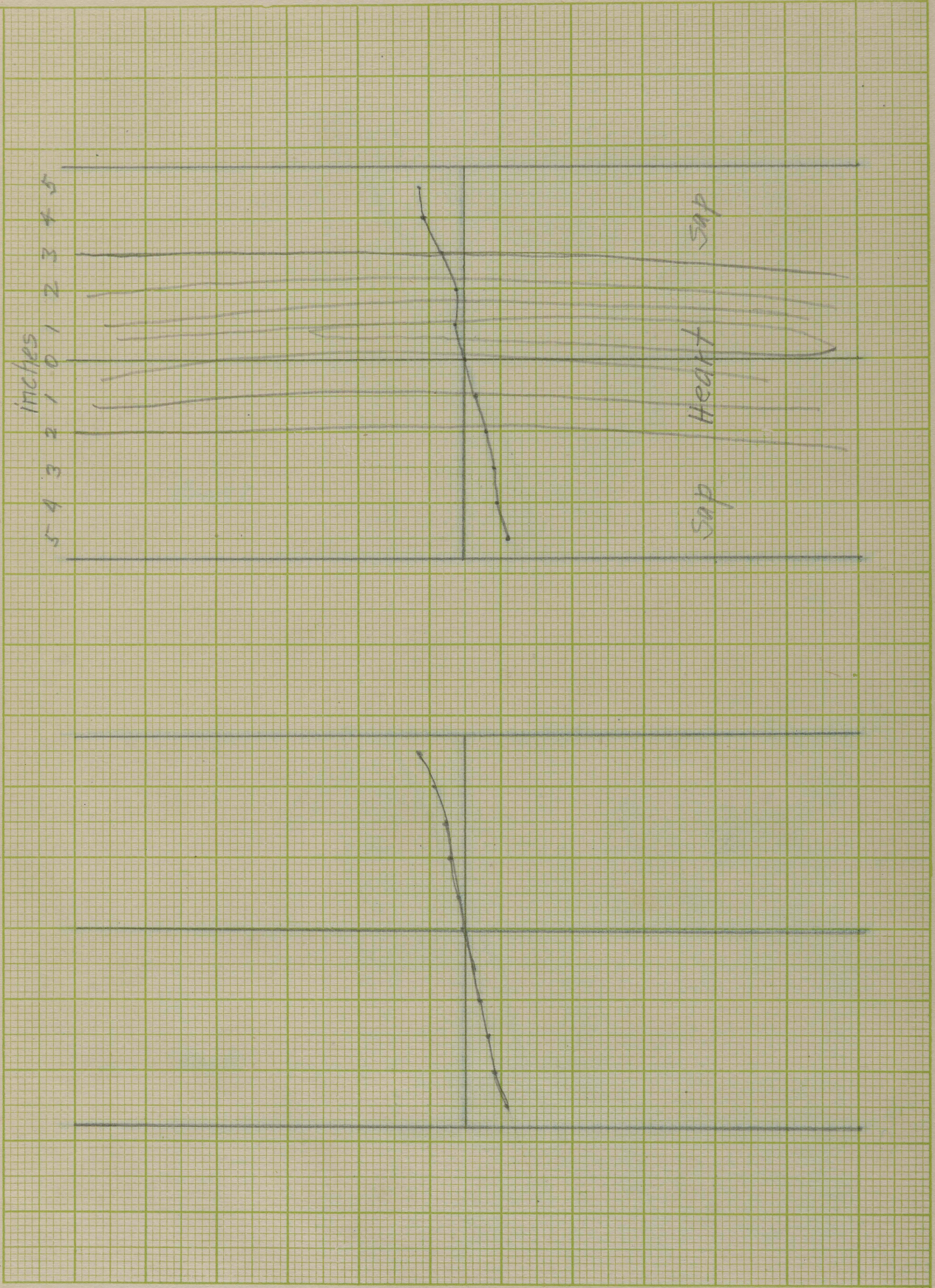
Quarter Point
20,000 lb. load

Front View
No. unit strain in./in.

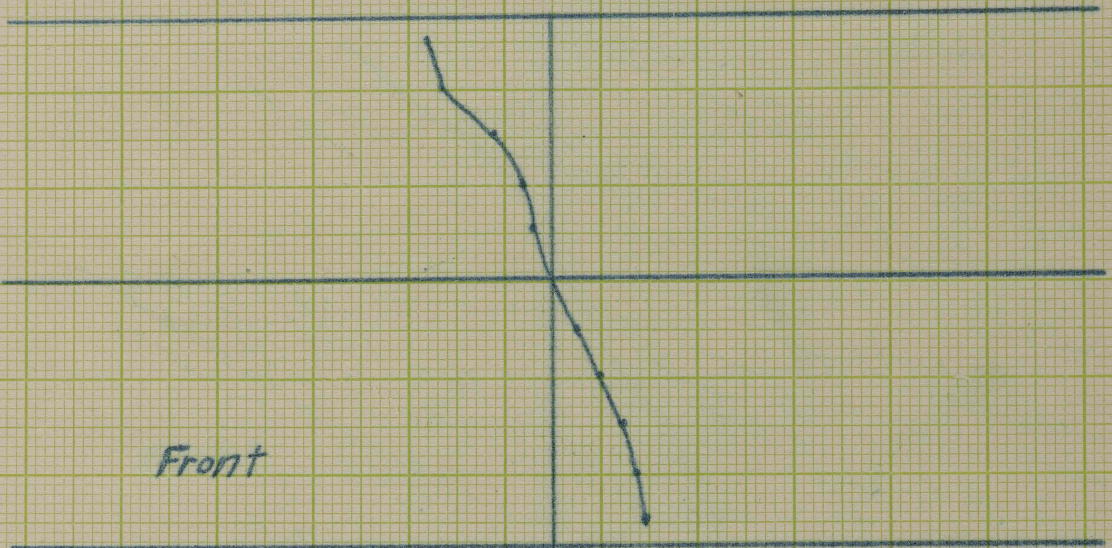
Back View
unit strain in./in.

1 -.001200
2 -.000900
3 -.000775
4 -.000675
5 -.000175
6 -.000175
7 .000175
8 .000575
9 .000775
10 .000850
11 .001500

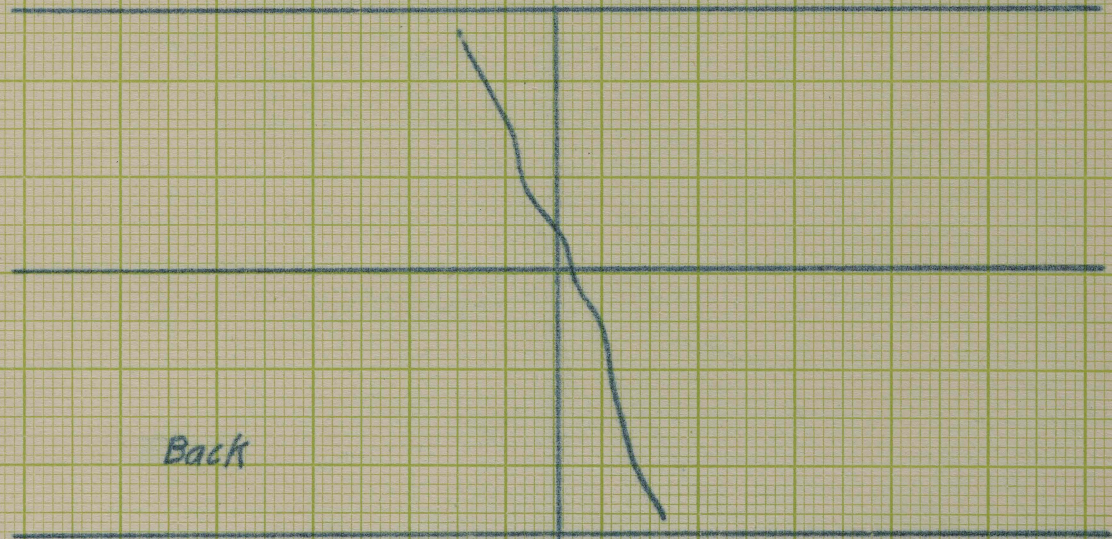
-.000900
-.001300
-.000825
-.000700
-.000575
-.000150
.000100
.000100
.001100
.001425
.001625



4000 # (center section)

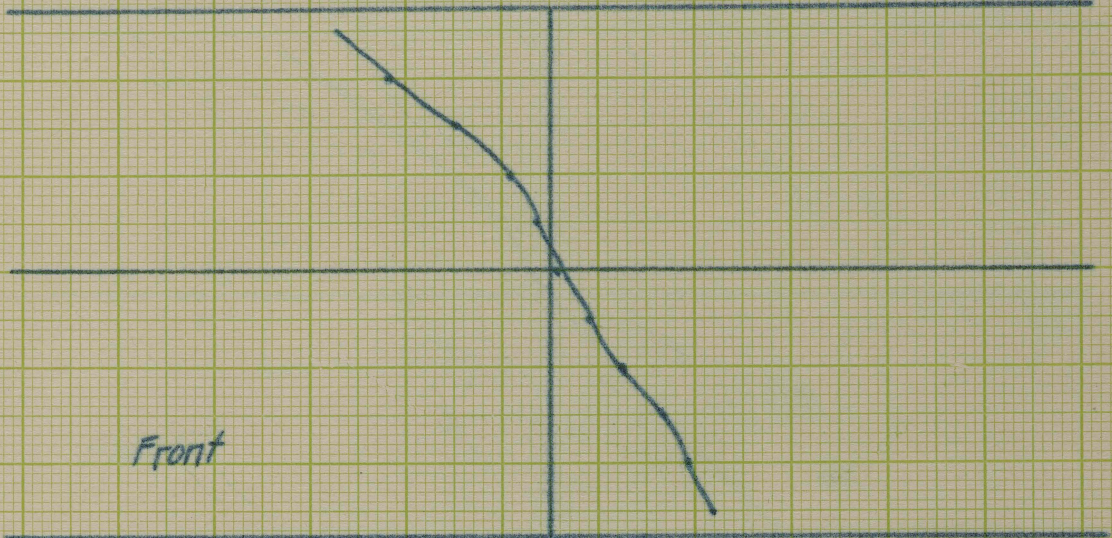


Front

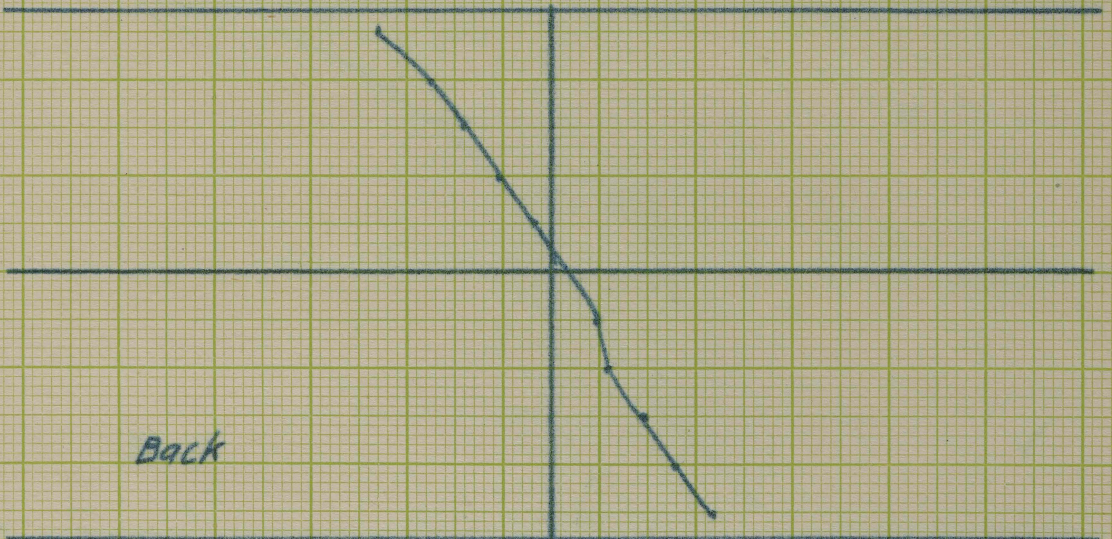


Back

8000 # (Center)

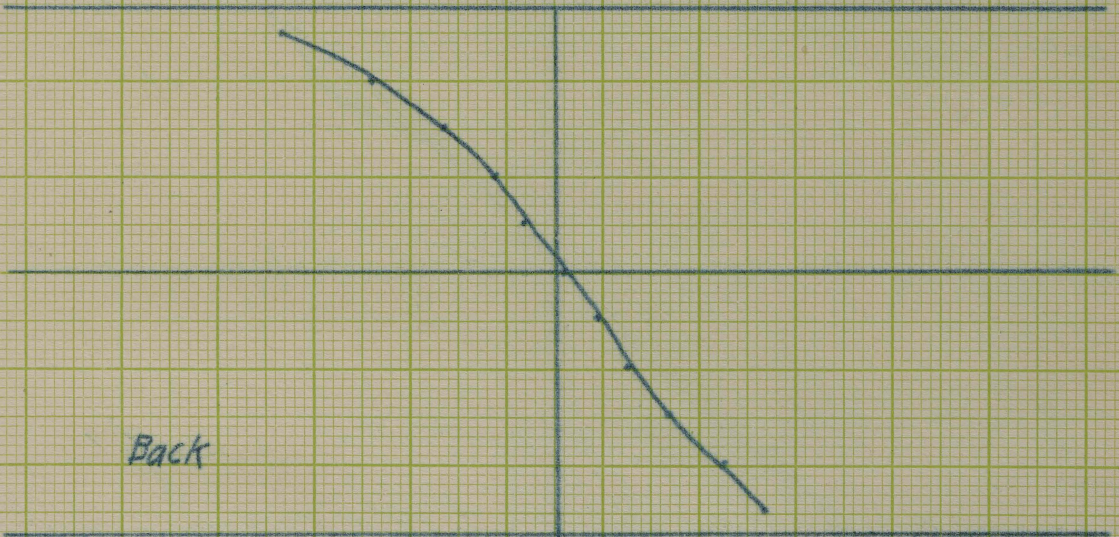
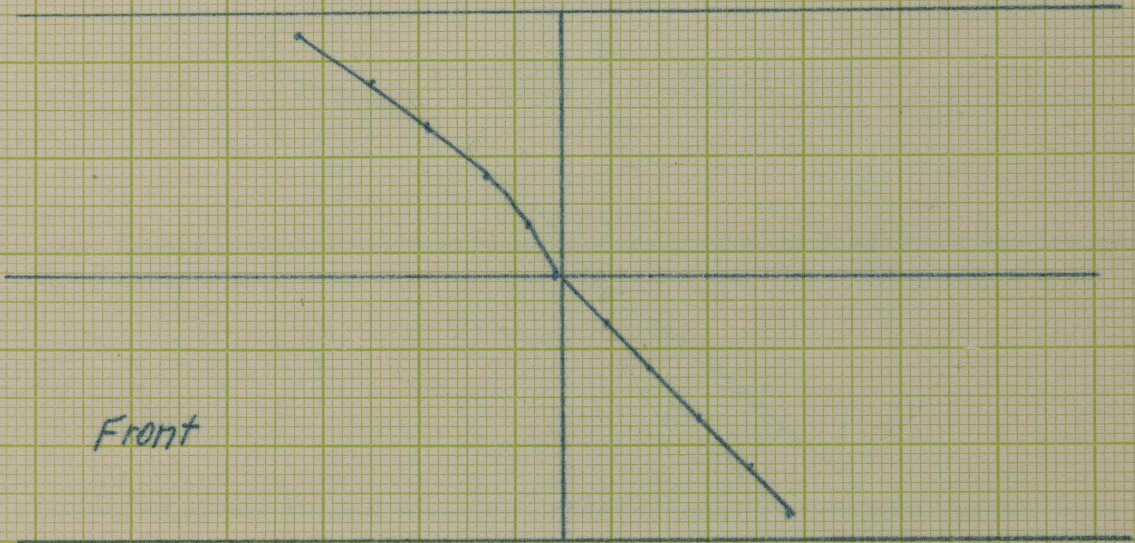


Front

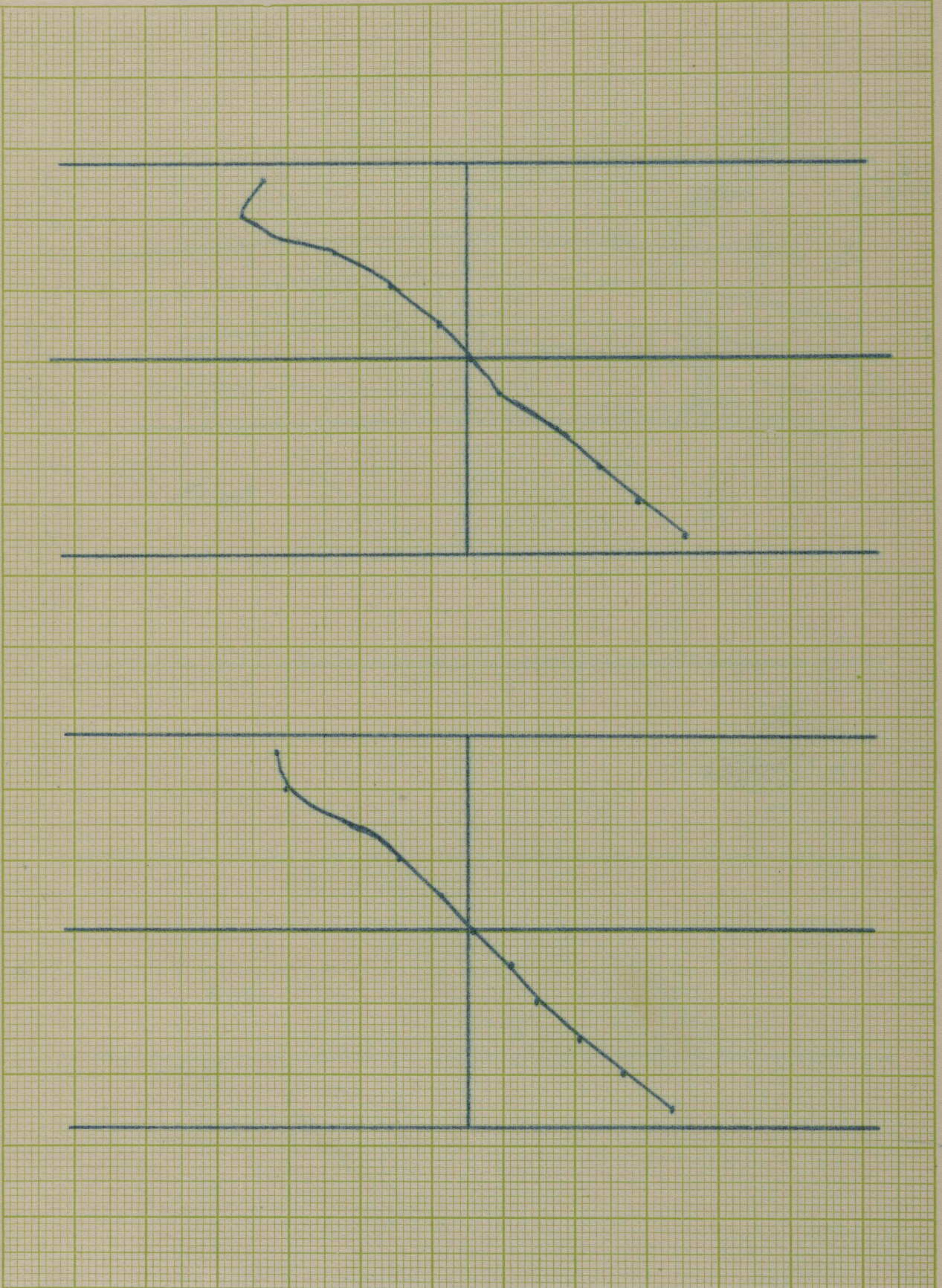


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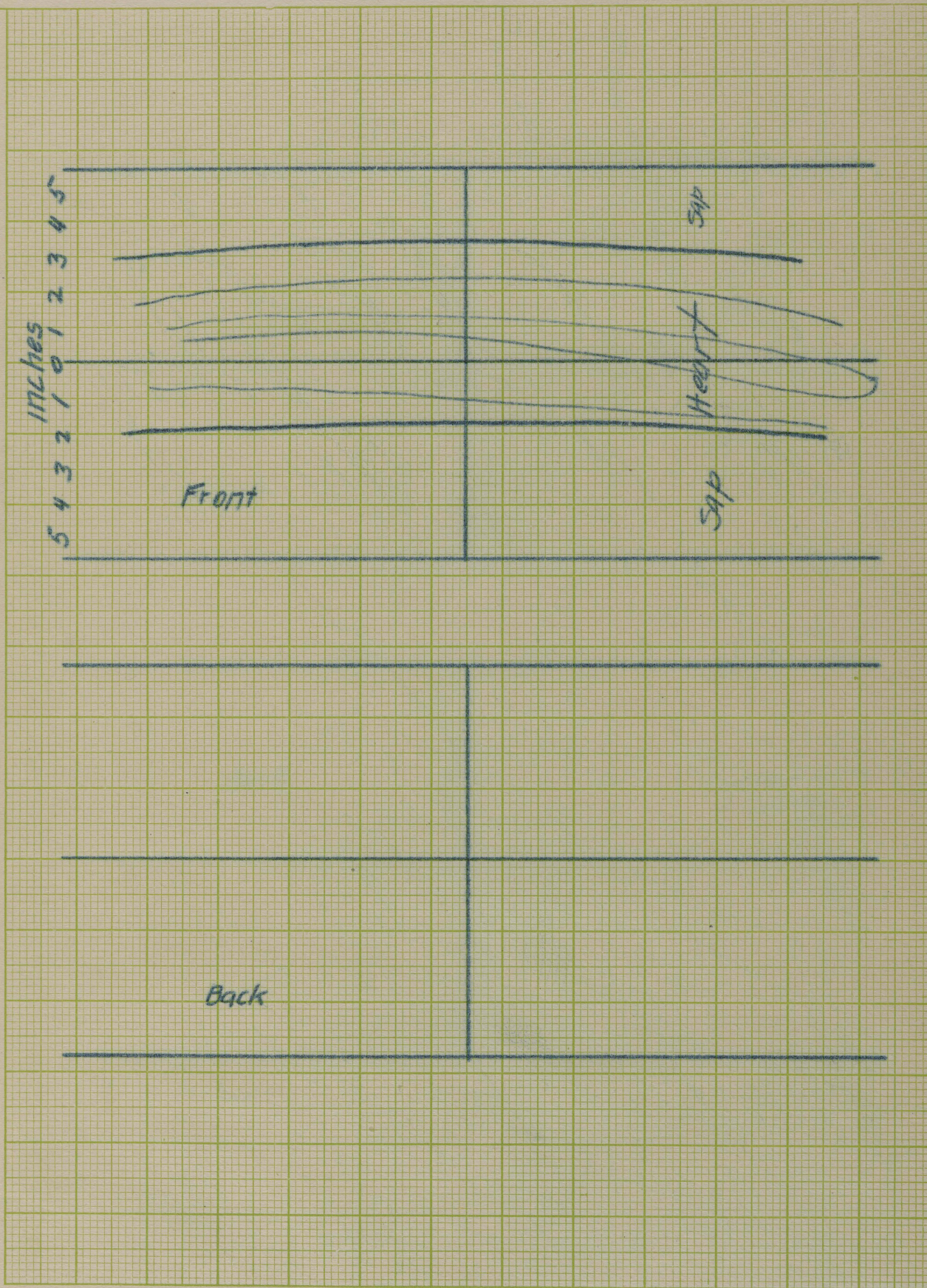
12000 (Center)



16,000 # (Center)



20000# Center

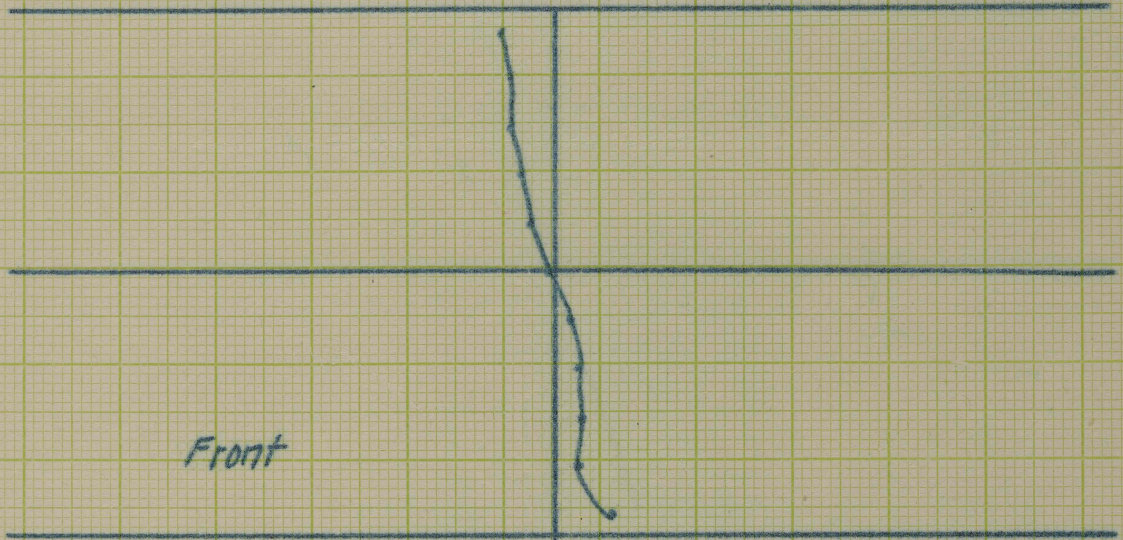


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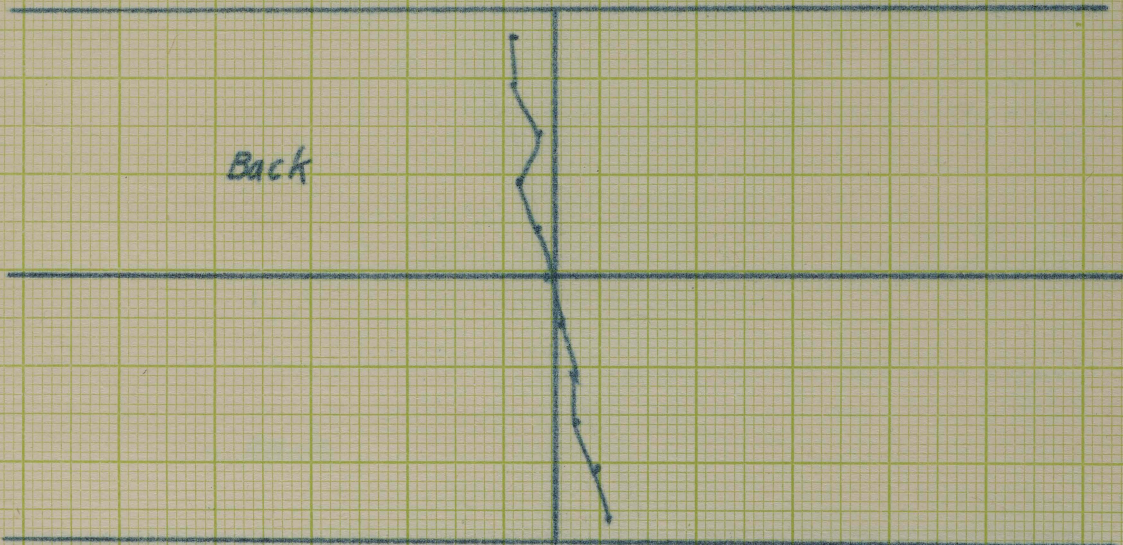
4000 # (Quarter Point)

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20 LINES = 1 INCH

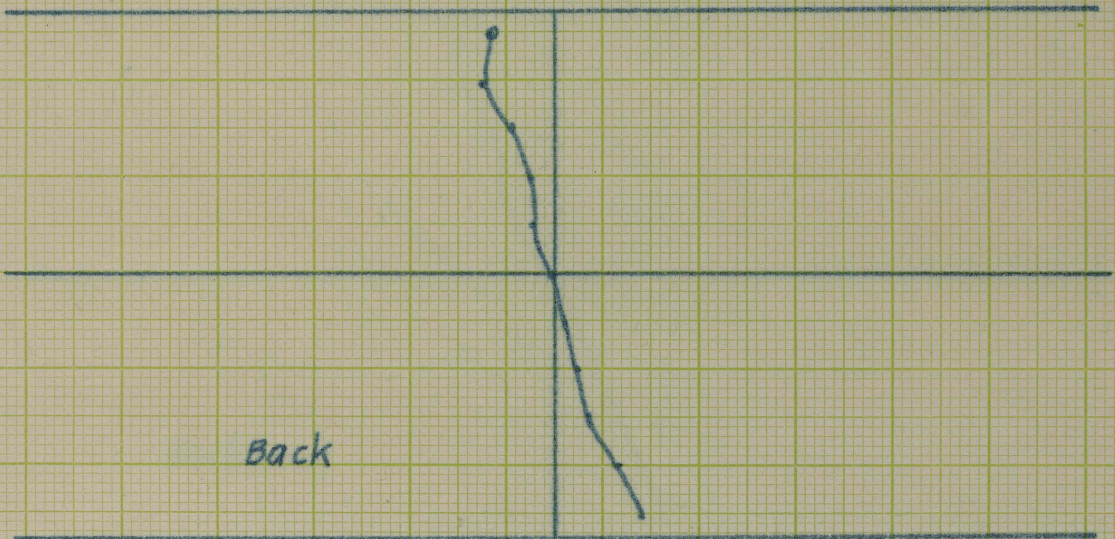
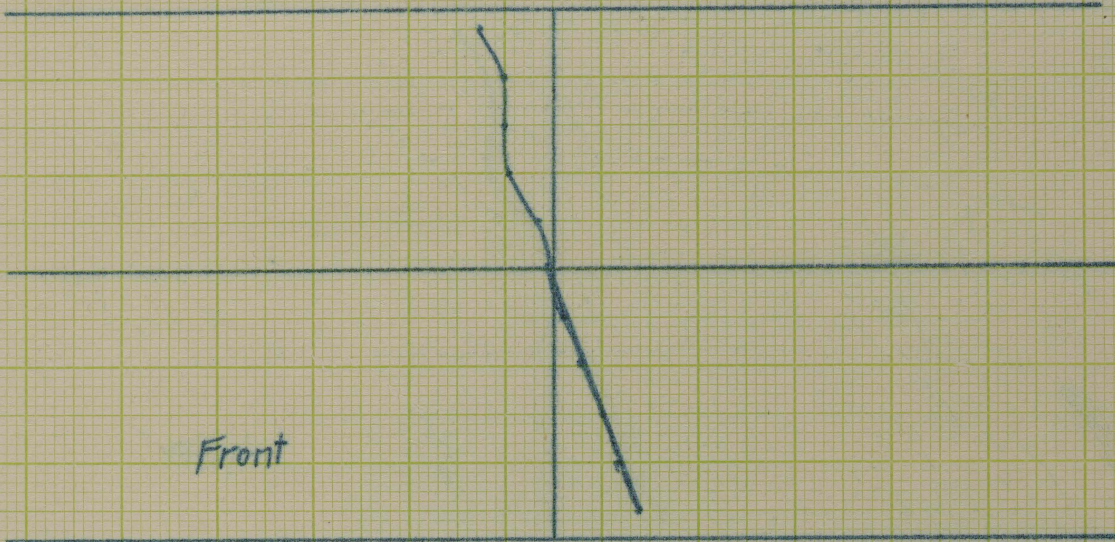


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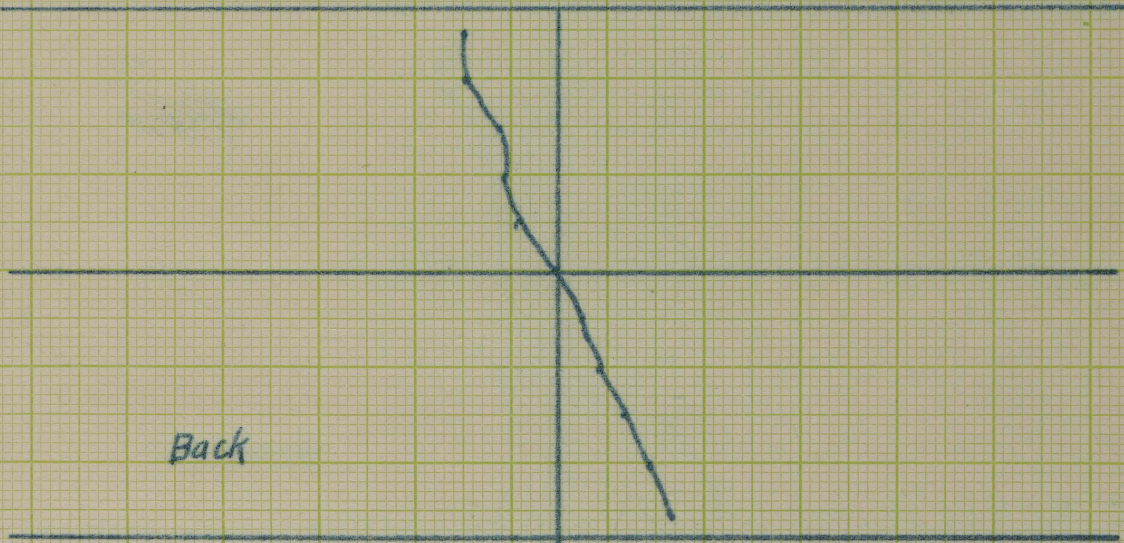
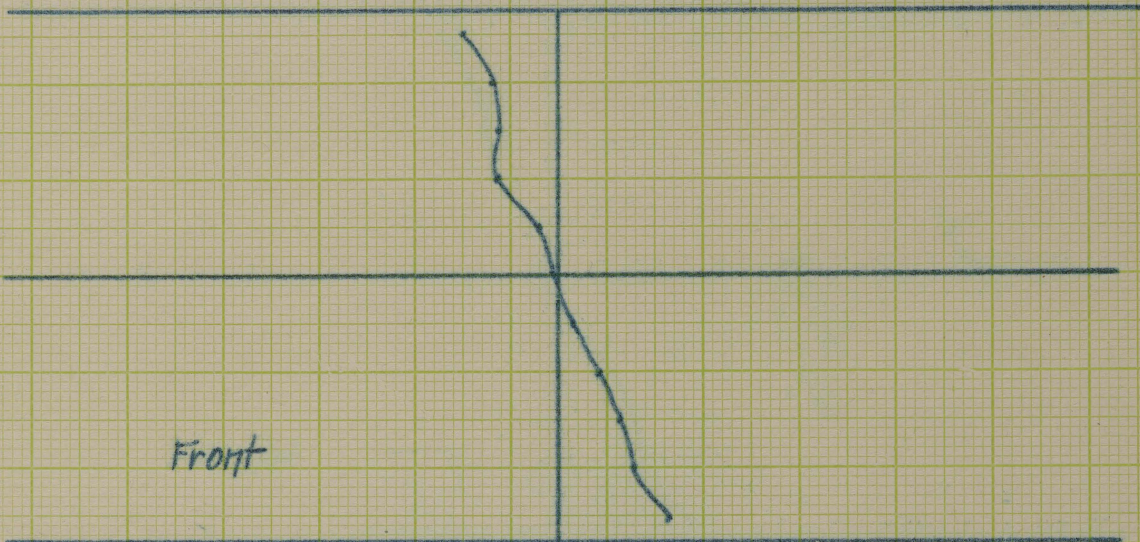


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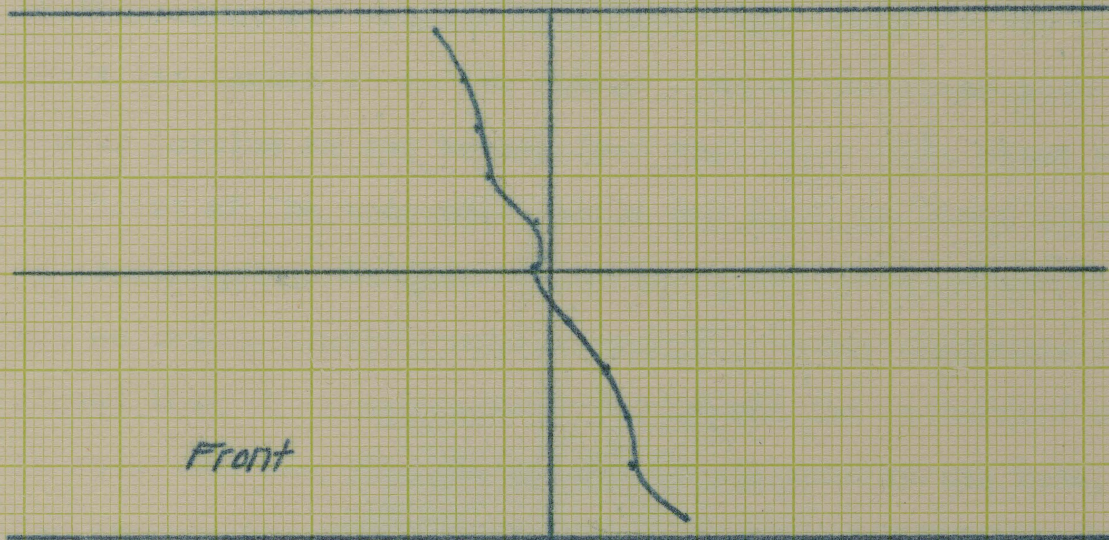
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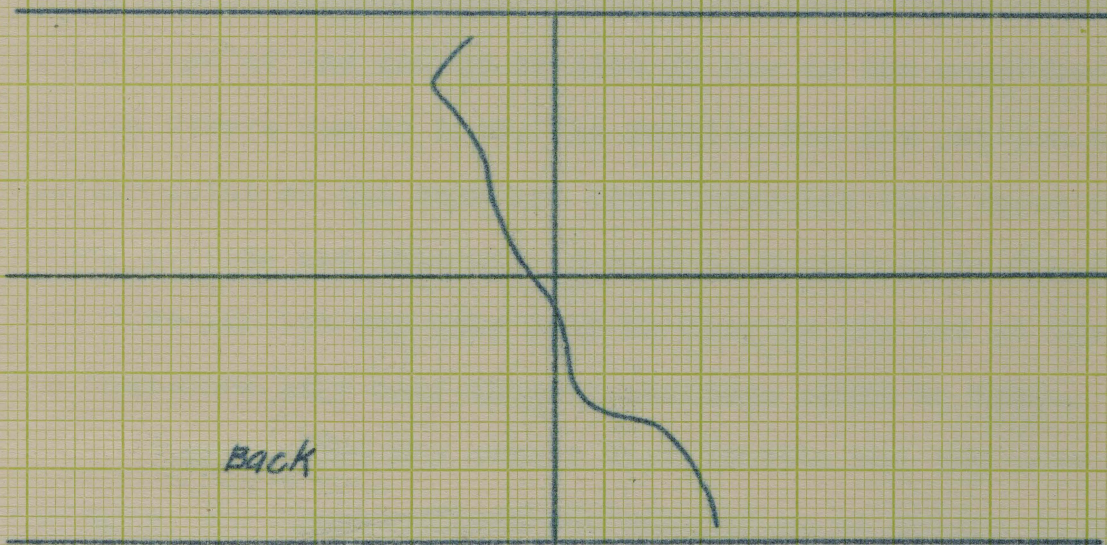
12000# (Quarter Point)



16000# (Quarter Point)



Front



Back

20000# Quarter Point

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20 LINES = 1 INCH

Discussion

From the diagrams it can be seen that the strain did not vary as a straight line. However, some of the irregularities of the curves are easily explained. The "hump" in the curves about two inches above the center line on the front view of the center portion is due to the fact that below this point was the heart of the tree while above was sap. The heart extended to about an equal distance below the center of depth of the beam but no erratic results were observed. It may therefore be concluded that the elongation of the fibers due to tensile stresses is about the same for the heart and sap part of the beam, but for compressive stresses, the contraction of the fibers is much greater for the sap than for the heart of the beam. The break in the twenty-thousand-pound-load curve four inches above the center line of the center section is due to the compression of the top fibers due to load. The results for the portion near the quarter point of the beam are more irregular than those for the center portion and this may in part be explained by the fact that this portion was only half as long as the one at the center and therefore only half as many readings could be taken.

Apparently the strain distribution was the same before and after the elastic limit was reached as no change in the shape of the strain curves could be observed.

Conclusion

From the results of this investigation it may be concluded that the shape of the strain diagram for any beam will depend on the internal structure of the beam and the nearness of concentrated loads to the section under consideration. For a homogeneous beam with no concentrated loads near the section, the strain curve would possibly be a straight line, but for beams not homogeneous, the strain diagrams will not be straight lines and their shape will depend on the internal structure of the beam. However, before any law for the variation of the strain in beams could be established, a large number of beams should be investigated. Even then, for any particular beam the shape of the strain curve would be influenced by the properties of that beam and would be different from that of a beam with different properties.