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14 August 1939

RECOIL FORCES BETWEEN TURRET AND HATCH OPENINGS.

By

H. B. Maris

Report No.H-1551

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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report

on

Recoil Forces Between Turret and Hatch Openings.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

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APPENDICES

AUTHORIZATION

1. This problem was authorized by Bureau of Construction and Repair letter NP14-(6) of 29 March 1939.

PURPOSE

2. This study was made to determine by photoelastic methods the importance of recoil stress concentrations near a hatch opening for different angles of turret fire.

SCOPE OF THE WORK

3. Stresses were measured for four angles of fire, along the center line of the ship, at 32° with the center line, or along the line joining the center of the turret and the center of the hatch, at 60° from the center line and normal to the center line. The problem was considered as static with the outer edges of the deck supported by an immovable barrier.

RESULTS

4. If the total recoil force divided by the diameter of the turret be taken as unity, recoil along the center line gave a maximum stress of 2.1 on the hatch side nearest the center and .64 on the outside, recoil through the center of the hatch gave about equal maximum of 2.8 on either side of the hatch, recoil at 60° with the center line gave maximum stress of 1.6 on opposite corners at the hatch opening, while recoil at 90° gave a maximum stress of only .3 on the hatch sides.

EXPERIMENTAL METHOD

5. The model deck section of Fig. 1 with one turret and three hatch openings was made of celluloid .2 inch thick. Dimensions of the hatch 1.25 by 1.5 inches sufficient for satisfactory measurements was obtained by using a model scale of .5 inch to one foot. This gave a deck section 48 inches wide by 40 inches high. A celluloid sheet of this size was obtained by cementing two standard sized sheets together with a lap weld as shown in Fig. 1. There was no evidence that this weld interfered in any way with the elastic properties of the model.

6. The deck model was mounted in an aluminum frame 4 inches wide by .375 inch thick. An aluminum disk .25 inch thick was cut for a neat fit of the turret opening. The celluloid was clamped to this disk around the turret opening and around the outer edges to the aluminum frame tight enough to prevent distortion, but not tight enough to take any appreciable tension load in the plane of the deck. The celluloid model was placed under compression by loading along the axis, as shown in Fig. 1, A for the center line of the ship, B for the center of the hatch opening, C for 60 and D for normal. When a load sufficient for satisfactory measurements (2500 lbs.) was applied, the deck warped, making measurements impossible.

[redacted]

The aluminum bars E were placed across the deck to hold the loaded "turret" disk in the plane of the deck. As an additional restraint, the most highly stressed part of the deck was placed between two glass plates F, held against the deck by wedges under the two loading rods G. These restraints interfered with the accuracy of the work, but in spite of them it is believed that an accuracy of ±10 per cent of the unit load was maintained.

7. Figures 2, 3, 4 and 5 show on the left in a the isoclinic and stress flow maps, and on the right the P-Q maps for the four different directions of recoil. In each case, the arrow shows the direction and center of the load applied through the central disk. Each of the four directions of recoil were measured for both the right and left side of the deck, and for loading as shown in Fig. 1 and with the load applied at H on the aluminum disk. The four sets of original maps were combined to form Figs. 2 to 5.

8. All four figures show approximately the same (1.7) maximum load between turret and deck. Fig. 3, as would be expected, shows the greatest maximum 2.8 near the hatch. Fig. 2 shows a maximum of only 2.1. Fig. 4 shows the maximum hatch stress to be approximately equal to the contact stress with the turret. Fig. 5 shows, as would be expected, negligible hatch stresses.

INTEGRATIONS

9. Integrations of separate P and Q values for the four different methods of loading were not satisfactory. The only free boundaries of celluloid edges where one of the principle stresses becomes zero were at the hatch openings. There the great thickness of the celluloid, nearly one-sixth of the width of the hatch, introduced edge effects which made integration from those edges unsatisfactory for the first eighth of an inch, equivalent to three inches on the battleships, therefore integrations could not be exact, but a general analysis of the isoclinics of the figures gives a fairly accurate estimate of the transverse stresses.

10. Integration along the line AA^1 of figure 2 would show close to the hatch a very rapid increase in transverse compression, within three or four inches, on the battleship. This rate of increase would drop to a slow increase. At about two feet the rate of change in transverse force would be reversed. There would be a slow decrease in transverse pressure up to about five feet from the hatch; beyond that the change would be negligible. All changes beyond 3 inches from the hatch would amount to less than .1 at the unit load. The stress in the direction of the line AA^1 probably is negative or a compression for all parts of the line.

11. Integration along the lines AA^1 and BB^1 of Plate 3 would show negligible changes in the transverse stress for all parts of both lines except the first three or four inches from the hatch. For both lines the initial change would be the development within the first three or four inches of a transverse compression; beyond this the change would be negligible. Most of the area of Fig. 3, then, like Plate 2, is probably under a small transverse compression.

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12. Integration along AA^1 of Plate 4 would show negligible transverse compression for the entire length of the line. The initial values near the hatch would be low.

13. Integration along AA^1 of Plate 5 gives no appreciable transverse stress for the first foot and a gradually increasing tension beyond that. The final value near A^1 is calculated to be .4 unit load. This is greater transverse load than would have been obtained from any of the other lines on the other plates. This integration gives 1.3 as the value of the direct compression on the celluloid at A.

CONCLUSIONS

14. The static load test of this study shows that when a turret is fired in the arc within 30° of normal to the ship's center line, recoil stresses near the hatch are less than those of direct contact between turret and deck. When the angle of fire is more than 30° from normal, excessive hatch stresses are to be expected. These reach a maximum for fire at 58° from normal when the presence of the hatch reduces the strength of the deck to 60° of the strength with no hatch opening.

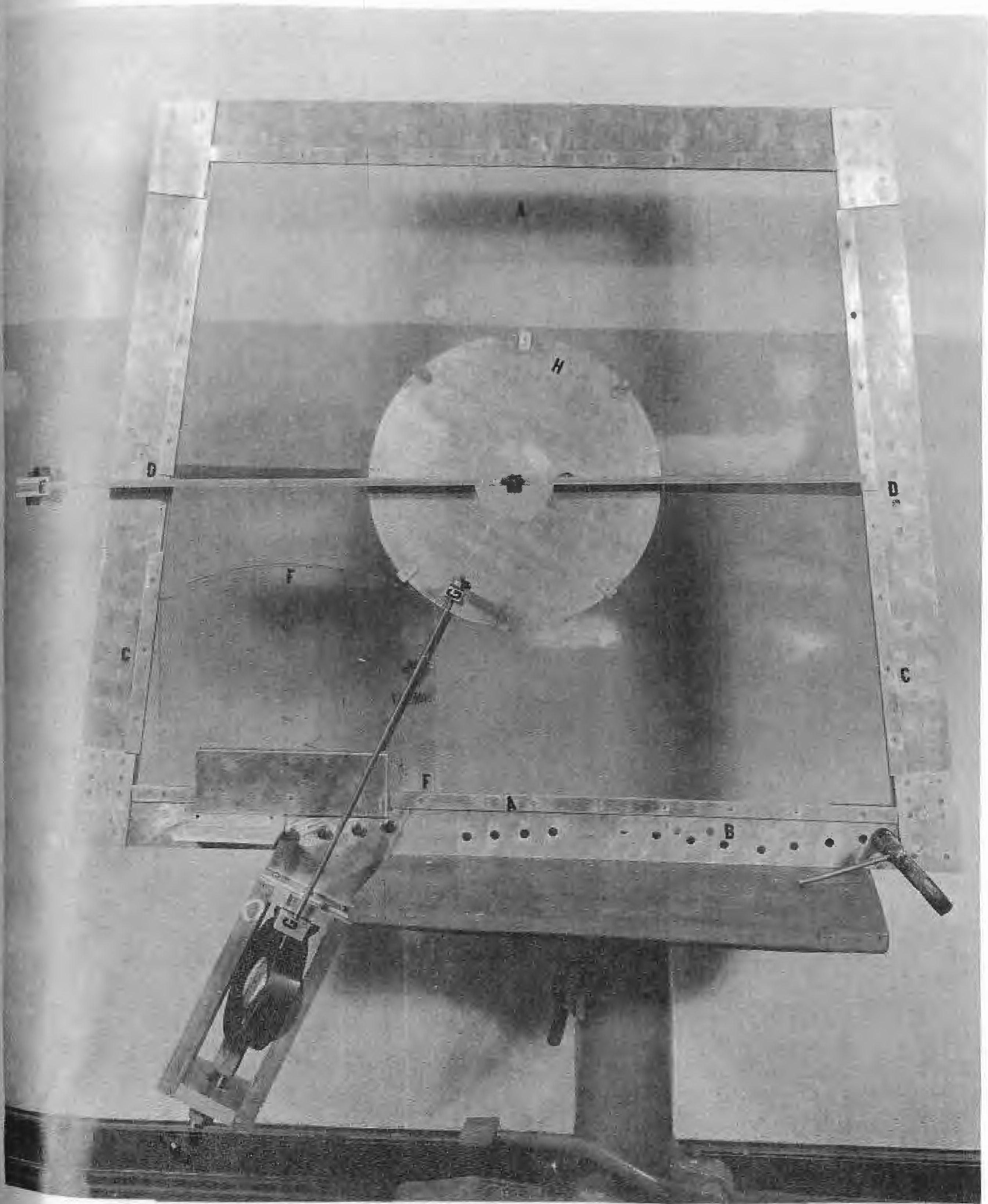

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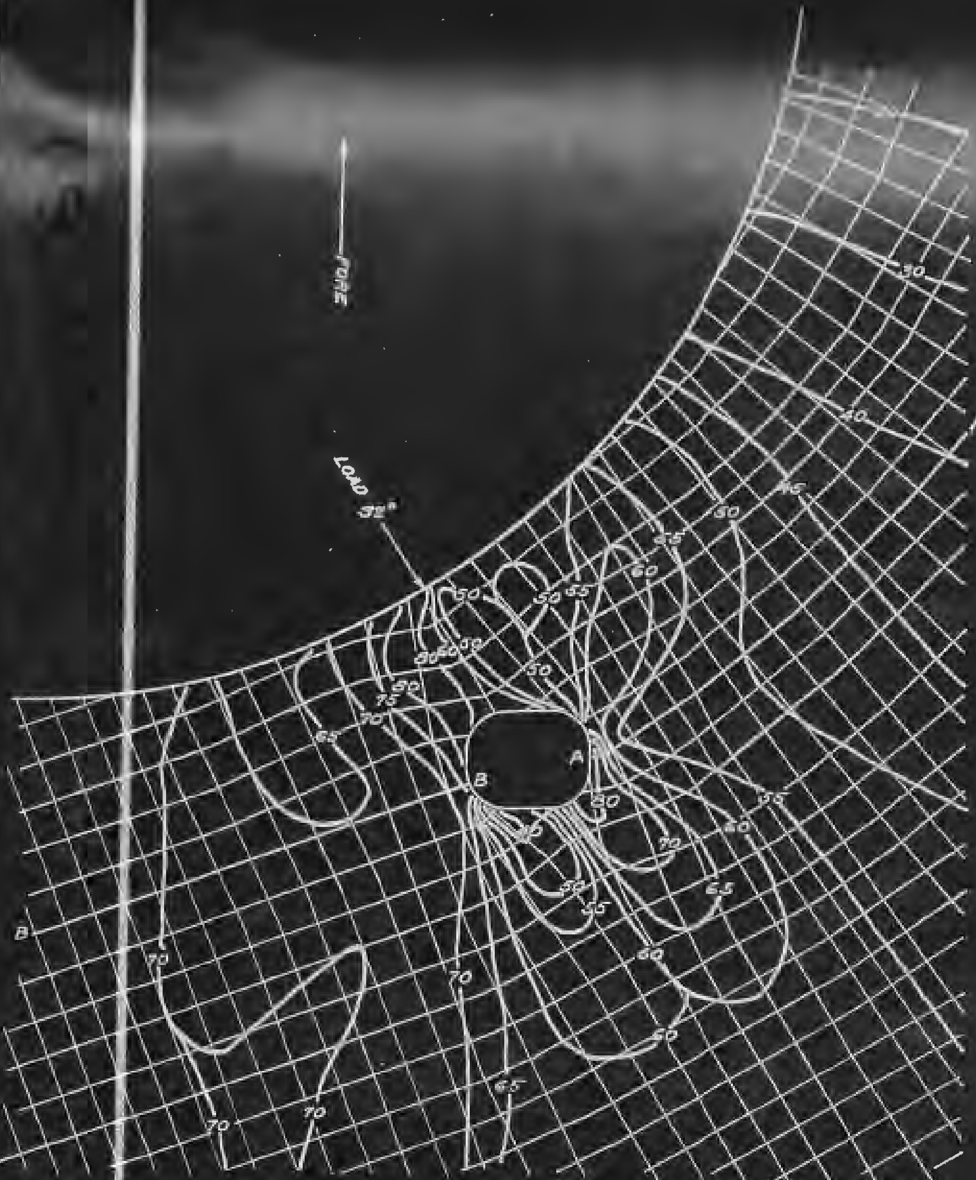
PLATE I

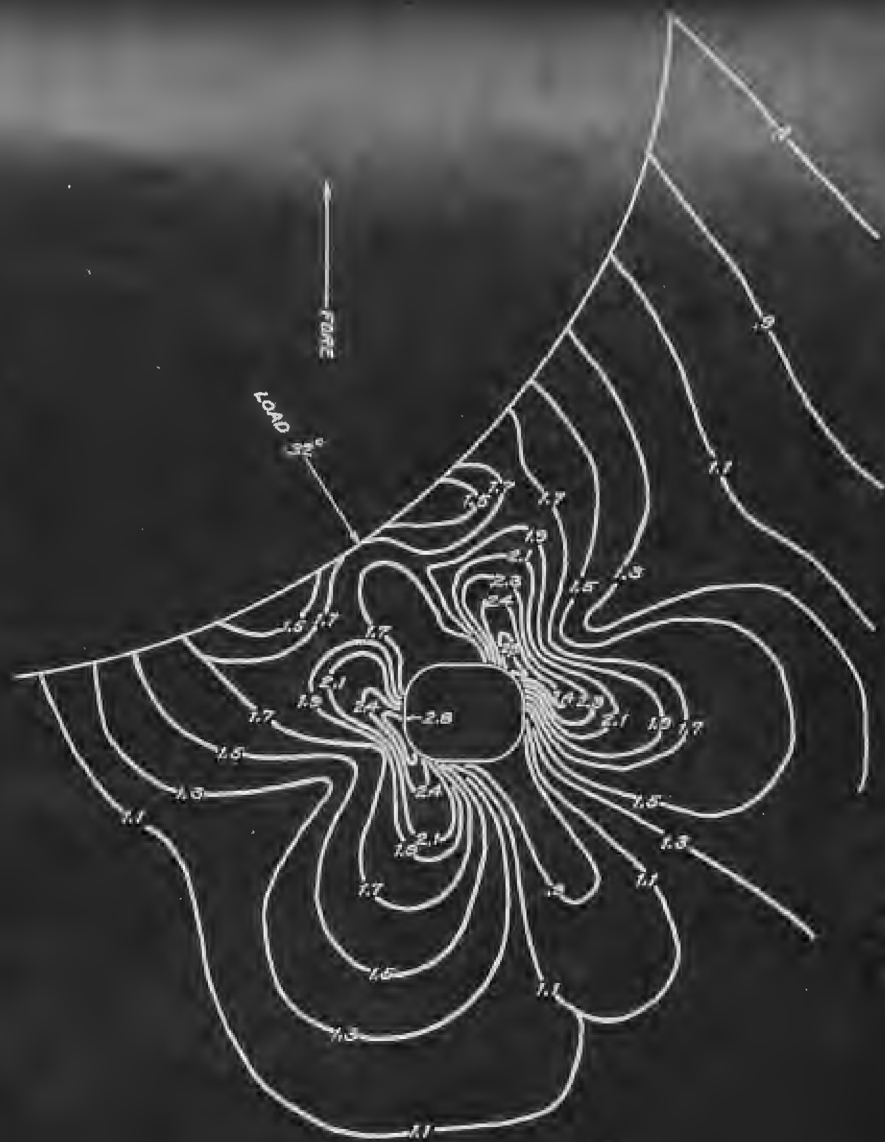
a, ISOCLINICS AND STRESS FLOW MAP

b, P-Q MAP

PLATE 2

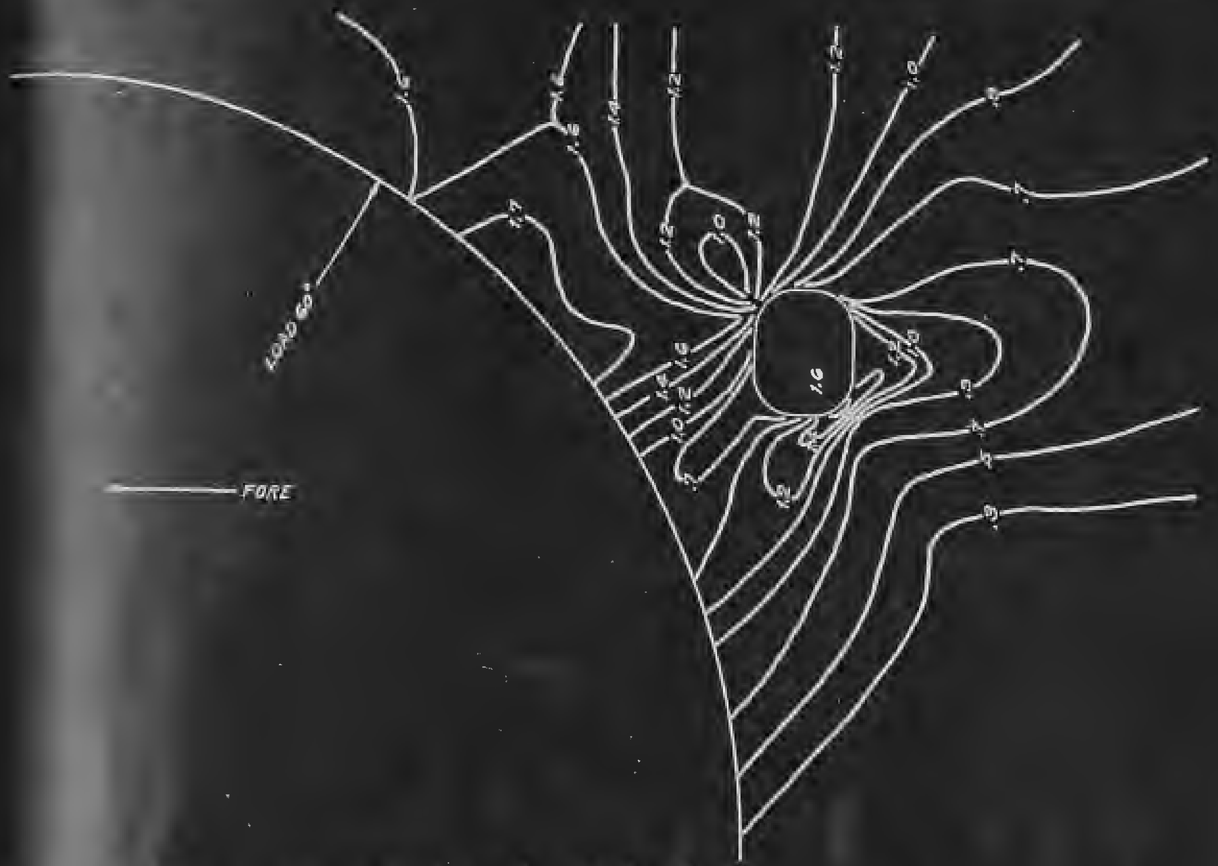


a – ISOCLINICS AND STRESS FLOW MAP.

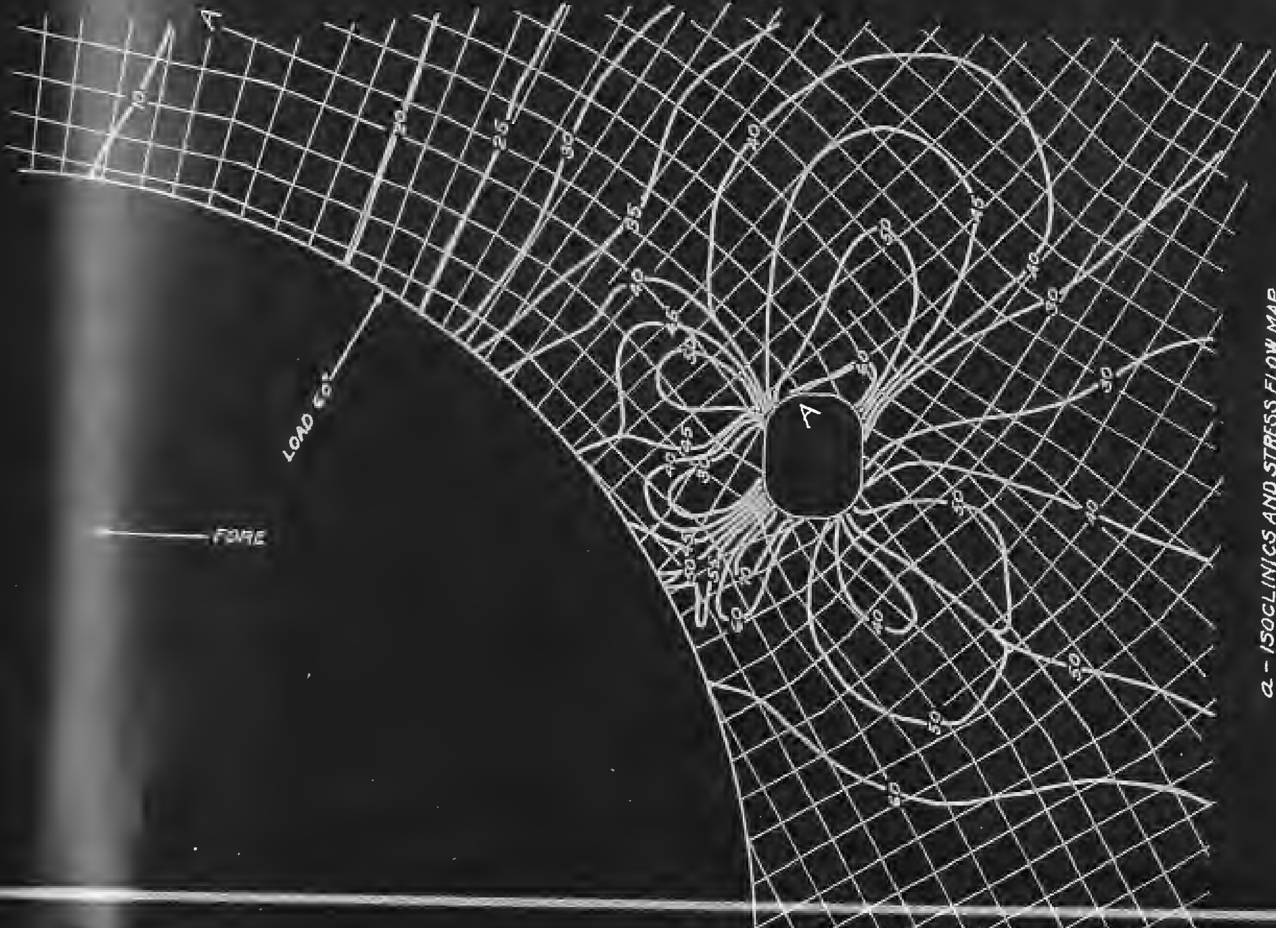


b – P–Q MAP.

PLATE 3

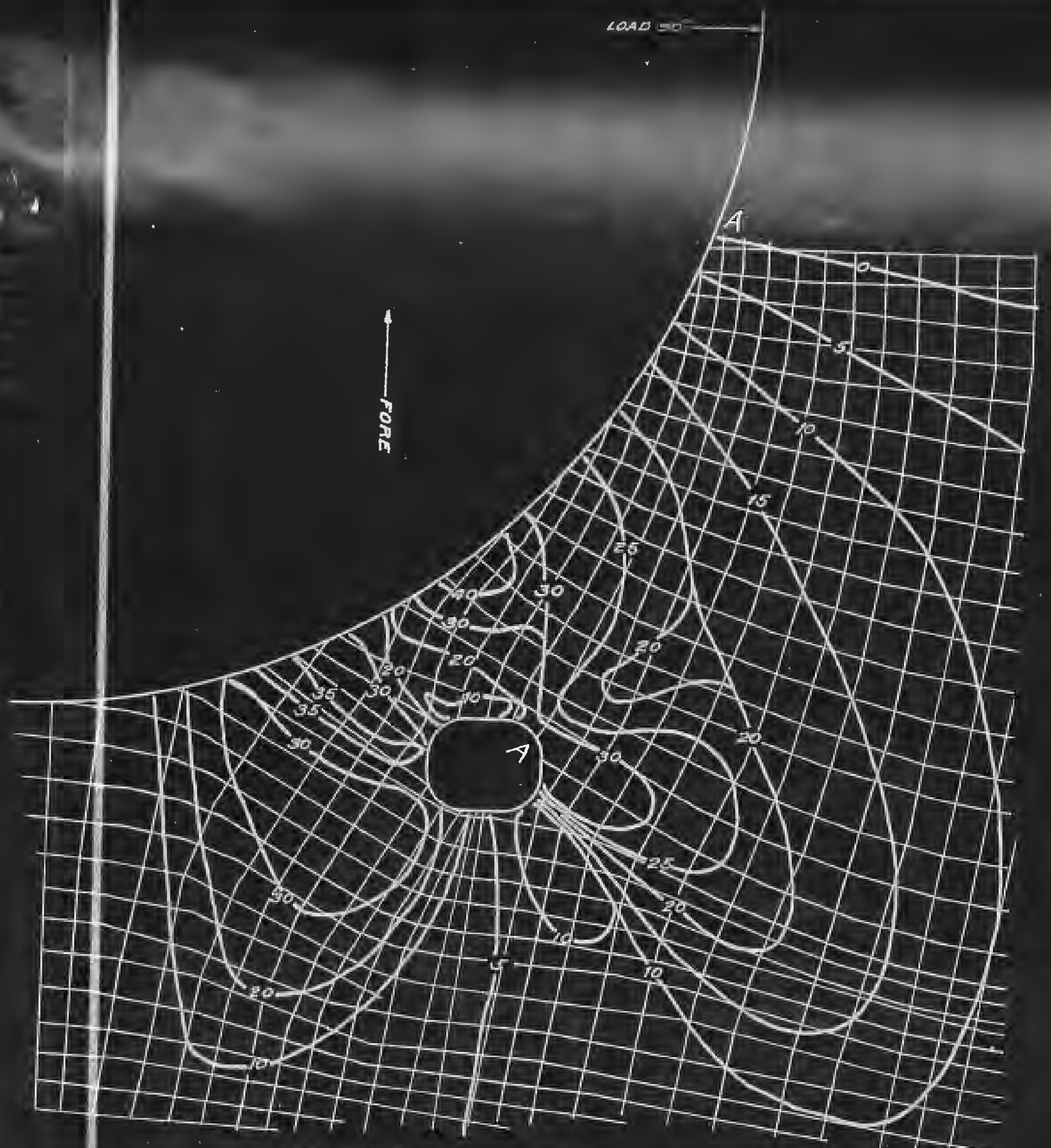


b - P-Q MAP



a - ISOCLINICS AND STRESS FLOW MAP

PLATE 4



a - ISOCLINICS AND STRESS FLOW MAP

b - P-Q MAP.

PLATE 5