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## Eye-shaped End of Bar investigated by Photo-elastic Method.

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### Abstract.

The point of maximum stress at the inner edge of eye-shaped end changes its position according to the manner of loading, and the magnitude of the maximum stress varies considerably with the contour of eye-shaped end.

### Introduction.

A bar or rod having eye-shaped end plays an important part in the construction of machine and structure, but it is proportioned in various ways, the regard not being paid to the distribution of stress induced.

The determination of the best contour and proportion of eye-shaped end will be difficult without the knowledge of stress distribution at the eye-shaped end. So far as the writers are

aware, there is no readier and quicker way than the photo-elastic method for finding how stress is distributed at the end.

Although this method may not give a very accurate result still it will afford sufficient means to grasp general aspect.

### **Test pieces.**

Six test pieces were prepared from cellulose of the thickness of some 3 mm., their detailed dimensions being given in Figs. 1 to 6. The diameter of hole and the width of diametral section perpendicular to the direction of loadnig are kept constant for all test pieces and equal to 11 mm. and 24 mm. respectively.

The size of hole was made purposely larger than the usual proportion in order to obtain a more distinct colour representation of stress due to greater stress brought about by lessening the annular area.

### **Method of testing.**

The apparatus used for optical stress determination is shown in Fig. 7. This apparatus acts on the same principle as one<sup>(1)</sup> used by Prof. Coker in the University College, London, but with some modifications in its component parts. The test was done both by plane polarized and by circularly polarized light, the former being used for determining the "isoclinic lines",<sup>(2)</sup> and the latter for finding the curve of the difference of principal stresses or so called "p-q curve."<sup>(3)</sup>

### **Result of tests.**

All test pieces were tested at first under a tensile load, the diameter of pin put into the eye being a little less than the diameter of the eye. The isoclinic lines and the lines of principal

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(1) Kimball—Stress determination by means of the Coker Photo-elastic Method, G. E. Reivew, Jan. 1921.

(2), (3) Coker—Photo Elasticity for Engineers, Part 1, G. E. Review, Nov. 1920.

stresses obtained in this case are shown in Figs. 8 to 13.

The numbers near the isoclinic lines indicate the angle of deviation of one of principal stresses from the vertical line.

It will be observed that the lines of principal stresses in the eye end are generally curved but there is one which may be taken as straight or very nearly so.

For the sake of simplicity let it be called the "principal line." The stress at the point of intersection of this "principal line" with the inner edge of eye was found to be maximum by means of the "comparison test piece". Again for simplicity let this intersection be called the "principal point."

The position of "principal point" varies according to the shape of the contour of eye-shaped end. The plate with parallel sides shown in Fig. 8 has principal point at the intersection of the hole with a diameter drawn perpendicular to the direction of loading. The case of ring shown in Fig. 13 is similar to the case of Fig. 8. However, in the case of variously shaped eye ends given in Figs. 9 to 12, the position of principal point is displaced towards the non-stem side of the eye bar, the amount of displacement varying according to the shape of contour.

But when the diameter of pin just fits to the diameter of hole the position of principal point moves towards the stem side of the eye bar as shown in Fig. 14,<sup>(1)</sup> which indicates that the principal point changes its position if the manner of loading is altered. Figs. 15 to 20 show p-q curves along the "principal lines" for different cases, while Fig. 21 shows these p-q curves superposed in order that easy comparison may be made, the numbers on the curves being the test piece numbers. As one of principal stresses at the periphery of hole may be looked as zero, the p-q curve will give

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(1) cf. Photoelastische Untersuchungen von Augenbolzenbeanspruchungen, Der Motor Wagen, 31 Oktober, 1925.

directly the principal stress at "principal point" which will be always situated on the periphery of hole. Thus the values of p-q curve at the right end (Fig. 21) will give the maximum stress at the "principal points".

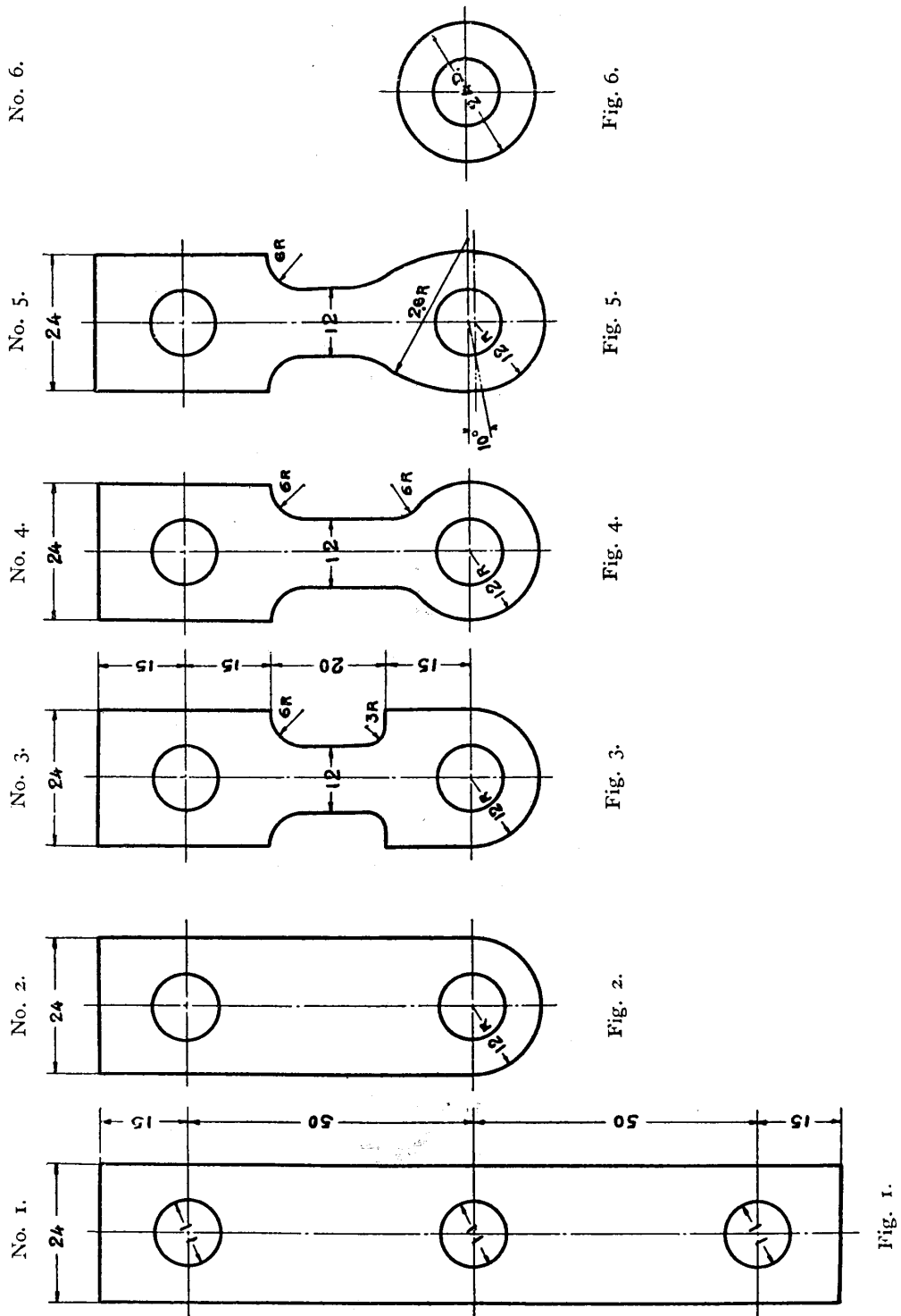
Whatever shape may be given to the contour of eye ended bar, the maximum stress at "principal point" will more than likely not become less than the value for the case of plate with central hole or test piece No. 1. Referring to the curves in Fig. 21, the maximum stress in test piece No. 2 is very nearly equal to that in test piece No. 1, but unfortunately it is not convenient to adopt it for the eye-shaped end of bar. The shape shown in Fig. 3 or Fig. 4 is undoubtedly better than in Fig. 1, but the maximum stress induced is far greater.

There will be a shape or form which is not so inconvenient to adopt as eye bar end without showing an excessive stress. As the result of an investigation, the end shown in Fig. 5 is recommended as one of the good shapes. The main points of improvement are rounding off the shoulder at the end (See Fig. 3) and displacing the centre of circular arc which forms part of the contour, the details of modification being given in Fig. 5. The maximum stress in this case is, as shown in Fig. 21, nearly equal to that for test piece No. 1, and further the stress distribution is equally good to contend with that in the test piece No. 1.

When it is possible to vary the thickness along the principal line as in the case of eye bar end into which wire rope is attached, the thickness is advantageously made thicker at the periphery of hole just as in a crane hook.

(March, 1926.)

Test Pieces.



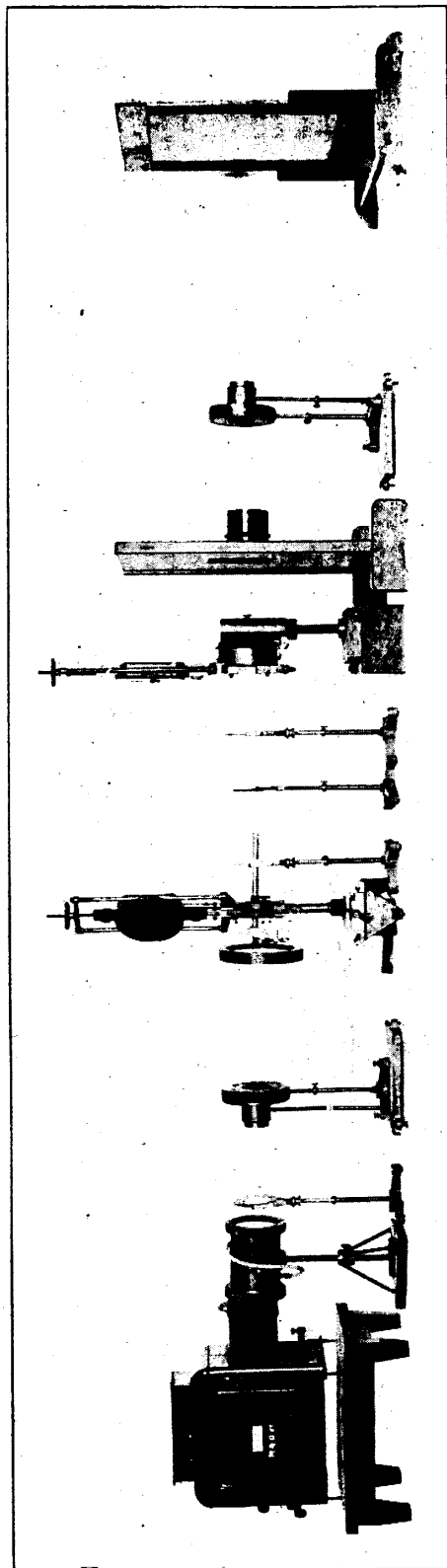


Fig. 7.

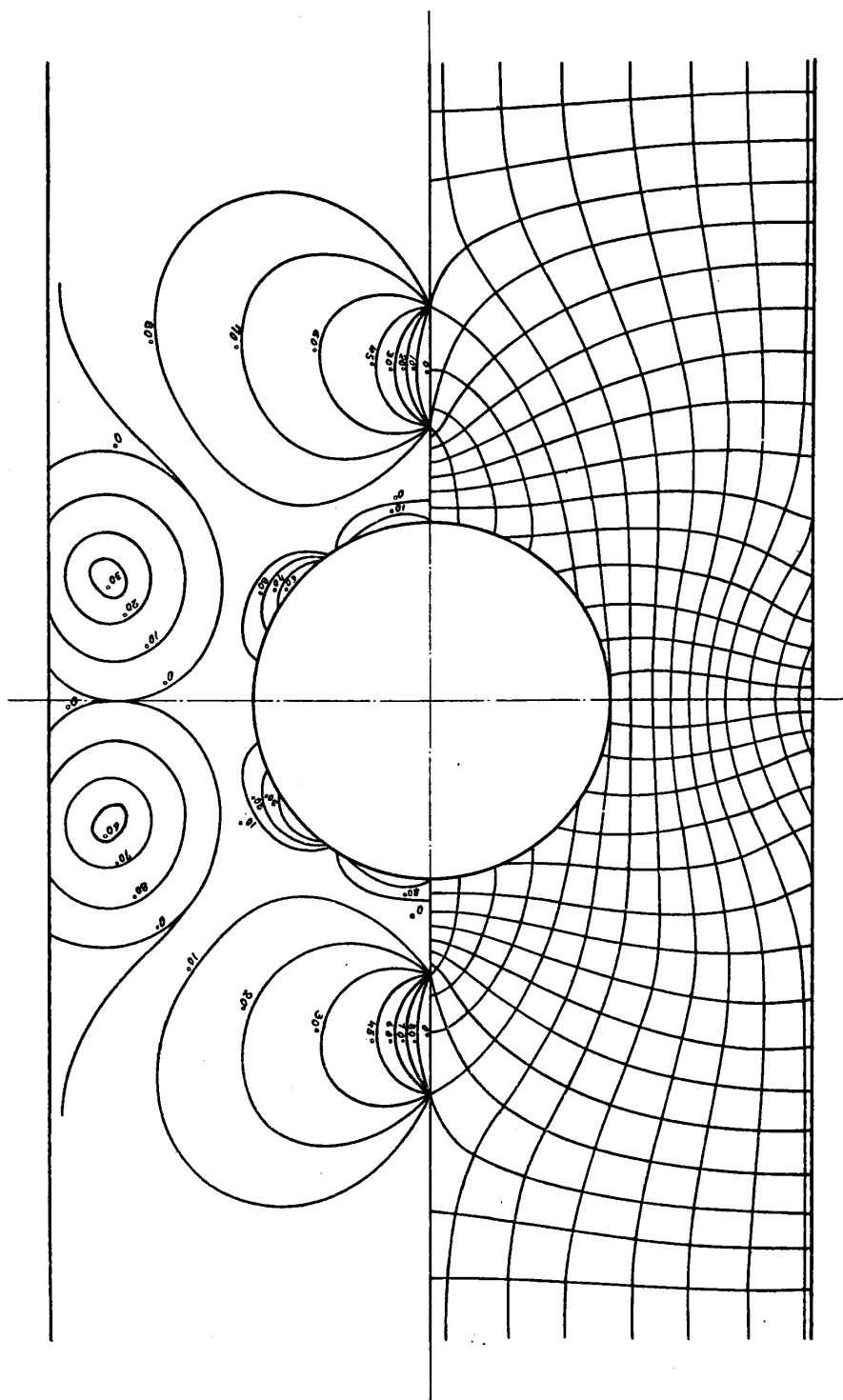


Fig. 8.

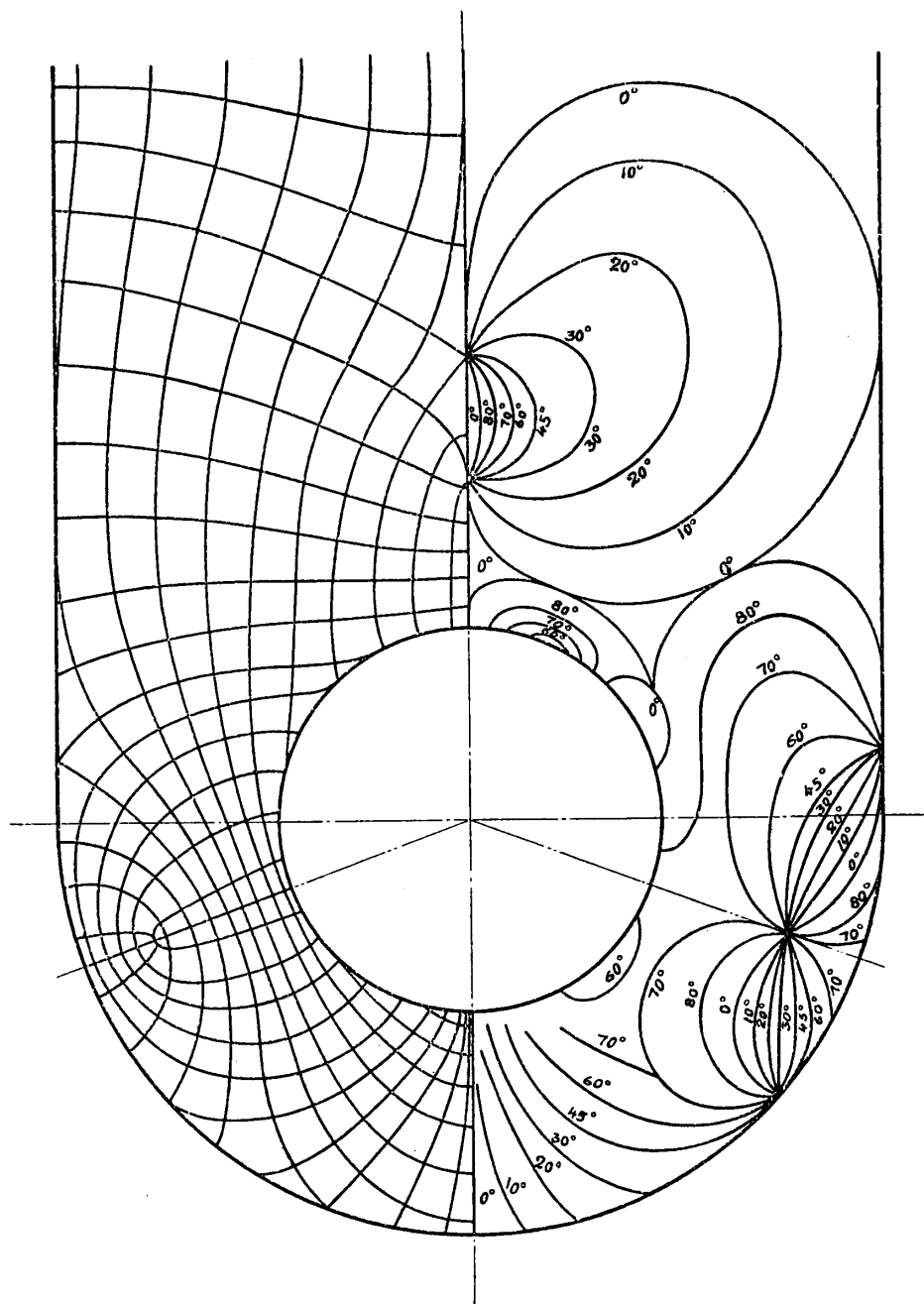


Fig. 9.



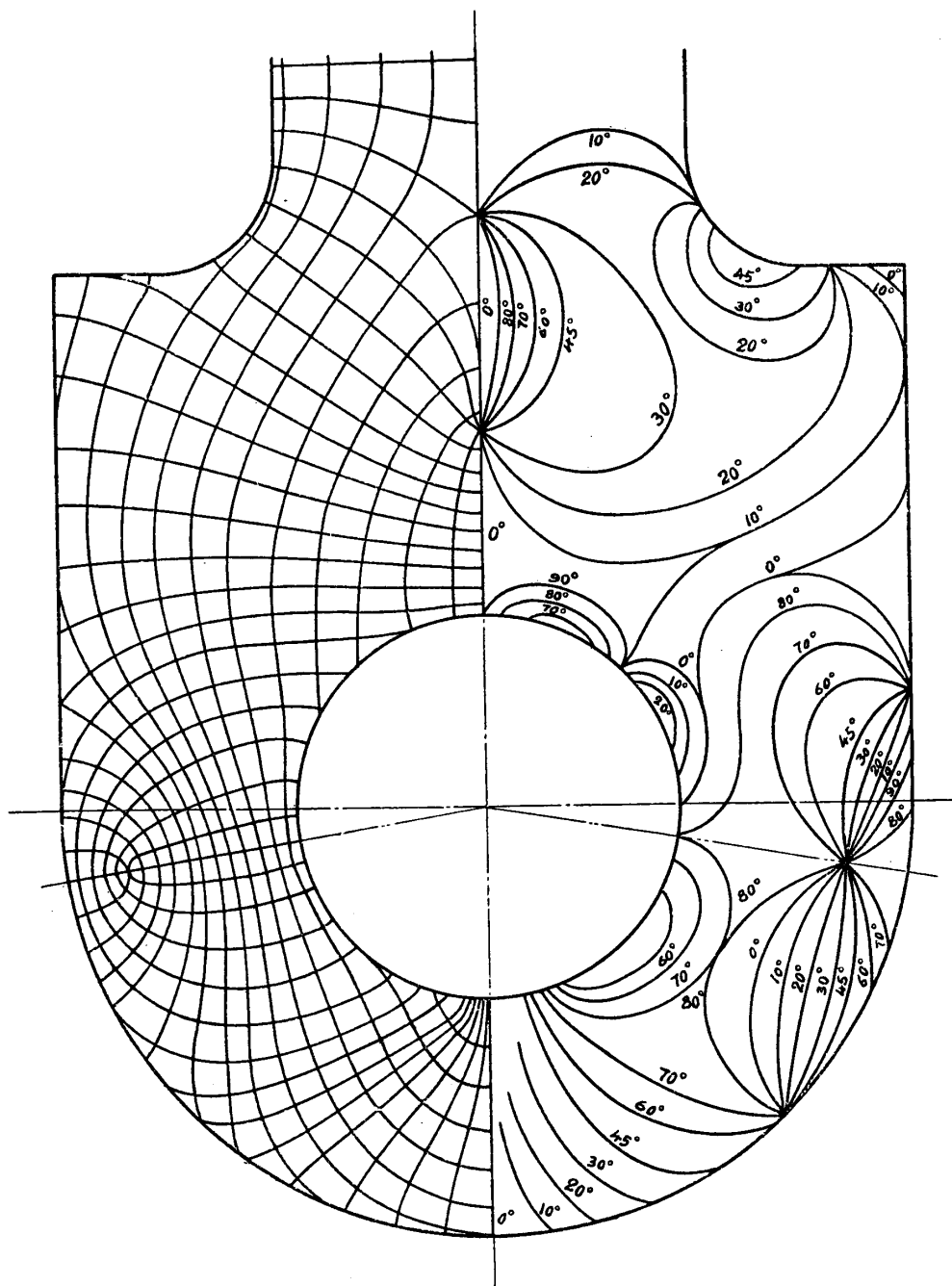


Fig. 10.

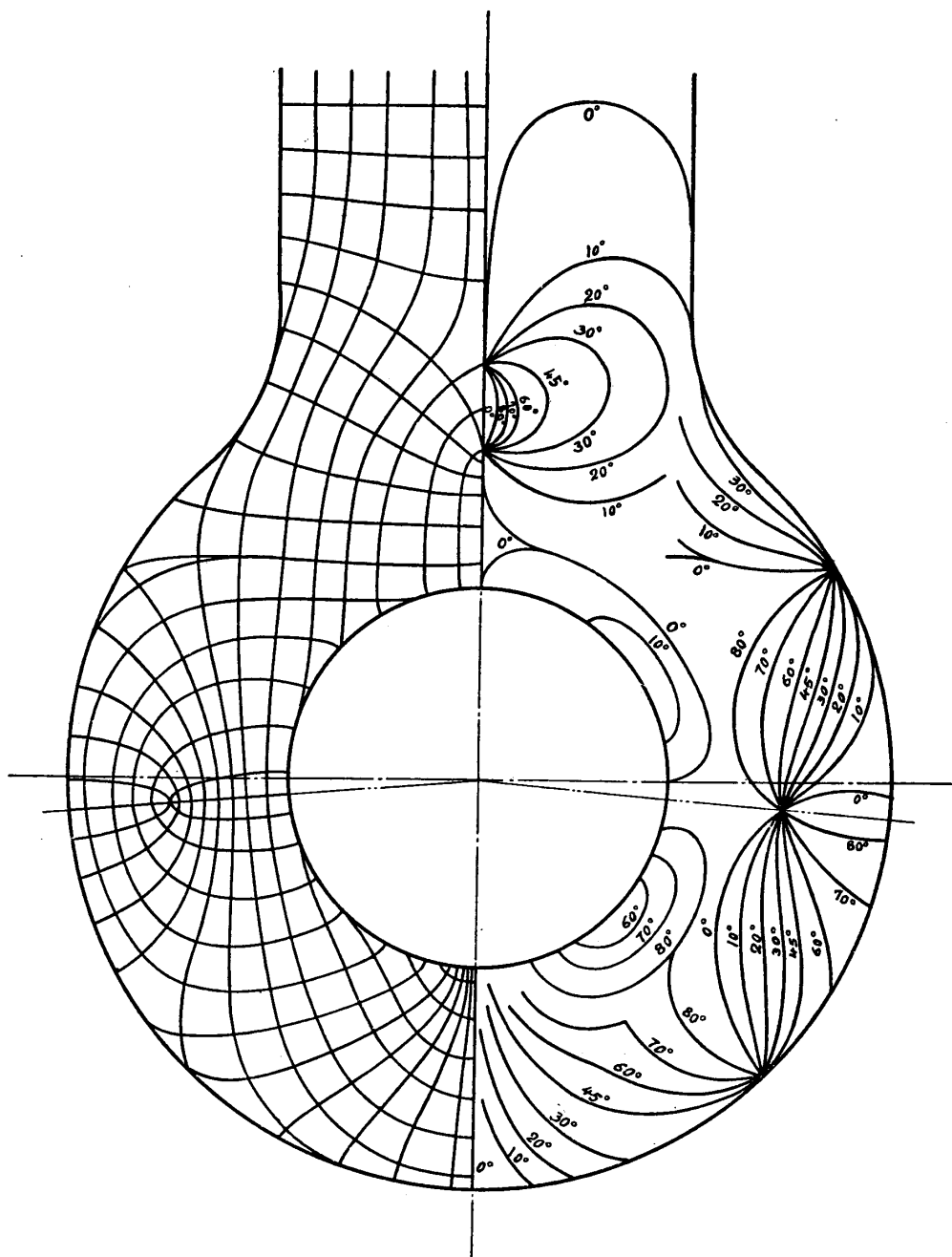


Fig. 11.

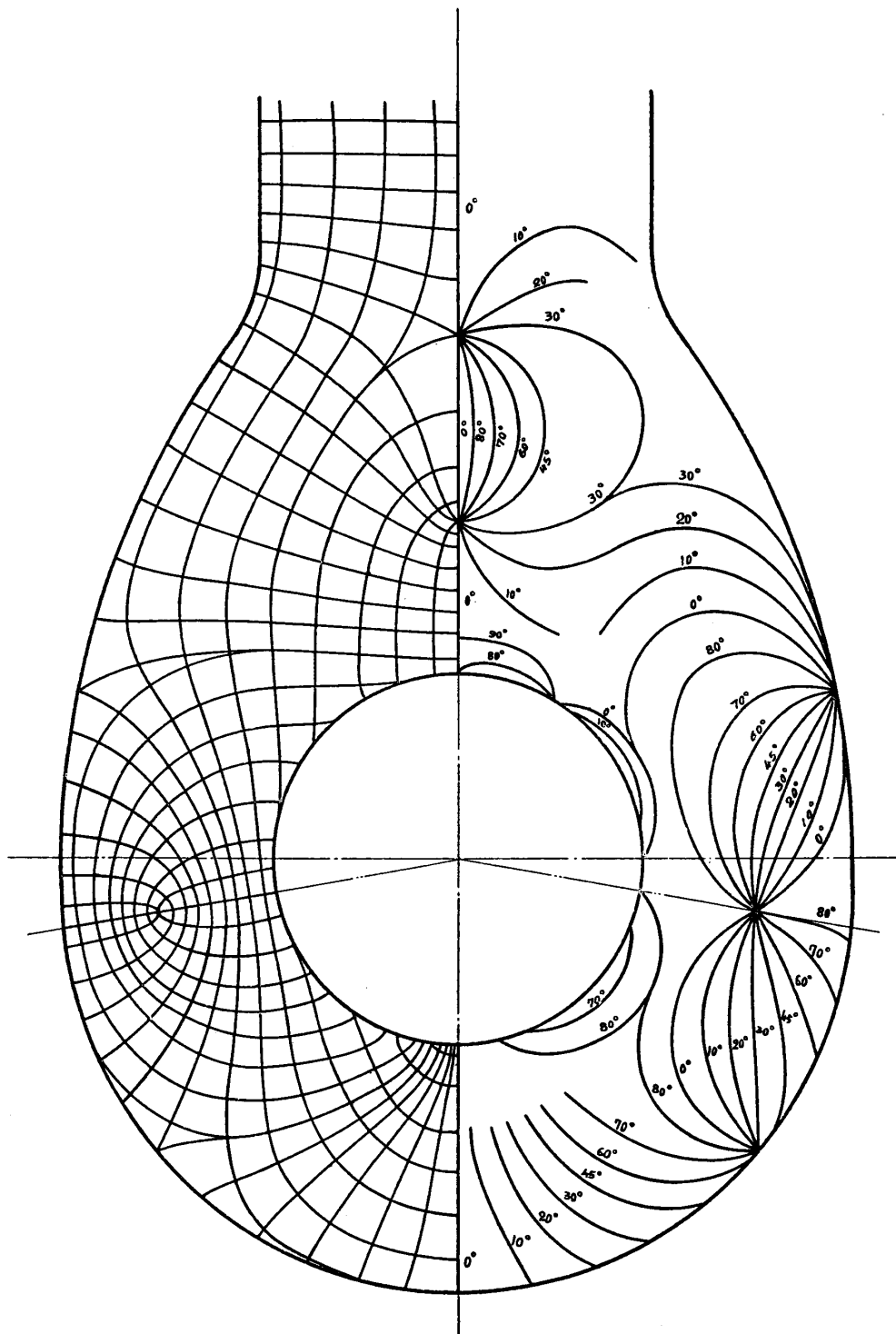


Fig. 12.

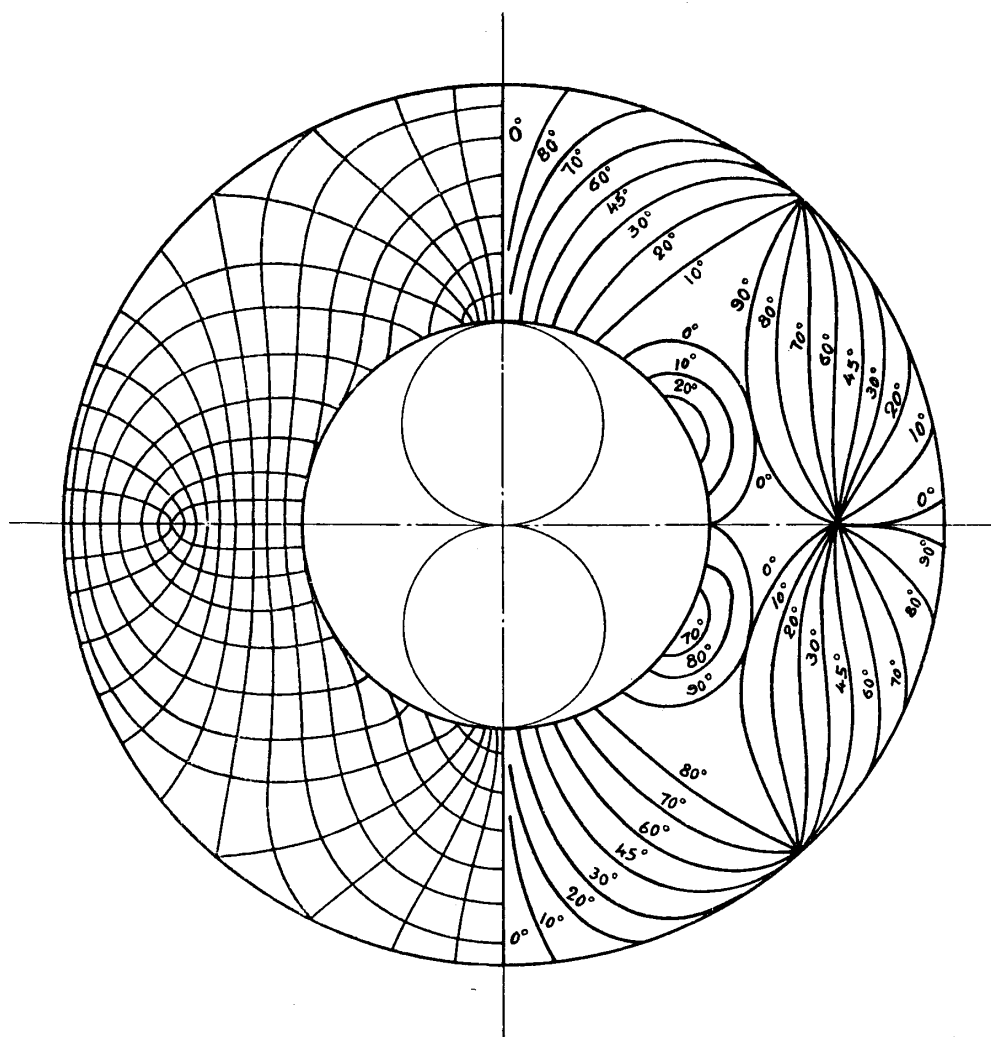


Fig. 13.

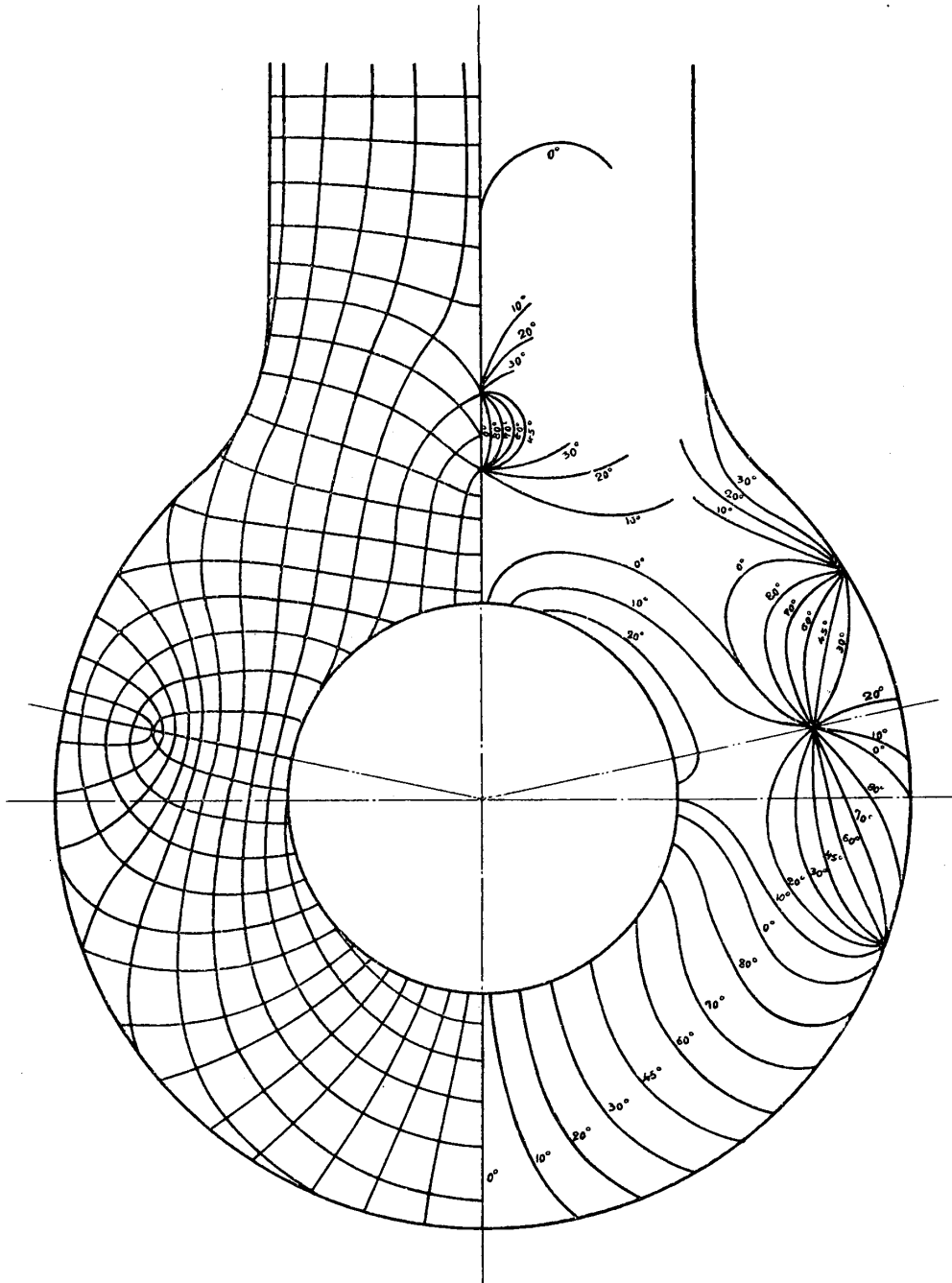


Fig. 14.

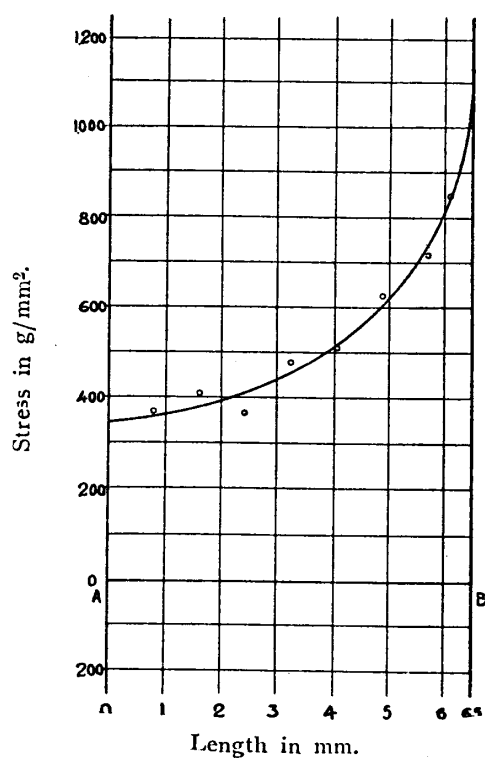
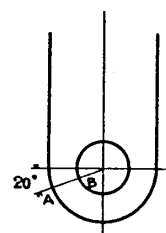
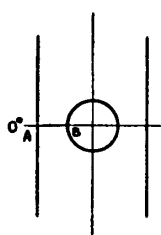


Fig. 15.

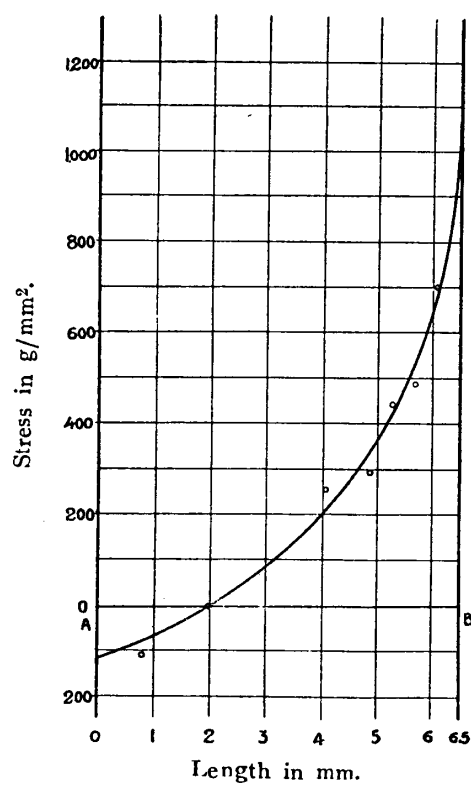


Fig. 16.

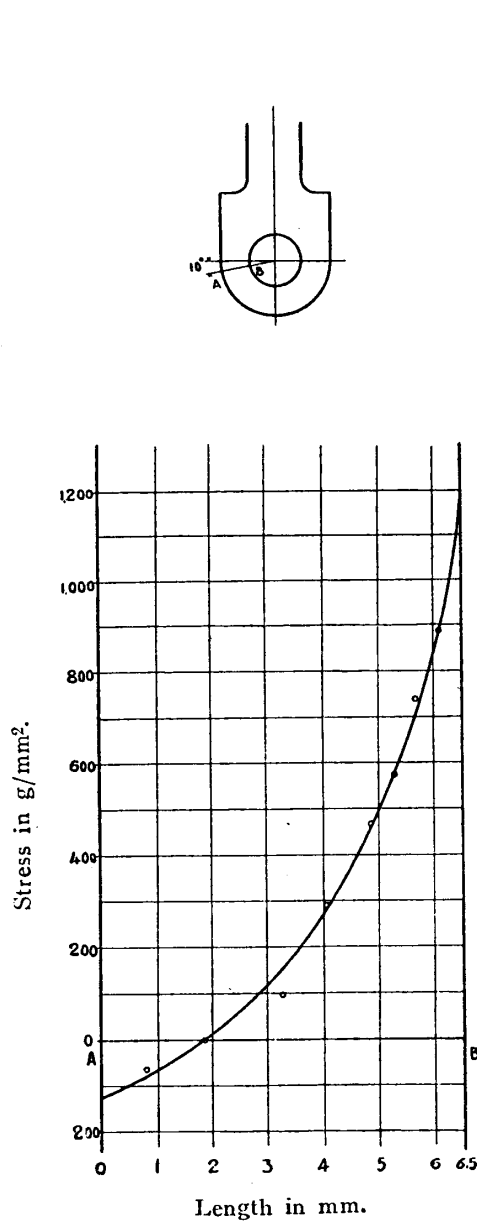


Fig. 17.

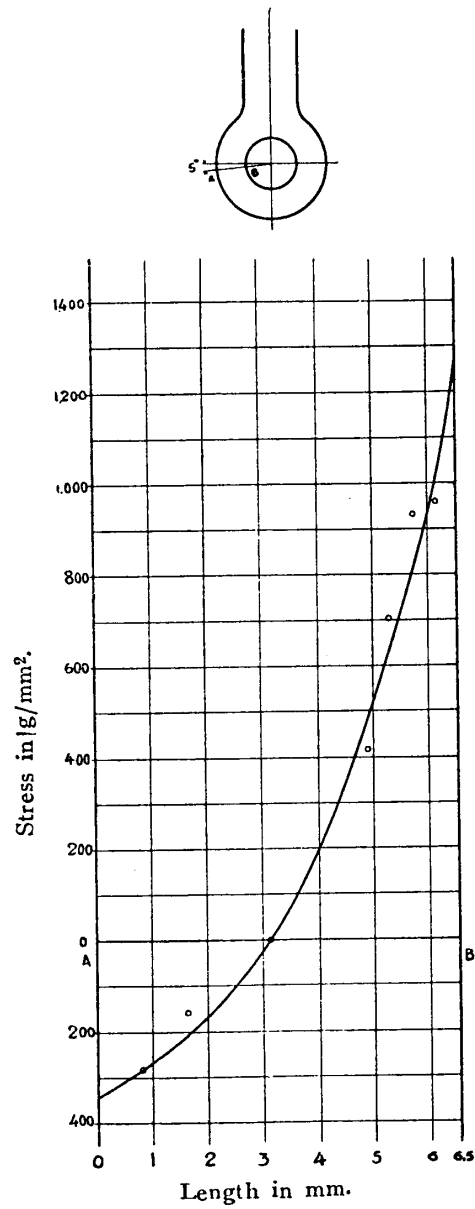


Fig. 18.

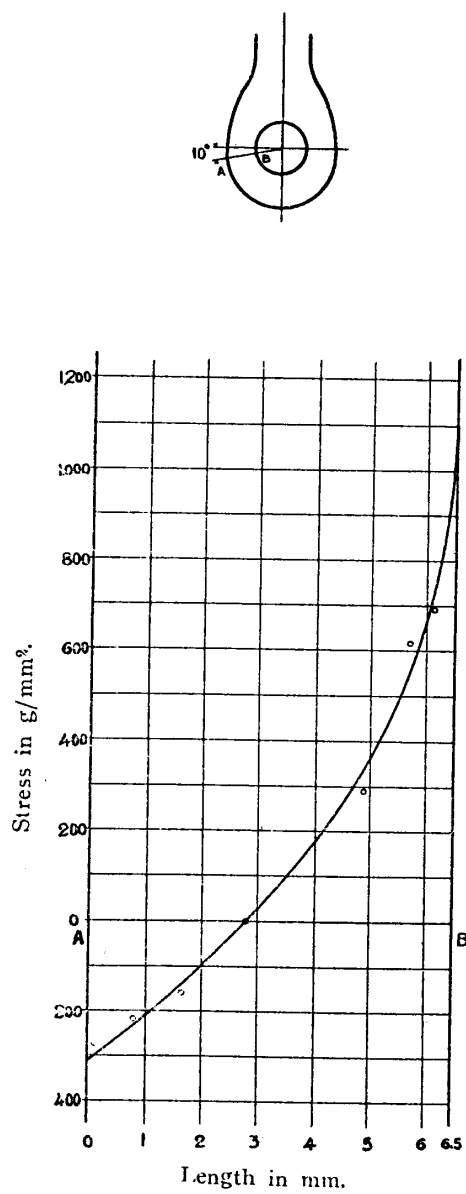


Fig. 19.

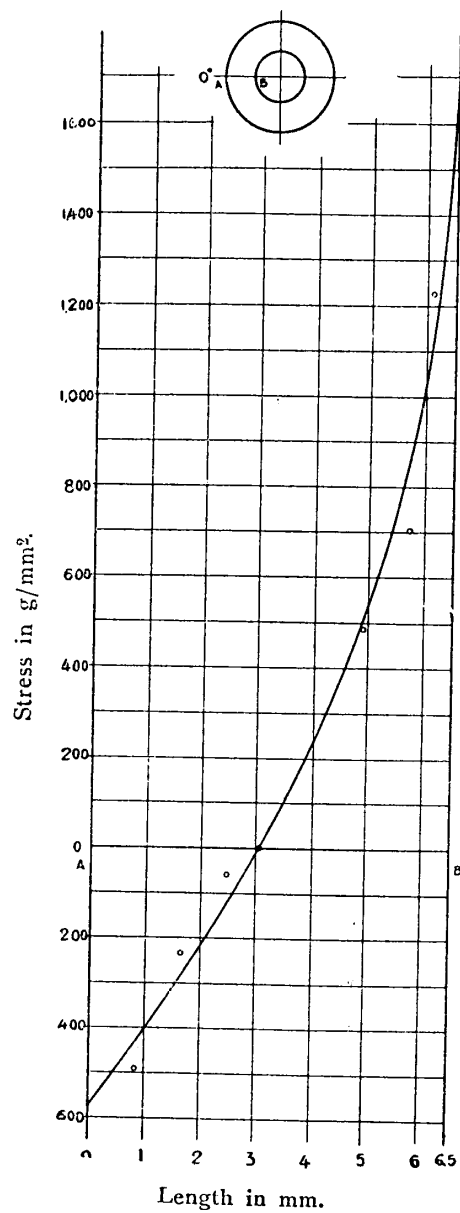


Fig. 20.



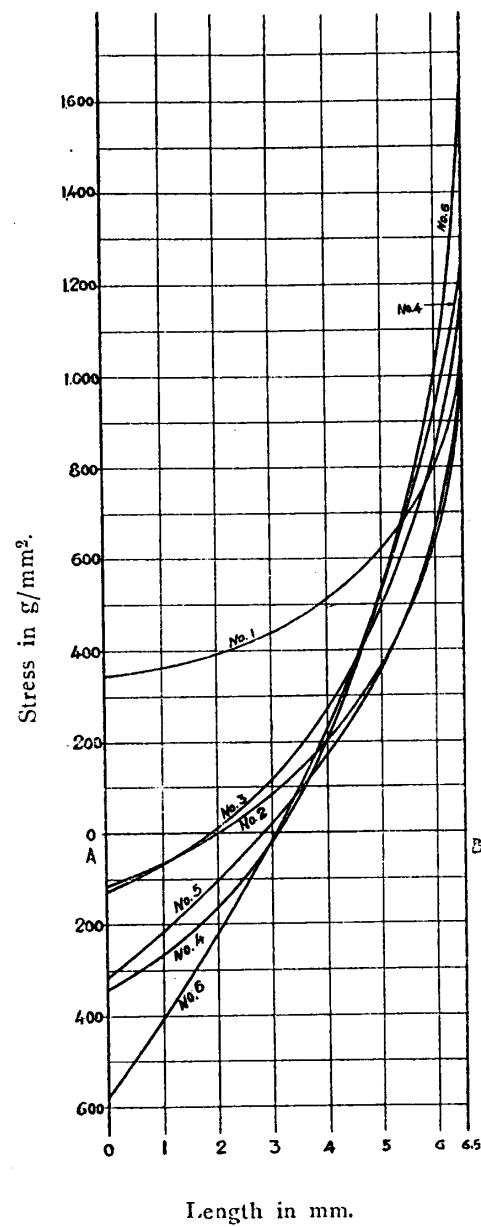


Fig. 21.