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First progress report on seat angle research, 1934

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First Progress Report

on

Seat Angle Research

by

Norman G. Schreiner

SEAT ANGLE RESEARCH

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FIRST PROGRESS REPORT

ON

SEAT ANGLE RESEARCH

by

Norman G. Schreiner*

January 2, 1934

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A. INTRODUCTION

1. Purpose of Investigation - A proposed program for seat angle research has been submitted to the Structural Steel Welding Committee of the American Welding Society under date of December 11, 1933. This report will concern itself with the fundamental aspects of the problem and the progress made to date.

2. This investigation is being carried on as one of the projects of the Structural Steel Welding Committee of the American Welding Society using the facilities of the Fritz Engineering Laboratory at Lehigh University. The steel is being furnished by the Bethlehem Steel Company, and to date all fabrication has been done in the laboratory shop. The author is indebted to Mr. Charles H. Mercer, Consulting Engineer, McClintic-Marshall Corporation, and the staff of the Fritz Engineering Laboratory for their many critical and constructive suggestions.

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B. GENERAL STATEMENT OF PROBLEM

1. It was deemed advisable to confine the study for
the present to the problem of the simple beam seat connection,
wherein the beam is welded, riveted, or bolted to the support-
ing angle, which in turn is welded or riveted to the support-
ing member, which may be either a column or girder web. Each
variable will be studied on laboratory specimens, and supple-
mentary tests will be made on full size connections fabricated
under field conditions.

2. A study of the literature reveals little or no in-
formation regarding the design of beam seats. Such design as
is being done is by empirical formulae and rule of thumb
methods, seemingly supported only by practical experience.
Textbooks and design manuals hurriedly pass over the subject.
The Journal of the American Welding Society and the Transact-
ions of the American Society of Civil Engineers, references to
which may be found in the bibliography appended, have furnish-
ed helpful information which it is hoped can be correlated
with the results of this investigation.

3. In the preliminary investigation the proposed pro-
gram laid out by Mr. Priest will be followed, supplemented by
photoelastic studies of bakelite models of the specimens test-
ed. The progress to date has been slow due to the time required
to make up the loading and gaging rigs and the intention to ob-
tain as much data as possible, in order to eliminate that which

is irrelevant. One 4 by 4 by $\frac{1}{2}$-inch angle specimen welded at
the ends to a 7/8-inch plate has been subjected to three de-
formation tests and finally tested to destruction. A model
of the same connection has been shaped out of bakelite and
studied under polarized light in the photoelastic apparatus.

C. TEST PROGRAM

1. <u>Description of Test Specimen</u> - Two pieces 8 inches
long were cut from a length of 4 by 4 by 1/2-inch angle and
centrally placed on either side of an 8 by 7/8-inch plate, 12
inches long, which was machined parallel on the long edges.
The outstanding legs of the angles were level with the top
edge of the plate, in which position they were clamped for
welding.

The welding was done at the Fritz Engineering Labora-
tory by a qualified welder. A 3/8-inch fillet weld, 4 inches
long was run along each end of the vertical leg of the angles,
attaching them to the plate. At the same time a standard end
fillet qualification specimen was made according to specifica-
tions in the Report of Structural Steel Welding Committee, p.
109, Fig. 53. This specimen showed an ultimate strength of
86,400 lb. or 14,433 lb. per lineal inch of weld. This is 20
per cent in exeess of that required by the specification. The
welds gaged 7/16 by 3/8 inches, giving a throat area of 0.284-
inch and a unit stress at failure of 50,700 lb. per sq.in. or
12.7 per cent in excess of that required by specification.

2. <u>Description of Loading Apparatus</u> - In order to obtain flexibility and ease in applying the loads at varying lever arms, the loading rig shown in Fig. 1a, 1b, and 1c, was designed. This consists of two horizontal steel plates each 10 by 1-5/8 inches by 11 inches long. The top plate, immediately under the spherical bearing block, is channeled to clear the adjusting bolt heads, the lower plate is slotted to allow for adjustment of the vertical legs. The vertical legs are also 1-5/8 inch plates, 6 inches long and 8 inches wide. A bolt passes through the slot in the bottom plate into a tapped hole in the vertical leg, allowing for easy adjustment of the vertical legs to any desired lever arm. The load is transmitted to the specimen through 1-inch diameter rollers, held loosely in place by light steel fingers. Sufficient clearance is provided for Huggenberger extensometers to be bridged from the ends of the angle to the plate.

3. <u>Description of Gaging Devices</u> - It was desired to obtain the elastic curve of the outstanding leg and the deflection at the heel of the angle. The former was obtained by means of four sets of Ames Dials set on 6-inch gage lines as shown in Fig. 1a, 1b, and 1c. The plungers of the dials were extended as necessary by means of hardened steel pins. The inner two dials in each row read to

0.0001 inches, the others to 0.001 inches. Because of clearance limitations, it was possible to place only three dials under one of the angles.

The deflection at the heel of the angles was measured by Huggenberger extensometers, using a 1/2-inch gage length, one on each end of each angle as shown in Fig. 1b, and 1c.

The location of the gag**es**/identifying nomenclature
and
is shown on Fig. 2.

4. <u>Description of the Tests</u> - Three tests were made with this specimen before it was tested to destruction. The load was placed at 1.2 inch, 2 inches, and 3 inches respectively from the heel of the angles. The 300,000-lb. Olsen testing machine using a head speed of 0.05-inches per minute applied the loads in increments of 4000 lb. for 1.2 lever arm and 2000 lb. for 2 and 3-inch arms. Readings were taken on all Ames dials and each Huggenberger for each load increment. Before the final test to destruction, for which the lever arm was 1.2 inches, the welds and the fillet of the angle were whitewashed in order to better observe strain lines.

Before testing, the welds were gaged. They were found to average 7/16-inch in the longitudinal direction of the plate by 3/8-inch perpendicular to the plate. This gave a throat dimension of 0.284-inch as against 0.265 for a nominal 3/8-inch fillet.
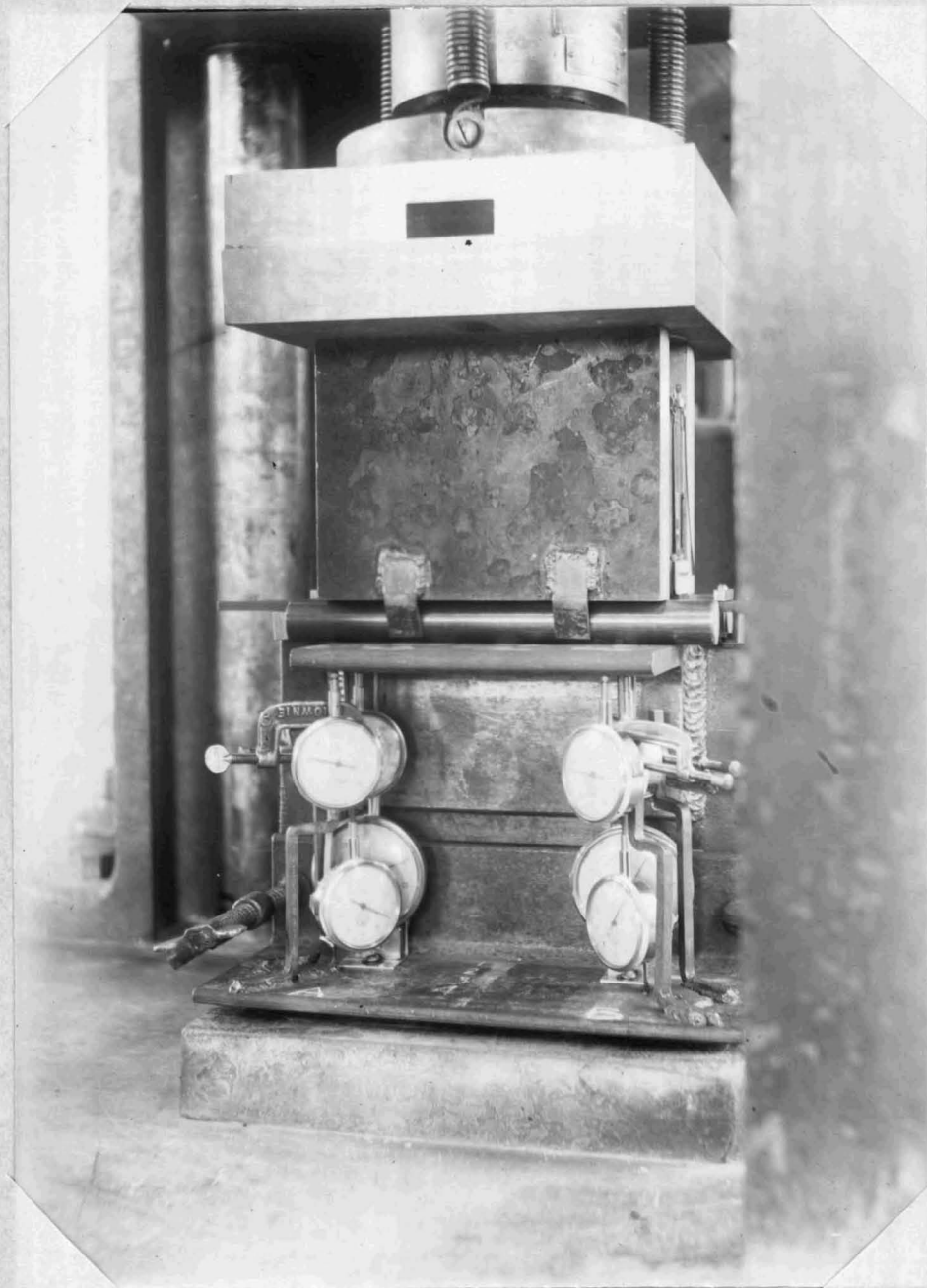
Fig. 1a - Specimen 1 in Testing Machine Showing
Spherical Bearing Block, Loading Rig,
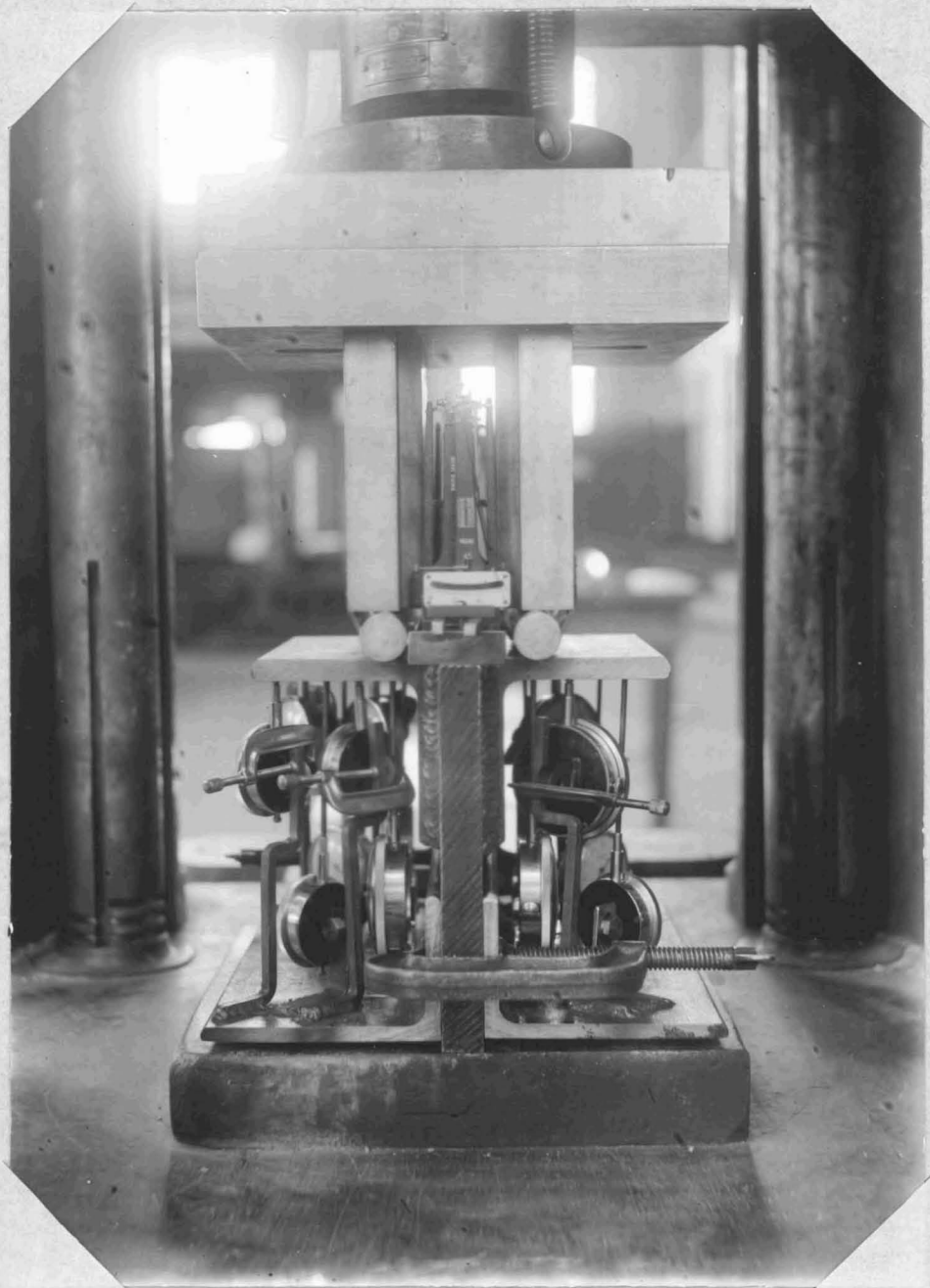and Gages.   South Face

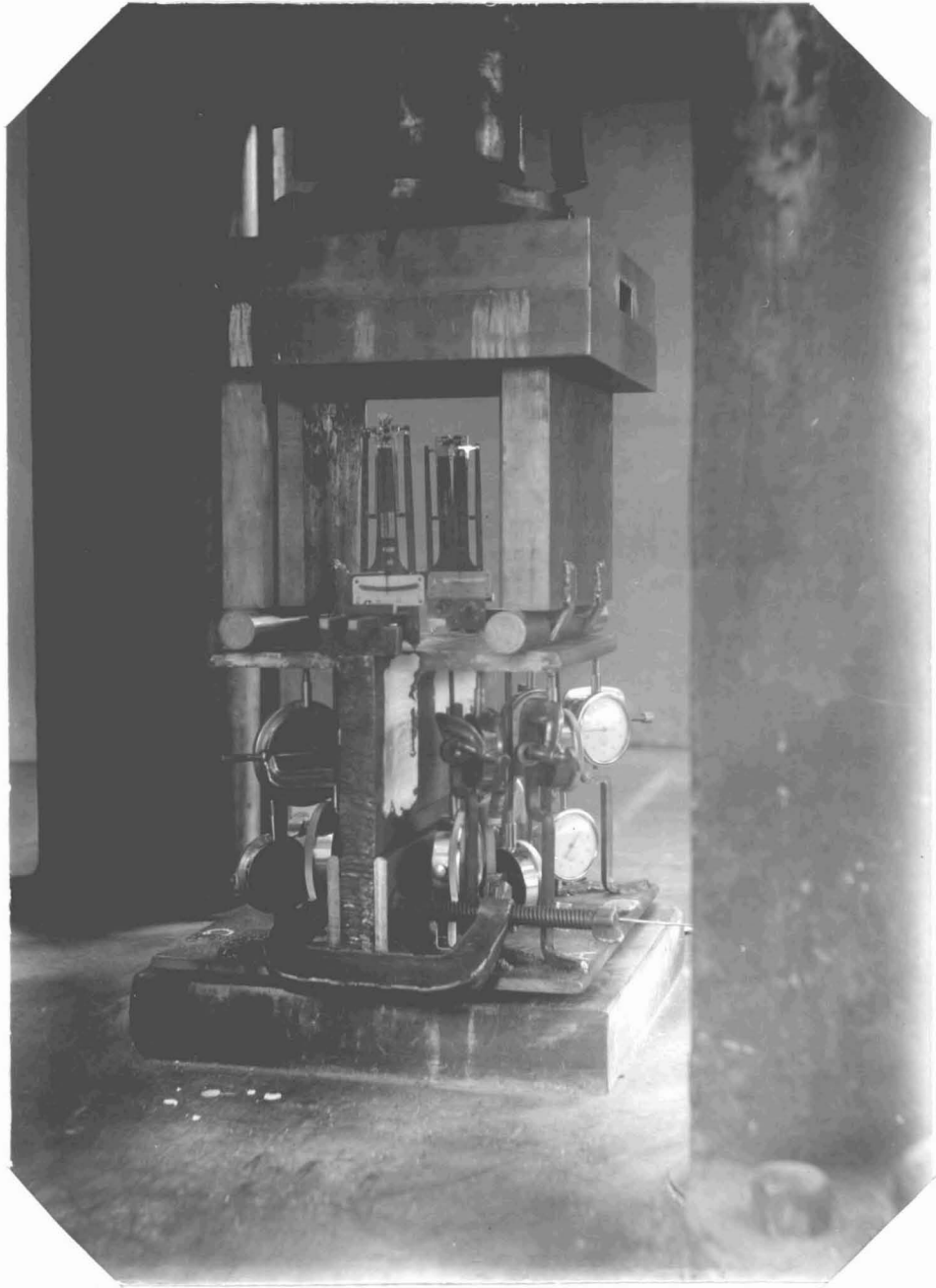Fig. 1b - West Face, Specimen 1

Lever Arm   1.2 inches

Fig. 1c - East Face, Specimen 1
Lever Arm 3 inches

Subject *Struc. Steel Weld'g Comm. - HMP 4/15/33 Sh. #1*   Date 12/21/33

Location of Gage Points   Specimen No. 1 {2 Ls 4×4×½ - 0'8" Lg / 1 ₽ 12"× 8"× ⅛}   Party S & D.M.S
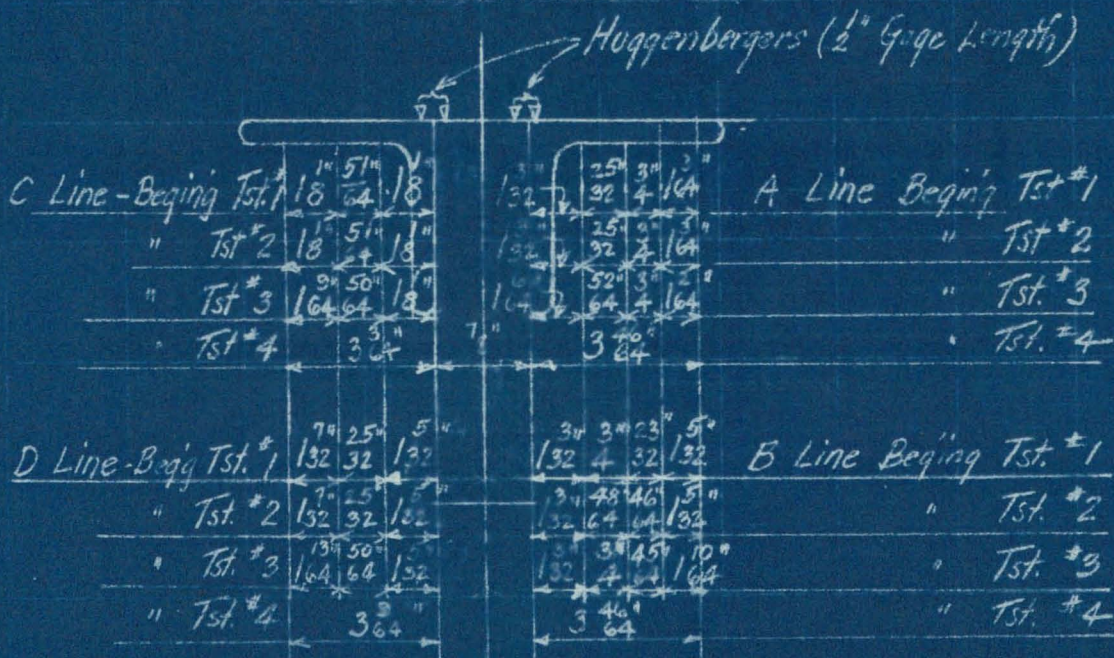
Notes: *& Nomenclature*

*No Scale.*

FIGURE 2
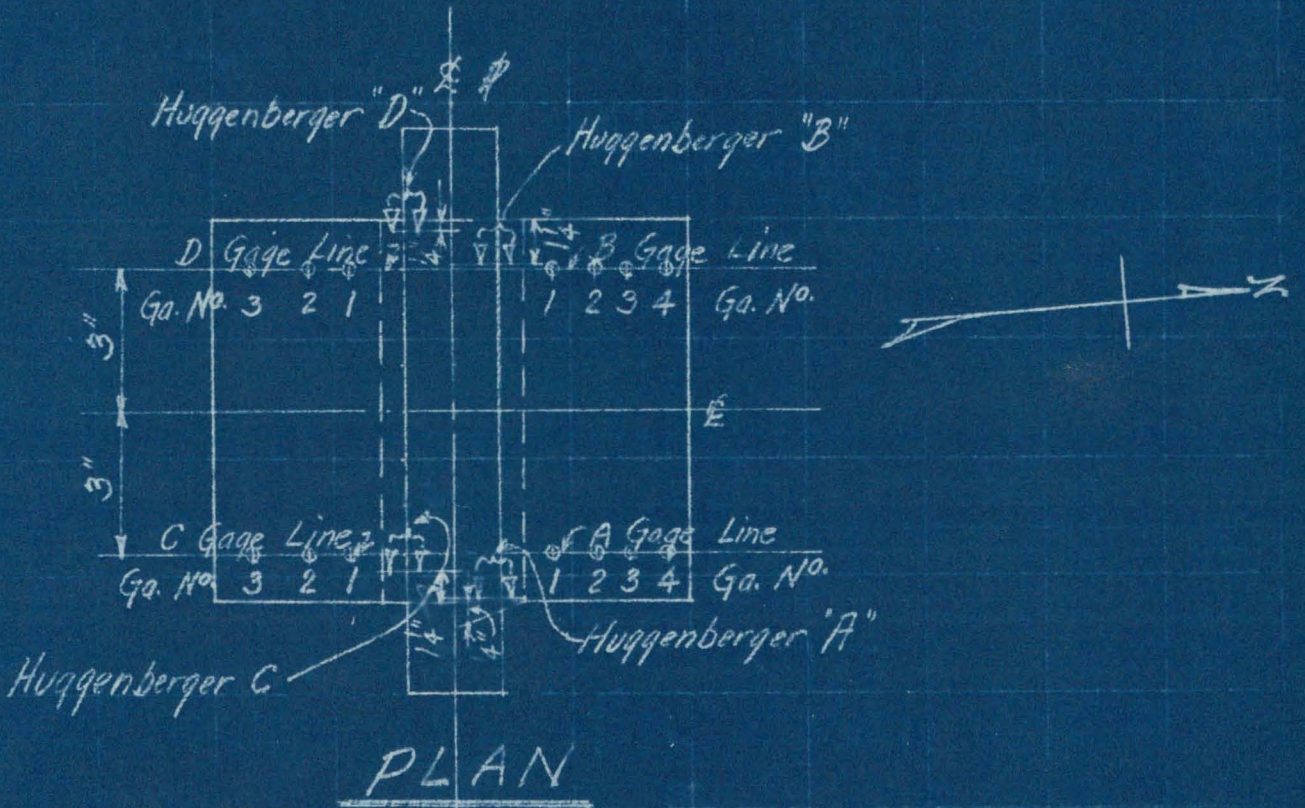
PLAN

END ELEVATION

5. <u>Description of the Test to Obtain the</u>

<u>Ultimate Load</u> - In testing the specimen to destruction, all instruments were removed and the load was steadily applied without any sign of distress until a load of 57,100 lb. was reached, when a crack appeared in the whitewash at weld C at the heel of the angle, accompanied by a drop of the beam of the testing machine. After an evident redistribution, the specimen picked up more load until 58,650 lb. was reached, the crack in weld C opened visibly and one crack appeared in weld A. This was also accompanied by a drop of the beam. At 59,900 lb. the whitewash scaled off the fillets of the angles and welds B and D opened up. The angles continued to deform and the welds to tear, upon continued motion of the head of the machine, the maximum load reached being 60,860 lb. Fig. 5 shows the condition of specimen at the end of the test.
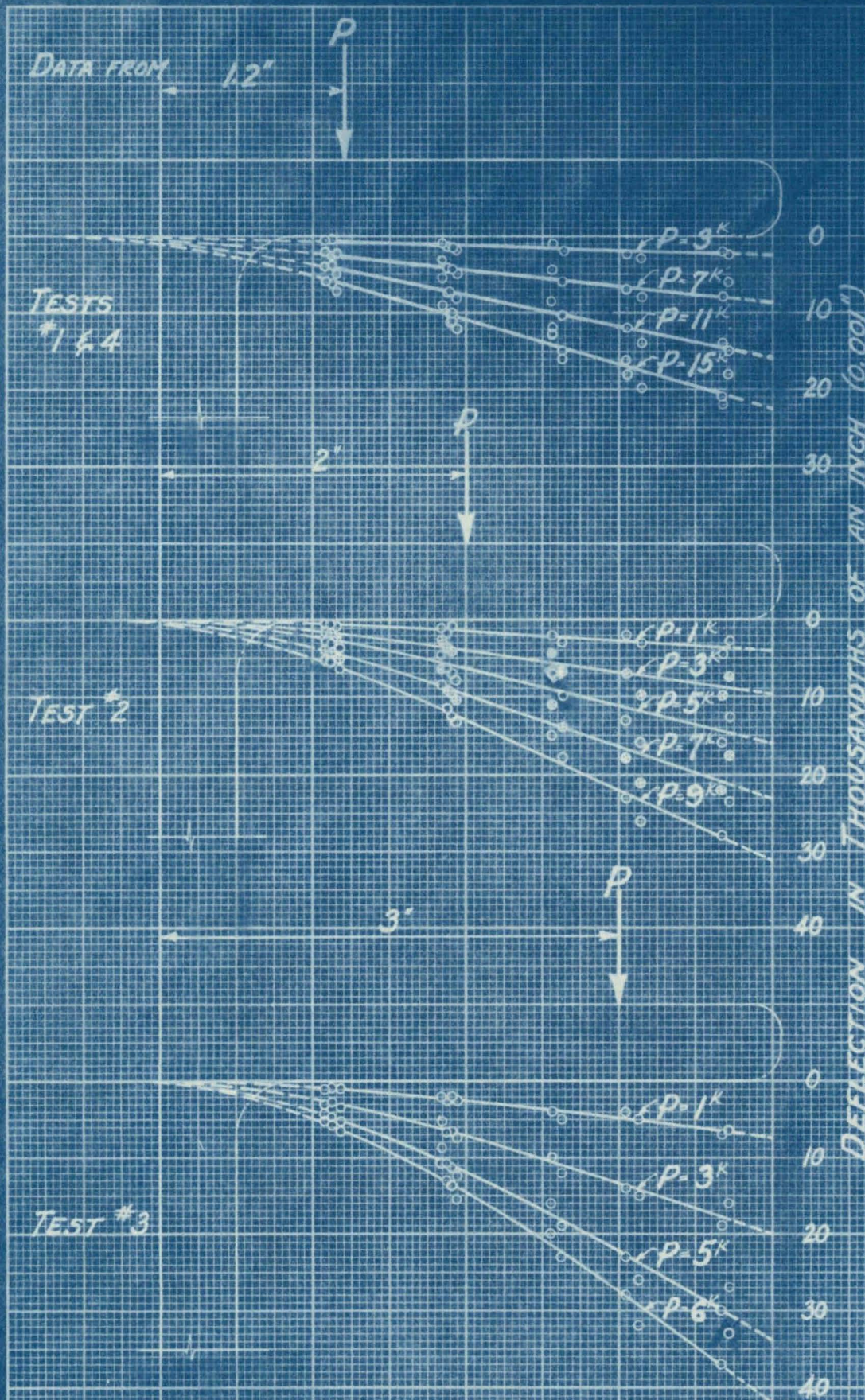
ELASTIC CURVES OF OUTSTANDING LEGS
SPECIMEN #1 - 4" x 4" x ½" ANGLE - Scale (Horiz.- Full
Vert.- As noted)
SEAT ANGLE RESEARCH   FIG. 3

D. RESULTS

  1. <u>Observations</u> - No difficulty was experienced
in the operations of the Ames dials, the readings on each
dial being in good agreement with the others of the same
set. The agreement between sets of readings varied with-
in ten percent, and it was found that this could be cor-
rected by accurately centering the loading rig with the
angle in the long direction, an error of 1/8-inch in cen-
tering causing approximately a ten per cent variation in
deflection between the ends of the angle.

  The Huggenberger extensometers, because of their
short range, had to be reset approximately every second
increment of load. Their readings show a wider variation
than the other instruments, although the average curve is
a straight line.

  Upon increase in load it was found that the ver-
tical legs of loading rig spread 1/4-inch at 60,000 lb.
and therefore two bolts have been introduced to keep the
legs vertical.

  2. <u>Plots</u> - The elastic curves for each loading
are plotted on Fig. 3. It will be noted that the center
of rotation seems to be at the heel of the angle. Fig.
4 shows the horizontal deflections at the heel of the
angle as measured by the Huggenberger extensometers.

HORIZONTAL DEFLECTIONS
AT HEEL OF THE ANGLE
SPECIMEN #1 - 4"x 4"x 1/2" ANGLE
Symbols:
○ Data from Tests #1 & 4
△ "   "   "   Test #2
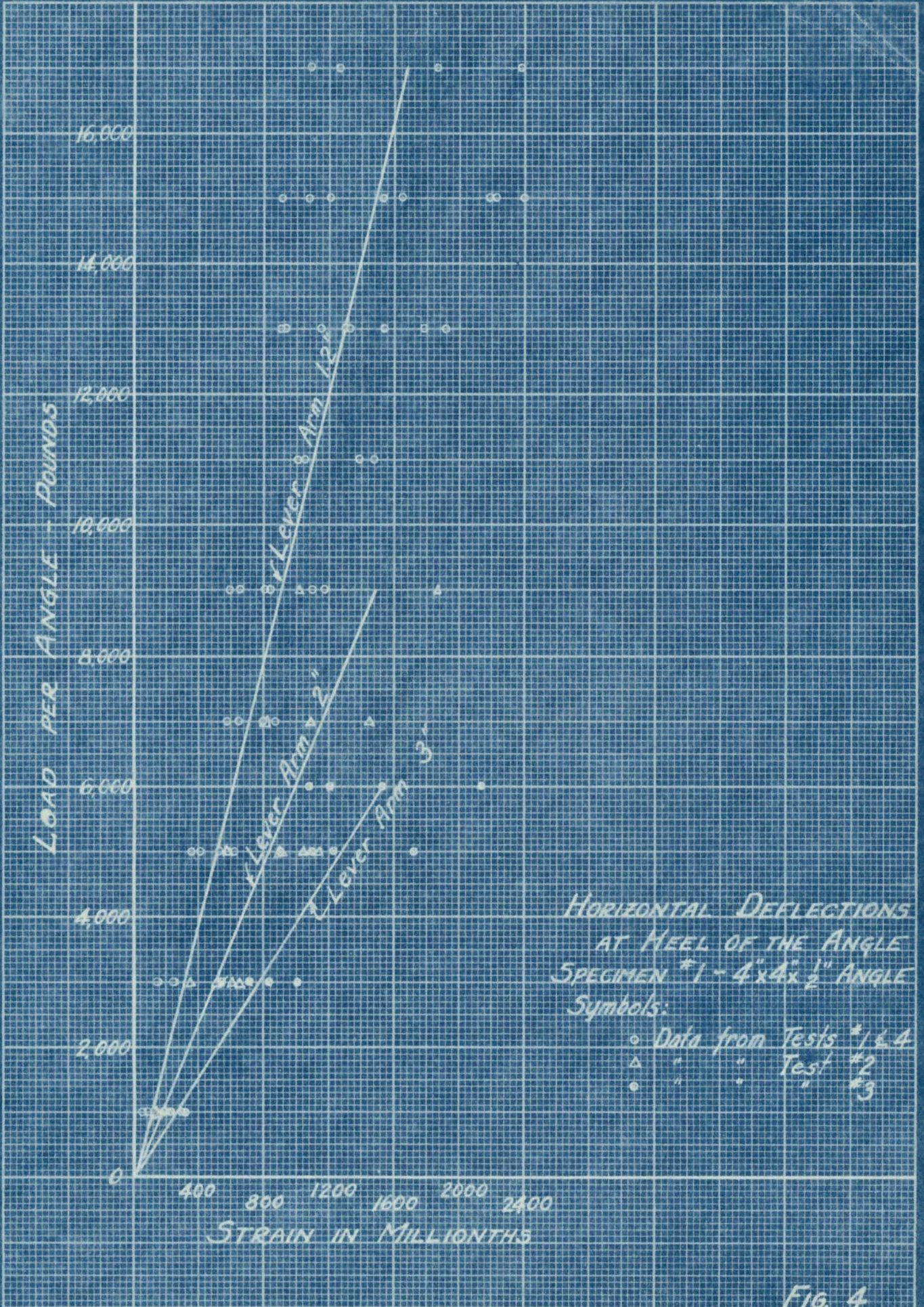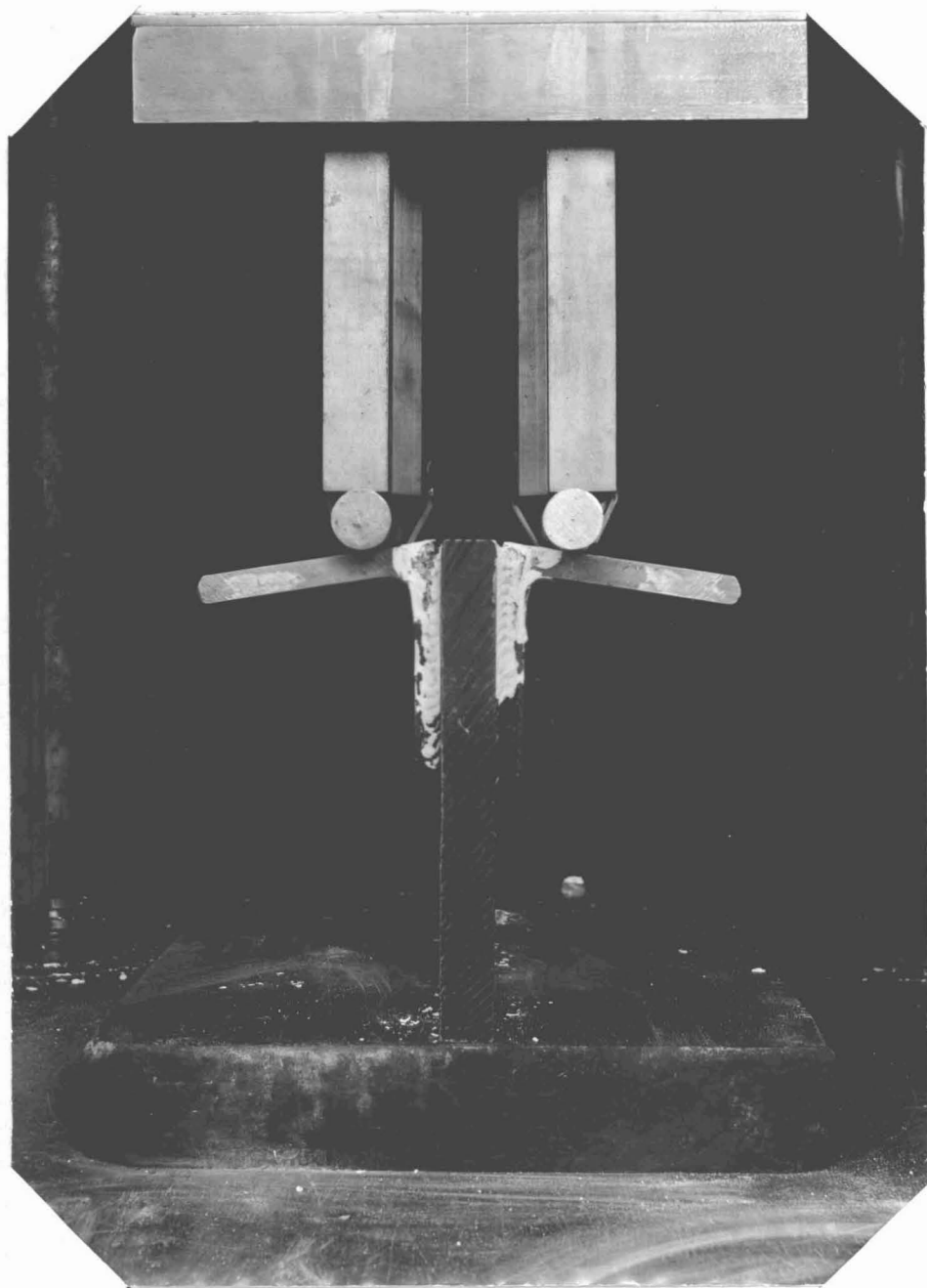◎ "   "   "   #3

FIG. 4

Fig. 5 - Condition of Specimen 1
at Ultimate Load

E. PHOTOELASTIC STUDIES

A half-size transparent bakelite model was made 0.25 inches thick and loaded in a manner similar to the above tests. Fig. 6a, 6b, 7, and 8 show the appearance of these loaded models under polarized light. A quantitative analysis has not yet been made but the concentrations of stress about the fillets of the angles and the small magnitude of the stress in the vertical legs of the angles and the plate is easily discernible from the photograph.

Fig. 6a and 6b show that the stress distribution in the outstanding leg is complicated by the localized stresses under the load applied through a short lever arm.

Fig. 7 and 8 indicate that with longer lever arms the stress in the outstanding leg more nearly approaches pure bending.
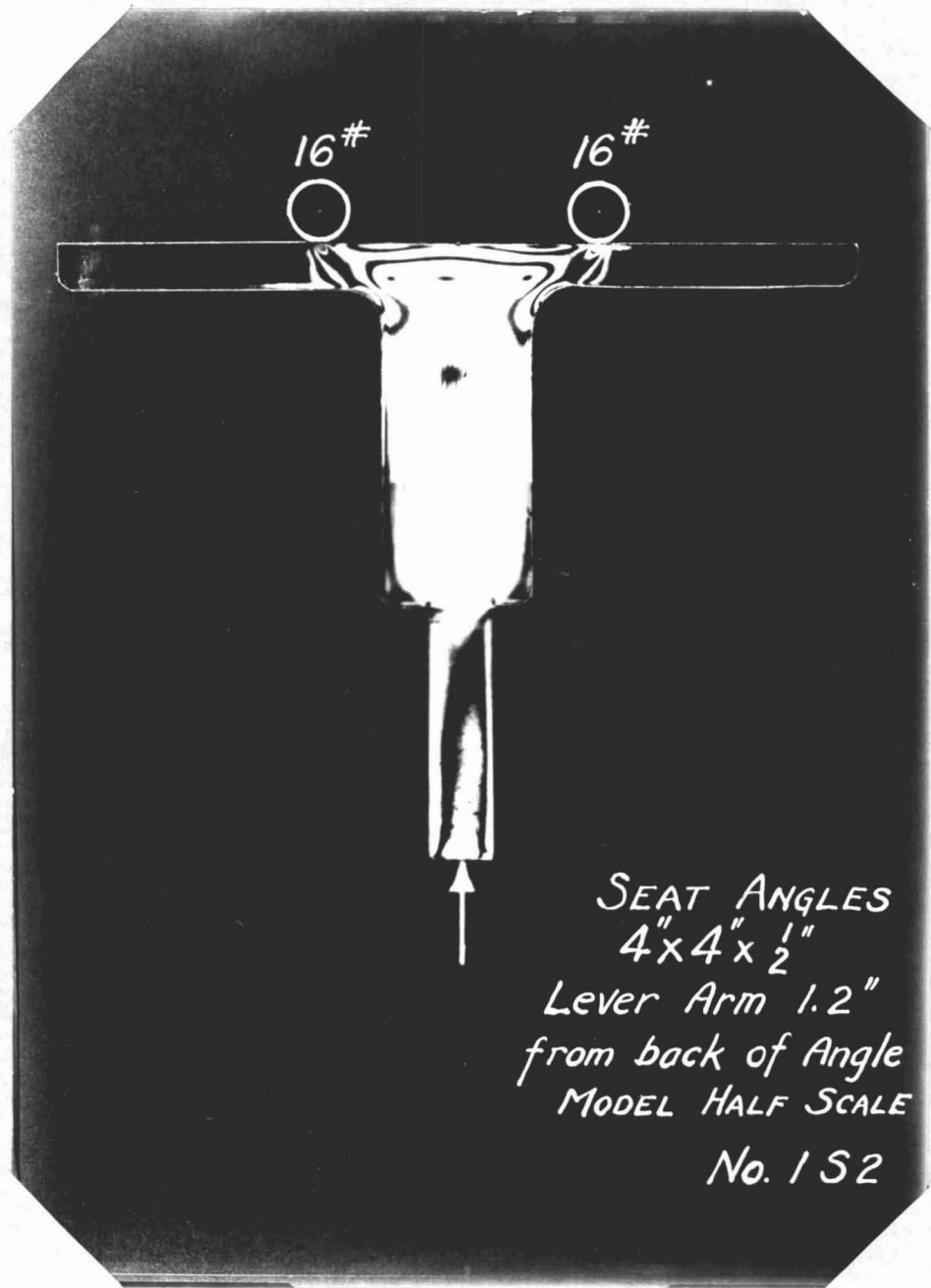
Fig. 6a – Photoelastic Model Showing Isochromatics

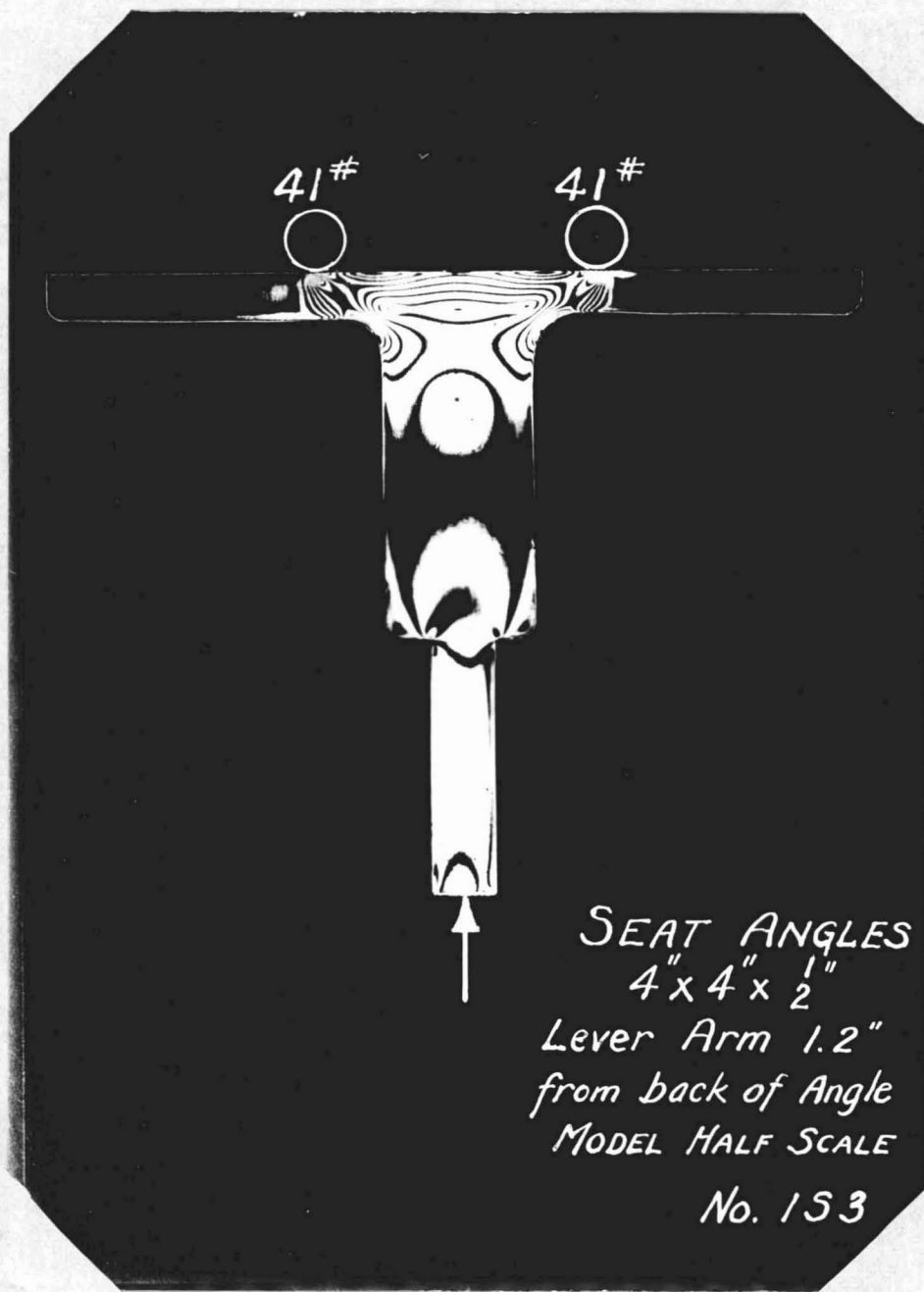(lines of equal difference of the principal
stresses)

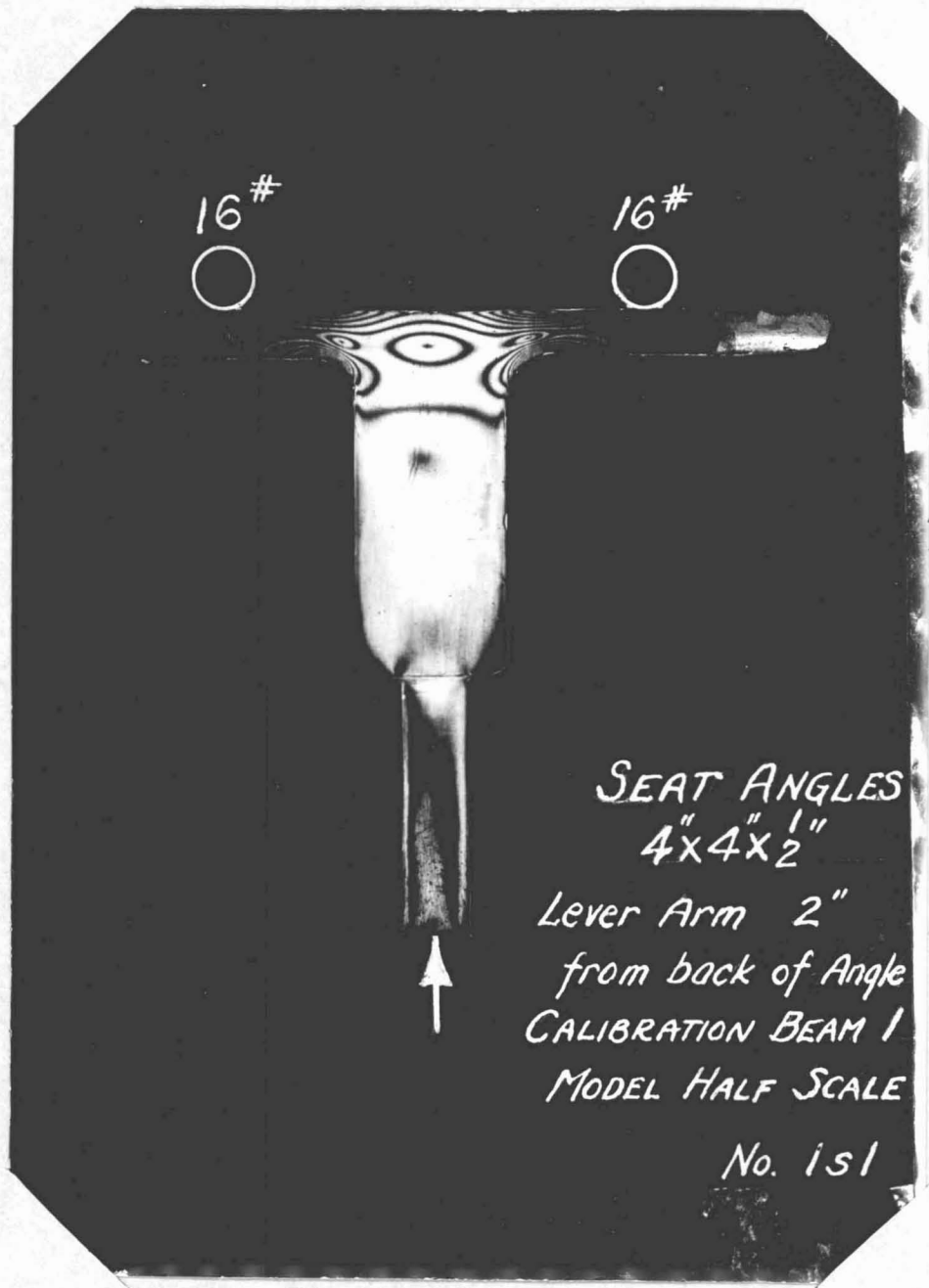Fig. 6b - Photoelastic Model Showing Isochromatics

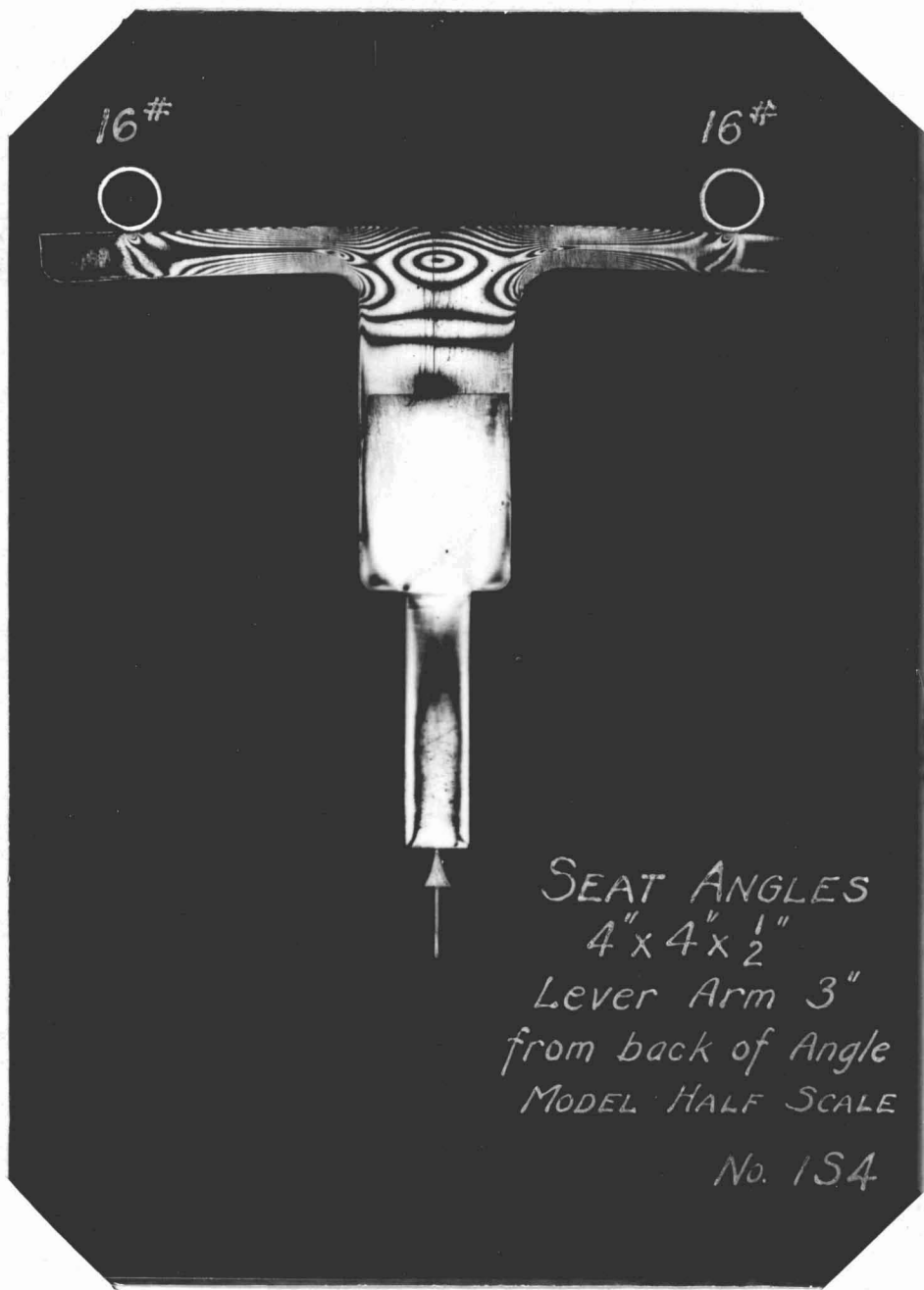Fig. 7 - Photoelastic Model Showing Isochromatics

Fig. 8 - Photoelastic Model Showing Isochromatics

F. FUTURE PROCEDURE

It is proposed to continue with Mr. Priest's program, modified somewhat by results. The following projects will next be studied:

(1) Effect of length of vertical leg

(2) Effect of thickness of angle

(3) Effect of size of weld, both in length and cross-section

(4) Effect of location of weld

(5) Full-sized actual connections to be made and tested alongside the tests proposed by Mr. Priest.

It is proposed to continue measuring the deflection of the outstanding legs of the angles, using Ames dials only between the load and the heel of the angle, and measuring the tangent to the deflection curve with a level bar.

It is proposed to locate the position of the neutral axis of the weld, since this seems to be the determinant of the strength of the connection.

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