PROGRESS REPORT

on

CLEAVAGE FRACTURE OF SHIP PLATES AS INFLUENCED BY SIZE EFFECT

by

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Under Navy Contract NObs-31224

COMMITTEE ON SHIP CONSTRUCTION
DIVISION OF ENGINEERING & INDUSTRIAL RESEARCH
NATIONAL RESEARCH COUNCIL

Advisory to

BUREAU OF SHIPS, NAVY DEPARTMENT
Under Contract NObs-34231

Serial No. SSC-3

Copy No. 6

August 20, 1946

August 20, 1946

Chief, Bureau of Ships
Navy Department
Washington 25, D. C.

Dear Sir:

Attached is Report Serial No. SSC-3, entitled "Cleavage Fracture of Ship Plates as Influenced by Size Effect". This report has been submitted by the contractor as a progress report on the work done on Research Project SR-93 under Contract NObs-31224 between the Bureau of Ships, Navy Department and the University of Illinois.

The report has been reviewed and acceptance recommended by representatives of the Committee on Ship Construction, Division of Engineering and Industrial Research, NRC, in accordance with the terms of the contract between the Bureau of Ships, Navy Department and the National Academy of Sciences.

Very truly yours,

Frederick M. Feiker
Chairman, Division of Engineering
and Industrial Research

Enclosure

PREFACE

The Navy Department through the Bureau of Ships is distributing this report to those agencies and individuals that were actively associated with this research program. This report represents a part of the research work contracted for under the section of the Navy's directive "to investigate the design and construction of welded steel merchant vessels".

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PROGRESS REPORT

NAVY BUREAU OF SHIPS CONTRACT NObs-31224
PROJECT NRC-93

CLEAVAGE FRACTURE OF SHIP PLATES AS INFLUENCED BY SIZE EFFECT.

September 1, 1945 to February 28, 1946

From:
University of Illinois
College of Engineering

Report Prepared by:

Wilbur M. Wilson

Robert A. Hechtman

Walter H. Bruckner

ABSTRACT

This report supplements the Final Report, OSRD No. 6457, Serial No. M-614, "Cleavage Fracture of Ship Plates as Influenced by Size Effect," (NS-336), dated January 15, 1946. It is a Progress Report of tests made subsequent to that date under the direction of the Bureau of Ships, U. S. Navy Department.

The report contains a description of tests made to determine why ship plates crack in service. The tests were based upon the hypothesis that the cracks begin at points where there are severe geometrical stress-raisers and that the tendency for the plates to crack increased, for specified geometrical characteristics, with an increase in the notch-sensitivity of the steel.

Plates with nominal widths of 72, 48, 24 and 12 inches were tested. The 72-in., 48-in., and 12-in. plates were made of three kinds of steel, rimmed-steel E as-rolled, killed-steel D as-rolled, and killed-steel D normalized. The 24-in. plates were made of four kinds of steel, rimmed-steel E as-rolled, killed-steel D as-rolled, killed-steel D normalized, and a low-carbon, high-manganese killed-steel F as-rolled. All plates of each kind of steel were from the same heat. Tests of both flat and round coupons were made to determine the ultimate strength, yield point, elongation, and reduction of area. Impact values, determined by tests of standard V-notch specimens, were obtained for all steels throughout the temperature range covered by the tests of the wide plates.

The standard stress-raiser, which was centrally located in the plate, was a transverse slot 1/2 in. wide with a hacksaw cut at each end which terminated in a jeweler's-saw cut 1/8 in. long. For a few specimens, the hacksaw cut terminated in a No. 47 drill-hole. For a few others, it terminated in a 1/4-in. drill-hole. The $\frac{L}{W}$ ratio $\left(\frac{\text{length of stress-raiser}}{\text{width of plate}}\right)$ had values of 0.125, 0.25, 0.33, 0.50, and 0.75 for two series of tests. For all other series, $\frac{L}{W}$ was equal to 0.25. The plates were tested at temperatures ranging from -73 to 141 degrees F.

The elongation at all loads of the wide plates at mid-length was measured by mechanical gages on a gage length equal to 3/4 of the gross width of the plate. The elastic and early plastic strains in the plate at mid-length were measured with electric strain gages having a 13/16-in. gage length; the plastic strain in the same region was measured with mechanical gages of 1/4-in. and 1-in. gage lengths at loads up to the initial fracture. All strains were measured on both sides of the plate. After failure, the thickness of the plate adjacent to the fracture was measured with micrometer calipers and the mode of fracture, percentage of shear and cleavage in the fracture, was determined.

The tests were planned to determine:

(1) The relative energy-absorbing capacity and strength of plates of the four kinds of steel.

(2) The relation between the width of the plates and their strength and energy-absorbing capacity.

(3) The relation between the temperature of the plates and their strength and energy-absorbing capacity.

(4) The relation between the value of $\frac{L}{W}$ and the strength and energy-absorbing capacity of the plates.

(5) The effect of the type of stress-raiser upon the strength and energy-absorbing capacity of rimmed-steel plates.

(6) The correlation of the V-notch impact test and the wide plate test with the jeweler's-saw cut type of stress-raiser.

There was a total of 61 wide plates tested. There were also two incidental plate failures, not planned but of considerable interest, that have been included in this report. The details of the results are given in Appendix A. The results are discussed on pages 8 to 25, and the conclusions are given on pages 26 to 28.

PROGRESS REPORT

NAVY BUREAU OF SHIPS CONTRACT NObs-31224

PROJECT NRC-93
"CLEAVAGE FRACTURE OF SHIP PLATE
AS INFLUENCED BY SIZE EFFECT"

SEPTEMBER 1, 1945 TO FEBRUARY 28, 1946.

From:
University of Illinois
College of Engineering

Report Prepared by:
Wilbur M. Wilson
Robert A. Hechtman
Walter H. Bruckner

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INTRODUCTION

The object of the investigation covered by this report was to determine the factors that influence the formation of cleavage fractures in ship plates. Because ship plates are much wider than plates that can be tested in a testing machine, tests were made on plates with nominal widths of 72 in., 48 in., 24 in., and 12 in., in order to obtain information on which to base extrapolations that might indicate the behavior of wider plates. The information obtained relative to the behavior of wide plates containing severe stress-raisers may be divided into four major divisions, as follows:

A. The static strength.

B. The energy-absorbing capacity.

C. The V-notch impact test as an indicator of the performance of the wide plate test.

D. The distribution of plastic deformation at the ends of the stress-raiser prior to maximum load.

The standard stress-raiser consisted of a transverse slot 1/2 in. wide with a hacksaw cut at each end which terminated in a jeweler's-saw cut 1/8 in. long, and which had an $\frac{L}{W}$ ratio $\left(\frac{\text{length of stress-raiser}}{\text{width of plate}}\right)$ of 0.25. This standard stress-raiser was used for all except two series. For one of the latter, the influence of the $\frac{L}{W}$ ratio was being studied and five values of $\frac{L}{W}$ were used. For the other, the type of stress-raiser was the variable being studied. Details of the three types of stress-raisers are shown in Fig. 2. The specimens for the latter two series were 24-in. rimmed-steel E as-rolled plates, and the tests were made at two temperatures, -40 and 90 degrees F.

In order to determine the relation between the behavior of the wide plates and the mechanical properties of the material, tests were made on both flat and round coupons cut from the wide plates to determine the ultimate strength, yield point, elongation, and the reduction of area. Likewise, impact tests were made at various temperatures on standard V-notch specimens cut from some of the plates.

The following steels were used in this investigation.

Rimmed-Steel as-rolled, designated as Steel E As-Rolled.
Killed-Steel as-rolled, designated as Steel D As-Rolled.
Killed-Steel normalized, designated as Steel D Normalized.*
Killed-Steel as-rolled, designated as Steel F As-Rolled.
Killed-Steel as-rolled, designated as Steel G As-Rolled.

The mechanical properties and chemical composition of these steels are given in Appendix B.

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* The normalizing treatment is described in Appendix B, page 8b.

EXPERIMENTAL WORK.

1. Procedure.

The procedure followed in the tests described in this report is described on pages 3 to 9 of the Final Report, OSRD No. 6457, Serial No. M-614, "Cleavage Fracture of Ship Plates as Influenced by Size Effect," (NS-336), dated January 15, 1946. The data for one test, together with a fairly complete description of the manner in which it was obtained, are presented on pages 13 to 21, inclusive, of the Final Report.

A 72-in. plate mounted in the testing machine is shown in the photograph of Fig. 1. Figure 2 gives the general dimensions of the wide plate specimens and the three types of stress-raisers. The location of the electric gages and of the gage points for the mechanical gages are also shown in Fig. 2. Four widths of specimens were tested: 72, 48, 24 and 12 inches.

2. Data.

The tests included in this report and those in the above report are listed in Tables I and II. There were a large number of tests and the amount of data obtained for each was so great that the whole is quite voluminous, and its presentation in a brief but understandable form is quite difficult. The data included in this report are presented in the form of tables and graphs that either accompany the discussion of the results or are given in Appendix A of this report. The tensile properties and the impact values of the plates are given in Appendix B.

The terms used in presenting these data are defined as follows:

The average strength of the wide plates was expressed as the average stress on the net section corresponding to the maximum load. The energy-absorbing capacity was taken as the area under the load-strain curve for a gage length equal to 3/4 of the gross width of the plate. Two values are reported. One is the energy absorbed up to the maximum load, the other is the energy absorbed up to failure.

The percentage of cleavage, single shear, and double shear given in Tables III, IV, V, and VI, were obtained by macroscopic examination of the fractured edges of the wide plates. A microscopic examination would undoubtedly reveal small amounts of cleavage in shear fractures or of shear in cleavage fractures.

Unless otherwise designated, the term, impact test, was used to mean the Charpy type impact test of a standard V-notch specimen made in accordance with A.S.T.M. Specifications. The energy absorption in foot-pounds of this test was called the V-notch impact value, or simply the impact value.

TABLE I.

DESCRIPTION OF SPECIMENS.

Stress-Raiser: Jeweler's-Saw Cut. L/W = 0.25

SPECIMEN NO.	TEMPERATURE OF STEEL WHEN TESTED, Degrees F.	KIND OF STEEL	NOMINAL WIDTH OF SPECIMEN, In.
18A-1	141	Rimmed-Steel E As-Rolled	72
13A-7	110		
CG-1	74		
23-7	38		
17A-7	31	Killed-Steel D As-Rolled	72
5-1	15		
17-7	0		
15-7	32	Killed-Steel D Normalized	72
11-1	15		
5-7	0		
14-7	-38		
13-7	123	Rimmed-Steel E As-Rolled	48
18-8	110		
22-7	84		
22A-7	38		
17B-7	43	Killed-Steel D As-Rolled	48
18-2	39		
5-4	32		
18-1	18		
15A-1	42	Killed-Steel D Normalized	48
5A-2	31		
5A-5	15		

Table I.
(Continued)

SPECIMEN No.	TEMPERATURE OF STEEL WHEN TESTED, Degrees F.	KIND OF STEEL	NOMINAL WIDTH OF SPECIMEN, In.
20A-13	111	Rimmed-Steel E As-Rolled	24
20A-3	89		
22-9	86		
20-9	-36		
17B-6	37	Killed-Steel D As-Rolled	24
17B-4	30		
17B-5	10		
3-1	40	Killed-Steel D Normalized	24
3-2	33		
3-3	16		
A-2	32	Killed-Steel F As-Rolled	24
A-1	0		
A-3	-40		
23-3B	109	Rimmed-Steel E As-Rolled	12
13A-5B	74		
13A-5A	40		
20-2A	-73		
23-3A	78	Rimmed-Steel E Normalized	12

TABLE II.

DESCRIPTION OF SPECIMENS.

24-In. Rimmed-Steel E As-Rolled Plates.

Five Values of L/W and Three Kinds of Stress-Raisers.

SPECIMEN NO.	TEMPERATURE OF STEEL WHEN TESTED, Degrees F.	L/W	KIND OF STRESS-RAISER
20A-1 20-8	93 -44	0.125	Jeweler's-Saw Cut
20A-3 22-9 20-9	89 86 -36	0.25	Jeweler's-Saw Cut
20A-4 20-10	88 -43	0.33	Jeweler's-Saw Cut
20A-5 20-11	84 -35	0.50	Jeweler's-Saw Cut
20A-6 20-12	80 -39	0.75	Jeweler's-Saw Cut
20A-7 20-13	75 -42	0.125	No. 47 Drill-Hole
20A-8 20-14	86 -40	0.25	No. 47 Drill-Hole
20A-9 20-15	81 -39	0.33	No. 47 Drill-Hole
20A-10 20-7	80 -44	0.50	No. 47 Drill-Hole
20A-15 20A-11	88 -42	0.75	No. 47 Drill-Hole
22A-9 20A-14	83-95# -37	0.25	1/4-In. Drill-Hole

Temperature increased to 95° F. due to plastic deformation.

3. Discussion of Results.

a. Strength:- The strength of the specimens with a jeweler's-saw cut type of stress-raiser and an $\frac{L}{W}$ value of 0.25, expressed as the average stress on the net section at the maximum load, is given in Table III. The relation between the strength and the temperature for 72-in. and 48-in. plates made of various kinds of steel,* is shown by the diagrams of Fig. 3. The relation between the strength and the temperature for 24-in. and 12-in. plates is shown by the diagrams of Fig. 4. For cleavage fractures, there was no significant change in the average strength of the plates.

The figure beside each point is the total amount of shear in the fracture of the wide plate. The percentage of the fracture that was cleavage, single shear, or double shear is given in Table III. In general, the strength was somewhat greater for the specimens represented by the right-hand portion of the diagram. The right-hand point represents a shear-type fracture in four instances, and a part-cleavage-part-shear fracture in five instances. A change in the character of the fracture from cleavage to shear would seem to indicate an increase in strength.

The relation between the strength and the width of wide plates is shown by the diagrams of Fig. 5. These diagrams indicate that the unit strength decreased with an increase in the width of the plate of all kinds of steel, but the relation

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* The letter designations and properties of all steels are given in Appendix B.

TABLE III.

STRENGTH OF WIDE PLATES.

Stress-Raiser: Jeweler's-Saw Cut. L/W = 0.25.
Loads in 1000's of lbs., Stresses in 1000's of lb. per sq. in.; Energy in 1000's of in.lb.

SPEC. NO.	TEMP. °F.	COUPON STRENGTH Y.P.	COUPON STRENGTH Ult.	ULTIMATE LOAD	FRACTURE* percent C	FRACTURE* percent SS	FRACTURE* percent DS	ULTIMATE STRESS ON NET SECTION	ENERGY ABSORBED At Max. Load	ENERGY ABSORBED At Failure
				72-In. RIMMED-STEEL E AS-ROLLED PLATES						
18A-1	141	29.8	57.9	1730	---	73	6	41.4	1898	3586
13A-7	110	28.8	54.6	1476	16	65	---	36.3	2361	3400
CG-1	74	30.5	61.3	1290	100	---	---	31.9	233	350
23-7	38	32.2	59.9	1360	100	---	---	33.6	120	200
				72-In. KILLED-STEEL D AS-ROLLED PLATES						
17A-7	31	39.4	66.0	1890	---	86	6	45.7	3024	4700
5-1	15	37.0	63.7	1730	100	---	---	41.5	476	563
17-7	0	38.8	65.4	1789	100	---	---	43.1	174	228
				72-In. KILLED-STEEL D NORMALIZED PLATES						
15-7	32	34.8	59.2	1750	---	55	19	43.2	2738	4650
11-1	15	34.4	60.3	1507	100	---	---	37.4	238	298
5-7	0	36.2	60.9	1614	100	---	---	38.9	210	260
14-7	-38	35.5	59.7	1541	100	---	---	38.6	179	234
				48-In. RIMMED-STEEL E AS-ROLLED PLATES						
13-7	123	31.1	59.1	1095	9	66	7	40.3	800	1683
18-8	110	30.4	59.3	1008	22	58	---	36.2	766	1446
22-7	84	33.9	60.5	987	100	---	---	35.7	245	361
22A-7	38	31.3	57.7	983	100	---	---	36.0	61	73
				48-In. KILLED-STEEL D AS-ROLLED PLATES						
17B-7	43	39.0	65.4	1276	85	8	7	45.9	560	1081
18-2	39	39.1	65.1	1185	96	2	2	43.5	288	416
5-4	32	37.0	63.7	1207	79	21	---	43.7	890	1110
18-1	18	39.1	65.1	1185	100	---	---	43.6	226	304
				48-In. KILLED-STEEL D NORMALIZED PLATES						
15A-1	42	34.9	59.5	1216	---	---	81	45.4	1340	2540
5A-2	31	34.5	60.7	1098	100	---	---	40.0	207	227
5A-5	15	34.5	60.7	1100	100	---	---	40.0	185	229

* C = Cleavage, SS = Single Shear, DS = Double Shear
Portion of width not accounted for was flame-cut.

Table III
(Continued)

Stress-Raiser: Jeweler's-Saw Cut. L/W = 0.25.
Loads in 1000's of lbs.; Stresses in 1000's of lb. per sq.in.;
Energy in 1000's of in.lb.

SPEC. NO.	TEMP. °F.	COUPON STRENGTH		ULTI-MATE LOAD	FRACTURE* percent			ULTIMATE STRESS ON NET SECTION	ENERGY ABSORBED	
		Y.P.	Ult.		C	SS	DS		At Max. Load	At Fail-ure
		24-In. RIMMED-STEEL E AS-ROLLED PLATES								
20A-13	111	32.3	59.6	563	98	---	2	41.0	159	246
20A-3	89	32.3	59.6	483.8	100	---	---	35.4	102	135
22-9	86	33.9	60.5	486.4	100	---	---	36.7	74	125
20-9	-36	29.3	56.8	510	100	---	---	37.6	16	21
		24-In. KILLED-STEEL D AS-ROLLED PLATES								
17B-6	37	39.0	65.4	618	98	1	1	45.7	112	148
17B-4	30	39.0	65.4	653	19	81	---	48.3	260	656
17B-5	10	39.0	65.4	643	97	1	2	47.3	158	188
		24-In. KILLED-STEEL D NORMALIZED PLATES								
3-1	40	33.8	59.0	633	---	49	35	46.4	309	795
3-2	33	33.8	59.0	637	19	49	29	46.3	320	762
3-3	16	33.8	59.0	588	100	---	---	42.8	102	117
		24-In. KILLED-STEEL F AS-ROLLED PLATES								
A-2	32	34.1	60.8	655	17	49	34	47.6	351	868
A-1	0	34.1	60.8	675	81	10	9	49.9	400	496
A-3	-40	34.1	60.8	626	98	1	1	45.8	124	161
		12-In. RIMMED-STEEL E AS-ROLLED PLATES								
23-3B	109	32.2	59.9	310.9	13	76	11	48.9	60	199
13A-5B	74	28.7	54.6	254.8	100	---	---	40.5	40	53
13A-5A	40	28.7	54.6	236.2	100	---	---	37.6	17	17
20-2A	-73	29.3	56.8	245	100	---	---	37.9	10	12
		12-In. RIMMED-STEEL E NORMALIZED PLATES								
23-3A	78			306	---	93	---	47.5	88	204

*C = Cleavage, SS = Single Shear, DS = Double Shear.
Portion of width not accounted for was flame-cut.

can not be accurately determined. However, the tendency for the strength to decrease with an increase in width beyond a width of 72 in., would seem to be definitely established. Moreover, the rate of decrease would seem to be at least nearly as great for widths greater than 48 in. as it is for widths less than 48 in.

The relative strength of the three kinds of steel is shown by the diagrams of Figs. 6 and 7. In these figures, the strengths of 72-in., 48-in., and 24-in. plates are shown separately. For all three widths the strength of the three kinds of steel increases in the order, rimmed-steel E as-rolled, killed-steel D normalized, and killed-steel D as-rolled. For 24-in. plates, killed-steel F as-rolled showed about the same strength as killed-steel D as-rolled.

The strength of 24-in. rimmed-steel E as-rolled plates with a jeweler's-saw cut type of stress-raiser and values of $\frac{L}{W}$ ranging from 0.125 to 0.75, is given in Table IV. Two series of tests were made, one at a temperature of approximately -40 degrees F. and the other at approximately 90 degrees F. The relation between the strength and the value of $\frac{L}{W}$ for these plates, is shown by the diagrams of Fig. 8. These tests indicate that the average stress on the net section at failure was not greatly affected by the value of $\frac{L}{W}$. They also indicate that the strength was very nearly the same at -40 degrees F. as at 90 degrees F.

Tests similar to those made to determine the effect of the value of $\frac{L}{W}$ upon the strength of 24-in. rimmed-steel E as-rolled plates with jeweler's-saw cut stress-raisers, were also made to determine the effect of the value of $\frac{L}{W}$ upon similar plates with No. 47 drill-hole stress-raisers. The results of these tests are given in Table V. The relation between the strength and the value of $\frac{L}{W}$ is shown by the diagrams of Fig. 8. The unit strength increased with the value of $\frac{L}{W}$, the strength being approximately 20 percent greater for an $\frac{L}{W}$ of 0.75 than for an $\frac{L}{W}$ of 0.125. This was true for tests at both -40 and 90 degrees F. The strength was consistently about 5 percent greater at -40 degrees F. than at 90 degrees F.

A comparison of the strength and the value of $\frac{L}{W}$ for 24-in. rimmed-steel E as-rolled plates with two types of stress-raisers, the jeweler's-saw cut and the No. 47 drill-hole, tested at -40 and 90 degrees F., is shown by the diagrams of Fig. 9. The increase in strength with the increase in the $\frac{L}{W}$ ratio, was greater for the specimens with a No. 47 drill-hole stress-raiser than it was for the specimens with a jeweler's-saw cut stress-raiser. The plates with the less severe stress-raiser had the greater strength, and the difference between the strengths of wide plates with the two types of stress-raisers increased with the value of $\frac{L}{W}$, the difference being about 25 percent of the lesser for an $\frac{L}{W}$ of 0.75.

The strengths of 24-in. rimmed-steel E as-rolled plates with three types of stress-raisers are shown in Table VI. All specimens had an $\frac{L}{W}$ ratio of 0.25. The relative strengths of the plates with the three types of stress-raisers are shown by the diagrams of Fig. 10. The upper curve is for tests at approximately -40 degrees F., and the lower curve is for tests at approximately 90 degrees F. These diagrams indicate that, for a value of $\frac{L}{W}$ of 0.25, the plates increased in strength according to their stress-raisers, in the following order: jeweler's-saw cut, No. 47 drill-hole, and 1/4-in. drill-hole.

TABLE IV.

STRENGTH OF 24-IN. RIMMED-STEEL E AS-ROLLED PLATES.

Stress-Raiser: Jeweler's-Saw Cut. Five Values of L/W.
Loads in 1000's of lbs.; Stresses in 1000's of lb. per sq.in.; Energy in 1000's of in.lb.

SPEC. NO.	TEMP. °F.	COUPON STRENGTH Y.P.	COUPON STRENGTH Ult.	ULTIMATE LOAD	FRACTURE* percent C	FRACTURE* percent SS	FRACTURE* percent DS	ULTIMATE STRESS ON NET SECTION	ENERGY ABSORBED per inch of net width At Max. Load	ENERGY ABSORBED per inch of net width At Failure
				L/W = 0.125						
20A-1	93	32.3	59.6	554.6	100	---	---	34.7	5.45	10.00
20-8	-44	29.3	56.8	576.0	100	---	---	36.0	0.97	1.45
				L/W = 0.25						
20A-3	89	32.3	59.6	483.3	100	---	---	35.4	5.78	7.66
22-9	86	33.9	60.5	486.4	100	---	---	36.7	4.17	7.15
20-9	-36	29.3	56.8	510.0	100	---	---	37.6	0.92	1.21
				L/W = 0.33						
20A-4	88	32.3	59.6	463.8	100	---	---	38.3	8.18	8.18
20-10	-43	29.3	56.8	451.9	100	---	---	37.5	0.78	1.04
				L/W = 0.50						
20A-5	84	32.3	59.6	347.2	100	---	---	38.0	4.40	7.54
20-11	-35	29.3	56.8	327.4	100	---	---	36.0	0.45	0.45
				L/W = 0.75						
20A-6	80	32.3	59.6	181.5	58	21	---	40.0	3.70	8.42
20-12	-39	29.3	56.8	174.0	100	---	---	38.1	0.70	0.89

*C = Cleavage, SS = Single Shear, DS = Double Shear.
Portion of width not accounted for was flame-out.

TABLE V.

STRENGTH OF 24-IN. RIMMED-STEEL E AS-ROLLED PLATES.

Stress Raiser: No. 47 Drill Hole. Five Values of L/W.

Loads in 1000's of lbs.; Stresses in 1000's of lb. per sq.in.; Energy in 1000's of in.lb.

SPEC. NO.	TEMP. °F.	COUPON STRENGTH Y.P.	COUPON STRENGTH Ult.	ULTIMATE LOAD	FRACTURE* percent C	SS	DS	ULTIMATE STRESS ON NET SECTION	ENERGY ABSORBED per inch of net width At Max. Load	At Failure
				L/W = 0.125						
20A-7	75	32.3	59.6	616	100	---	---	38.8	8.86	10.00
20-13	-42	29.3	56.8	626	100	---	---	39.3	4.67	4.67
				L/W = 0.25						
20A-8	86	32.3	59.6	534	50	47	3	39.0	5.68	15.17
20-14	-40	29.3	56.8	546	100	---	---	39.8	3.43	3.63
				L/W = 0.33						
20A-9	81	32.3	59.6	437	97	3	---	39.4	5.15	11.80
20-15	-39	29.3	56.8	497	100	---	---	41.1	2.69	3.14
				L/W = 0.50						
20A-10	80	32.3	59.6	378	100	---	---	41.7	6.61	7.00
20-7	-44	29.3	56.8	391	100	---	---	43.4	3.37	3.76
				L/W = 0.75						
20A-15	88	32.3	59.6	218	100	---	---	47.5	6.61	7.34
20A-11	-42	32.3	59.6	226	100	---	---	49.5	4.64	5.08

*C = Cleavage, SS = Single Shear, DS = Double Shear.
Portion of width not accounted for was flame-cut.

TABLE VI.

STRENGTH OF 24-IN. RIMMED-STEEL E AS-ROLLED PLATES.

Three Types of Stress-Raisers. L/W = 0.25

Loads in 1000's of lbs.; Stresses in 1000's of lb. per sq. in.; Energy in 1000's of in. lb.

SPEC. NO.	TEMP. °F.	COUPON STRENGTH Y.P.	COUPON STRENGTH Ult.	ULTIMATE LOAD	FRACTURE* percent C	FRACTURE* percent SS	FRACTURE* percent DS	ULTIMATE STRESS ON NET SECTION	ENERGY ABSORBED per inch of net width At Max. Load	ENERGY ABSORBED per inch of net width At Failure
JEWELER'S-SAW CUT STRESS-RAISER.										
20A-3	89	32.3	59.6	483.3	100	---	---	35.4	5.78	7.66
22-9	86	33.9	60.5	486.4	100	---	---	36.7	4.17	7.15
20-9	-36	29.3	56.8	510.0	100	---	---	37.6	0.92	1.21
NO. 47 DRILL-HOLE STRESS-RAISER.										
20A-8	86	32.3	59.6	534	50	47	3	39.0	5.68	15.17
20-14	-40	29.3	56.8	546	100	---	---	39.8	3.43	3.63
1/4-IN. DRILL-HOLE STRESS-RAISER.										
22A-9	83-95#	32.3	59.6	602	13	79	8	45.4	11.90	37.80
20A-14	-37	32.3	59.6	635	100	---	---	46.0	9.10	12.50

*C = Cleavage, SS = Single Shear, DS = Double Shear.
Portion of width not accounted for was flame-cut.

#Temperature increased to 95 °F. due to plastic deformation.

b. <u>Energy Absorption</u>:- The relation between the energy-absorbing capacity and the temperature for 72-in., 48-in., 24-in., and 12-in. plates made of various steels and with a jeweler's-saw cut type of stress-raiser and an $\frac{L}{W}$ value of 0.25, is shown by the diagrams of Figs. 11, 12, 13 and 14. These diagrams indicate that, for the 72-in. plates: (1) The energy-absorbing capacity of killed-steel D plates in the as-rolled and in the normalized conditions was greatly reduced when the temperature was reduced from 30 to 15 degrees F. (2) The energy-absorbing capacity of rimmed-steel E plates in the as-rolled condition was greatly reduced when the temperature was reduced from 110 to 80 degrees F. (3) Killed-steel D plates in the as-rolled and in the normalized conditions had very nearly the same energy-absorbing capacity when tested at the same temperature for a temperature range from 0 to 30 degrees F. (4) Rimmed-steel E as-rolled plates had a much lower energy-absorbing capacity than killed-steel D as-rolled plates at temperatures from 20 to 80 degrees F.; and the maximum energy absorption for these rimmed-steel E as-rolled plates corresponded to a temperature of the order of 120 degrees F.

The relation between the energy absorption and temperature for the 48-in. and 24-in. plates, was quite erratic for the killed-steel D as-rolled but was more consistent for the killed-steel D normalized and the rimmed-steel E as-rolled. The transition temperature for each kind of steel was approximately the same for the four widths of plate.

The relation between the energy absorption and temperature for 12-in. rimmed-steel E as-rolled and rimmed-steel E normalized plates is shown in Fig. 14. The apparent improvement of this rimmed steel by normalizing as indicated by one test will be further studied in future tests.

The energy-absorbing capacity to failure of 24-in. rimmed-steel E as-rolled plates with jeweler's-saw cut stress-raisers and with five values of $\frac{L}{W}$, determined from the area under the load-deformation diagram* and for a gage length equal to 3/4 W, is given in the right-hand column of Table IV. The relation between the energy-absorbing capacity and the value of $\frac{L}{W}$ for these plates, tested at temperatures of approximately -40 and 90 degrees F., is shown by the diagrams of Fig. 15. These diagrams indicate that the energy absorption of the plates per inch of net width was not appreciably affected by the value of $\frac{L}{W}$. This was true for tests at both temperatures. However, the energy absorption was many times greater at 90 degrees F. than at -40 degrees F. This was true even though all fractures were of the cleavage type.

Similar tests were made of 24-in. rimmed-steel E as-rolled plates with a No. 47 drill-hole type of stress-raiser. The relation between the energy absorption to failure per inch of net width and the value of $\frac{L}{W}$ is shown by the diagrams of Fig. 16. For the tests at -40 degrees F., the energy absorption per inch of net width was less for $\frac{L}{W}$ equal to 0.33 than it was for values of $\frac{L}{W}$ of both 0.125 and 0.75; and it was very nearly the same for the latter two values of $\frac{L}{W}$. For the tests at 90 degrees F., the energy absorption per inch of net width was greatest with $\frac{L}{W}$ equal to 0.25, and had lesser values for

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* The load-deflection diagrams are given in Appendix A, Figures 1a to 33a, inclusive.

$\frac{L}{W}$'s of 0.125, 0.50 and 0.75. For the tests at 90 degrees F., the two highest values of the energy absorption, the fractures were cleavage-to-shear-to-cleavage, while for the three lowest values, the fractures were all wholly cleavage, that is, the variations in the energy absorptions were consistent with the types of fracture.

A comparison of the energy absorption and the value of $\frac{L}{W}$ for 24-in. rimmed-steel E as-rolled plates with two types of stress-raisers, the jeweler's-saw cut and the No. 47 drill-hole, tested at -40 degrees F., is shown by the diagrams of Fig. 17. These diagrams indicate that the energy absorption was several times greater for the plates with No. 47 drill-holes than it was for the plates with jeweler's-saw cuts. This was true for all values of $\frac{L}{W}$. In contrast with this, the diagrams of Fig. 17 for tests at 90 degrees F. indicate that, for values of $\frac{L}{W}$ of 0.50 and 0.75, the energy absorption was less for the plates with No. 47 drill-holes than it was for similar plates with jeweler's-saw cuts. For values of $\frac{L}{W}$ equal to 0.125, the plates with the two types of stress-raisers absorbed the same energy.

The energy absorption to failure of tests of 24-in. rimmed-steel E as-rolled plates with three types of stress-raisers is shown in Table VI, all specimens having an $\frac{L}{W}$ ratio of 0.25. The diagrams of Fig. 18 show that the plates increased in energy-absorbing capacity with a decrease in the severity of the stress-raiser.

c. <u>Correlation of the V-Notch Impact Test and the Wide Plate Test</u>:- The comparison of the results of the V-notch impact test and of the wide plate test with the jeweler's-saw cut type of stress-raiser and an $\frac{L}{W}$ ratio of 0.25 will be made in the following two ways:

1. A comparison of the manner in which these two tests segregate the various kinds of steels with respect to the transition temperature for a change from a cleavage to a shear type of fracture.

2. A study of the correlation of the energy absorption of these two tests for the various kinds of steel.

The relation between the energy absorption to failure and the testing temperature is given for the wide plates in Figs. 11, 12 and 13. The impact values are shown in Appendix B, Fig. 4b. A comparison of these diagrams indicates that the transition temperature for the wide plate test and for the V-notch impact test were approximately the same. In general, the V-notch impact test determined a wider temperature band of mixed fractures, cleavage and shear combined, than did the wide plate tests with the jeweler's-saw cut type of stress-raiser. The kinds of steel were segregated in the same order with respect to transition temperature by these two types of tests.

One question that has been raised is, whether or not impact values of steel are a measure of the capacity of a notched plate to absorb energy. The relation between the energy-absorbing capacity of 72-in. and 48-in. plates and the average V-notch impact value of the steel is shown by the diagrams of Fig. 19, and the same relation for 24-in. plates is shown by the diagrams of Fig. 20. Three kinds of steel are reported for 72-in. and 48-in. plates, rimmed-steel E as-rolled, killed-steel D as-rolled, and killed-steel D normalized. These three and an additional steel, killed-steel F as-rolled, are reported for the 24-in. plates. In Figs. 19 and 20 the average impact values and the energy absorptions of the plates are for the same temperature in each instance.

The diagram of Fig. 19 indicates that, for the three steels there reported, there was a good correlation between the impact value and the energy-absorbing capacity of the 72-in. plates except for one rimmed-steel E as-rolled plate tested at a temperature above the transition temperature. The correlation was fair for the 48-in. plates made of three kinds of steel. Moreover, the correlation was fair for the 24-in. plates of rimmed-steel E as-rolled, killed-steel D as-rolled, and killed-steel D normalized, but not for the killed-steel F as-rolled, where the impact value for a given energy absorption was two to three times as great as it was for the other three steels tested. It would seem, therefore, that no correlation of the absolute value of the energy absorption of the V-notch impact test and of the wide plate test is possible.

d. Distribution Across Plate of Longitudinal Strain:- The distribution across the plate of the longitudinal strain was discussed on page 29 of the Final Report, OSRD No. 6457, Serial No. M-614, January 15, 1946. Similar studies were made during the tests described in this report. Diagrams showing the longitudinal strain at the transverse center-line, as measured with electric A-1 strain gages with a 13/16-in. gage length, with mechanical gages of 1-in. and 1/4-in. gage lengths, and with mechanical gages of a gage length equal to 3/4 W, are given in Appendix A, Figures 34a to 99a, inclusive. With the electric strain gages, measurements were made only in the elastic and early plastic range of the wide plate test. Measurements with the 1-in. and 1/4-in. mechanical gages were taken up to the load where the first cracks appeared at the ends of the stress-raiser. Measurements with the mechanical gage having a gage length of 3/4 W were taken at all loads including failure. As noted in the report referred to above, the maximum strain for the electric strain gages on a 13/16-in. gage length, which occurred at the outer end of the stress-raiser, was many times greater than the average strain over the whole width for elastic and early plastic strains. Also, as stated in the above mentioned report, the strain at the end of the stress-raiser was very much greater on a 1/4-in. gage length than it was on a 1-in. gage length for loads up to the load at which initial fracture at the end of the stress-raiser occurred. (See Appendix A, Figures 100a to 132a, inclusive).

The distortion at the end of the jeweler's-saw cut at loads from zero up to a load only slightly below the maximum, is shown by the photographs of Fig. 21. The plates were of killed-steel D normalized. The fracture began at mid-thickness of the plate and extended to the rolled surfaces, as shown in the upper part of Fig. 22. The initial fracture for a rimmed-steel E as-rolled plate with a 1/4-in. drill-hole stress-raiser, is shown in the lower part of the same figure. For this specimen also, the origin of the fracture was at the mid-thickness of the plate. Fracture in the other wide plate tests began in the same manner as in these two tests with the first crack appearing at the end of the stress-raiser at mid-thickness of the plate.

e. Reduction in Thickness of Plates:- The reduction in thickness of plates is described on page 32 of the Final Report, OSRD No. 6457, Serial No. M-614, January 15, 1946. The thickness measurements for the tests described in this report are given in Figures 133a to 166a, inclusive of Appendix A of this report.

4. Incidental Failures.

Two incidental failures occurred during the testing program which, although not planned, were of sufficient interest to justify their inclusion in this report. These are described in the following sections.

a. Fracture of a Pulling Plate Without Artificial Stress-Raisers:- In order to avoid the use of an unnecessary amount of the special steels being tested and still have a considerable distance between the pulling heads, two pulling plates were welded to a specimen, one at each end, as shown in the photograph of Fig. 23. These pulling plates for the 24-in. specimens were 24-in. x 7/8-in. steel in cross section and were without geometrical stress-raisers. The vertical edges of the two pulling plates had been sheared in a structural shop in a large single-stroke plate shears. A length of about 2 feet of each pulling plate extended beyond its bolted end connection. These 24-in. x 7/8-in. plates transmitted the load to the 24-in. specimens, which had an actual section of $23\frac{1}{2}$ in. x 3/4 in. reduced at the center by a stress-raiser to an actual net section of $17\frac{5}{8}$ in. x 3/4 in.

Specimen 13-9, a 24-in. rimmed-steel E as-rolled plate with a 1/4-in. drill-hole stress-raiser, was being tested at 88 degrees F. A very small amount of shear fracture had occurred at both ends of the stress-raiser just before the maximum load. At the maximum load, there occurred simultaneous fractures with a loud report of the upper pulling plate and of the wide plate specimen through the stress-raiser, as shown by the photograph of Fig. 24. The cleavage fracture of the pulling plate was complete and the simultaneous fracture of the specimen was complete except for a 5/8-in. width at the extreme left edge. The fracture of the specimen, which was shear prior to maximum load, changed to cleavage at maximum load. The average stress on the pulling plate corresponding to the maximum load was 28 300 lb. per sq. in. The corresponding average stress on the specimen with a severe geometrical stress-raiser was 45 100 lb. per sq. in. of net section.

A metallographic examination of the pulling plate indicated that it was an acceptable grade of semi-killed steel, and that the direction of tension in the pulling plate was normal to the direction of rolling. The pulling plate had been used for other tests but no record had been kept of their number. It is fair to assume that it had been used for six tests. That would mean that it had been subjected to not more than six severe shocks. Macrographs of the fracture showed a herring-bone pattern indicating that the origin of the fracture was at the left edge of the plate as shown in Fig. 24.

The location of V-notch impact, hardness, and tensile specimens is shown in Fig. 25. Various metallographic studies are reported in Figs. 26 and 27. The hardening effect as shown in Fig. 26 by the hardness gradient for Line 1 penetrated approximately 1/8 in. from the sheared surface. Figure 27 shows the microstructures of regions in Sec. B-B of Fig. 26 which showed plastic deformation and cracks due to the shearing operation. The impact tests of V-notched bars with their length transverse to the direction of rolling and notch normal to the rolled surfaces, gave an average value of 9.9 ft.lb. at 70 degrees F. The mechanical properties of the pulling plate material, as given by a static test of two 7/8-in. square coupon specimens, were as follows:

Ultimate Strength:	66 050 psi.
Yield Point:	34 300 psi.
Percent Elongation in 2 In:	46.4 %
Percent Reduction of Area:	49.7 %

b. Fracture of Narrow Strip of Killed-Steel F As-Rolled:- A test was made to determine the welding rod to be used with the killed-steel F as-rolled.* The specimen of Steel F was approximately 3 in. wide by 12 in. long parallel to the direction of rolling. One longitudinal edge was sheared and the other was flame-cut. Pulling plates of the same width as the specimen and each about 6 in. long, were welded to the specimen, thus producing a piece about 3 in. wide and 24 in. long with two transverse butt welds. A sketch of this specimen appears in Fig. 28. Inasmuch as the sole purpose of the test was to determine whether or not the welds were as strong as the plate, no measurements were taken of the plate before the test. The test was made at room temperature.

The photographs of Fig. 29(a) taken at an average stress of 63 600 lb. per sq. in., indicate that there was no evidence of impending failure on the flame-cut edge but that cracks were beginning to open up on the sheared edge. The photographs of Fig. 29(b) taken after failure at an average stress of 65 700 lb. per sq. in., show a large number of cracks on the sheared edge. No cracks in the flame-cut edge are apparent from the photograph but a careful examination of the specimen itself revealed minute cracks in a few of the deep transverse flame-cut grooves.

The effect of the sheared edge upon the character of the fracture is all the more interesting as the V-notch impact value of this steel at room temperature is of the order of 100 ft.lb.

* The mechanical and chemical properties are given in Appendix B.

CONCLUSIONS.

The results of the tests of wide plates 3/4 in. thick with severe stress-raisers described in this progress report appear to justify the following conclusions.

1. For any one width of wide plate and for the different steels tested, variations in temperature within the temperature ranges in which tests were made, did not have a significant effect upon the average strength of the wide plates with a jeweler's-saw cut type of stress-raiser and an $\frac{L}{W}$ ratio of 0.25 except as the temperature affected the character of the fracture. In general, plates that failed with a shear fracture or with a fracture that was partly shear and partly cleavage, had a somewhat greater average strength than similar plates that failed with a cleavage fracture.

2. For 72-in. wide plates with a jeweler's-saw cut type of stress-raiser and an $\frac{L}{W}$ ratio of 0.25, the average strength of the plates was generally somewhat greater than the coupon yield-point strength of the material.

3. For wide plates with a jeweler's-saw cut type of stress-raiser and an $\frac{L}{W}$ ratio of 0.25, the average strength for the same type of fracture increased as the width of the plate decreased from 72 in. to 12 in.

4. The average strength of wide plates was somewhat greater for killed-steel D as-rolled, killed-steel D normalized, and killed-steel F as-rolled than for rimmed-steel E as-rolled, where all wide plates were of the same width. The first three steels mentioned had approximately the same average strength for wide plates of the same width.

5. For 24-in. rimmed-steel E as-rolled wide plates tested at temperatures of -40 and 90 degrees F. and with three different types of stress-raisers, and an $\frac{L}{W}$ ratio of 0.25, the average strength increased with a decrease in the severity of the stress-raiser. The severity of the stress-raiser decreased in the following order: the jeweler's-saw cut, the No. 47 drill hole, and the 1/4-in. drill hole.

6. The energy-absorbing capacity to either maximum load or failure of the wide plates with severe stress-raisers was many times greater under conditions that produced a shear-type fracture than it was under conditions that produced a cleavage-type fracture. The type of fracture appears to be a dependable indication of the energy-absorbing capacity of the wide plate.

7. When in the form of wide plates with severe stress-raisers, all of the steels tested except steel F as-rolled had a low-energy-absorbing capacity at the sub-zero temperatures which may be encountered in ship navigation.

8. In the tests of 24-in. rimmed-steel E as-rolled plates with two types of stress-raisers, the jeweler's-saw cut and the No. 47 drill hole, there was no apparent relation between the energy absorption to failure per inch of plate net width and the $\frac{L}{W}$ ratio, which varied from 0.125 to 0.75.

9. Tests of 24-in. rimmed-steel E as-rolled plates with three types of stress-raisers, the jeweler's-saw cut, the No. 47 drill hole, and the 1/4-in. drill hole, and all with an $\frac{L}{W}$ ratio of 0.25, showed that the energy absorption to failure increased with a decrease in the severity of the stress-raiser.

The severity of the stress-raiser decreased in the following order: the jeweler's-saw cut, the No. 47 drill hole, and the 1/4-in. drill hole.

10. For wide plates with a jeweler's-saw cut type of stress-raiser made from the steels tested in this program, the V-notch impact test gave an approximate indication of the transition temperature of the wide plate for the change of the mode of fracture from a cleavage to a shear type of fracture. The V-notch impact test also segregated the different kinds of steel tested with respect to transition temperature in the same order as the wide plate tests.

11. It appears that no correlation exists between the absolute values of the energy absorbed by the V-notch impact test and by the wide plate test with a jeweler's-saw cut type of stress-raiser.

12. The unit strain at the end of the stress-raiser was many times greater than the average strain over the net section for loads up to the load where fracture started. This was true for both the elastic and the plastic strains.

13. Most of the elongation near the end of the stress-raiser occured on a 1/4-in. gage length for loads up to the load where fracture started.

14. The fracture of all the wide plates started at the end of the stress-raiser at the mid-thickness of the plate.

RECOMMENDATIONS FOR FUTURE WORK:- Plans for future work include a group of tests to give more complete knowledge relative to the relation between the temperature of steel plates and their energy-absorbing capacity. The curve showing the relation between the temperature and the energy-absorbing capacity of steel plates is made up of three parts: (1) A nearly horizontal portion at the left, which corresponds to a low-energy-absorbing capacity. (2) A nearly horizontal portion at the right, which corresponds to a high energy-absorbing capacity. (3) A nearly vertical transition portion connecting (1) and (2). The tests necessary to define the three parts of this diagram for 12-in. and 72-in. plates of rimmed-steel E as-rolled, killed-steel D as-rolled, and killed-steel D normalized, will be made under the present contract.

Considerable work has already been done to establish the temperature energy-absorbing capacity of 24-in. and 48-in. plates made of the three steels designated above but time will not permit the completion of this work. It is desirable that the necessary tests be made to complete the temperature -energy-absorbing curves for 24-in. and 48-in. plates of the three kinds of steel, rimmed-steel E as-rolled, killed-steel D as-rolled, and killed-steel D normalized.

Acknowledgment.

The members of the engineering staff, who aided in the experimental work in this Progress Report, were as follows:

W. F. Lytle

W. J. Craig

J. S. Dobrovolny

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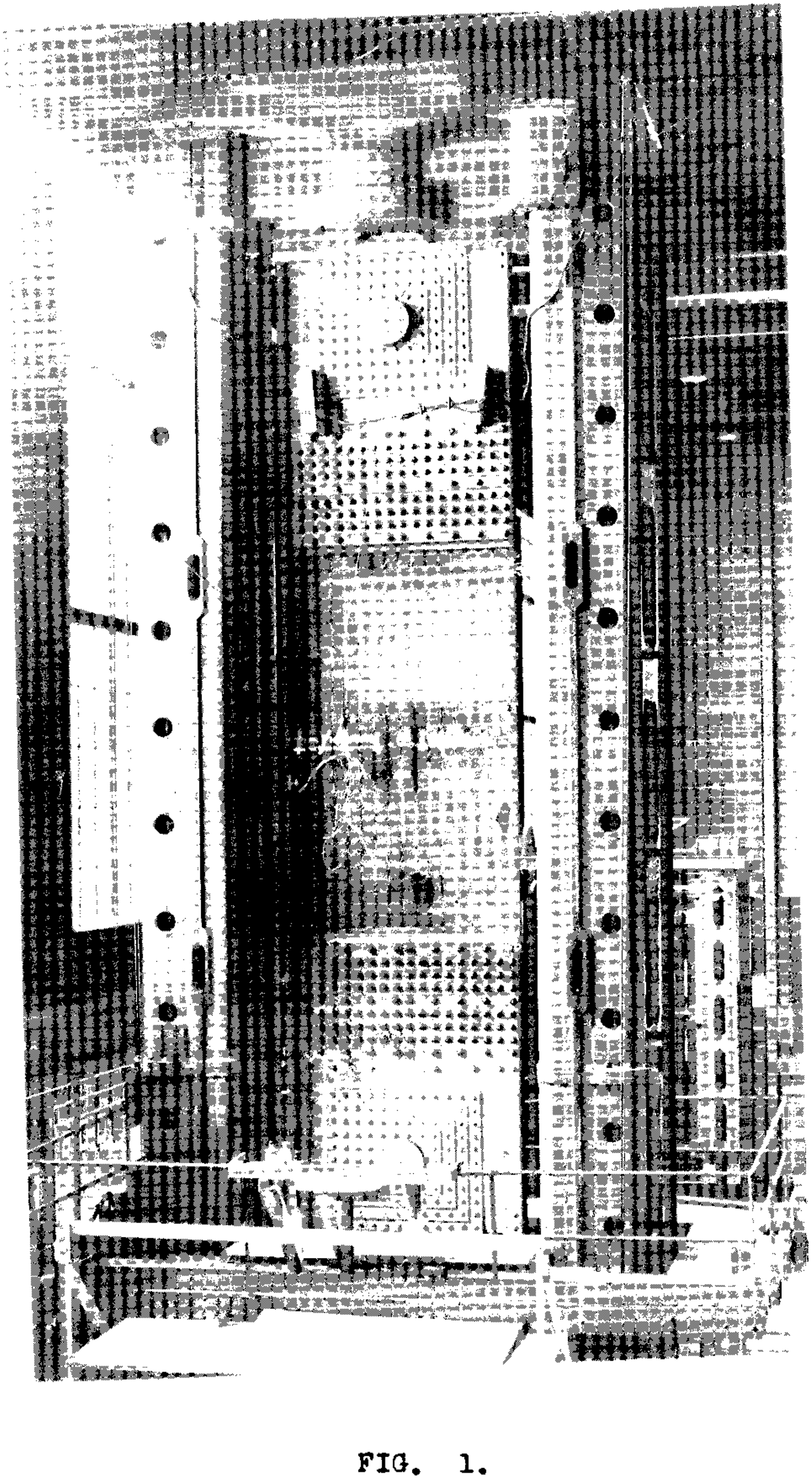


FIG. 1.

72-IN. SPECIMEN IN 3 000 000-LB. TESTING MACHINE.

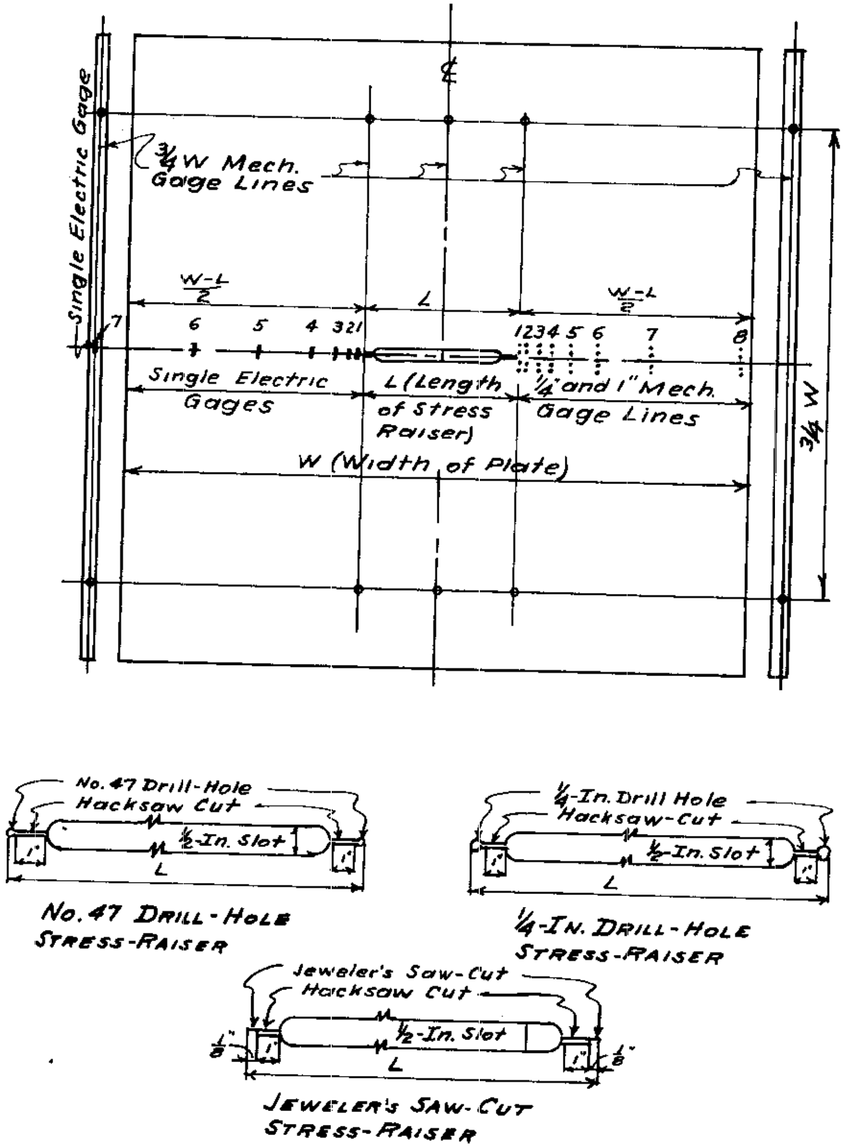
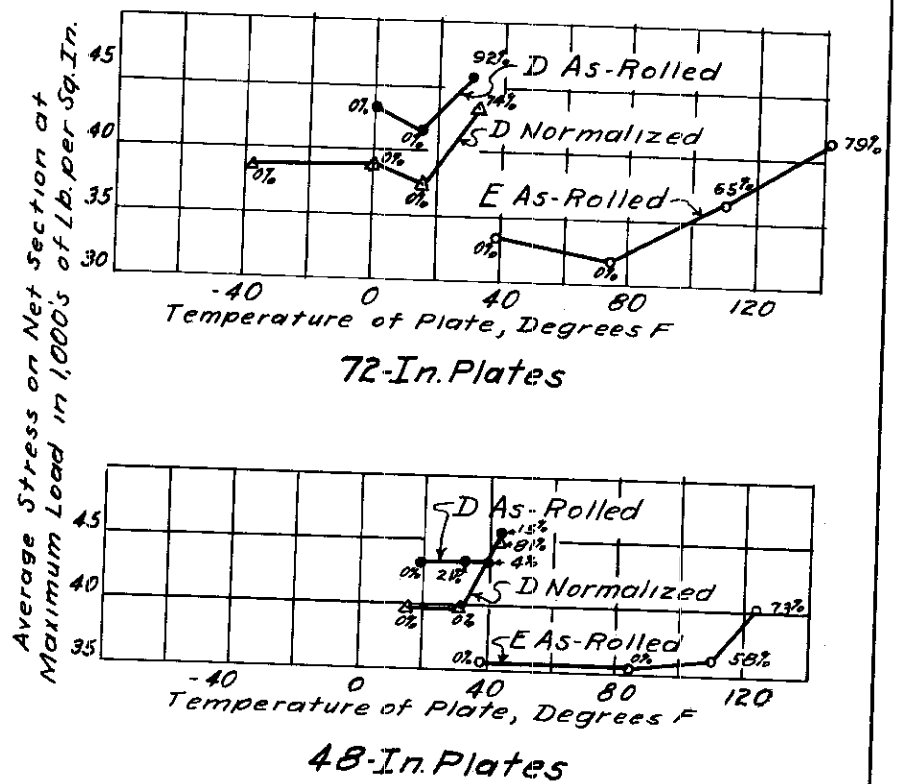
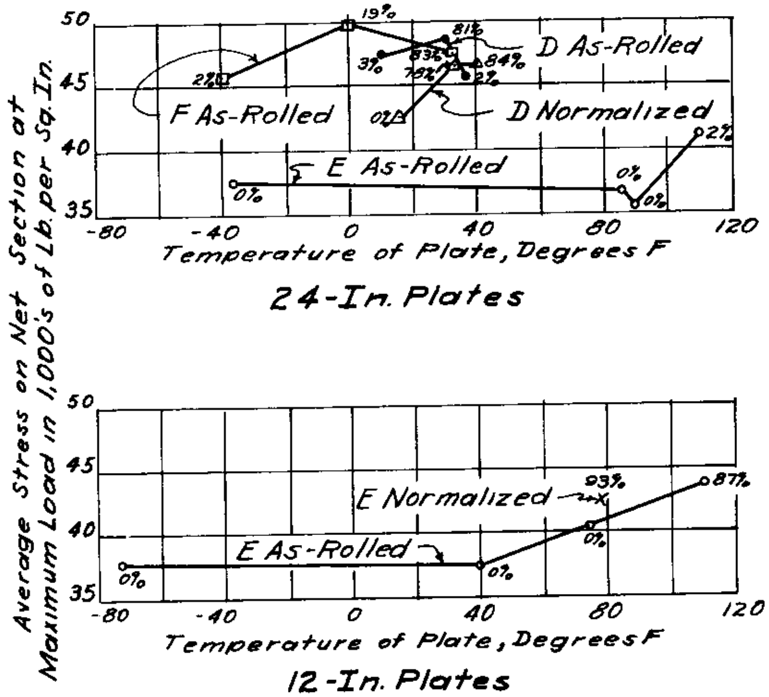


FIG. 2 SKETCH OF WIDE PLATE SPECIMENS AND THREE TYPES OF STRESS-RAISERS



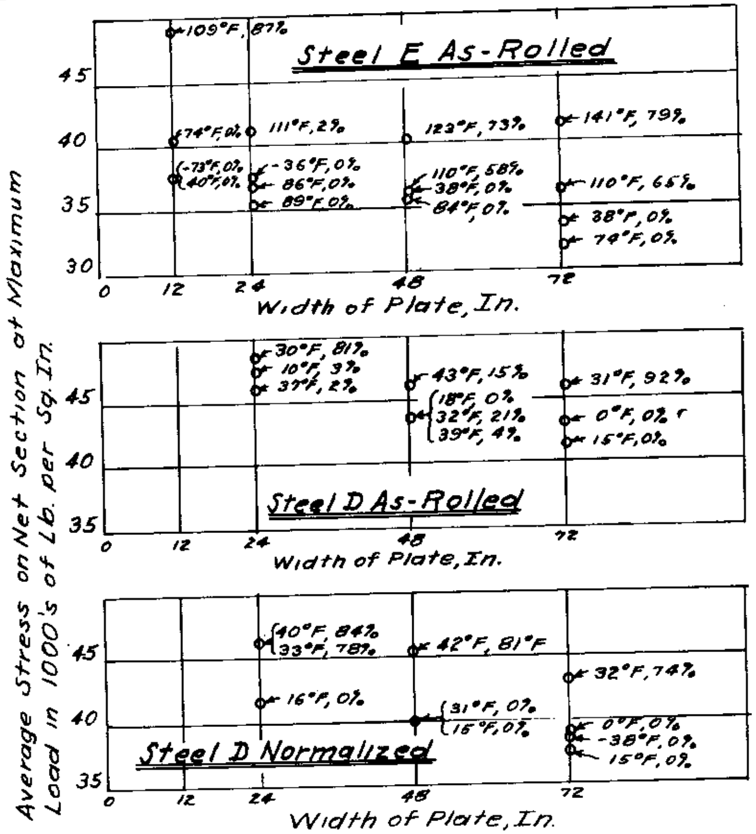
Numerals beside points indicate percentage of shear fracture

Fig. 3
Comparison of Average Strength of Wide Plates and Temperature
Stress-Raiser: Jeweler's-Saw Cut, $L/W=0.25$
72-In. and 48-In. Plates



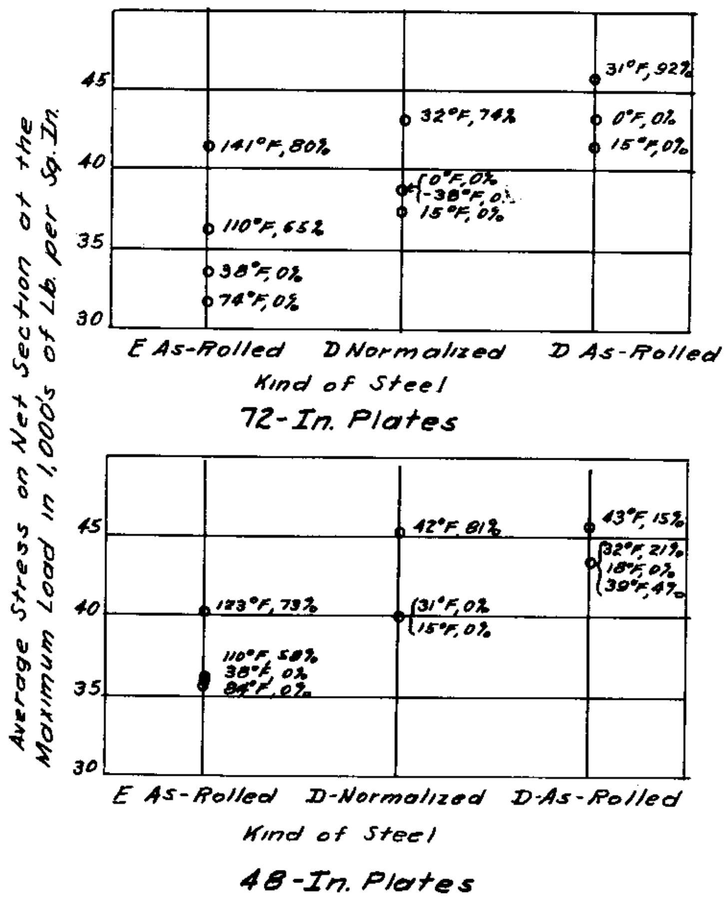
Numerals beside points indicate percentage of shear fracture

Fig. 4
Comparison of Average Strength of Wide Plates and Temperature Stress-Raiser: Jeweler's-Saw Cut, $L/W = 0.25$ 24-In. and 12-In. Plates



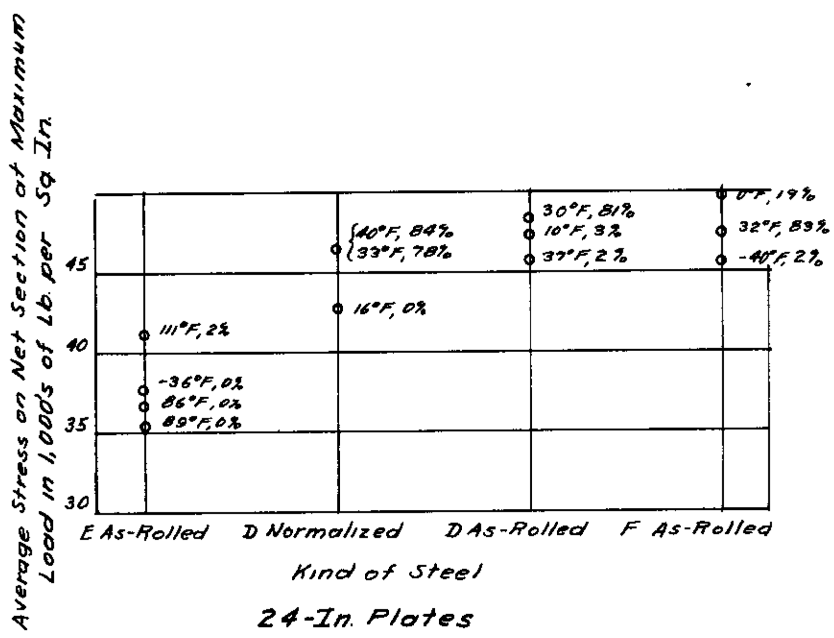
Note: Numerals beside points indicate temperature of test and percentage of shear fracture

Fig. 5
Comparison of Average Strength and Width of Wide Plates. Jeweler's-Saw Cut Stress-Raiser. $L/W = 0.25$. Steels: D As-Rolled, E As-Rolled, D Normalized



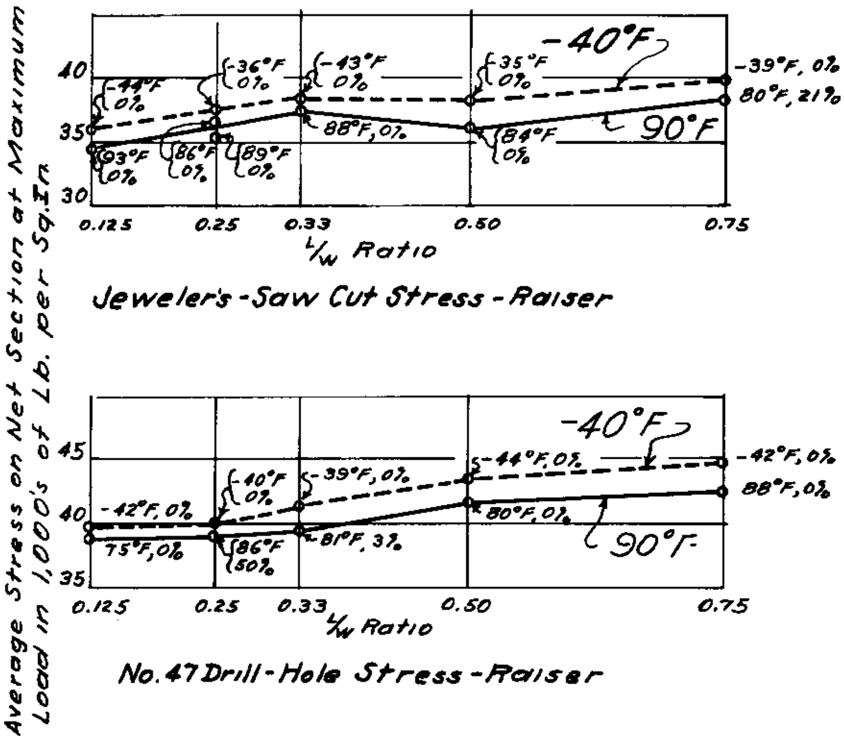
Note: Numerals beside points indicate temperature of test and percentage of shear fracture

Fig. 6
Average Strength of Three Kinds of Steel
72-In. and 48-In. Plates



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

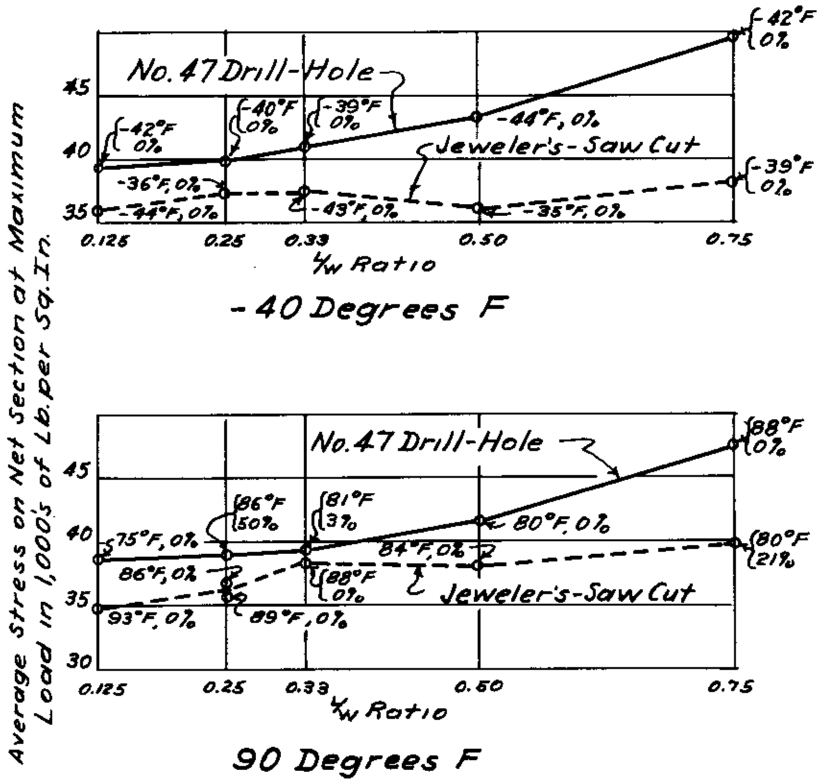
Fig. 7
Average Strength of Three Kinds of Steel
24-In. Plates



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

Fig. 8

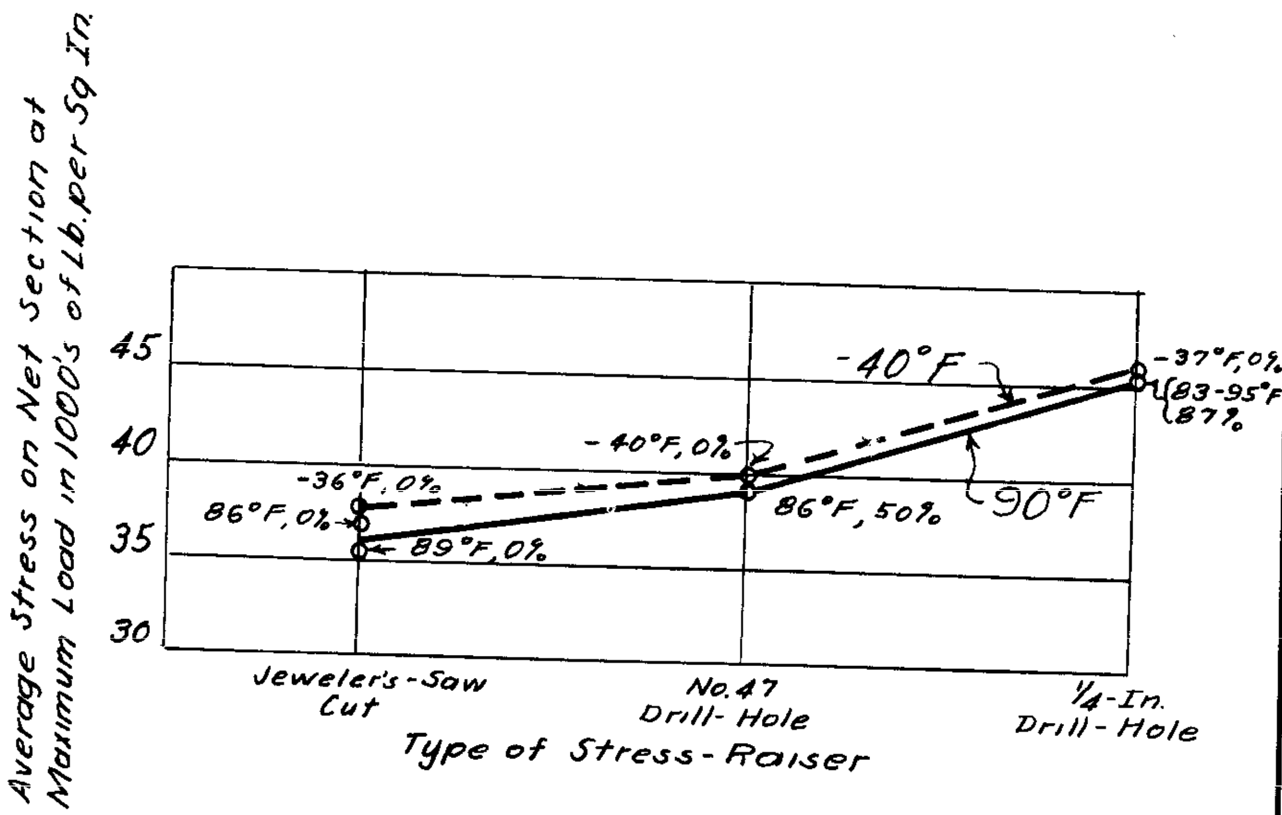
Comparison of Average Strengths of Plates Tested at Two Temperatures, -40 and 90 Degrees F, for Various L/W Ratios. 24-In. Steel E As-Rolled Plates With Two Types of Stress-Raisers.



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

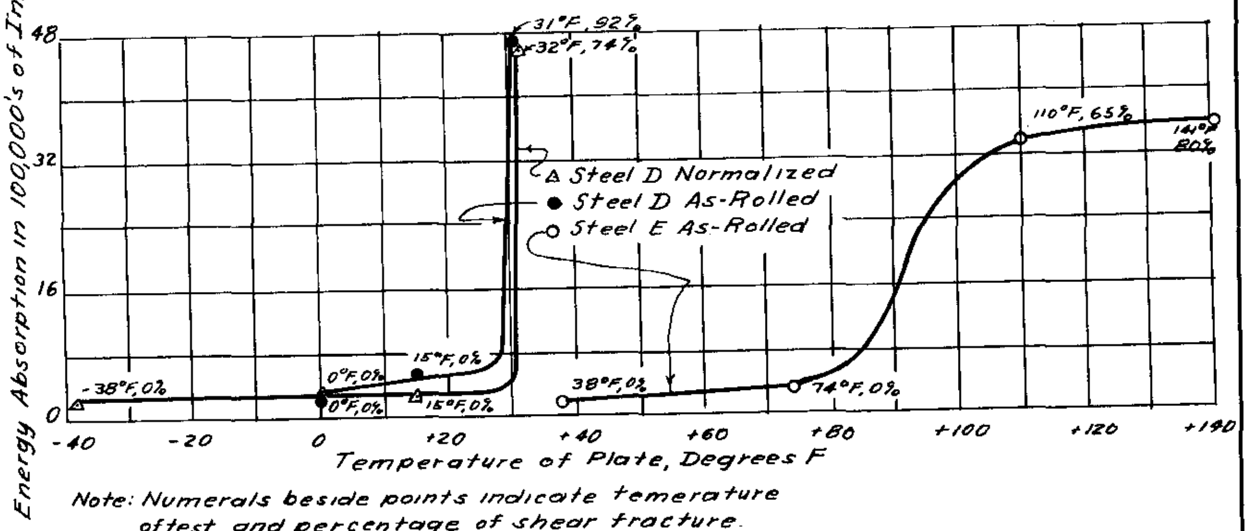
Fig. 9

Comparison of Average Strengths of Plates with Two Types of Stress-Raisers, Jeweler's-Saw Cut and No.47 Drill-Hole, for Various L/W Ratios. 24-In. Steel E As-Rolled Plates.



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

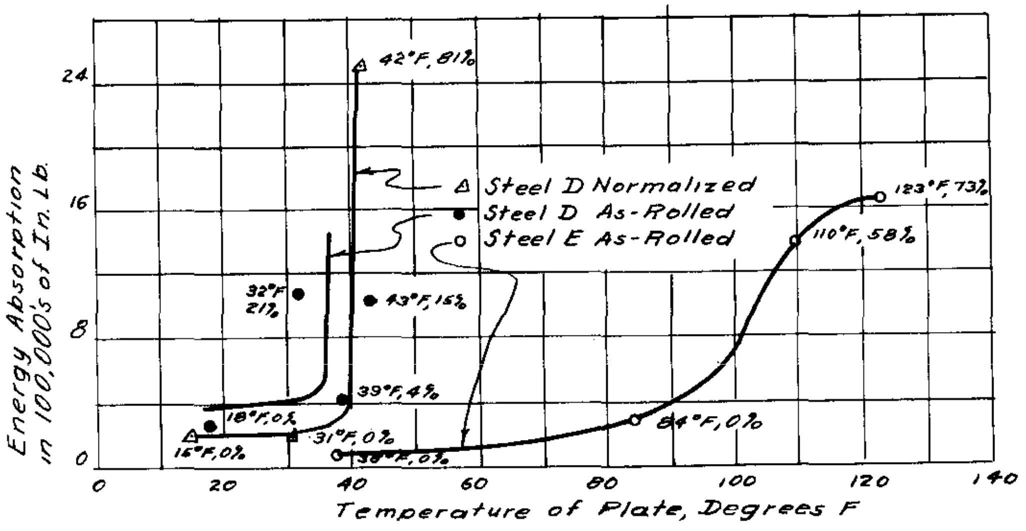
Fig. 10
Average Strength of 24-In. Steel E As-Rolled Plates. Three Types of Stress-Raisers $l/w = 0.25$.



Note: Numerals beside points indicate temerature of test and percentage of shear fracture.

Fig. 11

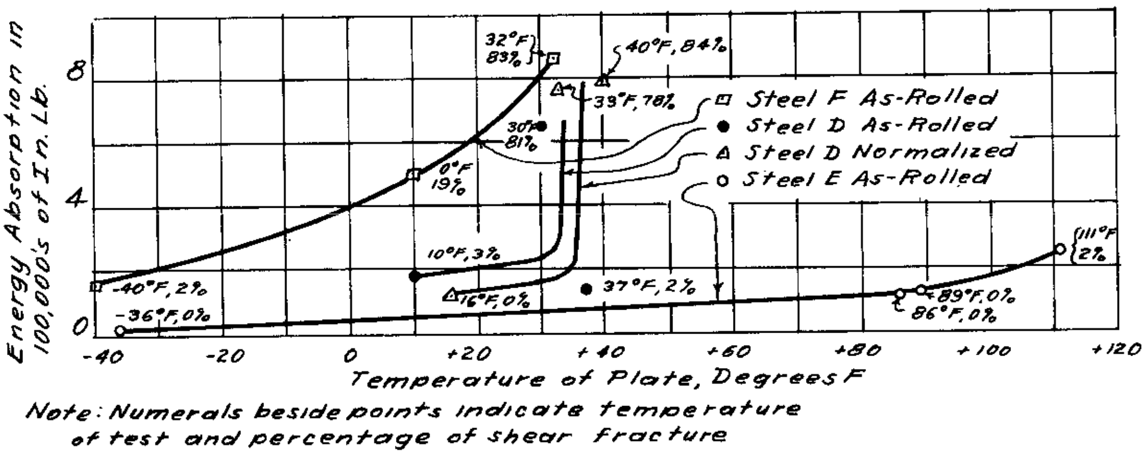
Comparison of Energy Absorption to Failure and Temperature of Test. 72-In. Plates. L/W = 0.25, Jeweler's-Saw Cut Stress-Raiser



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

Fig. 12

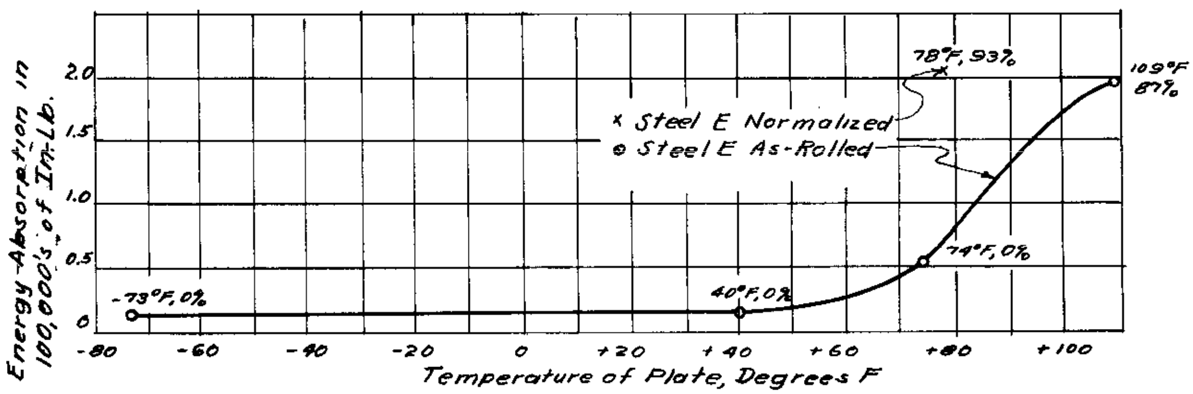
Comparison of Energy Absorption to Failure and Temperature of Test. 48-In. Plates. L/W = 0.25, Jeweler's-Saw Cut Stress-Raiser



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

Fig. 13

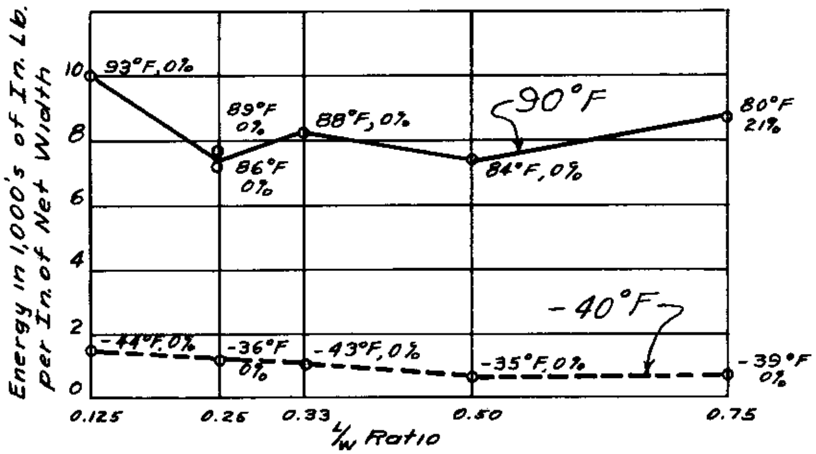
Comparison of Energy Absorption to Failure and Temperature of Test. 24-In. Plates. L/W = 0.25, Jeweler's-Saw Cut Stress-Raiser



Note: Numerals beside points indicate temperature of test and percentage of shear fracture.

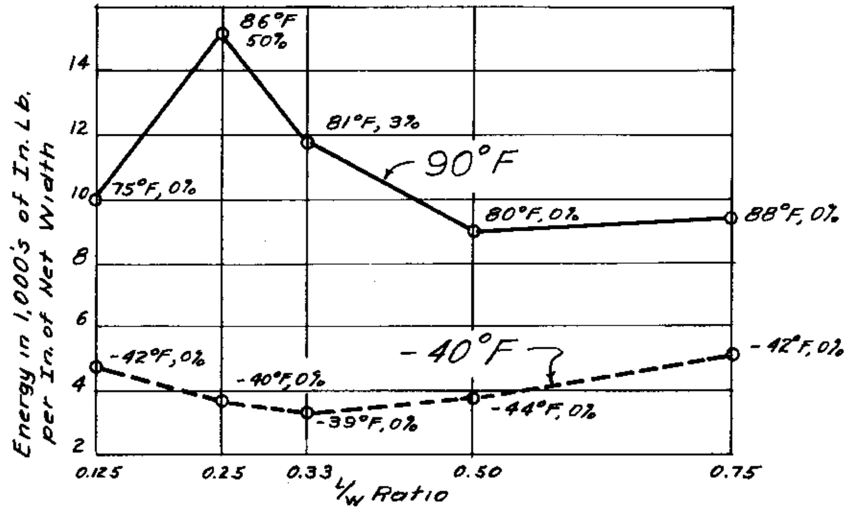
Fig. 14

Comparison of Energy Absorption to Failure and Temperature of Test. 12-In. Plates. L/W = 0.25, Jeweler's-Saw Cut Stress-Raiser



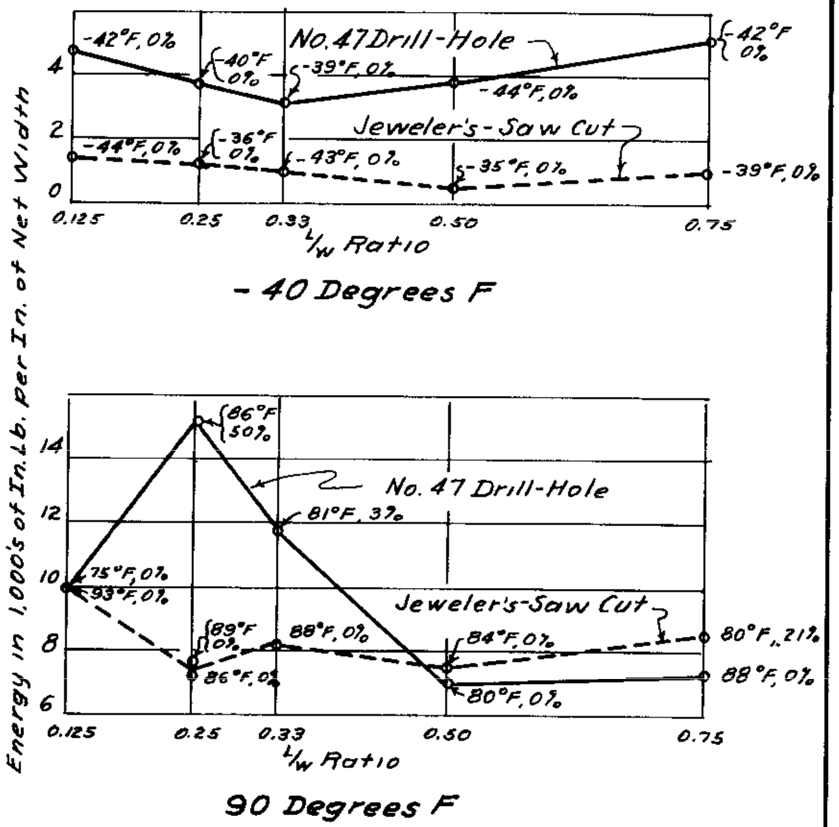
Note: Numerals beside points indicate temperature of test and percentage of shear fracture

Fig. 15
Comparison of Energy Absorption to Failure and L/W Ratio. 24-In. Steel E As-Rolled Plates with Jeweler's-Saw Cut Stress-Raiser at -40 and 90 Degrees F



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

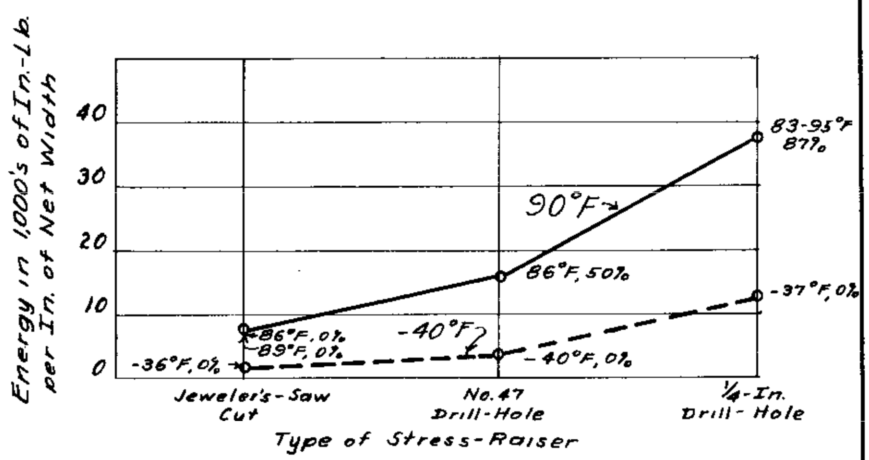
Fig. 16
Comparison of Energy Absorption to Failure and L/W Ratio. 24-In. Steel E As-Rolled Plates with No. 47 Drill-Hole Stress-Raiser at -40 and 90 Degrees F



Note: Numerals beside points indicate temperature of test and percentage of shear fracture.

Fig. 17

Comparison of Energy Absorptions to Failure of Plates with Two Types of Stress-Raisers, Jeweler's-Saw Cut and No.47 Drill-Hole for Various L/W Ratios. 24-In. Steel E As-Rolled Plates.



Note: Numerals beside points indicate temperature of test and percentage of shear fracture

Fig. 18

Energy Absorption to Failure of 24-In. Steel E As-Rolled Plates. Three Types of Stress-Raisers. L/W = 0.25

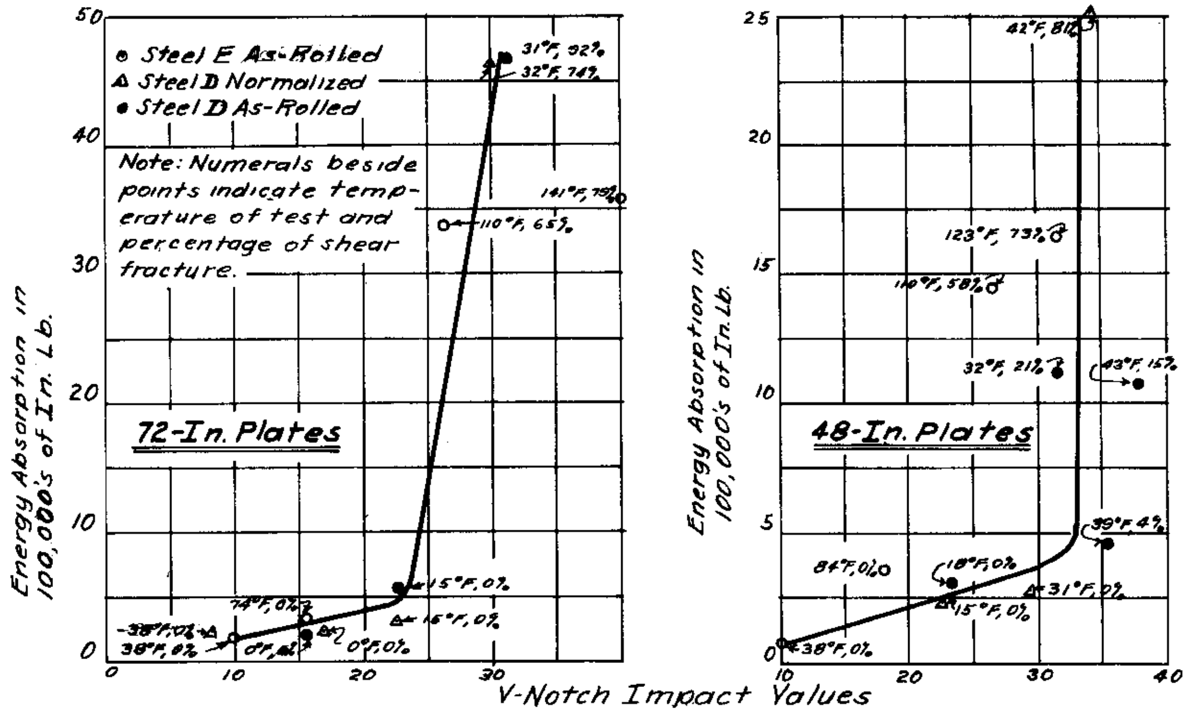


Fig. 19

Comparison of Energy Absorption to Failure and V-Notch Impact Value for 72-In. and 48-In. Plates. L/W = 0.25. Jeweler's-Saw Cut Strees-Raiser

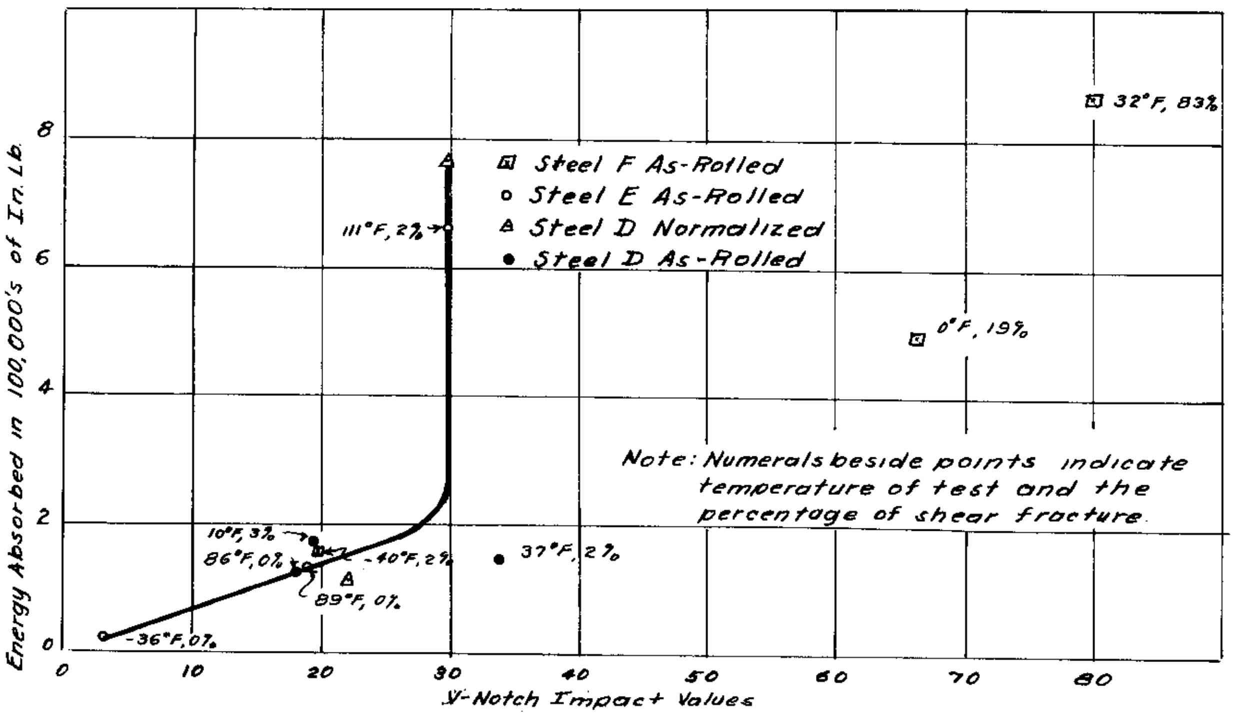
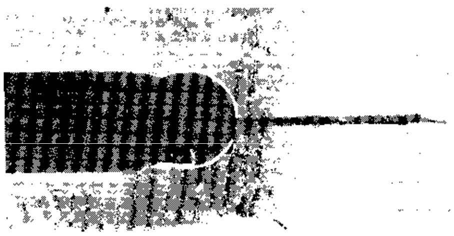


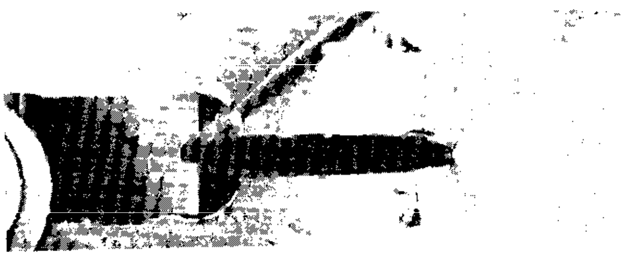
Fig. 20

Comparison of Energy Absorption to Failure and V-Notch Impact Values for 24-In. Plates L/W = 0.25. Jeweler's-Saw Cut Stress-Raiser



(No Stress)

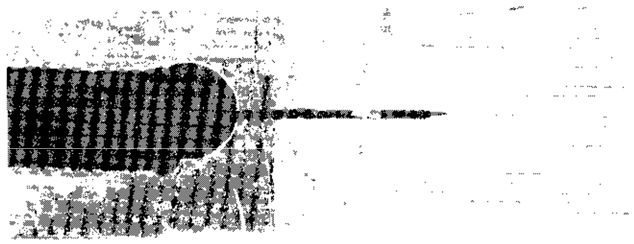
(40 000 psi.)



(41 800 psi.)

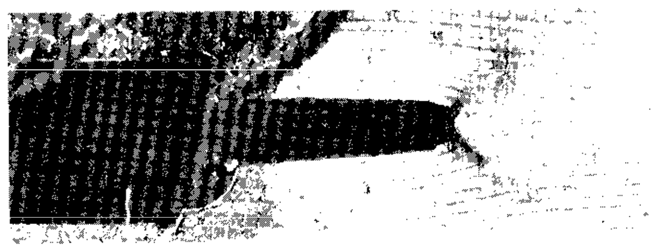
Specimen 3-3
Temperature 16° F.
Cleavage Fracture

Average Stress on Net Section
at Maximum Load 42 800 psi.



(No Stress)

(42 000 psi.)



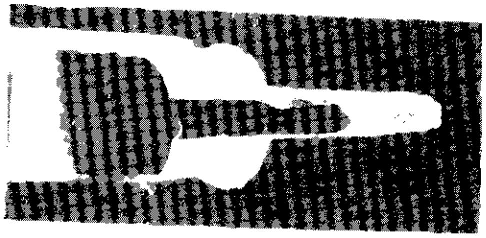
(44 000 psi.)

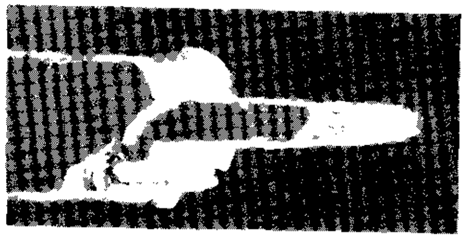
Specimen 3-2
Temperature 33°F.
Shear Fracture With
Slight Cleavage

Average Stress on Net Section
at Maximum Load 46 300 psi.

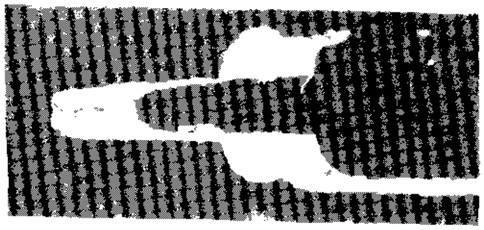
FIG. 21.

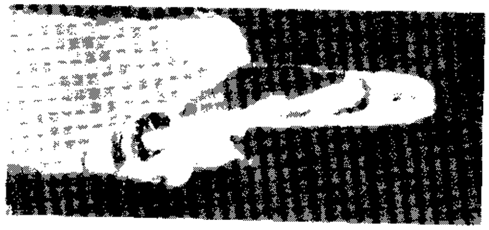
DISTORTION AT END OF JEWELER'S-SAW CUT STRESS-RAISER.
24-IN. KILLED-STEEL D NORMALIZED PLATES, L/W = 0.25
STRESS ON NET SECTION INDICATED.





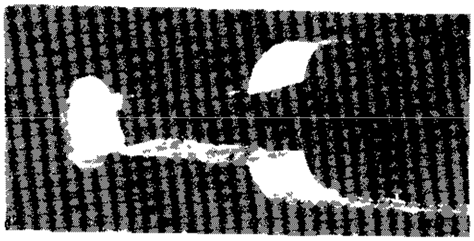
West (42 000 psi.) East



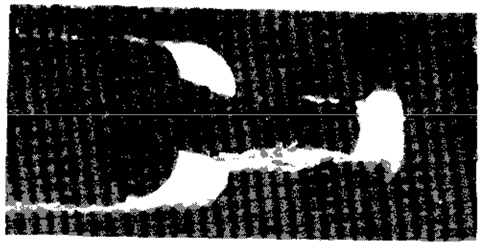


West (44 000 psi.) East

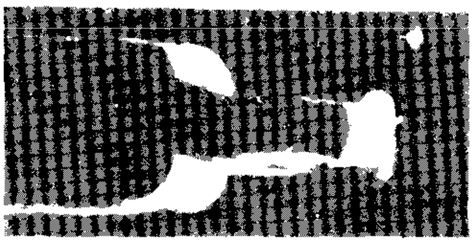
Jeweler's-Saw Cut Stress-Raiser, Specimen 3-2
Killed-Steel D Normalized at 33° F.
Average Stress on Net Section at Maximum Load 46 300 psi.



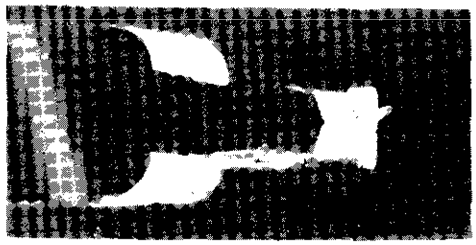
West
(43 800 psi.)



East
(44 800 psi.)



East
(45 000 psi.)



East
(44 600 psi. after
max. load of 45 400 psi.)

1/4-In. Diameter Drill-Hole Stress-Raiser, Specimen 22A-9
Rimmed-Steel E As-Rolled at 83° F. to 95° F.
Average Stress on Net Section at Maximum Load 45 400 psi.

FIG. 22.
PROPOGATION OF CRACK AT ENDS OF STRESS-RAISER.
24-IN. PLATES. L/W = 0.25.
STRESS ON NET SECTION INDICATED.

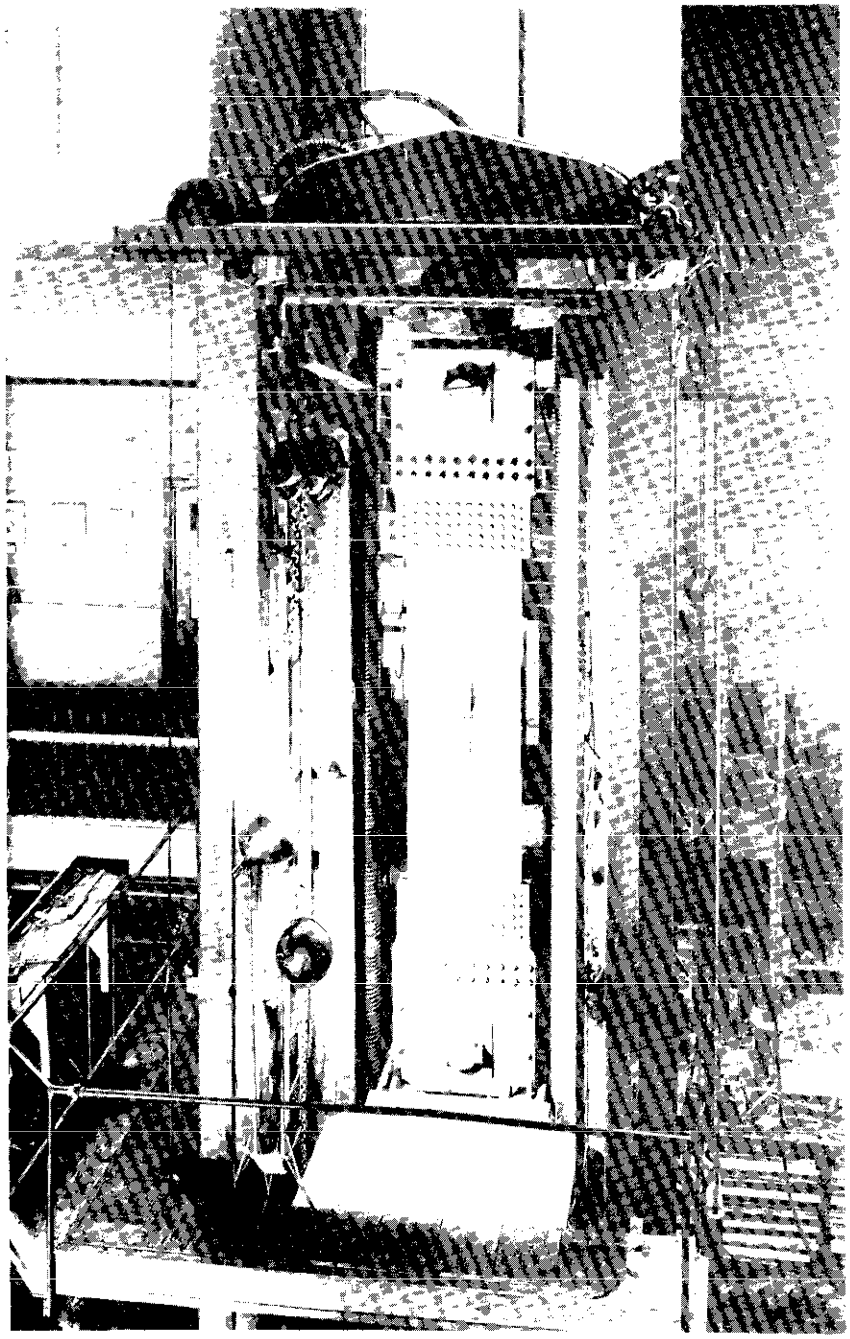


FIG. 23.
24-IN. SPECIMEN IN 600 000-LB. TESTING MACHINE.

Average Stress at Failure in Pulling Plate: 28 300 psi.
(Temperature 88° F.)

FIG. 24.

SOUTH ELEVATION OF 24-IN. x 7/8-IN. SEMI-KILLED STEEL PULLING PLATE AND SPECIMEN 13-9.

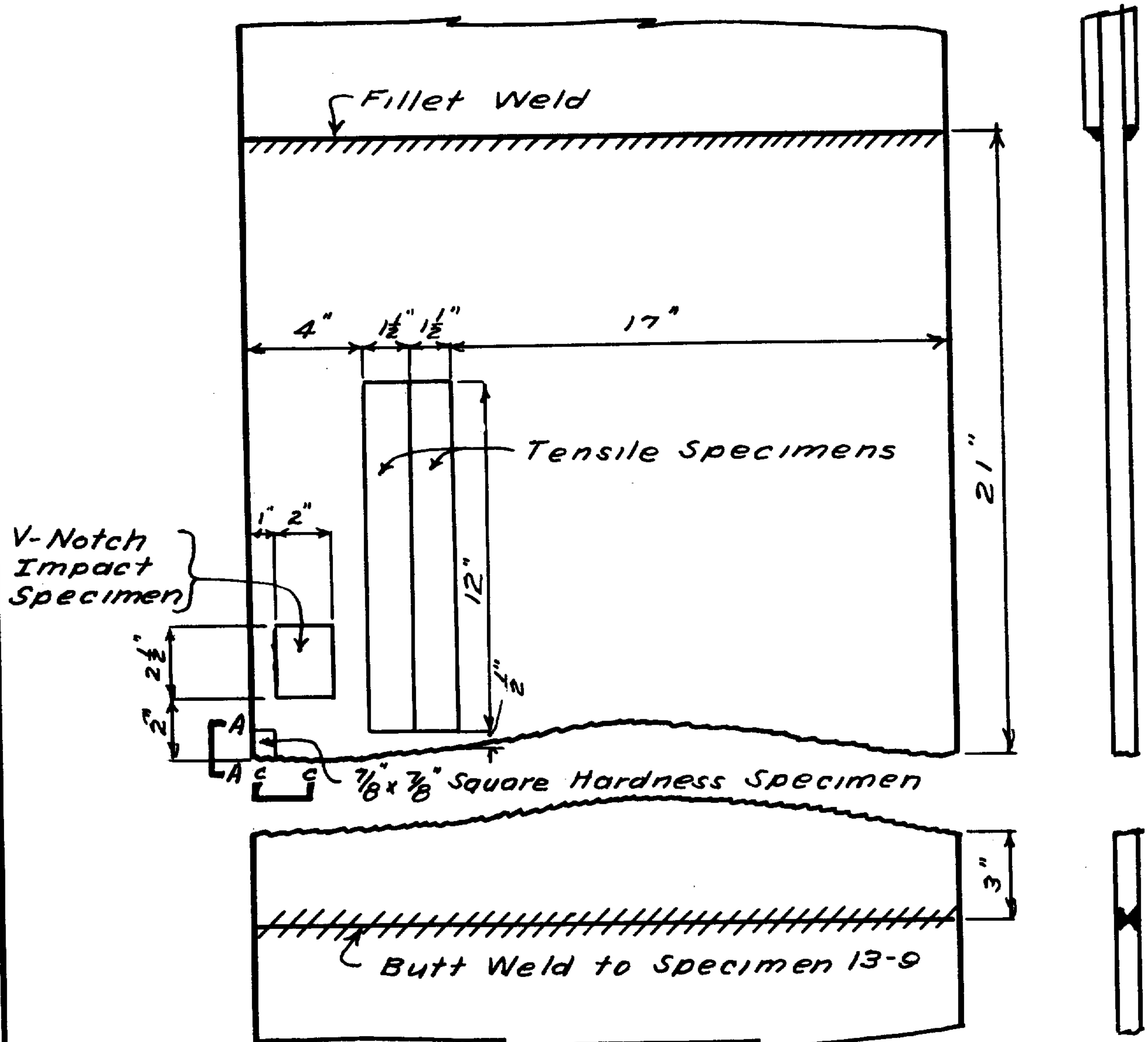
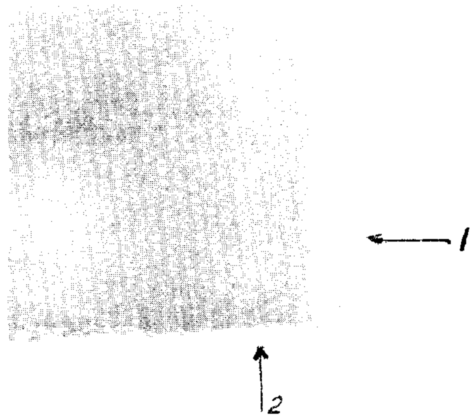


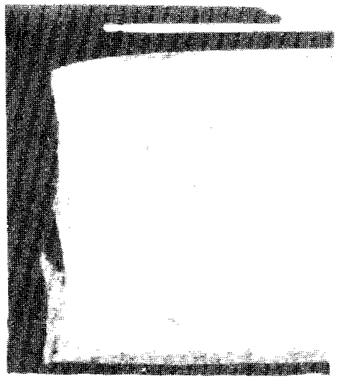
Fig. 25
Location of V-Notch Impact, Hardness, and Tensile Specimens Taken from Pulling Plate.

View AA of Fig. 25 showing Section B-B used for micro-examination and hardness surveys. Fracture is along bottom edge, sheared edge of plate faces reader. Original magnification $2\frac{1}{4}$x.

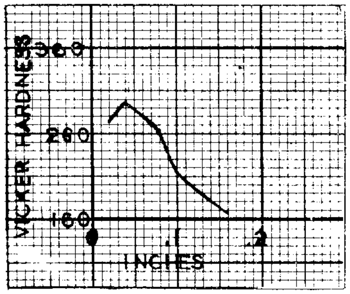


Section B-B. Polished surface etched with 5% Nital. The fracture is along bottom edge, sheared edge at right side which appears white. Location of hardness surveys shown by arrows. Original magnification $2\frac{1}{4}$x.

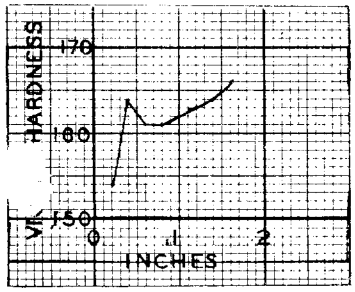
Photographs reduced 1/4 in reproduction.



View C-C of Fig. 25 before Section B-B was cut. The fracture surface faces reader, sheared edge is at left side. Original magnification $2\frac{1}{4}$x.



Vickers hardness gradient from sheared edge to base plate along line 1 of Section B-B approx. $\frac{1}{4}$ inch from fracture.



Vickers hardness gradient from fracture to base plate along line 2 of Section B-B approx. $\frac{1}{4}$ inch from sheared edge.

Fig. 26 Macrographs and Hardness Surveys of Fractured Pulling Plate.

Photographs reduced 1/4 in reproduction.

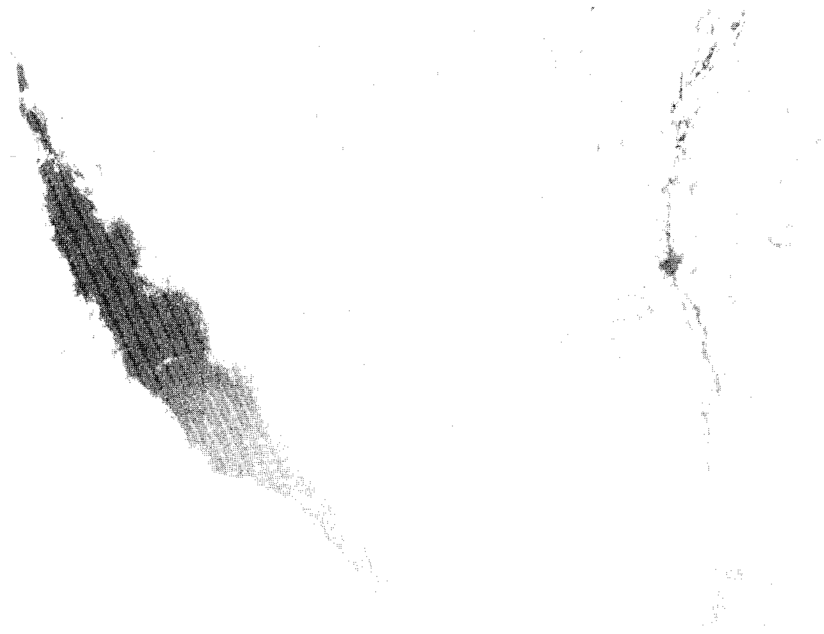


Fig. 27 . Microstructures of regions in Section B-B which showed plastic deformation and cracks at the junction of sheared edge and base metal. Original magnification 100x.

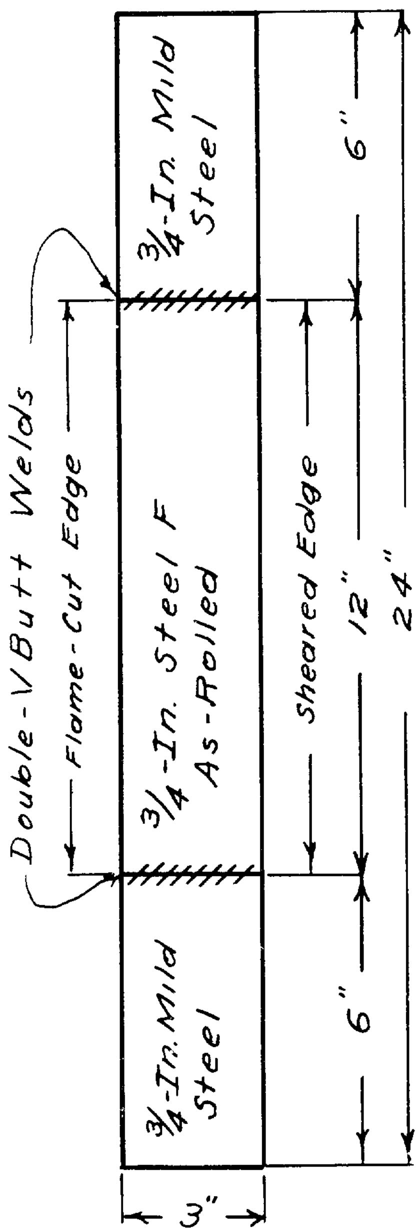
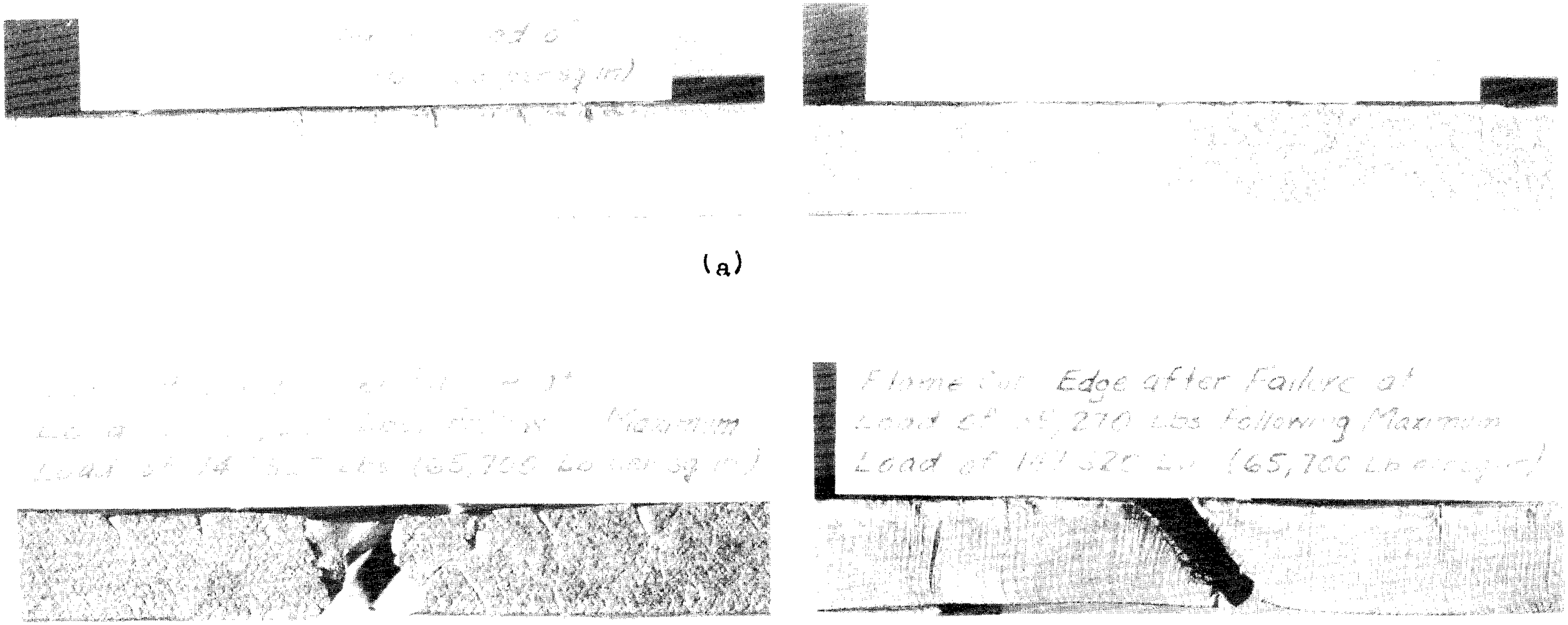


Fig. 28
Sketch of Specimen Made from Killed Steel F As-Rolled



(a)

(b)

FIG. 29

FAILURE OF SHEARED AND FLAME-CUT EDGES AT ROOM TEMPERATURE.
TENSILE SPECIMEN. KILLED-STEEL F AS-ROLLED.

APPENDIX A.

EXPERIMENTAL DATA FROM WIDE PLATE TESTS.

From:

University of Illinois
College of Engineering

Report Prepared by:

Wilbur M. Wilson
Robert A. Hechtman
Walter H. Bruckner

LIST OF DATA

Data for the tests listed in Tables I to VI of the body of this Progress Report and not included in Appendix A, are contained in Appendix A of the Final Report, OSRD No. 6457, Serial No. M-614, January 15, 1946.

APPENDIX A.

EXPERIMENTAL DATA FROM WIDE PLATE TESTS.

ABSTRACT

Experimental data from the wide plate tests described in this report are given in the following pages.

DESCRIPTION OF SPECIMENS.

All of the specimens, the tests of which are described in this Progress Report, are described in Tables I and II, pages 5, 6, and 7, respectively.

RELATION BETWEEN LOAD AND AVERAGE ELONGATION ON A GAGE LENGTH EQUAL TO 3/4 W.

The relation between total load and average elongation on a gage length equal to three-quarters of the width of the specimen, is shown for all specimens in Figures 1a to 33a, inclusive. The area under the total load-average elongation curve is the energy absorbed by the specimens.

STRAIN DISTRIBUTION ACROSS PLATE ON GAGE LENGTH EQUAL TO 3/4 W.

The strain distribution across the plate as measured by mechanical strain gages on a gage length equal to three-quarters of the actual width of the specimens is shown in Figures 34a to 66a, inclusive, for the tests described in this report.

STRAIN DISTRIBUTION ACROSS PLATE FROM ELECTRIC STRAIN GAGES.

The strain distribution across one-half of the plate as measured by SR-4 electric strain gages is shown in Figures 67a to 99a, inclusive, for the tests described in this report. All electric strain gages had a gage length of 13/16 in., except one gage of 1/4-in. gage length located next to the stress-raiser on 24-in. specimens. Strain readings with the electric strain gages were taken only in the elastic and early plastic ranges of the specimen.

PLASTIC DEFORMATION ACROSS PLATE ON 1/4-IN. AND 1-IN. GAGE LENGTHS.

The plastic strain distribution across one-half of the plate as measured on 1/4-in. and 1-in. gage lengths by mechanical strain gages is shown in Figures 100a to 132a, inclusive, for the tests of this report. These mechanical gage readings were taken up to the load at which the initial crack at the end of the stress-raiser appeared.

THICKNESS OF PLATE AT FRACTURE.

The thickness and profile of the plate at the fractured edge is shown in Figures 133a to 166a, inclusive, for the specimens of this report.

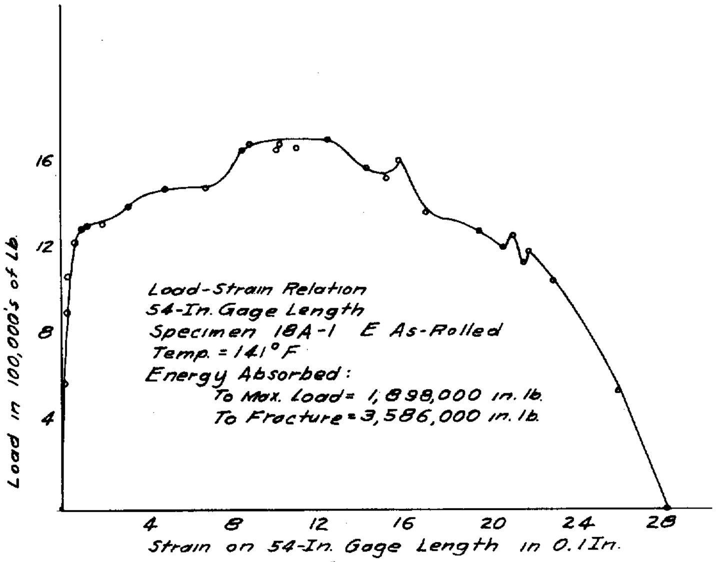


Fig. 1a.

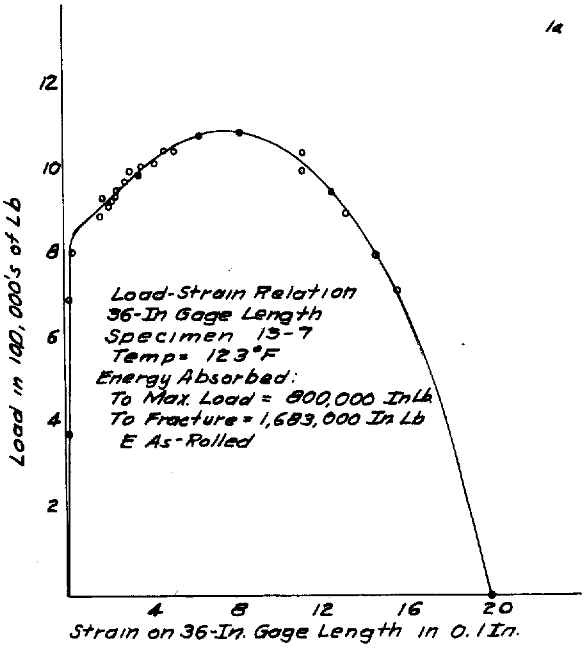


Fig. 2a.

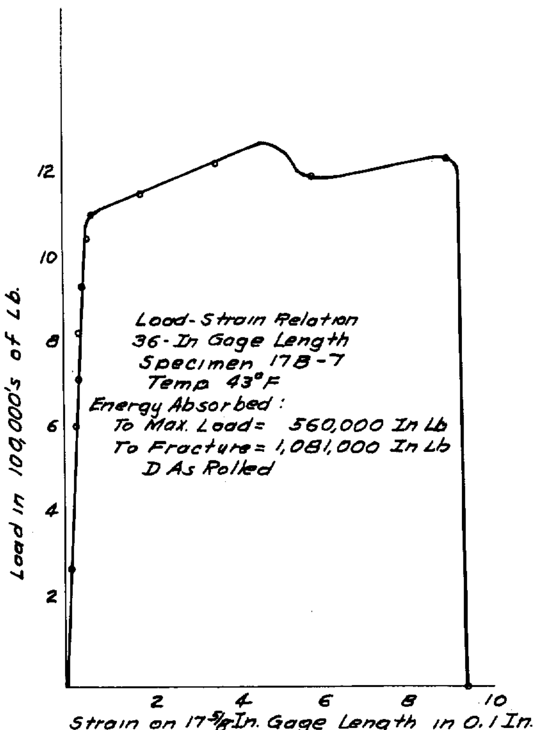


Fig. 3a.

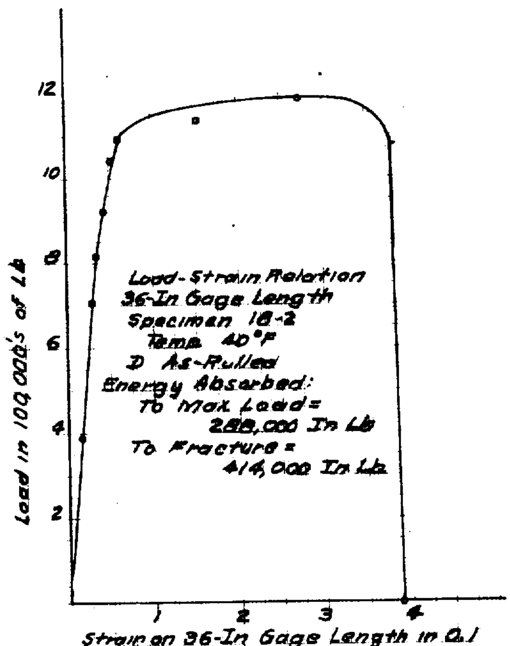


Fig. 4a.

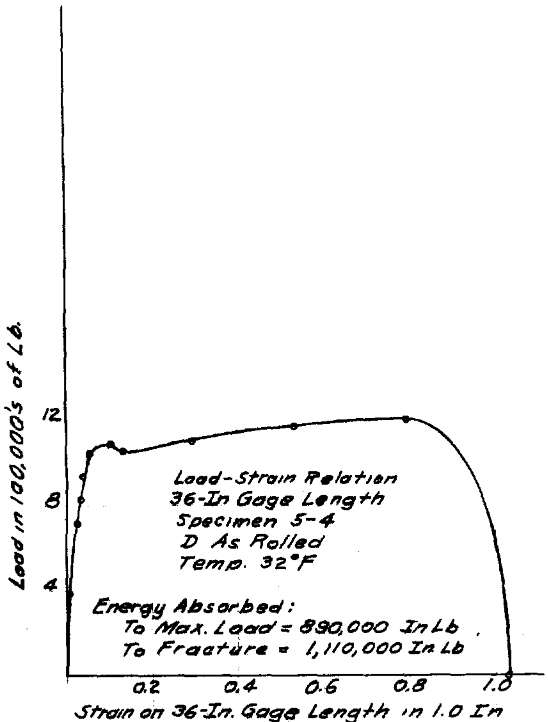


Fig. 5a.

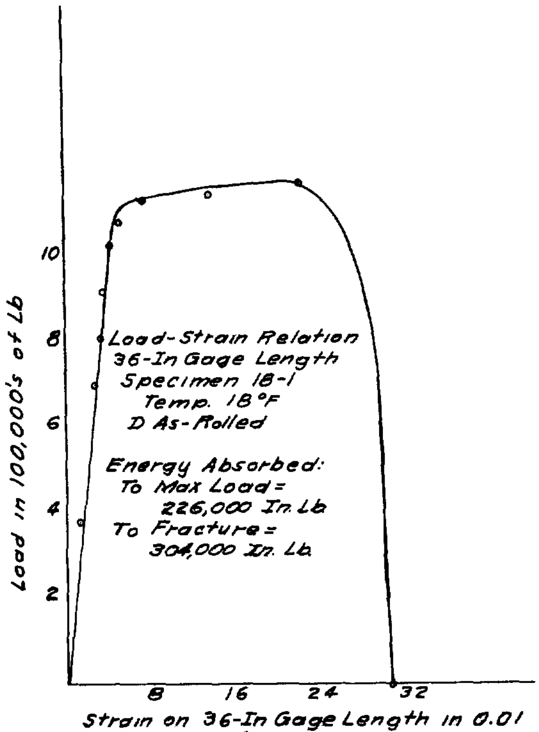


Fig. 6a.

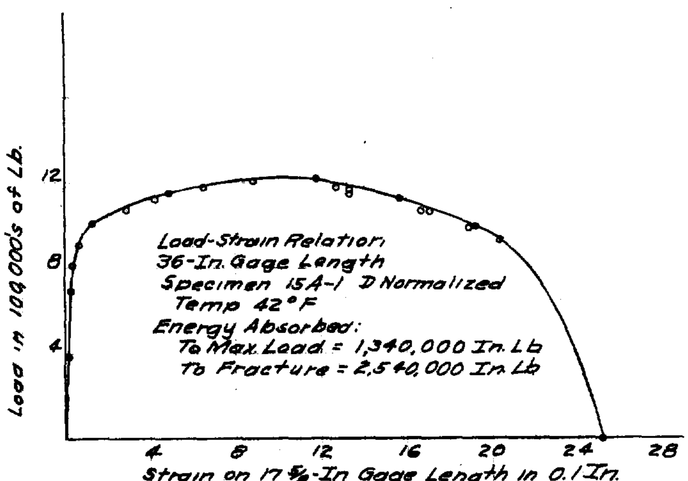


Fig. 7a.

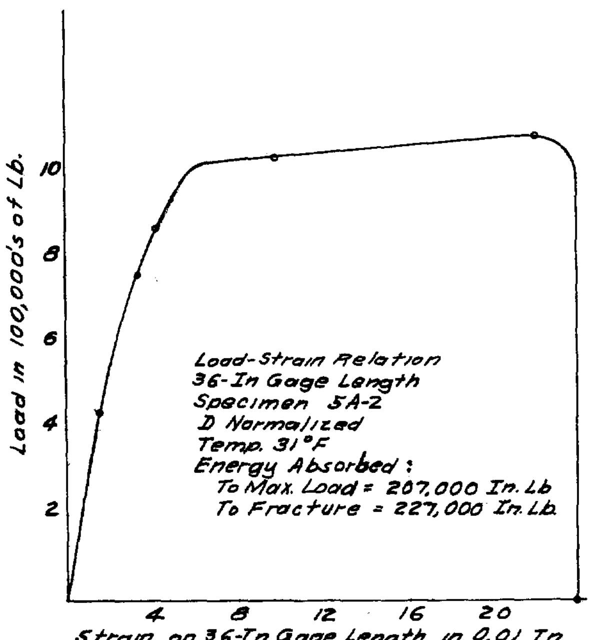


Fig. 8a.

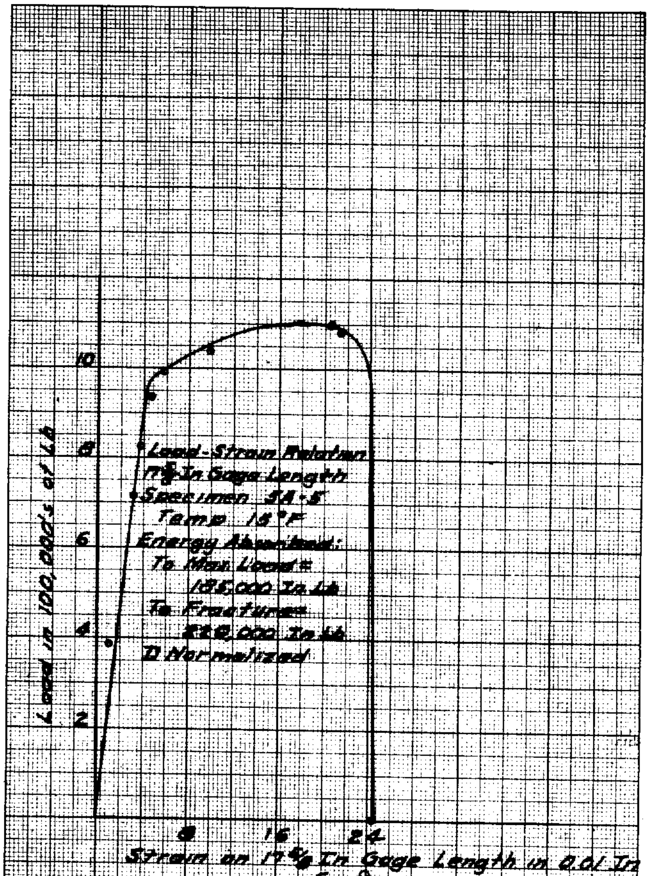


Fig. 9a.

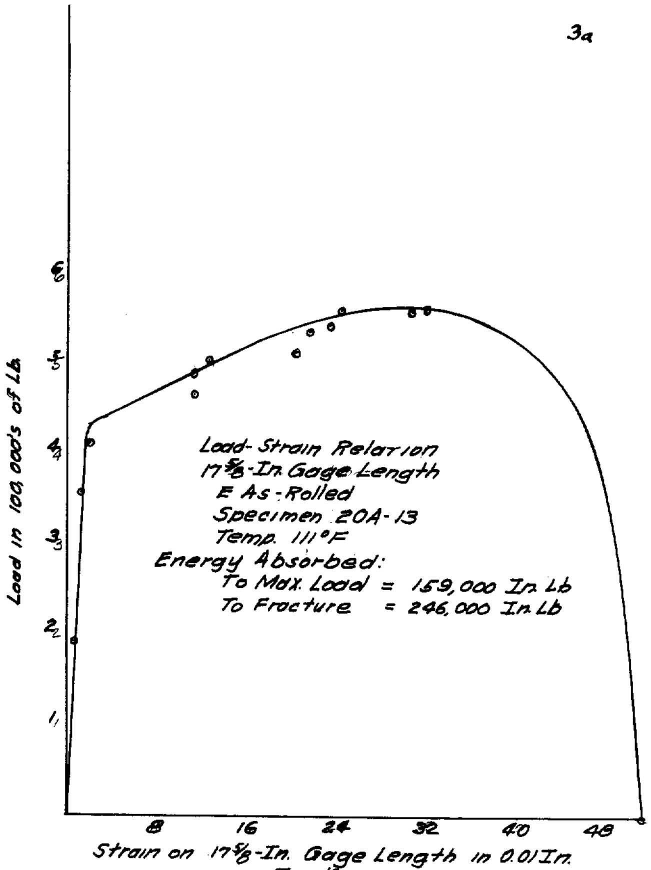


Fig. 10a.

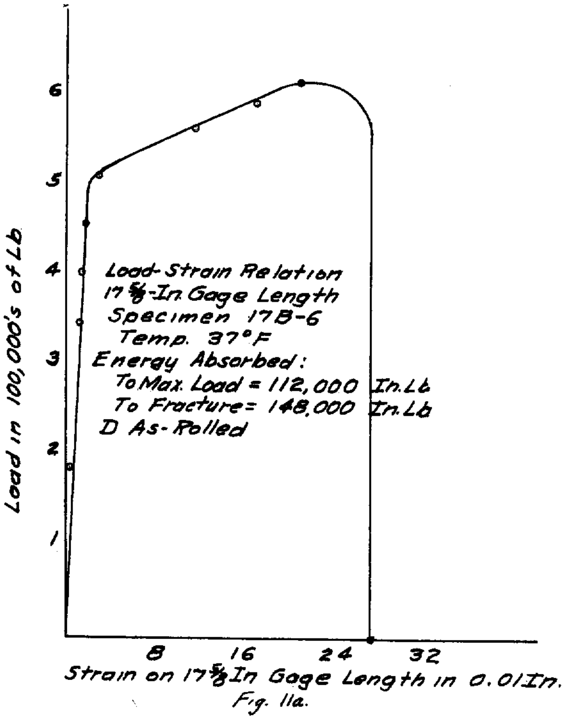


Fig. 11a.

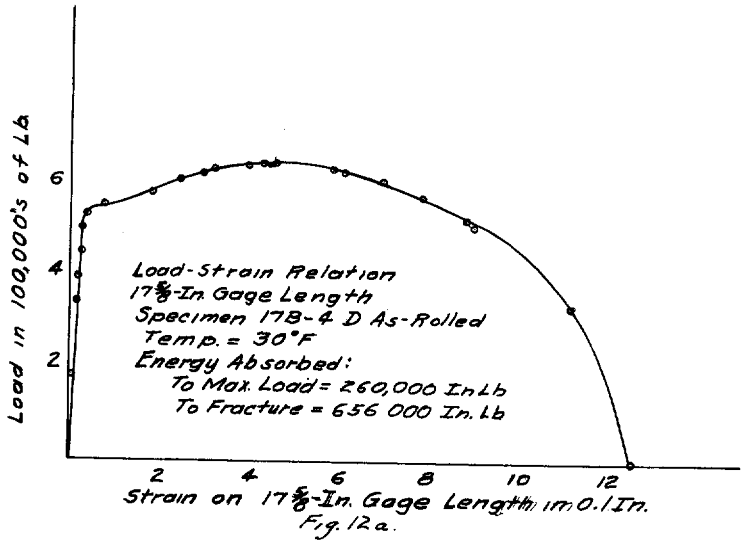


Fig. 12a.

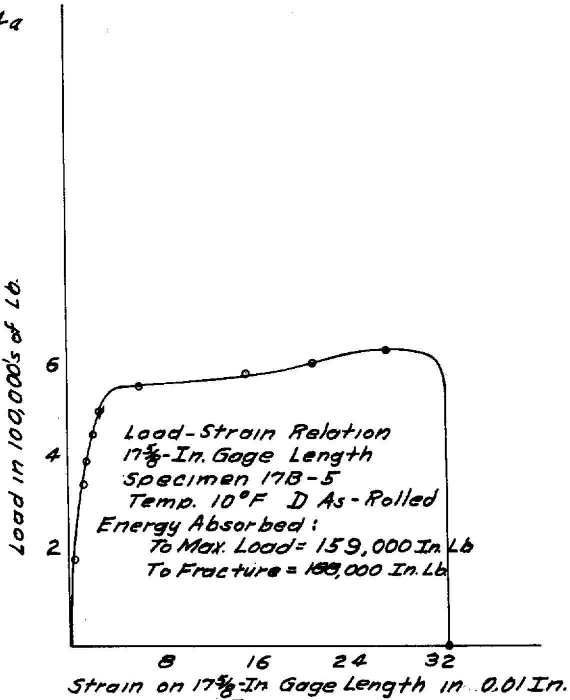


Fig. 13a.

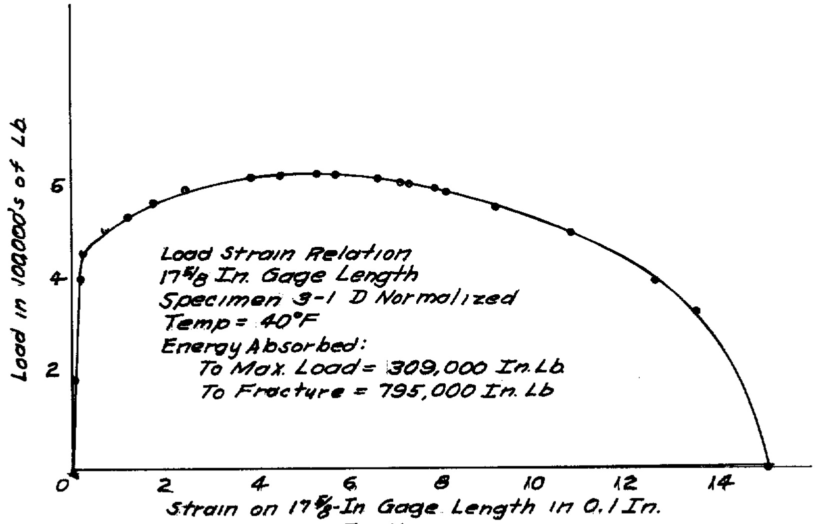


Fig. 14a.

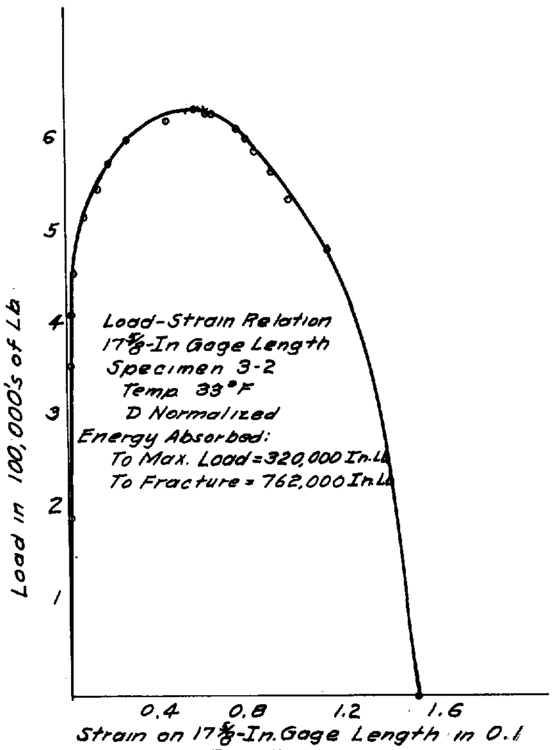


Fig. 15a.

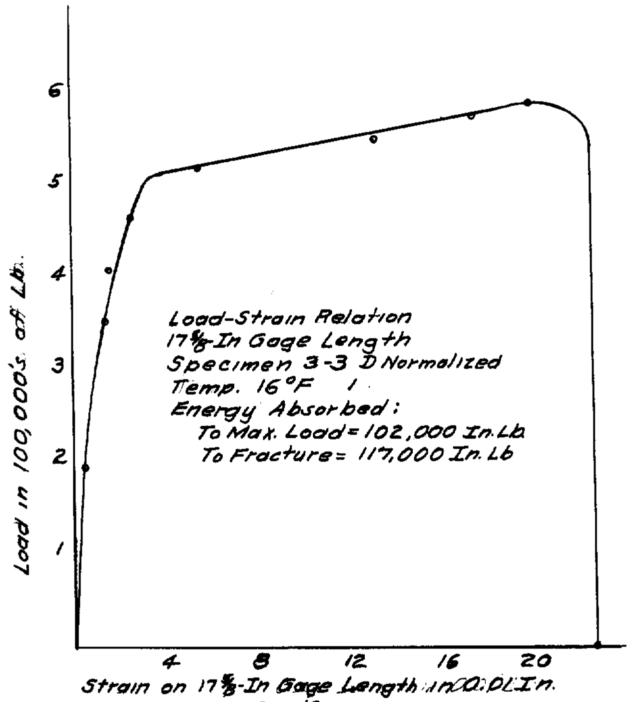


Fig. 16a.

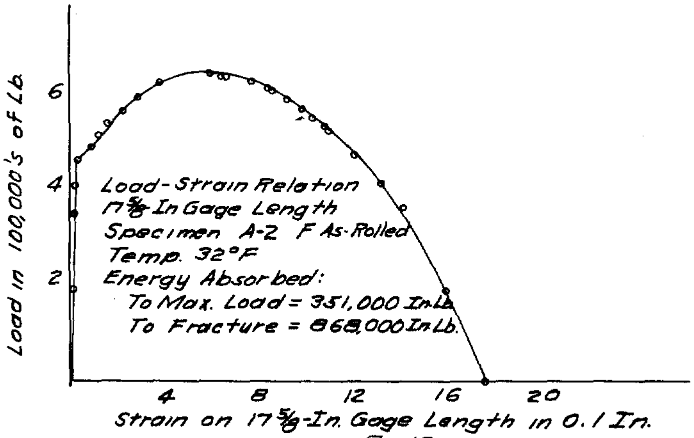


Fig. 17a.

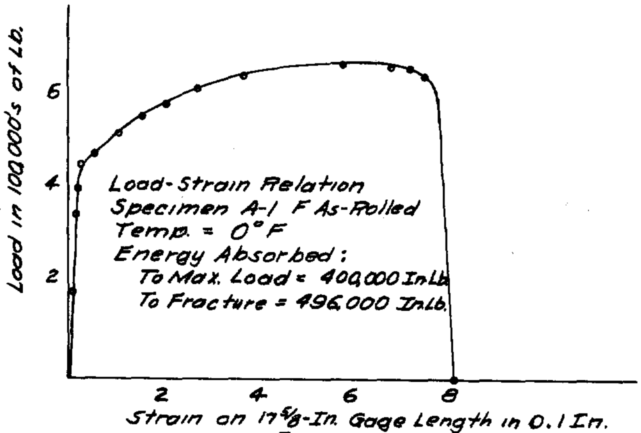


Fig. 18a.

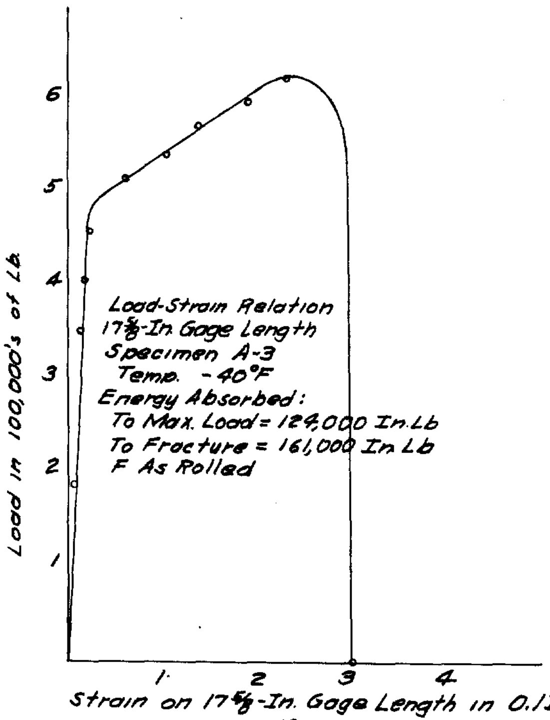


Fig. 19a.

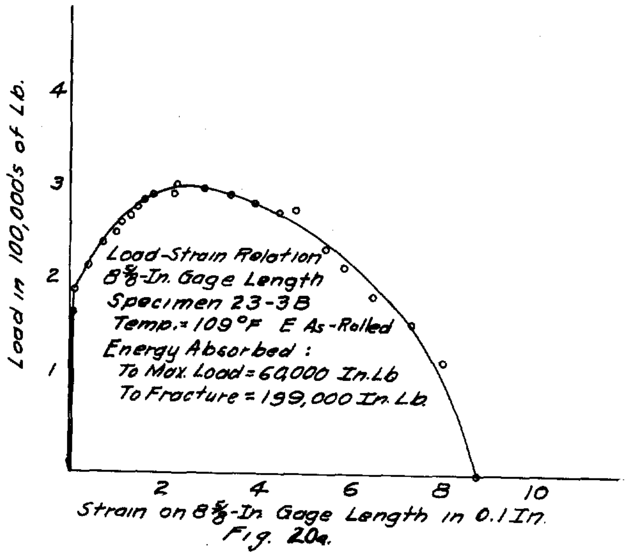


Fig. 20a.

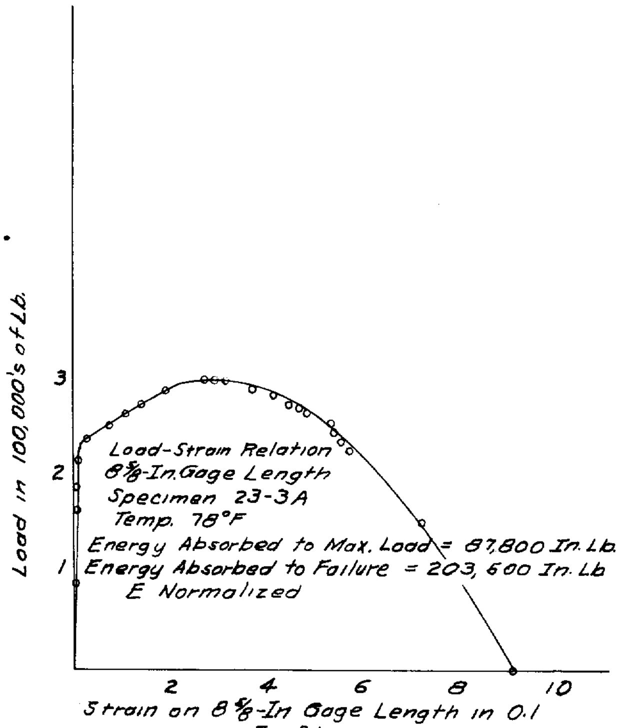


Fig. 21a.

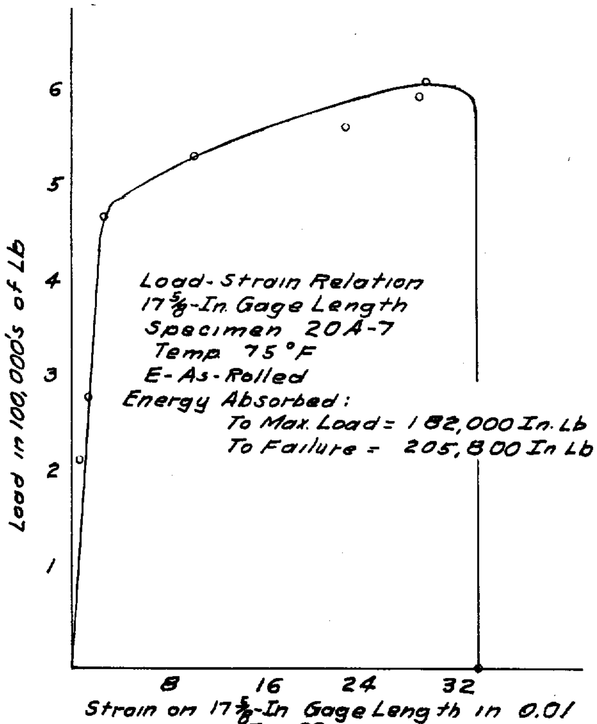


Fig. 22a.

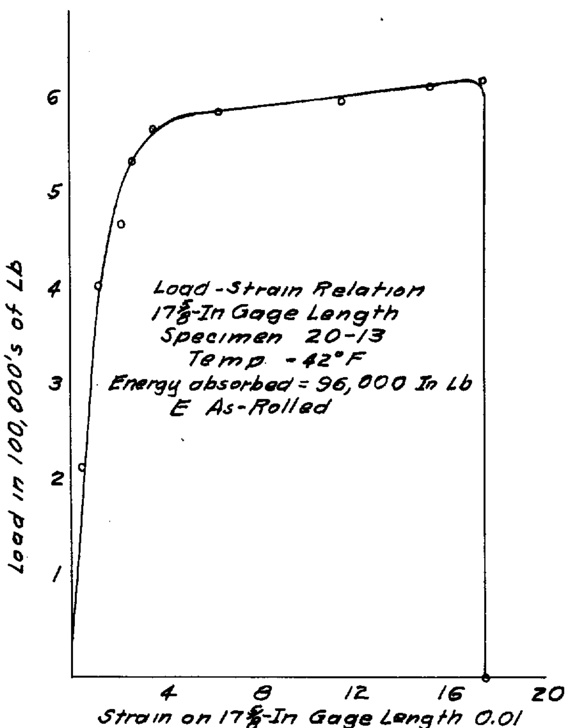


Fig. 23a.

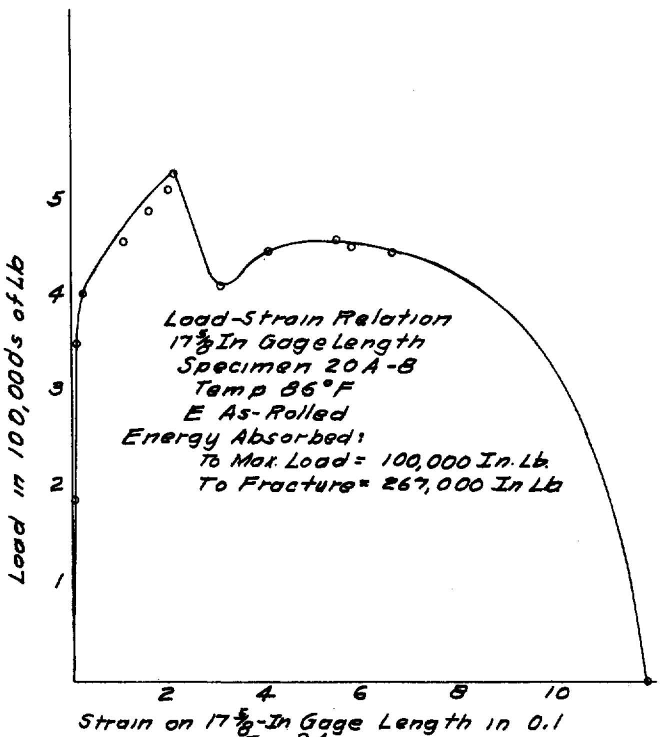


Fig. 24a.

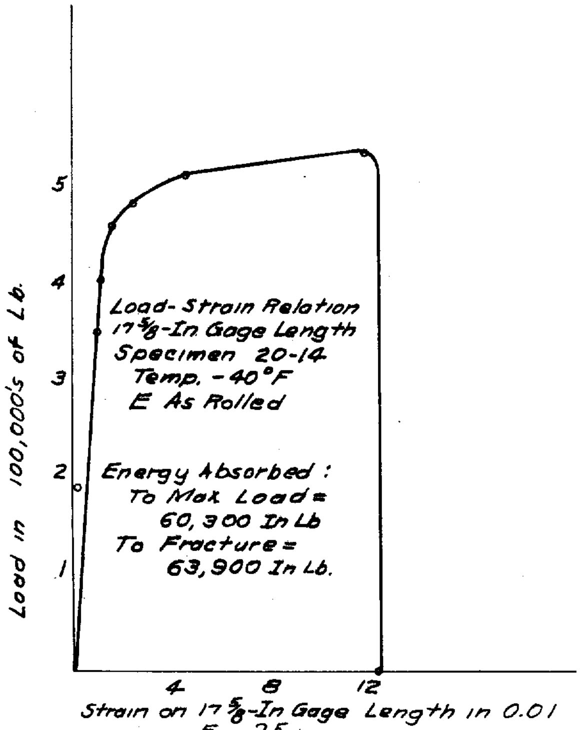


Fig. 25a.

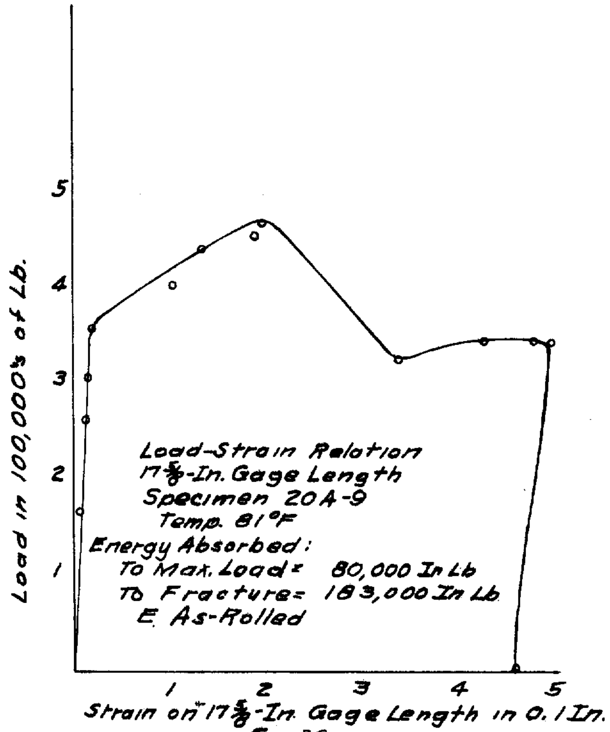


Fig. 26a.

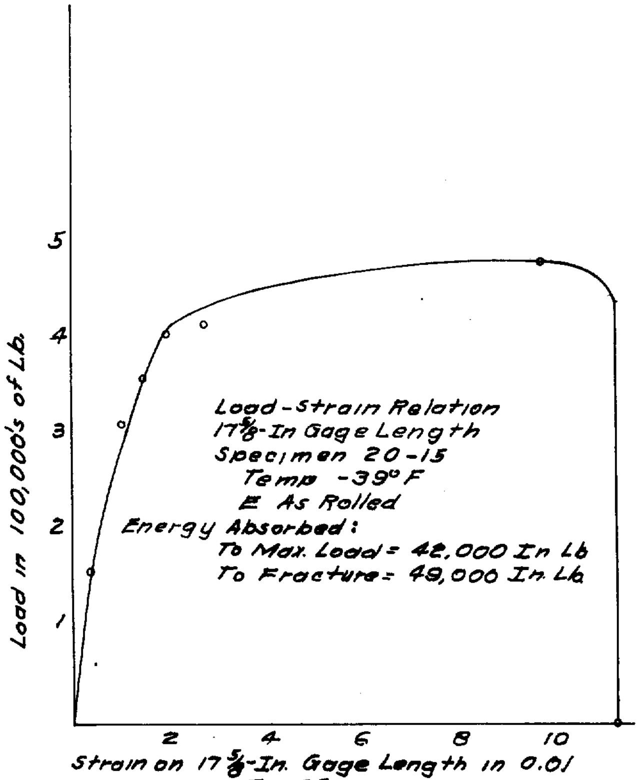


Fig. 27a.

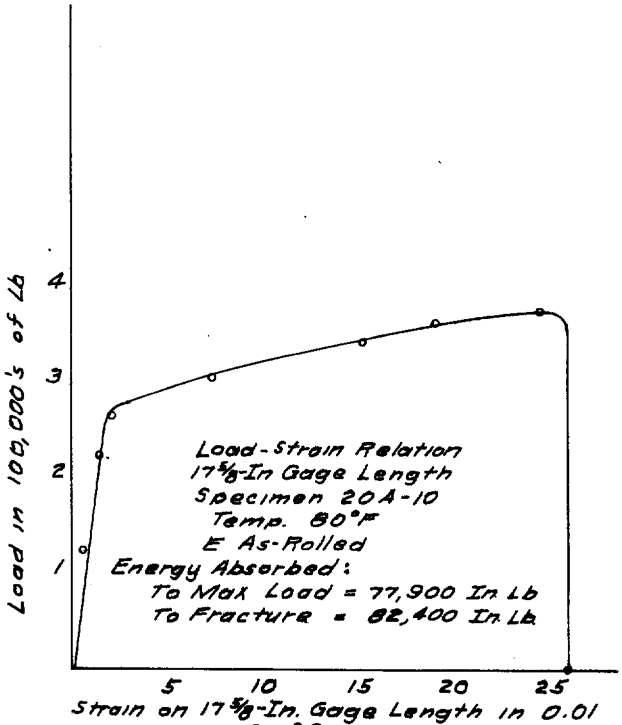


Fig. 28a.

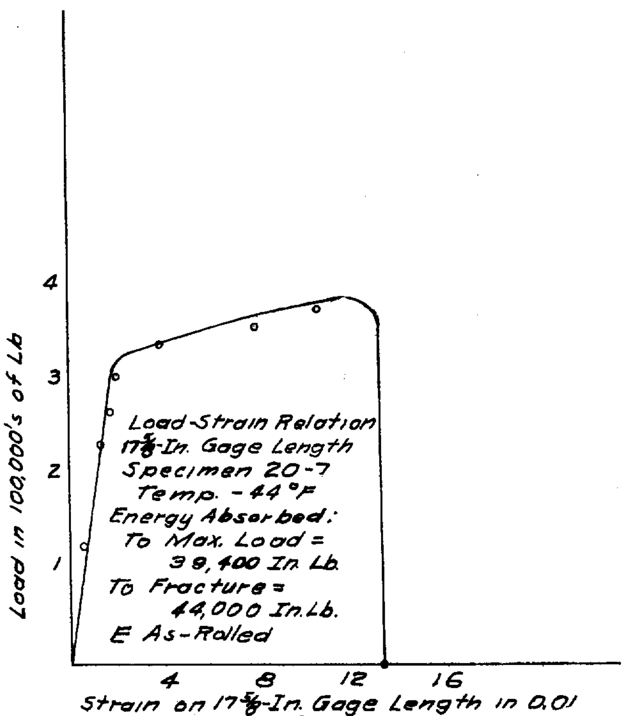


Fig. 29a.

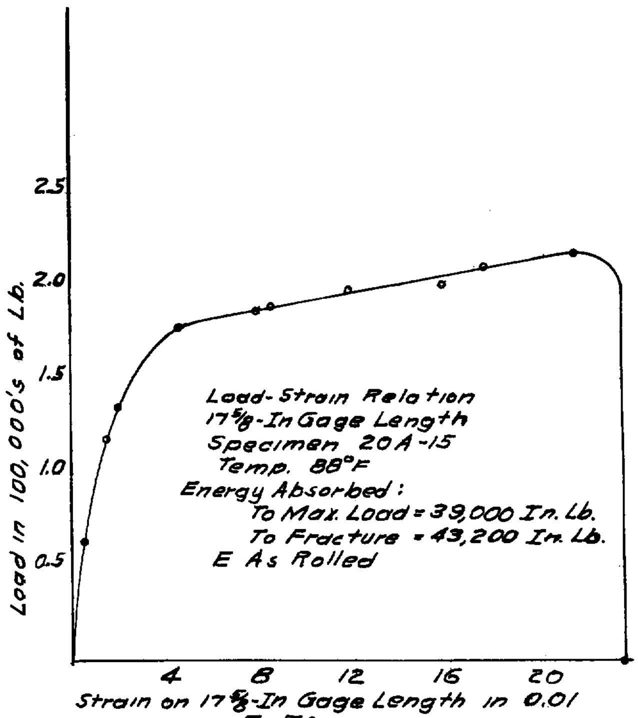


Fig. 30a.

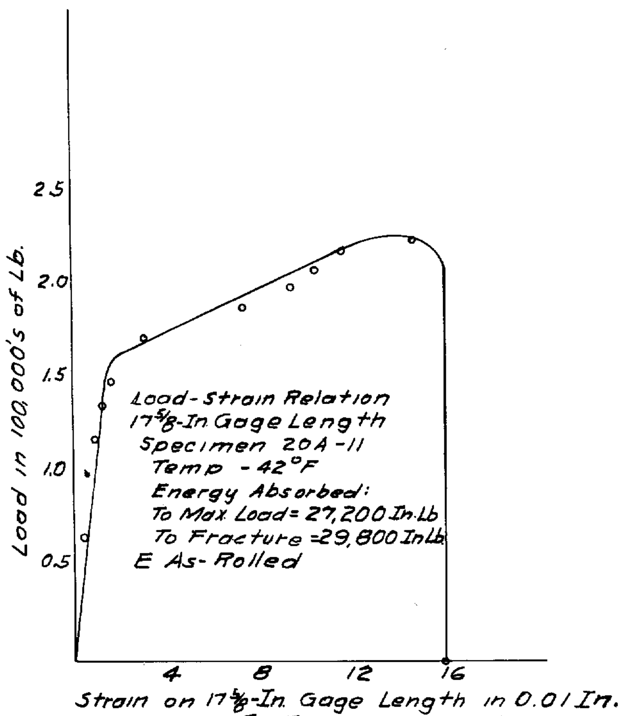


Fig. 31a.

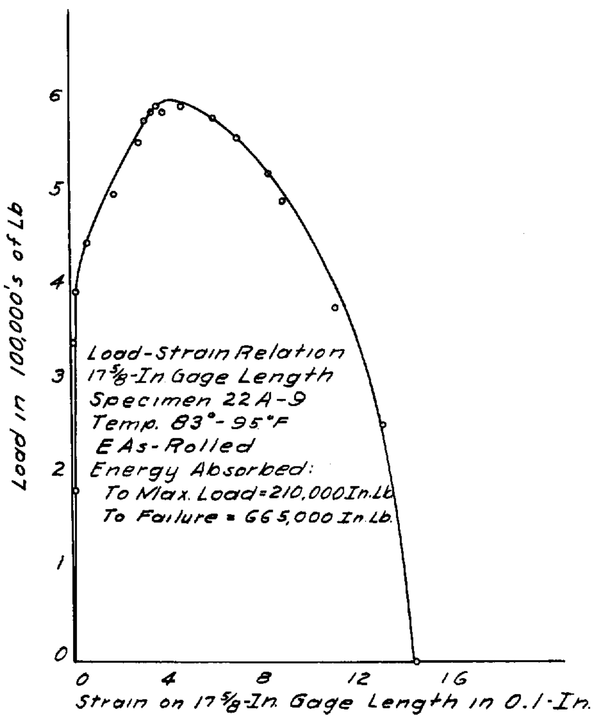


Fig. 32a.

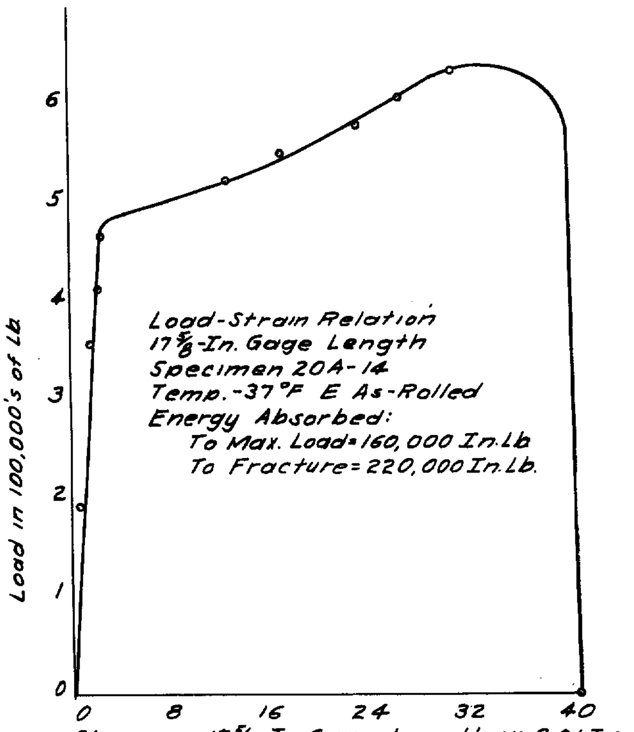
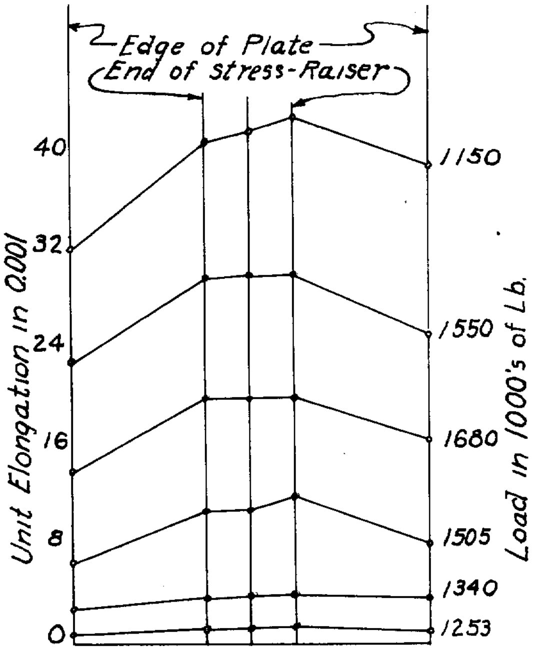
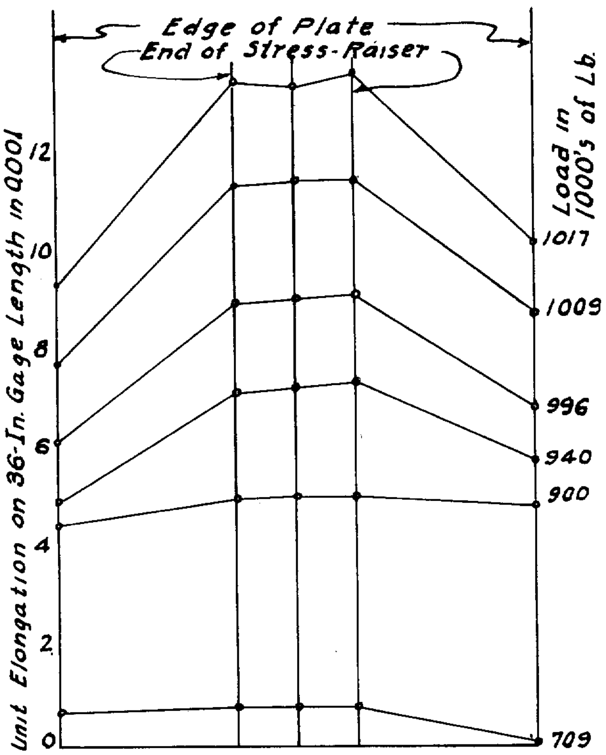


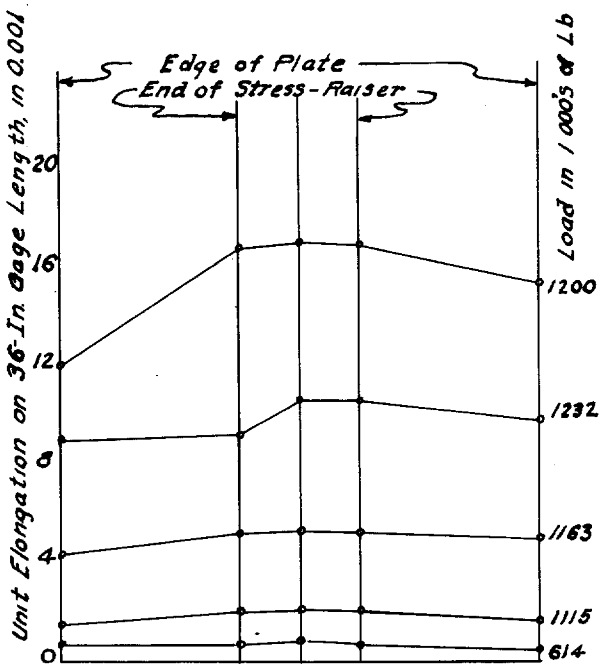
Fig. 33a.



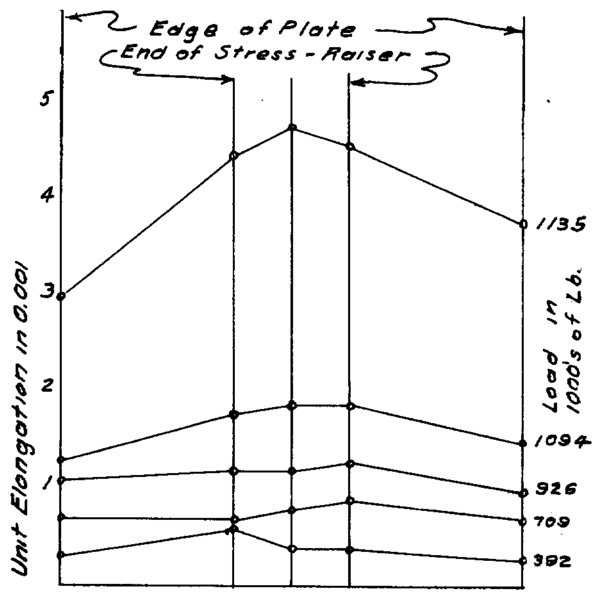
Strain Distribution Across 72-In Plate.
54-In. Gage Lines
Specimen 18A-1
Steel E As-Rolled
Fig. 34a.



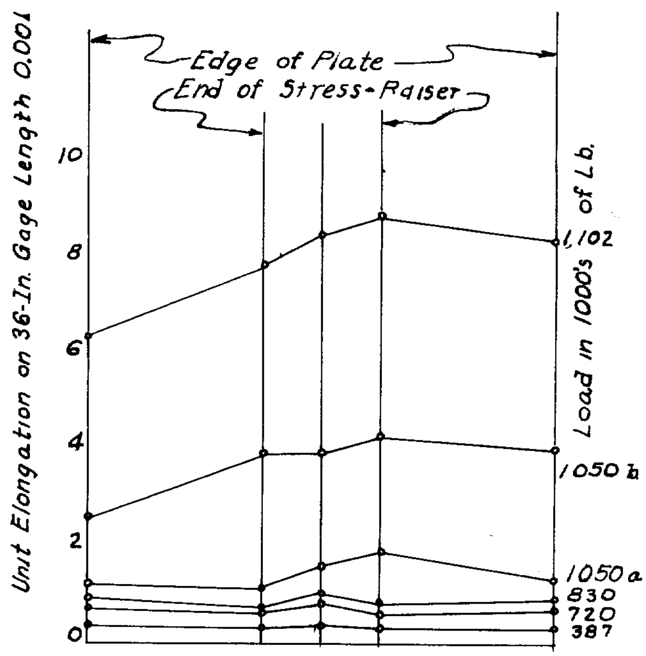
Strain Distribution Across 48-In. Plate.
36-In. Gage Lines
Specimen 13-7
Steel E As Rolled
Fig. 35a.



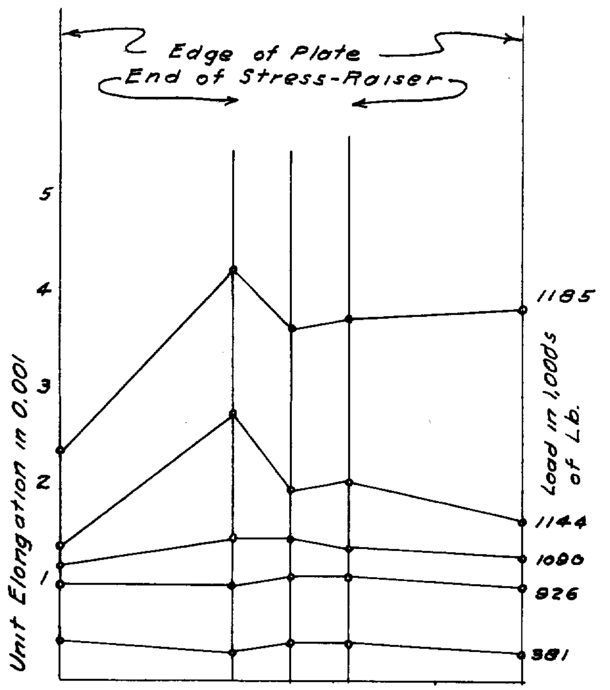
Strain Distribution Across 48-In. Plate
36-In. Gage Lines.
Specimen 17B-7
Steel D As-Rolled
Fig. 36a.



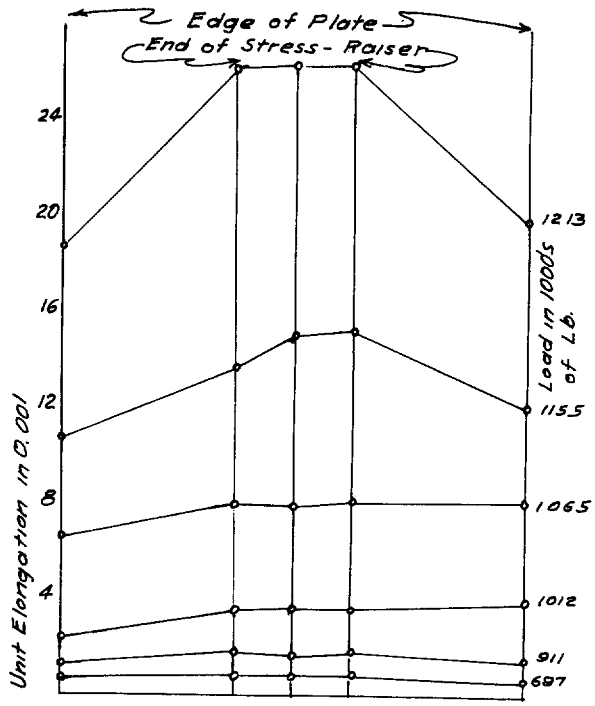
Strain Distribution Across 48-In. Plate
36-In. Gage Lines
Specimen 18-2
Steel D As-Rolled
Fig. 37a.



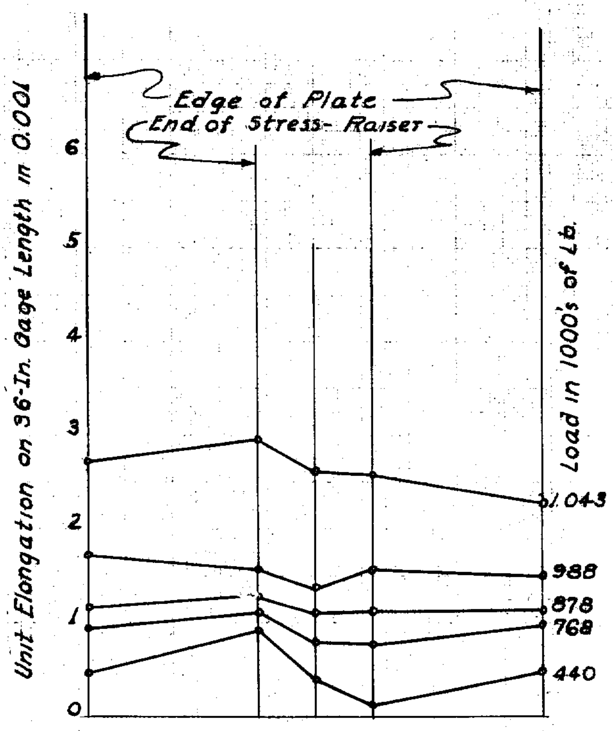
Strain Distribution Across 48-In Plate
36-In. Gage Lines.
Specimen 5-4
Steel D As Rolled.
Fig. 38a.



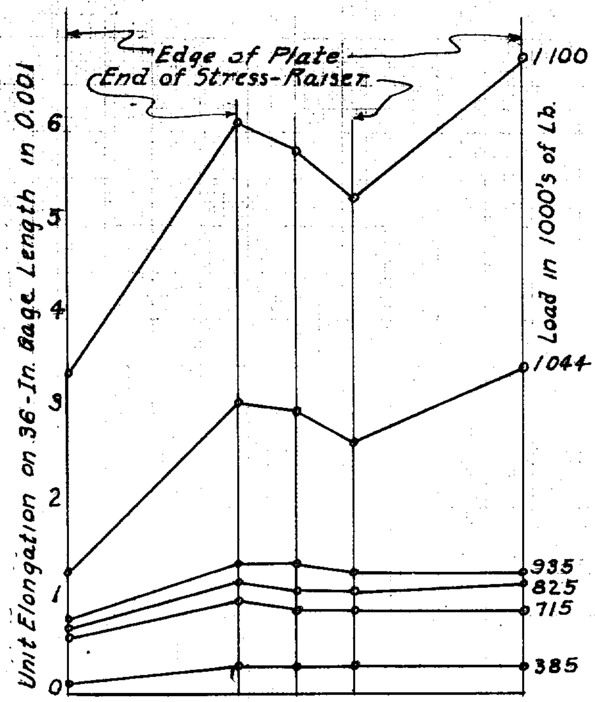
Strain Distribution Across 48-In Plate
36-In. Gage Lines
Specimen 18-1
Steel D As-Rolled
Fig. 39a.



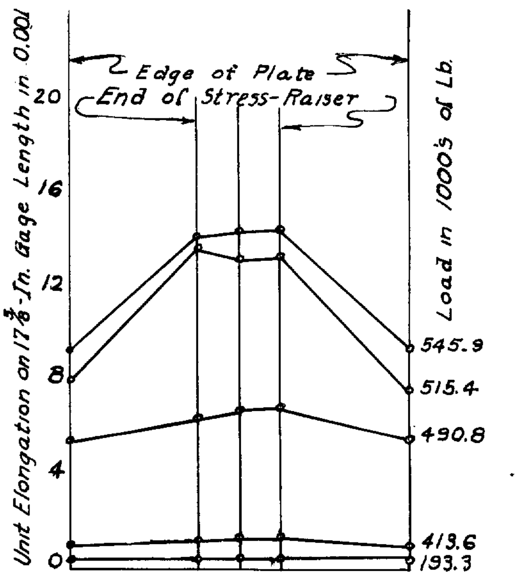
Strain Distribution Across 48-In. Plate
36-In. Gage Lines
Specimen 154-1
Steel D Normalized
Fig. 40a.



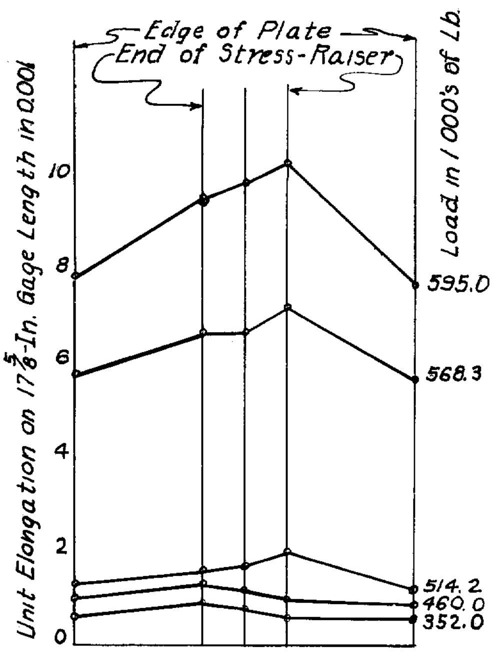
Strain Distribution Across 48-In. Plate.
36-In. Gage Lines
Specimen 5A-2
Steel D Normalized.
Fig. 41a.



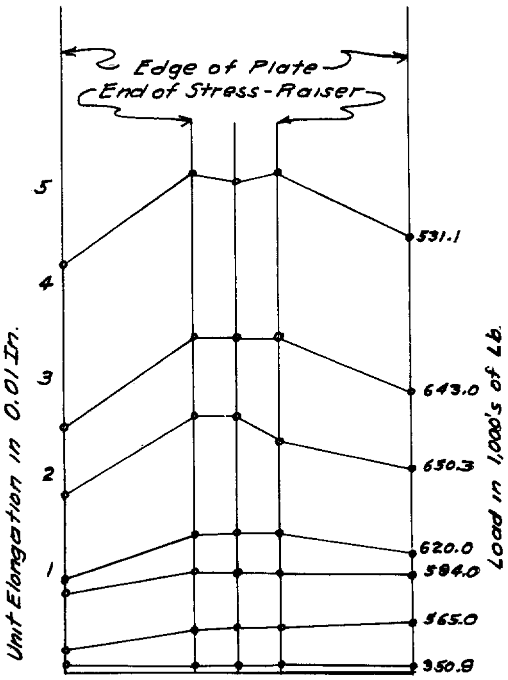
Strain Distribution Across 48-In Plates
36-In. Gage Lines
Specimen 5A-5
Steel D Normalized
Fig. 42a.



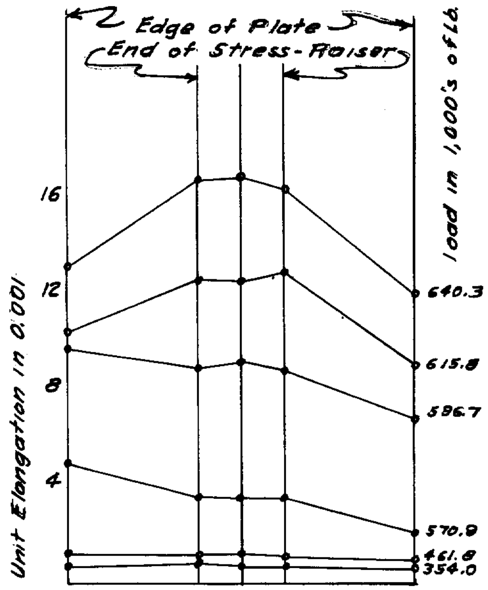
Strain Distribution Across 24-In. Plate.
17⅝-In. Gage Lines
Specimen 20A-13
Steel E As Rolled.
Fig. 43a.



Strain Distribution Across 24-In Plate.
17⅝-In. Gage Lines.
Specimen 17B-6
Steel D As Rolled.
Fig. 44a.

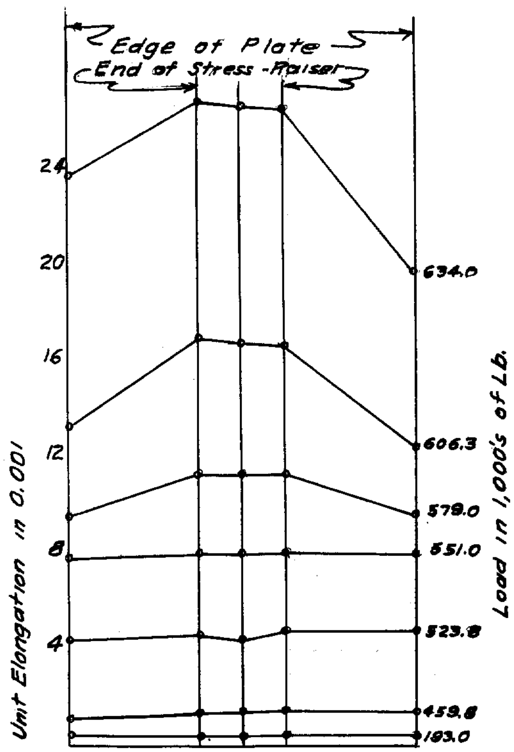


Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 17B-4
D As-Rolled
Fig. 45a.

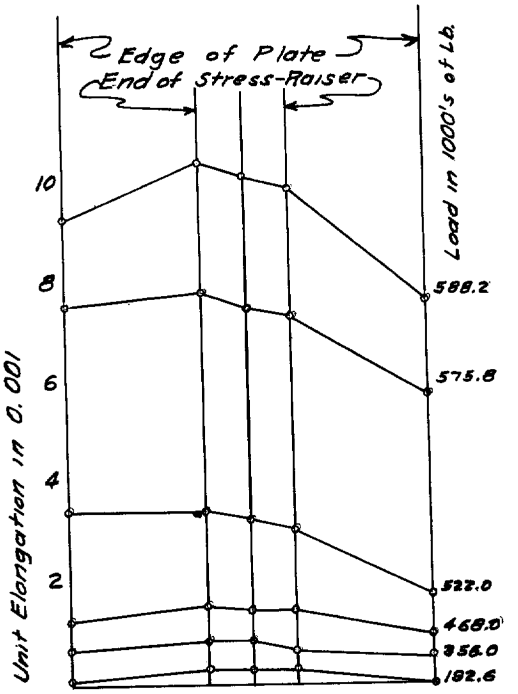


Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 17B-5
D As Rolled
Fig. 46a.

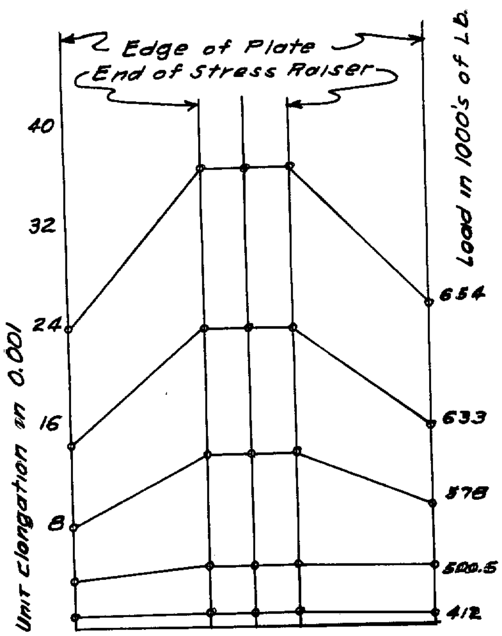
Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 3-1
Steel D Normalized
Fig. 47a.



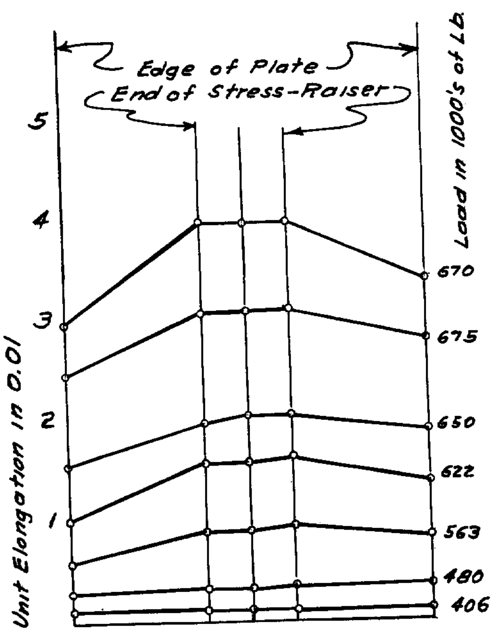
Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 3-2-
Steel D Normalized
Fig. 48a.



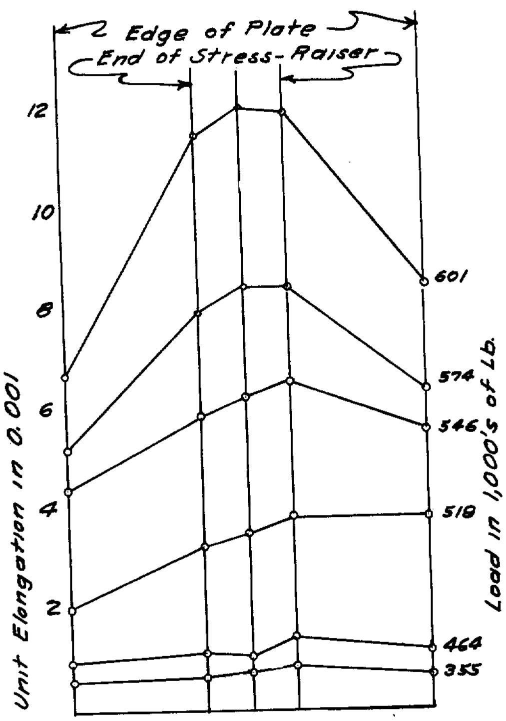
Strain Distribution Across 24aIa Plate
17⅝-In Gage Lines
Specimen 3-3
D Normalized
Fig. 49a.



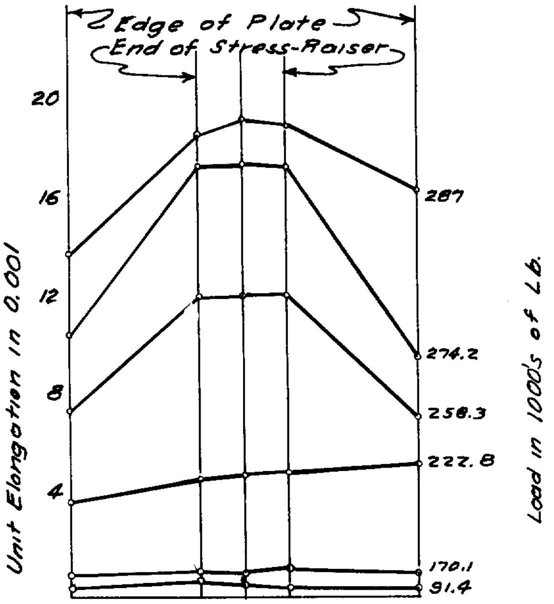
Strain Distribution Across 24aIa Plate
17⅝-In. Gage Lines
Specimen A-2
F As-Rolled
Fig. 50a.



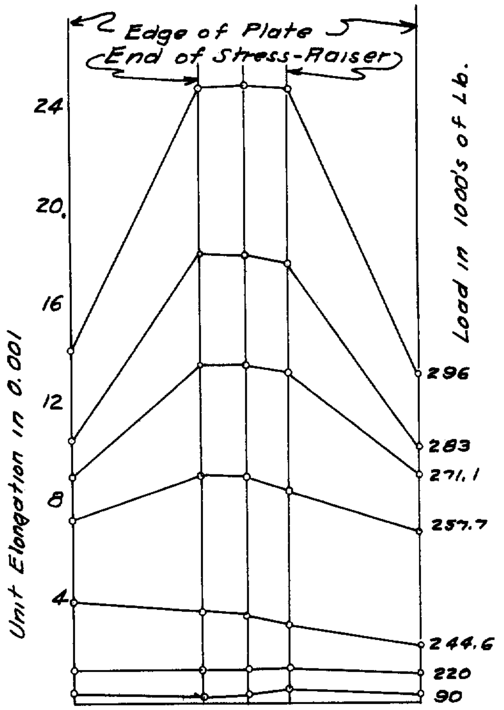
Strain Distribution Across 24aIa Plate
17⅝-In. Gage Lines
Specimen A-1
F As Rolled
Fig. 51a.



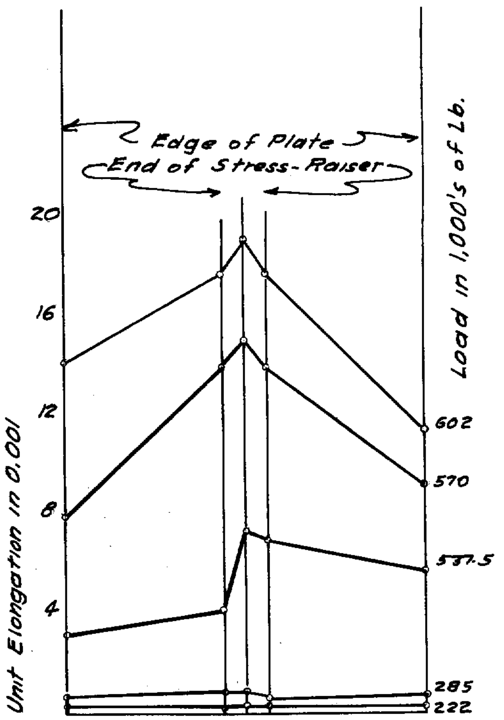
Strain Distribution Across 24aIa Plate
17⅝-In. Gage Lines
Specimen A-3
F As Rolled
Fig. 52a.



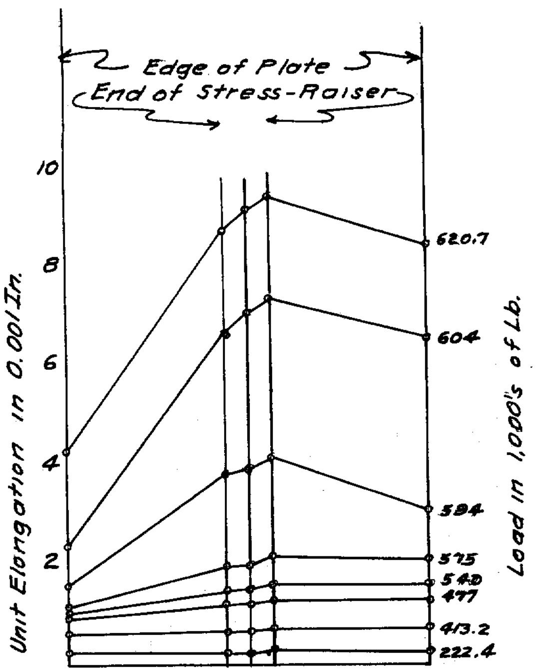
Strain Distribution Across 22-In. Pla
8⅝-In. Gage Length
Specimen 23-3B
E As Rolled
Fig. 53a.



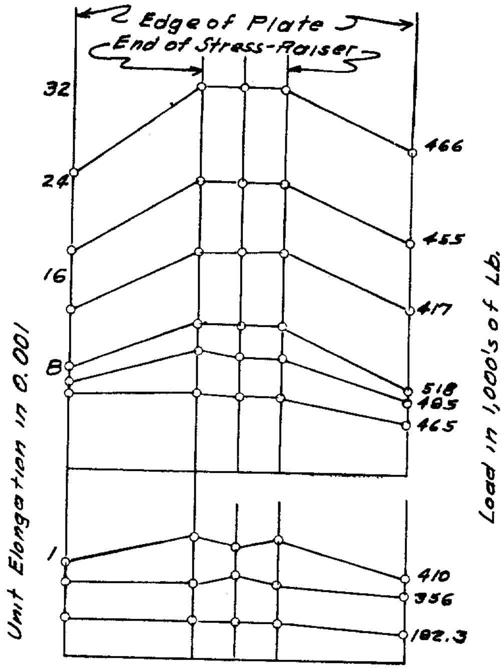
Strain Distribution Across 22-In. Plate
8⅝ Gage Length
Specimen 23-3A
E Normalized
Fig. 54a.



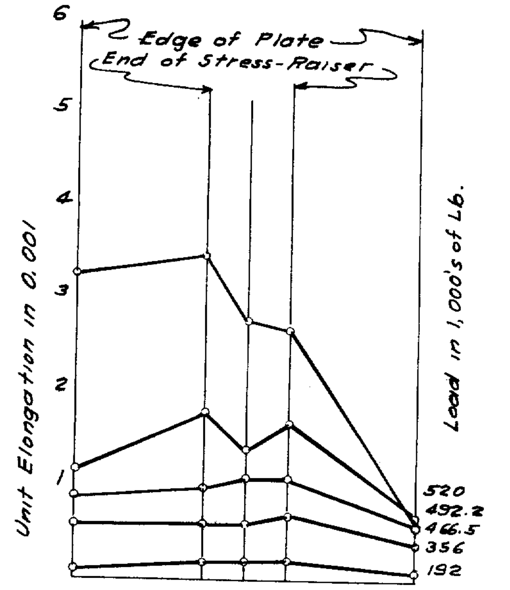
Strain Distribution Across 22-In. Plate
17⅝-In. Gage Lines
Specimen 20A-7
E As Rolled
Fig. 55a.



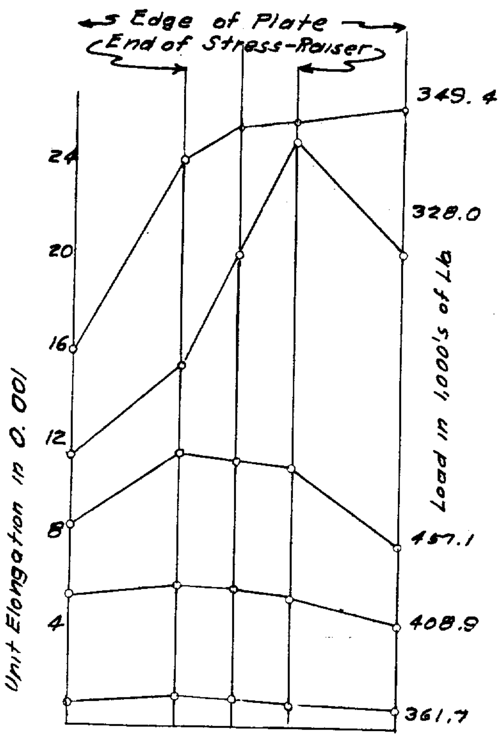
Strain Distribution Across 24-In. Plate
17⅝-In Gage Lines
Specimen 20-13
E-As Rolled
Fig. 56a.



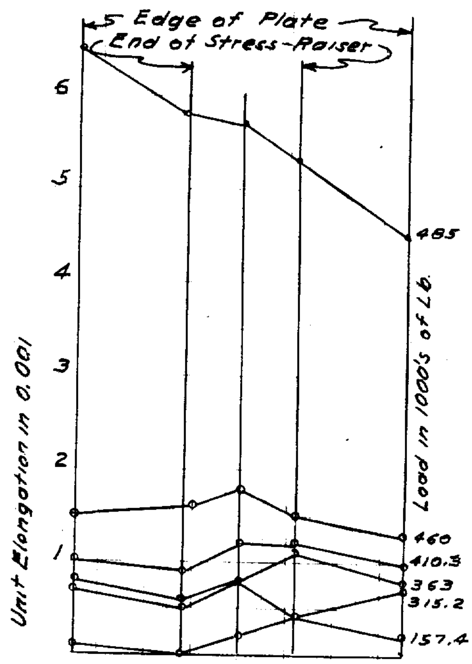
Strain Distribution Across 24-In Plate
17⅝-In Gage Lines
Specimen 20A-8
E As Rolled
Fig. 57a.



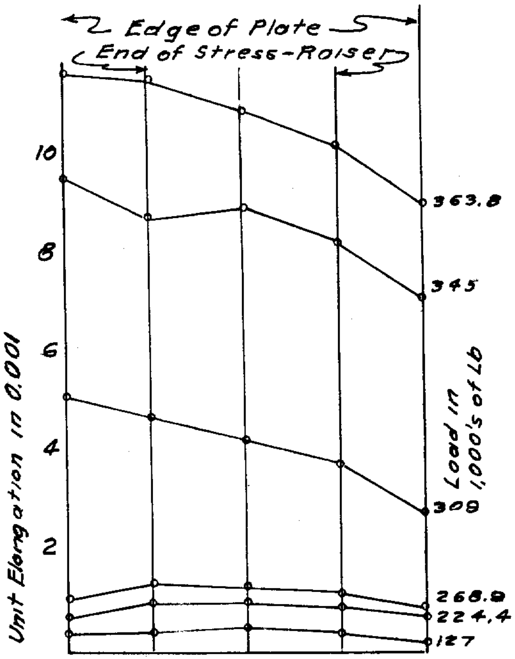
Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 20-14
E As Rolled
Fig. 58a.



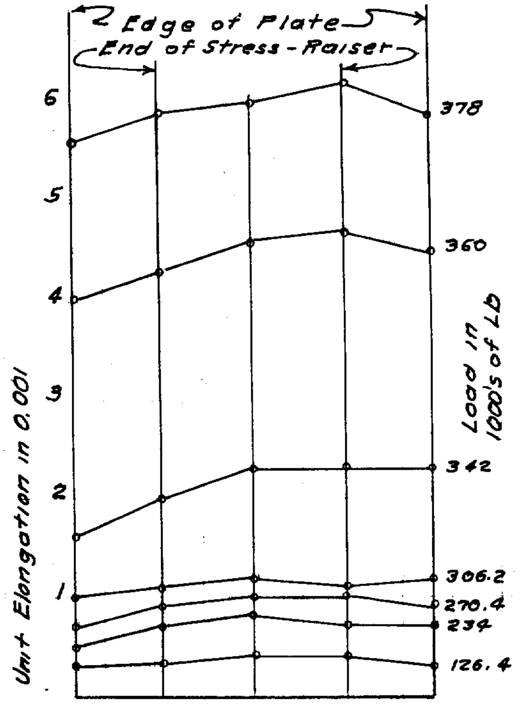
Strain Distribution Across 24-In Plate
17⅝-In Gage Lines
Specimen 20A-9
E As Rolled
Fig. 59a.



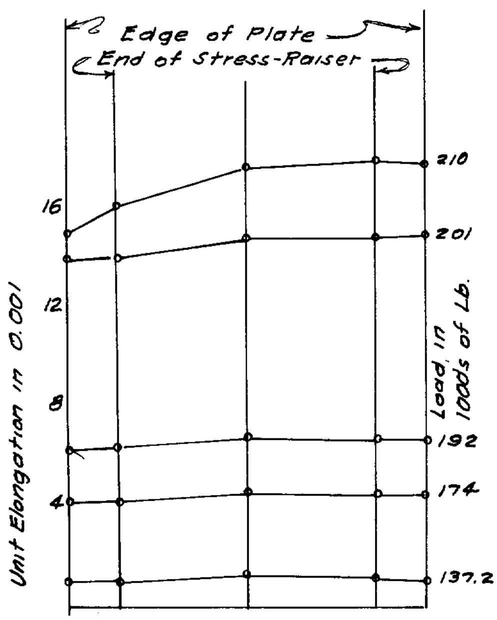
Strain Distribution Across 24-In Plate
17⅝-In. Gage Lines
Specimen 20-15
E As Rolled
Fig. 60a.



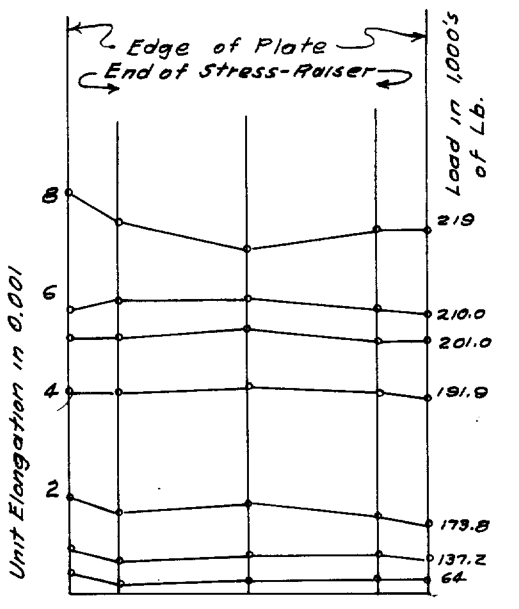
Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 20A-10
E As Rolled
Fig. 61a.



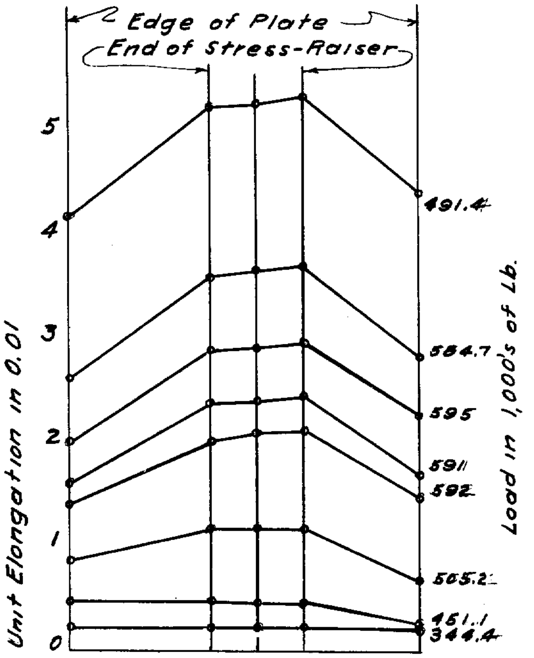
Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 20-7
Steel E As-Rolled
Fig. 62a.



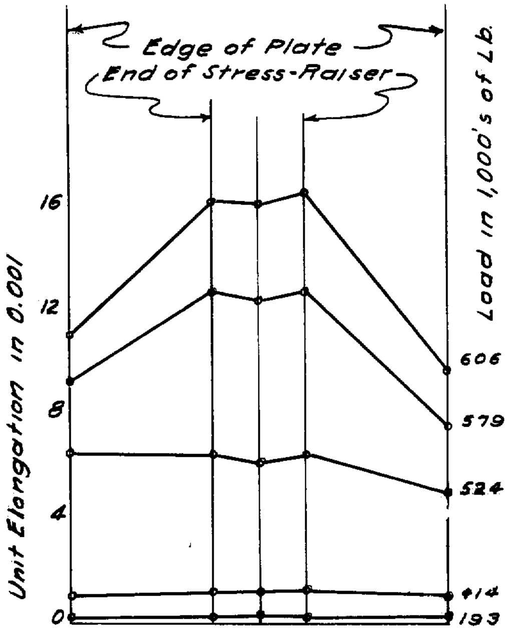
Strain Distribution Across 24-In. Plate
17⅝-In Gage Lines
Specimen 20A-15
Steel E As-Rolled
Fig. 63a.



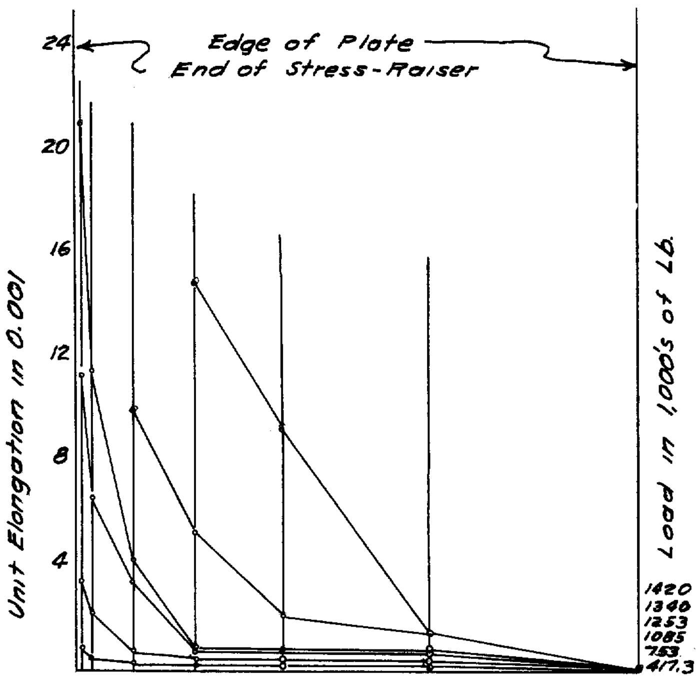
Strain Distribution Across 24-In. Plate
17⅝-In. Gage Lines
Specimen 20A-11
Steel E As-Rolled
Fig. 64a.



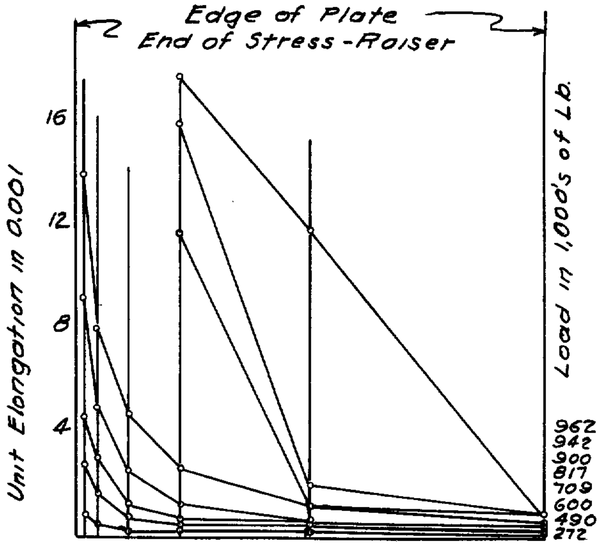
Strain Distribution Across 24-In. Plate
17 5/8-In. Gage Lines
Specimen 22A-9
Fig. 65a.



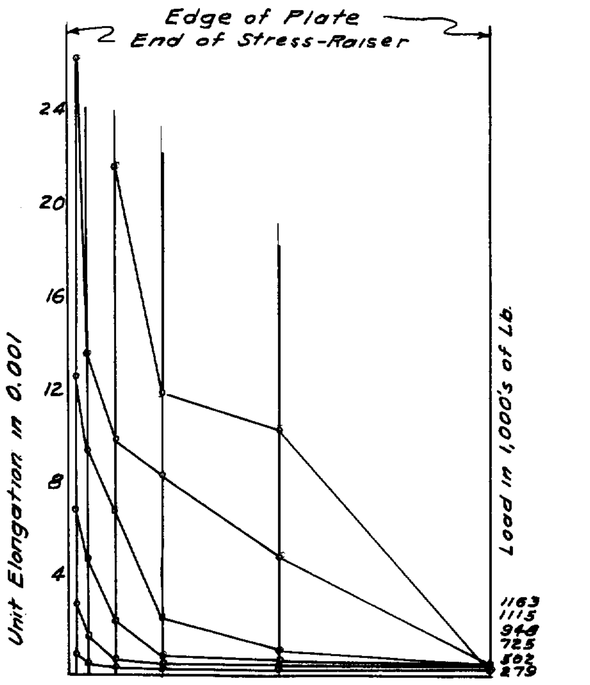
Strain Distribution Across 24-In. Plate
17 5/8-In. Gage Lines
Specimen 20A-14
Fig. 66a.



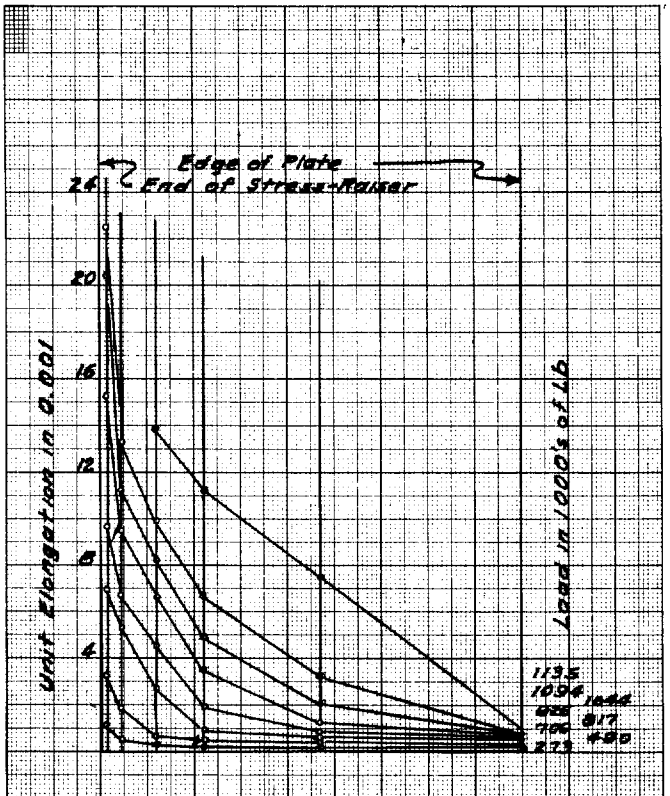
Strain Distribution Across Half of 72-In. Plate
from Electric Strain Gages
Specimen 18A-1
E As-Rolled
Fig. 67a.



Strain Distribution Across Half of 48-In
Plate from Electric Strain Gages
Specimen 13-7
E As-Rolled
Fig. 68a.



Strain Distribution Across Half of 48-In. Plate from Electric Strain Gages
Specimen 17B-7
D As-Rolled
Fig. 69a.



Strain Distribution Across Half of 48-In. Plate from Electric Strain Gages
Specimen 18-2
D As-Rolled.
Fig. 70a.

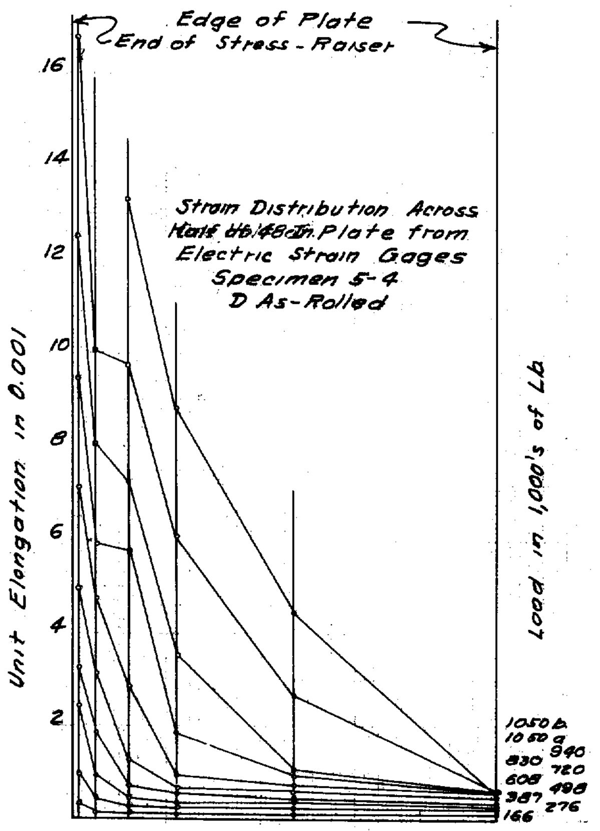
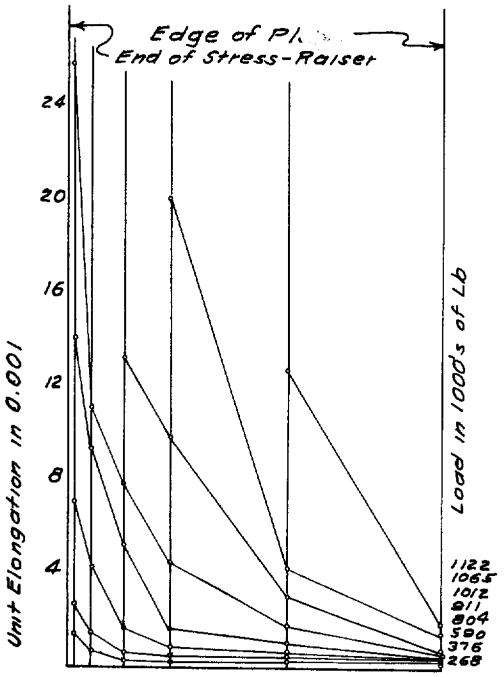
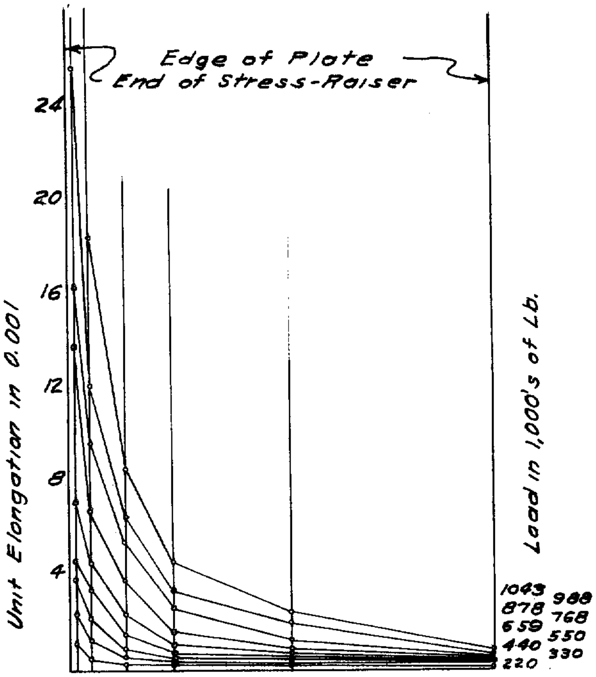


Fig. 71a.

Strain Distribution Across One Half of 48-In. Plate from Electric Strain Gages
Specimen 18-1
D As Rolled
Fig. 72a.

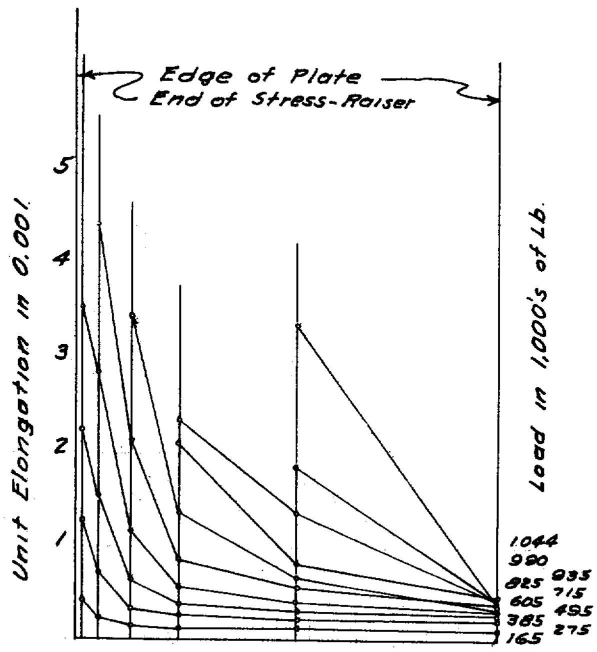


Strain Distribution Across One Half of 48-In. Plate from Electric Strain Gages
Specimen 15A-1
D Normalized
Fig. 73a.

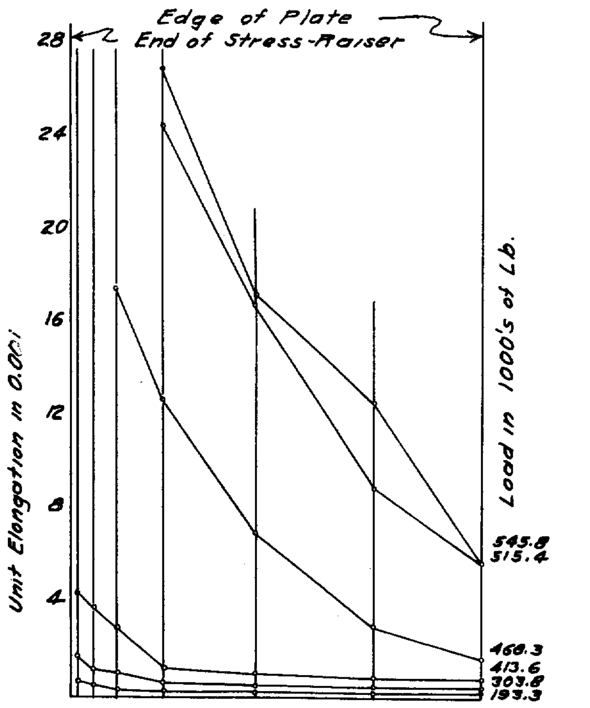


Strain Distribution Across Half of 48-In. Plate from Electric Strain Gages
Specimen 5A-2
D Normalized
Fig. 74a.

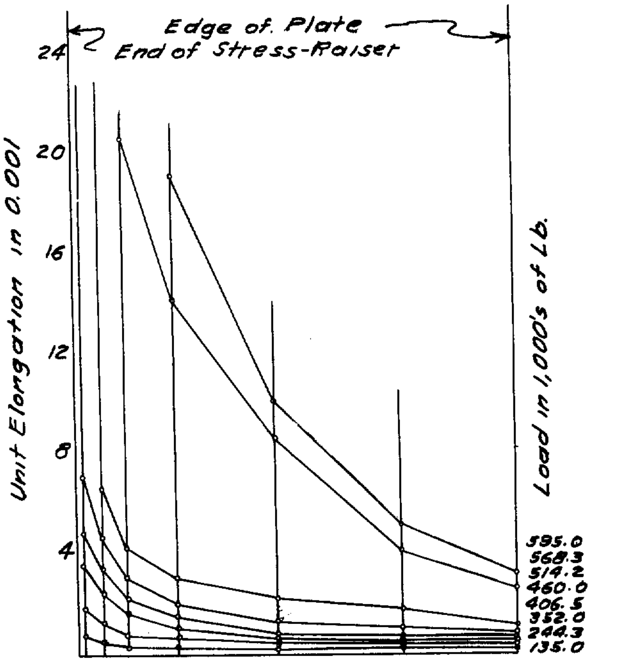
75a



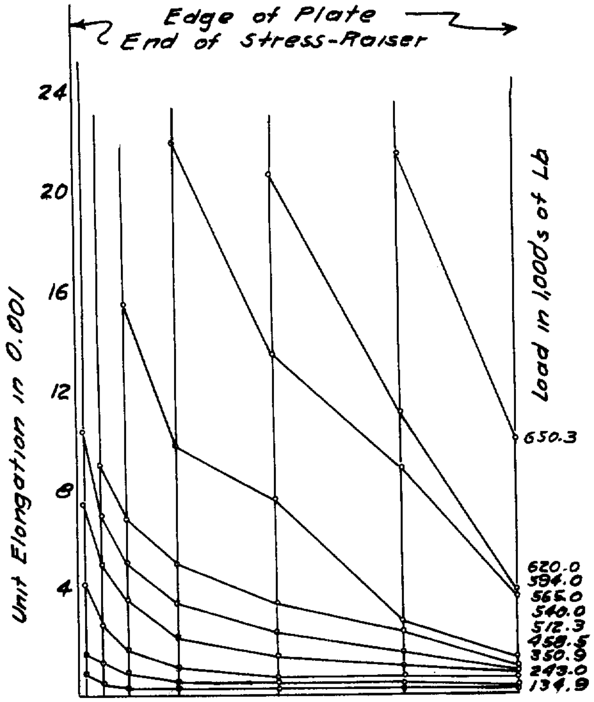
Strain Distribution Across Half of 48-In. Plate from Electric Strain Gages
Specimen 5A-5
D Normalized
Fig. 75a.



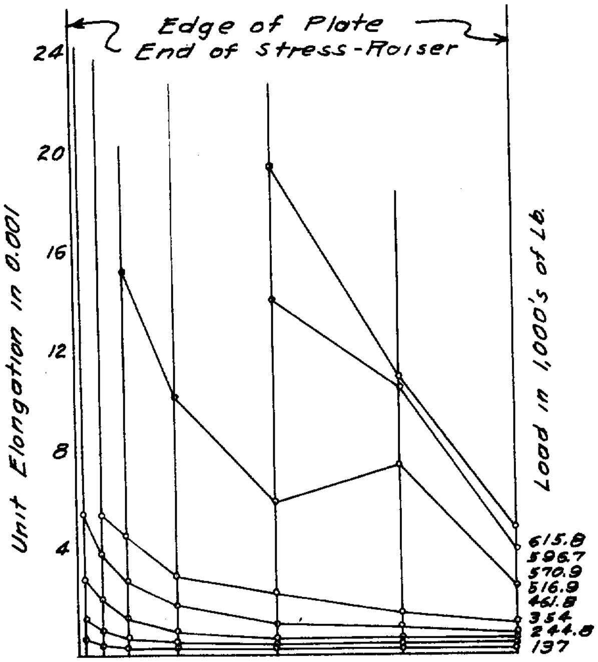
Strain Distribution Across Half of 24-In Plate from Electric Strain Gages
Specimen 20A-13
E As-Rolled
Fig. 76a.



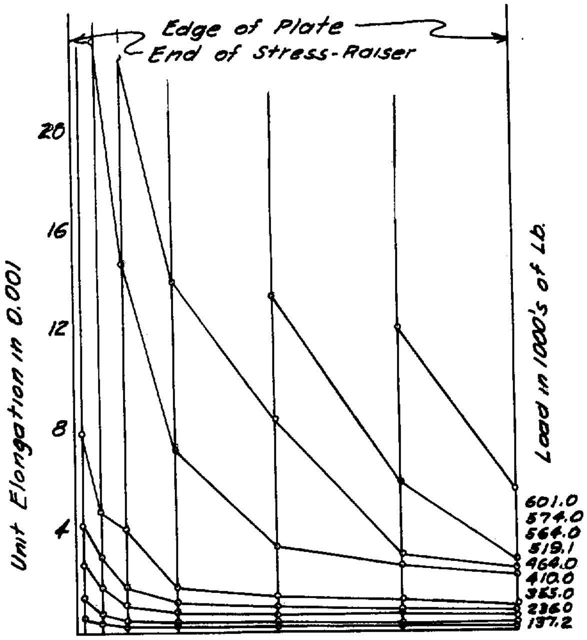
Strain Distribution Across Half of 24-In
Plate from Electric Strain Gages
Specimen 17B-6
D As Rolled
Fig. 77a.



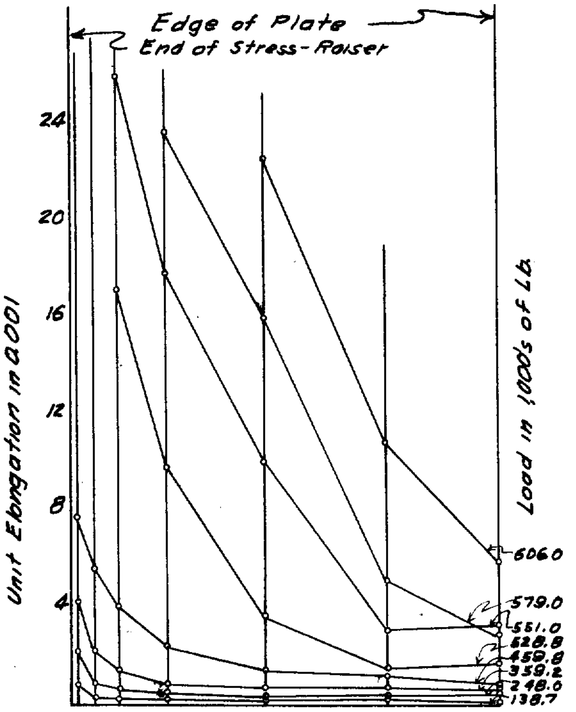
Strain Distribution Across Half of 24-In.
Plate from Electric Strain Gages
Specimen 17B-4
D As Rolled
Fig. 78a.



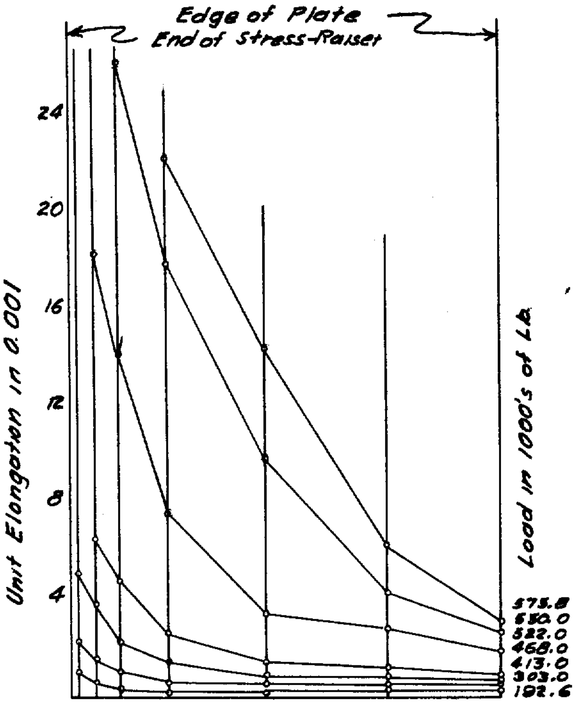
Strain Distribution Across Half of 24-In.
Plate from Electric Strain Gages
Specimen 17B-5
D As-Rolled
Fig. 79a.



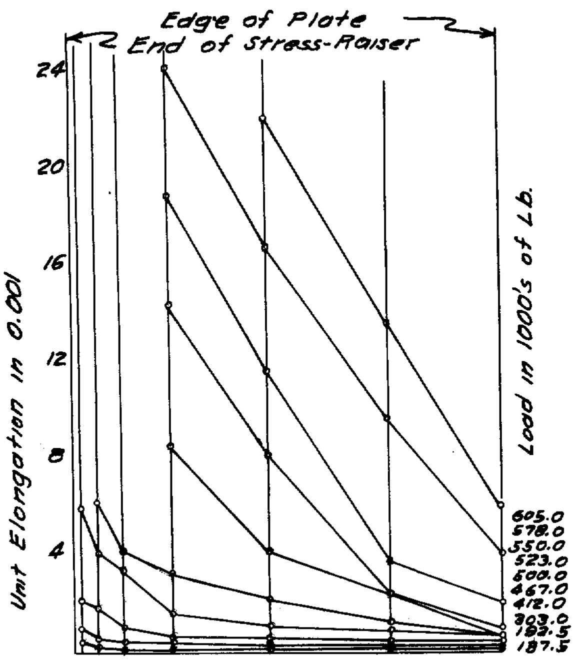
Strain Distribution Across One Half 24-In
of Plate from Electric Strain Gages
Specimen 3-1
D Normalized
Fig. 80a.



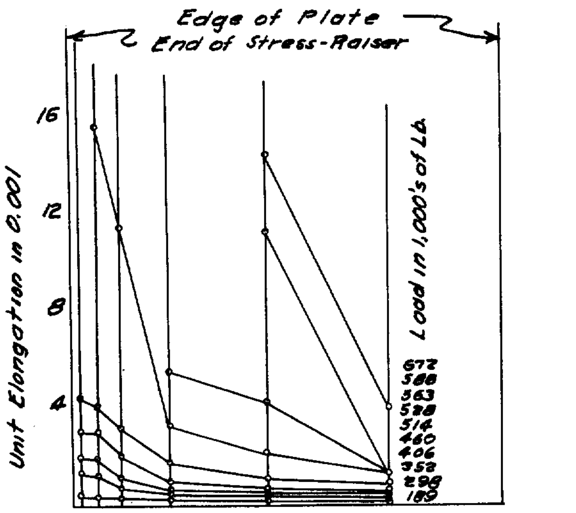
Strain Distribution Across One Half of 24-In. Plate from Electric Strain Gages
Specimen 3-2
D Normalized
Fig. 81a.



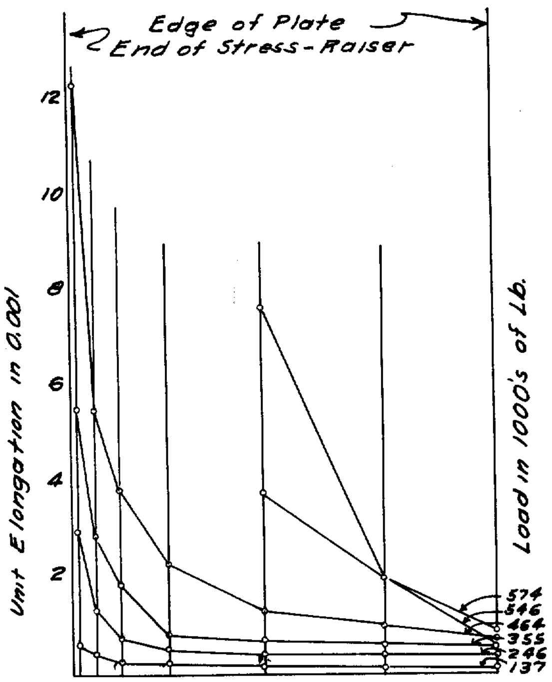
Strain Distribution Across One Half of 24-In. Plate from Electric Strain Gages
Specimen 3-3
D Normalized
Fig. 82a.



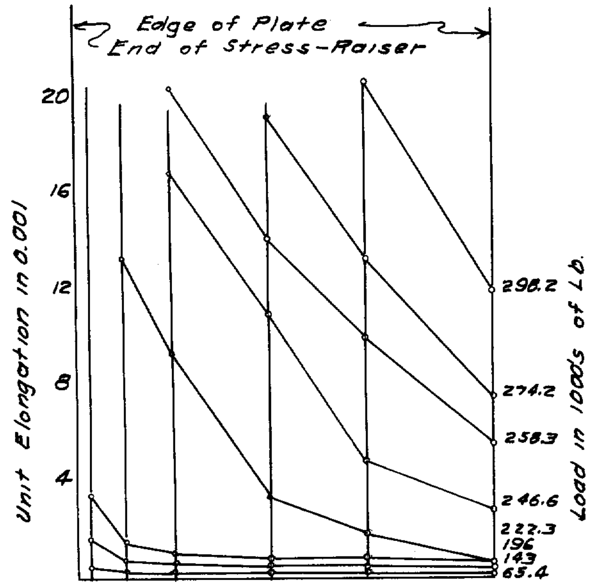
Strain Distribution Across One Half of 24-In. Plate from Electric Strain Gages
Specimen A-2
F As-Rolled
Fig. 83a.



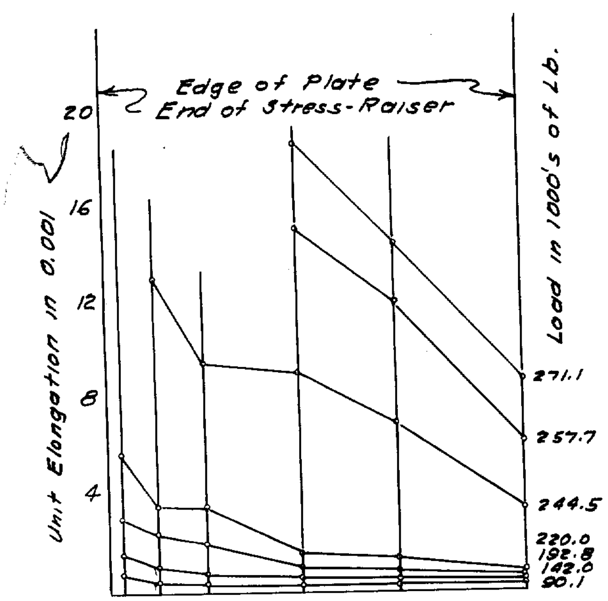
Strain Distribution Across One Half of 24-In. Plate from Electric Strain Gages
Specimen A-1
F As-Rolled
Fig. 84a.



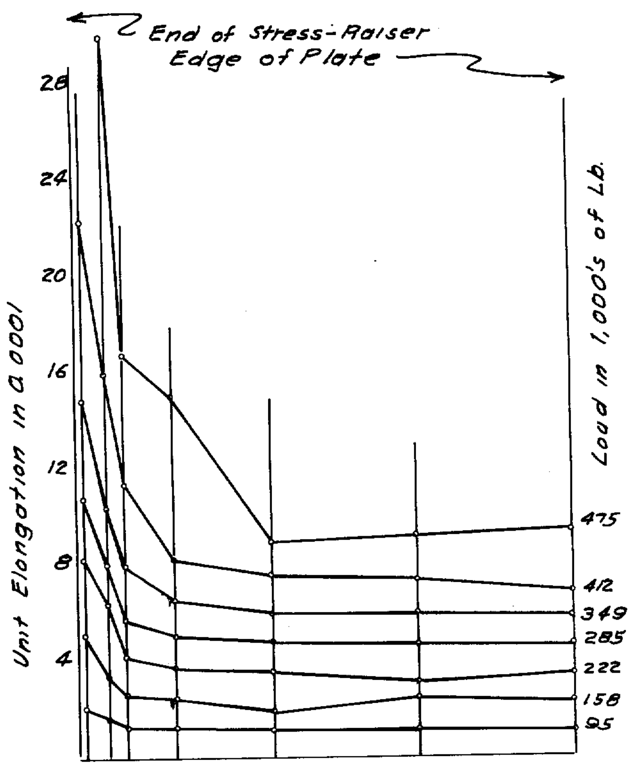
Strain Distribution Across One Half of 24-In. Plate from Electric Strain Gages
Specimen A-3
F As-Rolled
Fig. 85a.



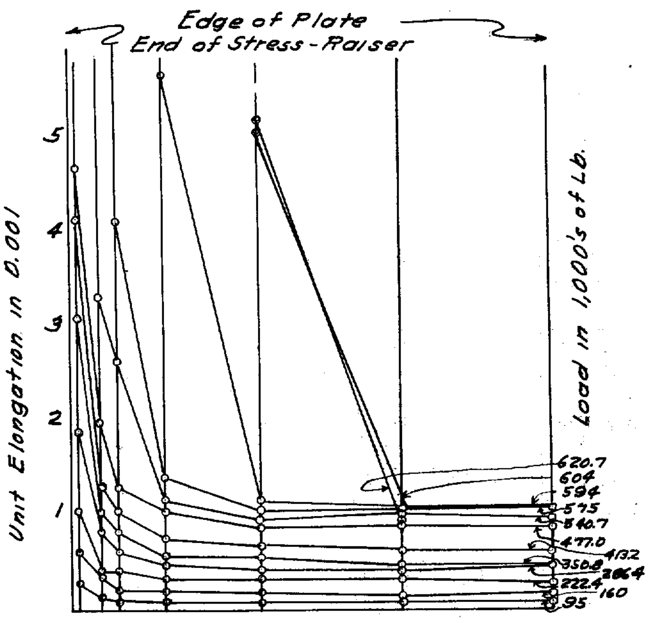
Strain Distribution Across One Half of 12-In. Plate from Electric Strain Gages
Specimen 23-3B
E As Rolled
Fig. 86a.



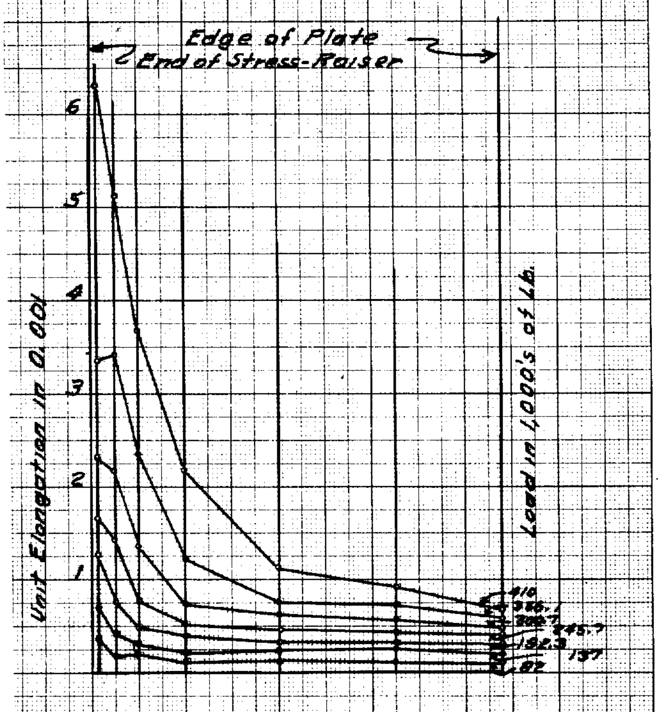
Strain Distribution Across One Half of 12-In. Plate from Electric Strain Gages
Specimen 23-3A
E Normalized
Fig. 87a.



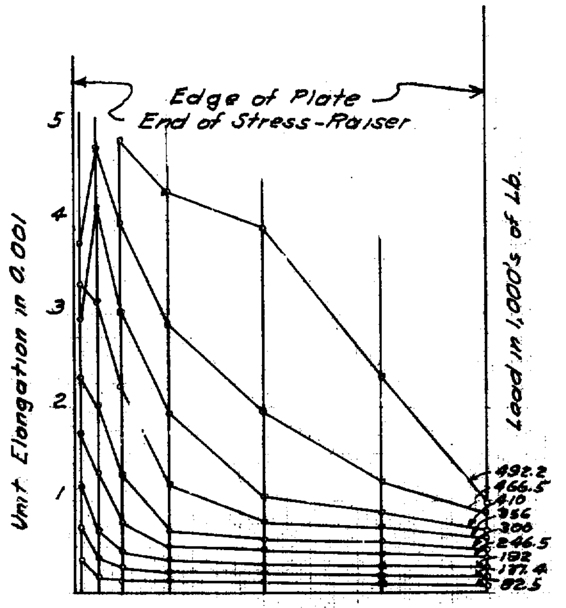
Strain Distribution Across Half of 24-In. Plate from Electric Strain Gages
Specimen 20A-7
E As-Rolled
Fig. 88a.



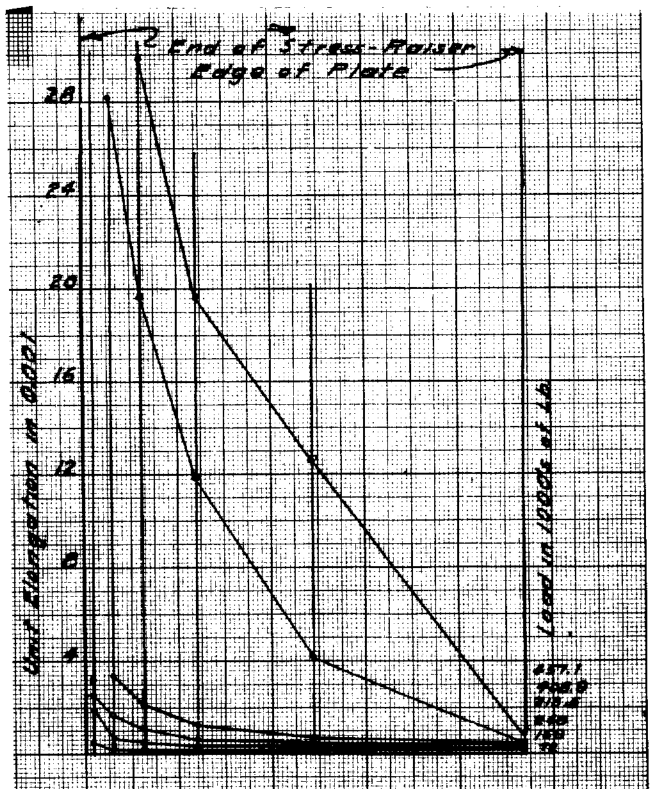
Strain Distribution Across One Half of 24-In.
Plate from Electric Strain Gages
Specimen 20-13
E As Rolled
Fig. 89a.



Strain Distribution Across One Half of 24-In.
Plate from Electric Strain Gages
Specimen 20A-8
E As Rolled
Fig. 90a.

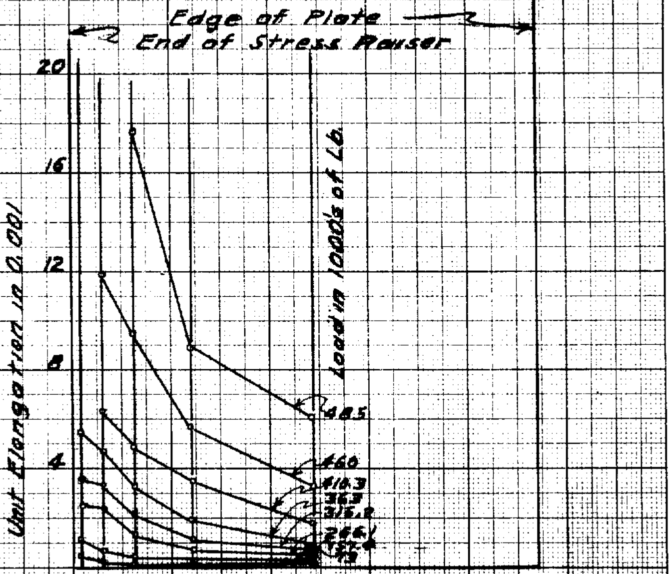


Strain Distribution Across One Half of 24-In.
of Plate from Electric Strain Gages
Specimen 20-14
E As Rolled
Fig. 91a.

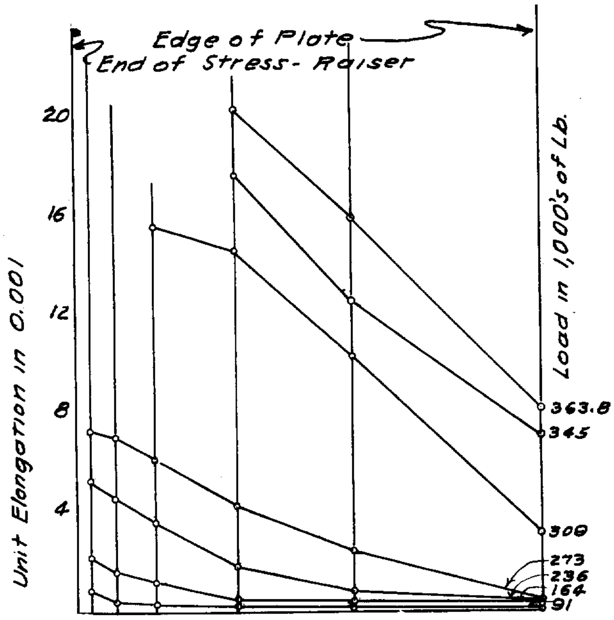


Strain Distribution Across One Half of 24-In.
of Plate from Electric Strain Gages
Specimen 20A-9
E As Rolled
Fig. 92a.

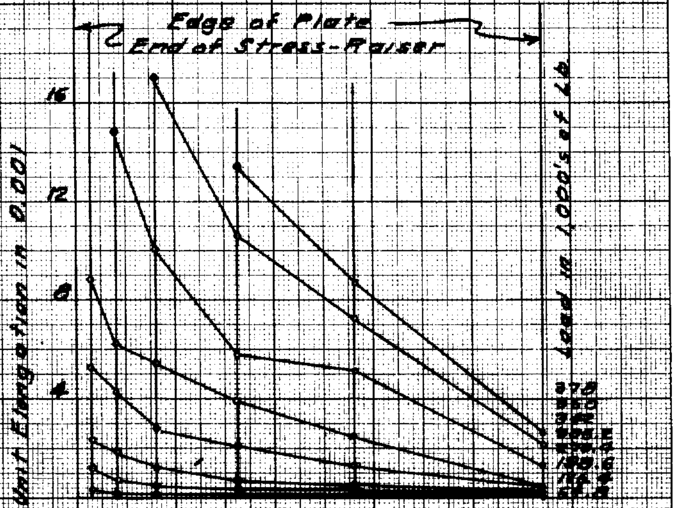
24a



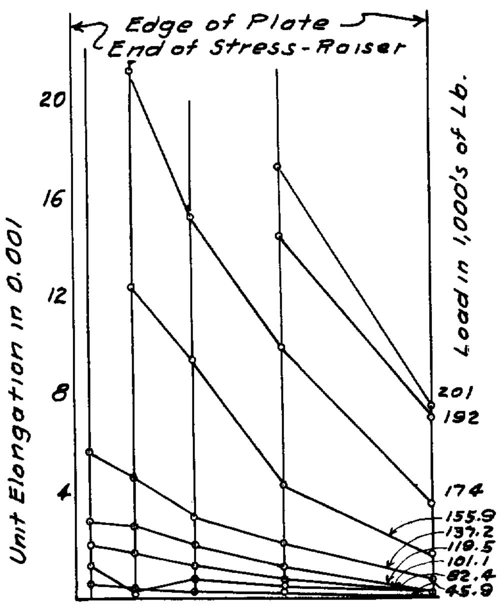
Strain Distribution Across One Half of 24-In.
of Plate from Electric Strain Gages
Specimen 20-15
E As-Rolled
Fig. 93a.



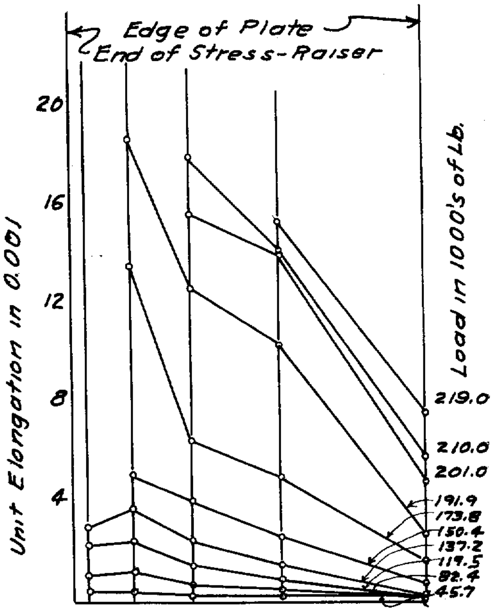
Strain Distribution Across One Half of 24-In.
Plate from Electric Strain Gages
Specimen 20A-10
E As-Rolled
Fig. 94-a.



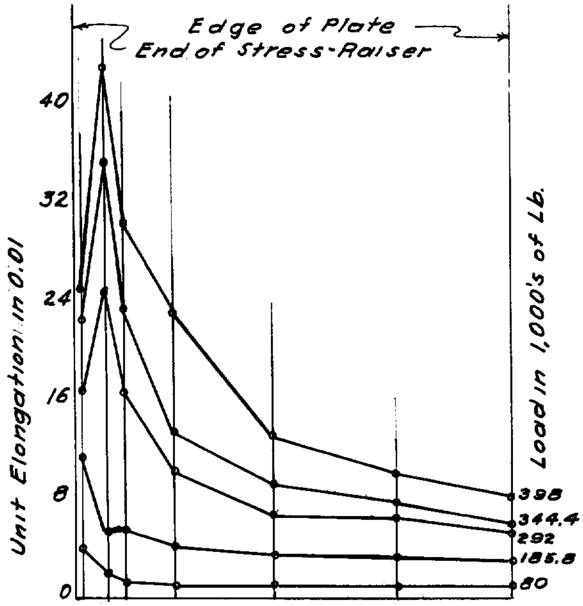
Strain Distribution Across One-Half of 24-In.
Plate from Electric Strain Gages
Specimen 20-7
E As-Rolled
Fig. 95a



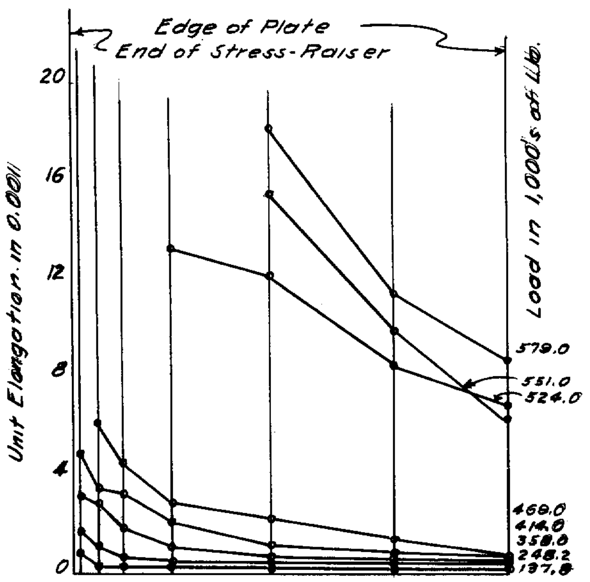
Strain Distribution Across One Half of 24-In.
Plate from Electric Strain Gages
Specimen 20A-15
E As-Rolled
Fig. 96a.



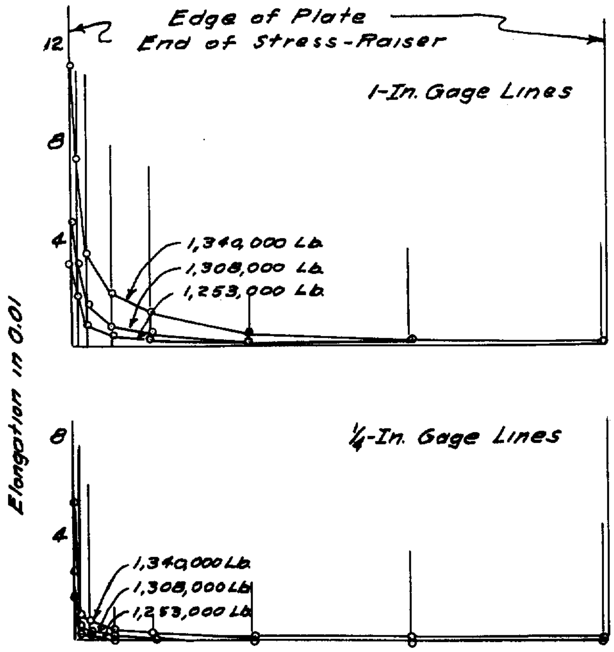
Strain Distribution Across One Half of 24-In.
Plate from Electric Strain Gages
Specimen 20A-11
E As-Rolled
Fig. 97a.



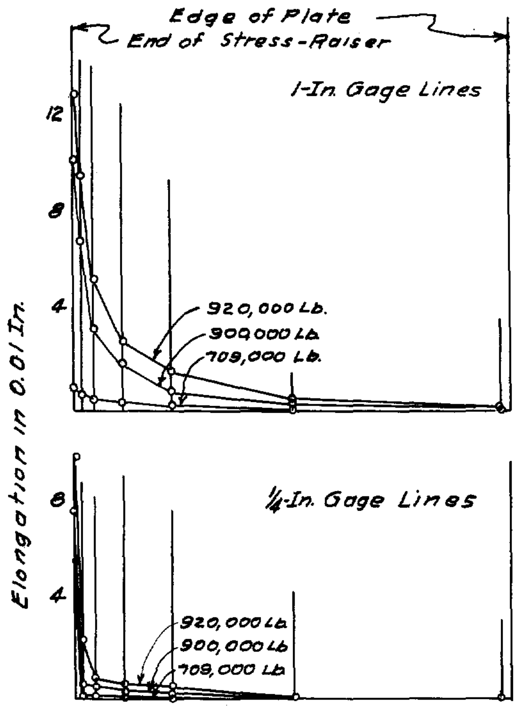
Strain Distribution Across Half of 24-In.
Plate from Electric Strain Gages
Specimen 22A-9
Fig. 98a.



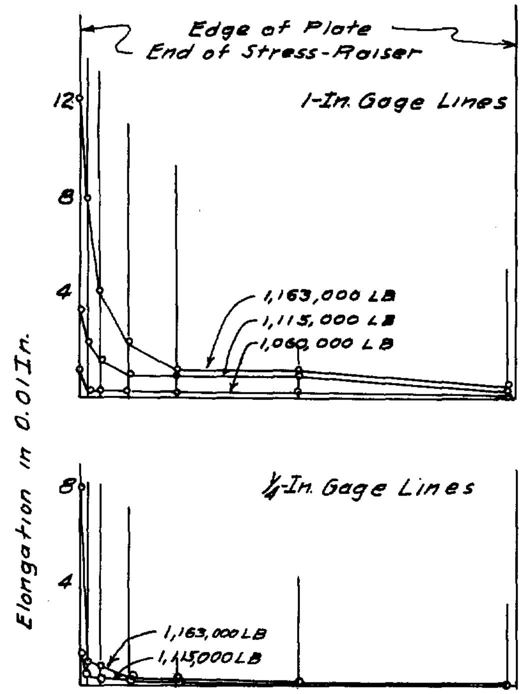
Strain Distribution Across Half of 24-In.
Plate from Electric Strain Gages
Specimen 20A-14
Fig. 99a.



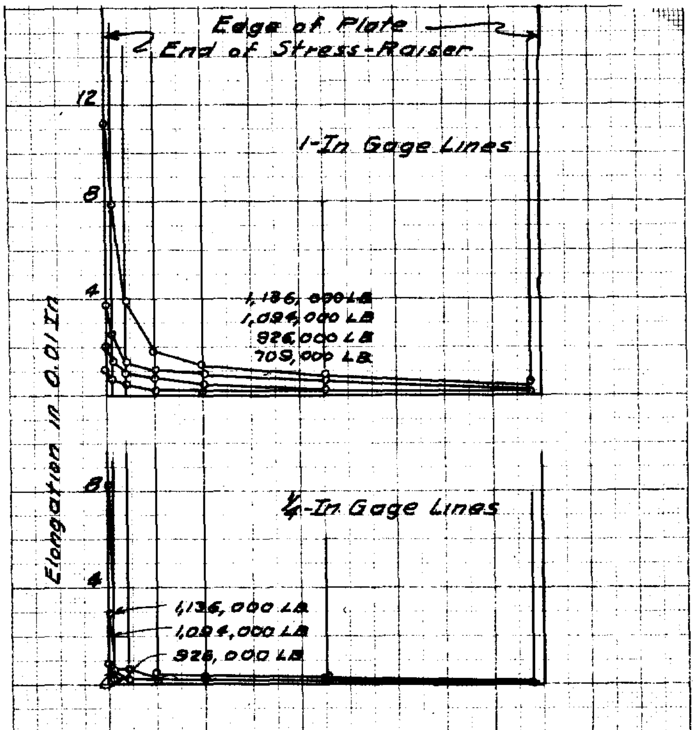
Strain Distribution Across Half of 72-In Plate
from ¼-In. and 1-In. Gage Lines
Specimen 18A-1
Steel E As-Rolled
Fig. 100a.



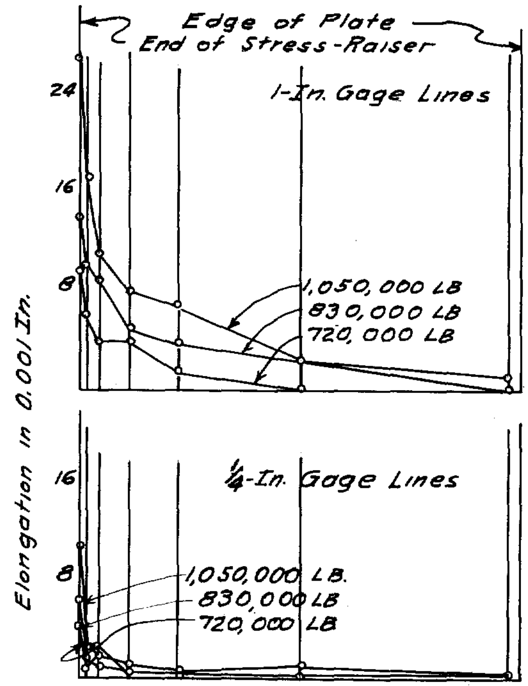
Strain Distribution Across Half of 48-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 13-7
Steel E As-Rolled
Fig. 101a.



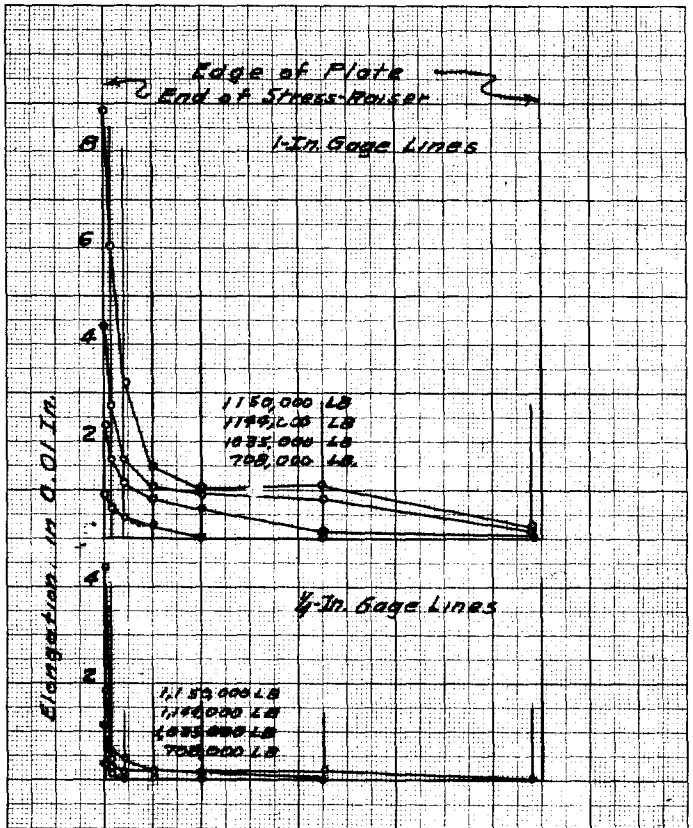
Strain Distribution Across Half of 48 In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 17B-7
Steel D As-Rolled
Fig. 102a.



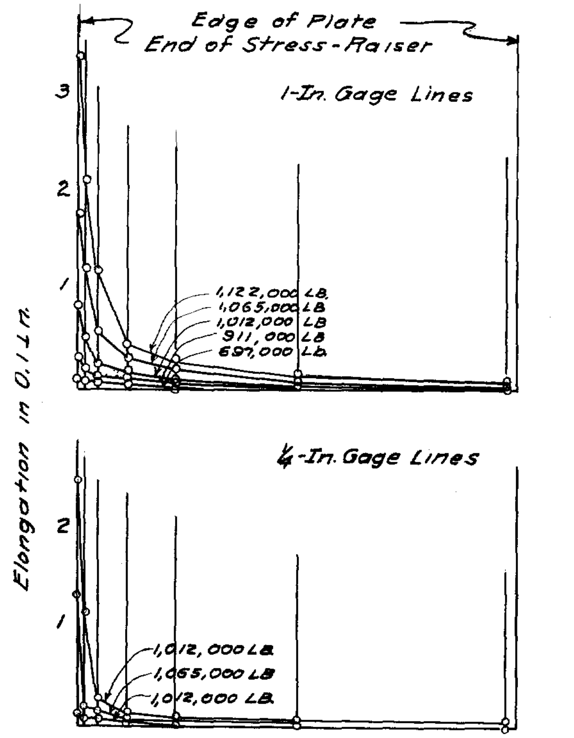
Strain Distribution Across Half of 48-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 18-2
Steel D As-Rolled
Fig. 103a.



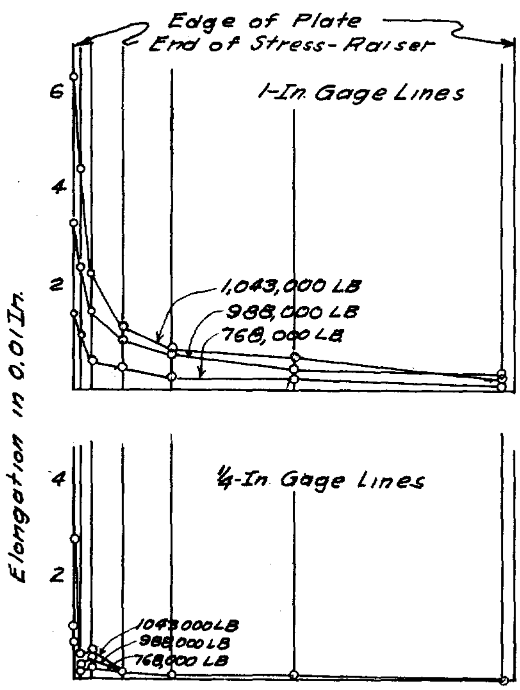
Strain Distribution Across Half of 48-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 5-4
Steel D As-Rolled
Fig. 104a.



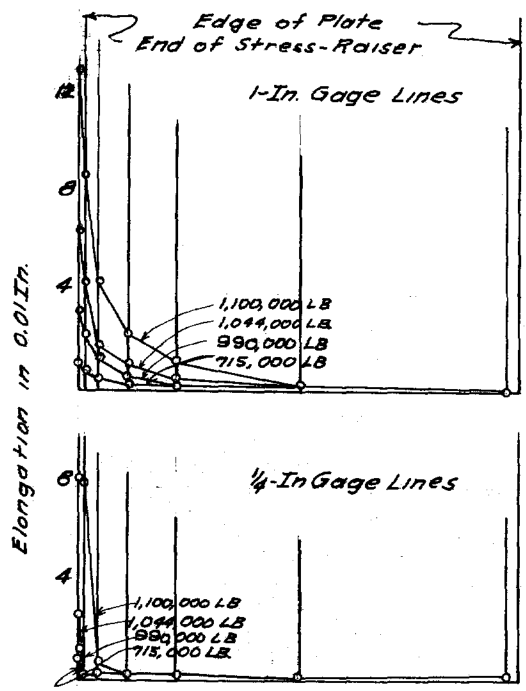
Strain Distribution Across Half of 48-In.
Plate from 1/4-In. and 1-In. Gage Lines
Specimen 18-1
Steel D Normalized
Fig. 105a.



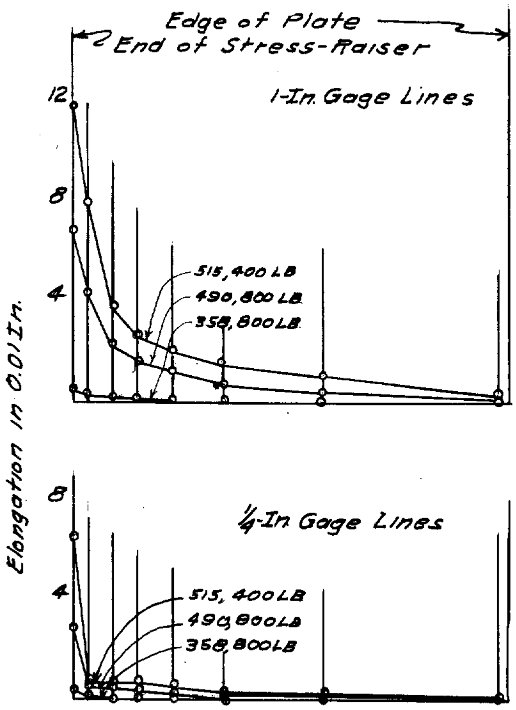
Strain Distribution Across Half of 48-In.
Plate from 1/4-In. and 1-In. Gage Lines
Specimen 15A-1
Steel D Normalized
Fig. 106a.



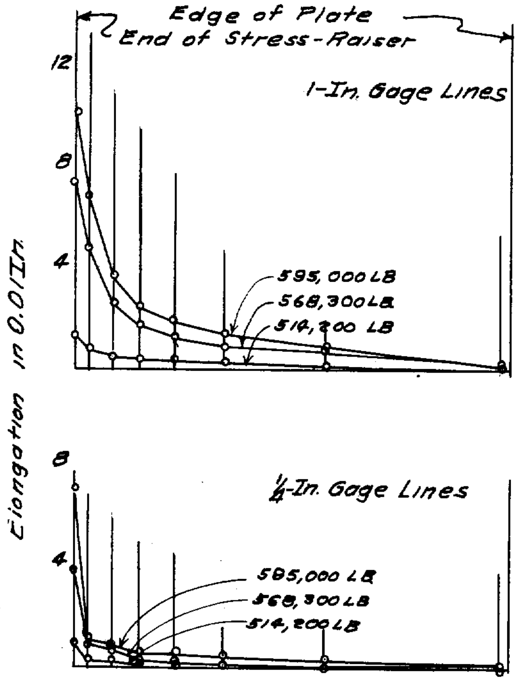
Strain Distribution Across Half of 48-In.
Plate from 1/4-In. and 1-In. Gage Lines
Specimen 5A-2
Steel D Normalized
Fig. 107a.



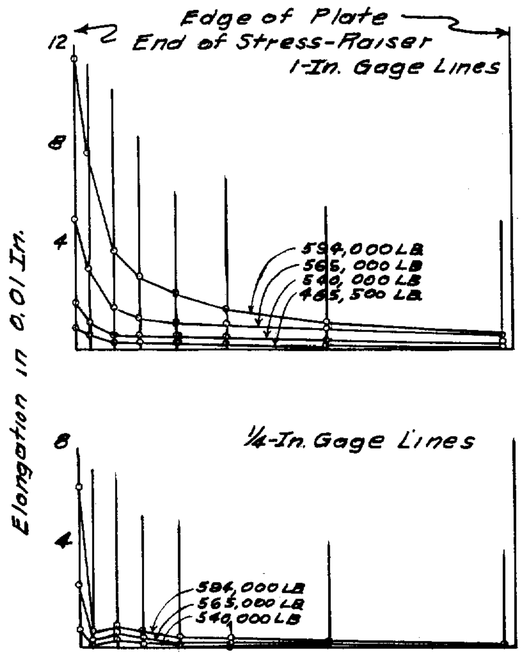
Strain Distribution Across Half of 48-In
Plate from 1/4-In. and 1-In. Gage Lines
Specimen 5A-5
Steel D Normalized
Fig. 108a.



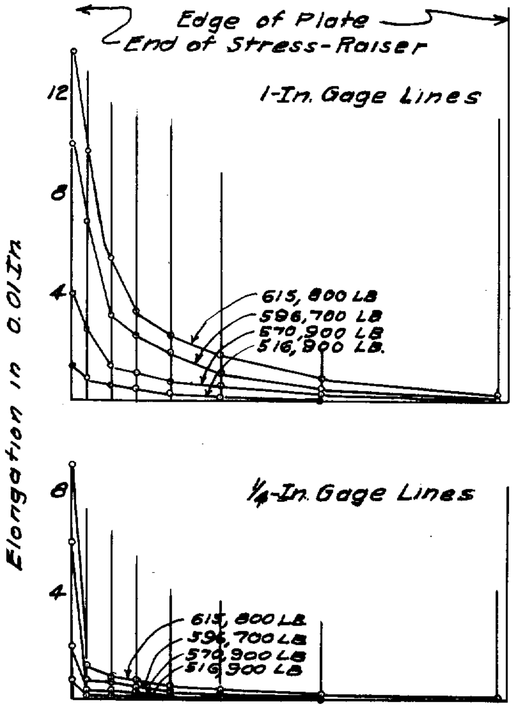
Strain Distribution Across Half of 24-In
Plate from 1/4-In. and 1-In. Gage Lines
Specimen 20A-13
Steel E As Rolled
Fig. 109a.



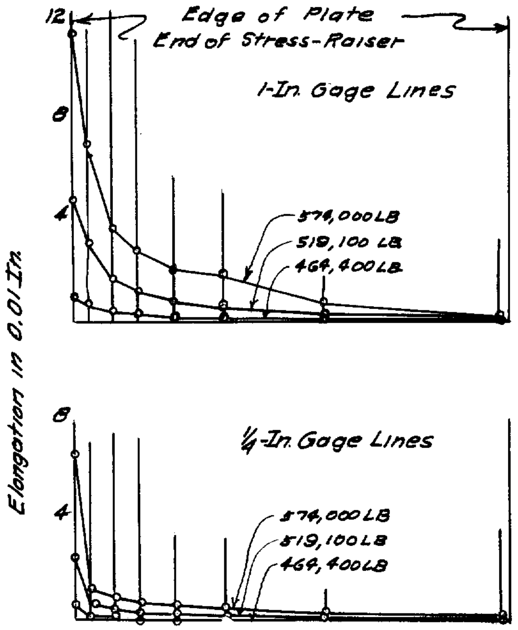
Strain Distribution Across Half of 24-In.
Plate from 1/4-In. and 1-In. Gage Lines
Specimen 17B-6
Steel D As-Rolled
Fig. 110a.



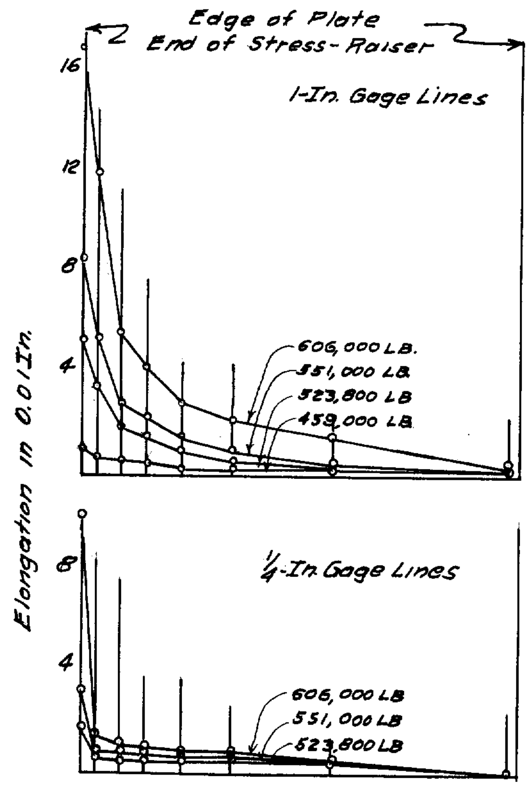
Strain Distribution Across Half of 24-In.
Plate from 1/4-In and 1-In Gage Lines
Specimen 17B-4
Steel D As-Rolled
Fig. 111a.



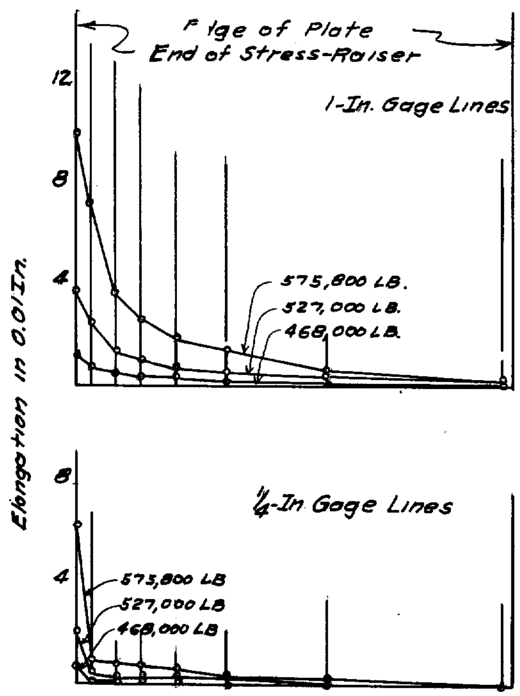
Strain Distribution Across Half of 24-In
Plate from 1/4-In. and 1-In Gage Lines
Specimen 17B-5
Steel D As-Rolled
Fig. 112a.



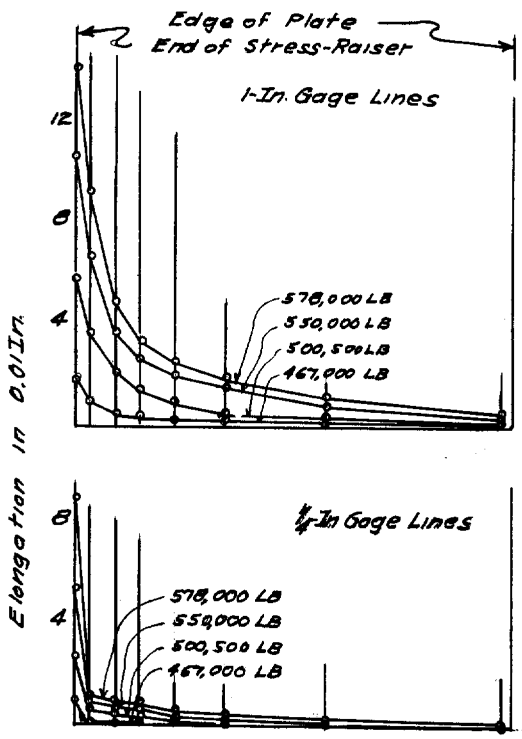
Strain Distribution Across Half of 24-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 9-1
Steel D Normalized
Fig. 113a.



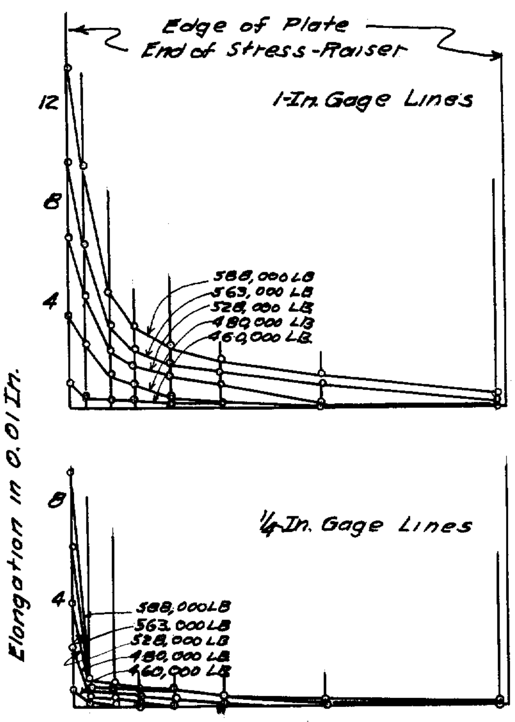
Strain Distribution Across Half of 24-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 3-2
Steel D Normalized
Fig. 114a.



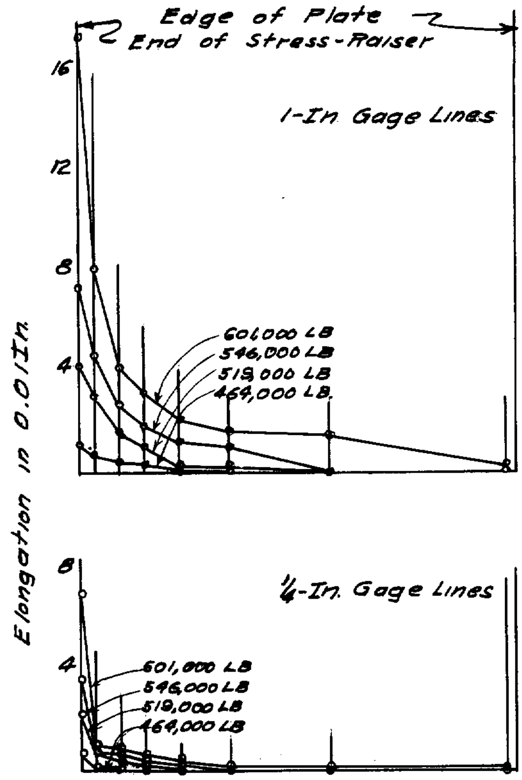
Strain Distribution Across Half of 24-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 3-3
Steel D Normalized
Fig. 115a.



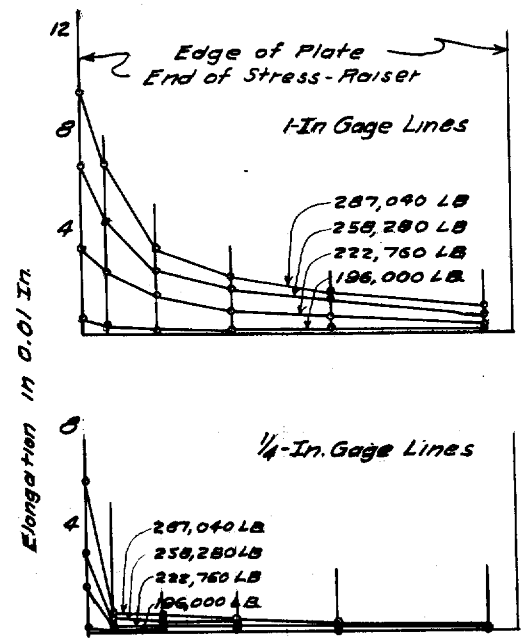
Strain Distribution Across Half of 24-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen A-2
Steel F As-Rolled
Fig. 116a.



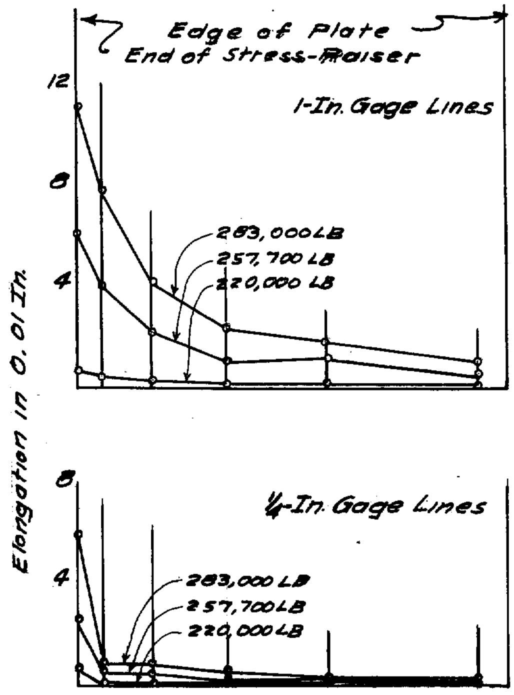
Strain Distribution Across Half of 24-In. Plate from 1/4-In. and 1-In. Gage Lines
Specimen A-1
Steel F As-Rolled
Fig. 117a.



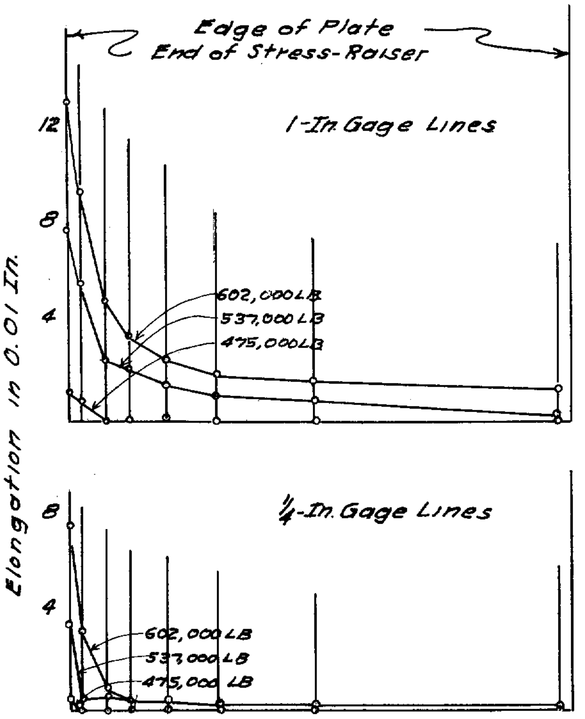
Strain Distribution Across Half of 24-In. Plate from 1/4-In. and 1-In. Gage Lines
Specimen A-3
Steel F As-Rolled
Fig. 118a.



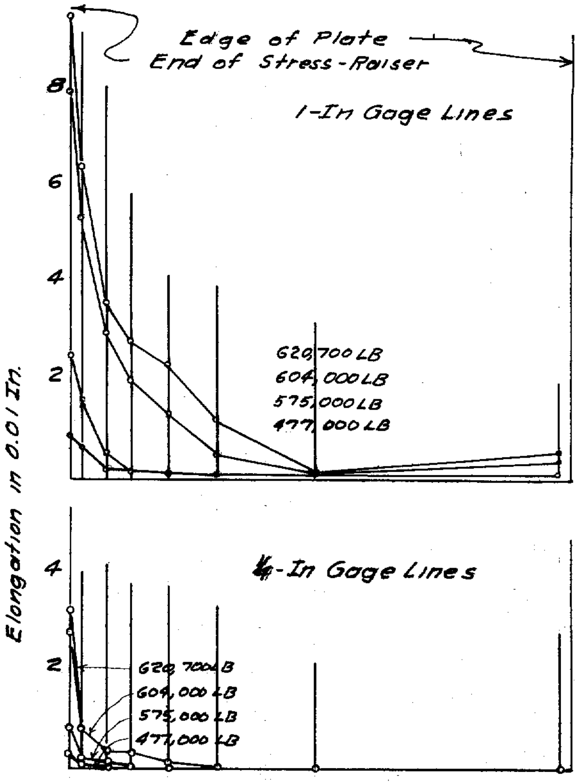
Strain Distribution Across Half of 12 In. Plate from 1/4-In. and 1-In. Gage Lines
Specimen 23-3B
Steel E As-Rolled
Fig. 119a.



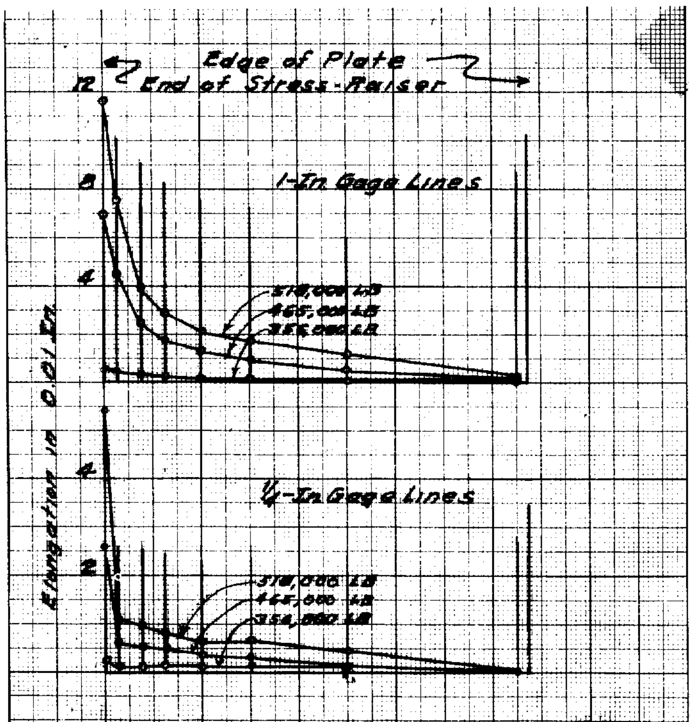
Strain Distribution Across Half of 12 In Plate from 1/4-In and 1-In Gage Lines
Specimen 23-3A
Steel E Normalized
Fig. 120a.



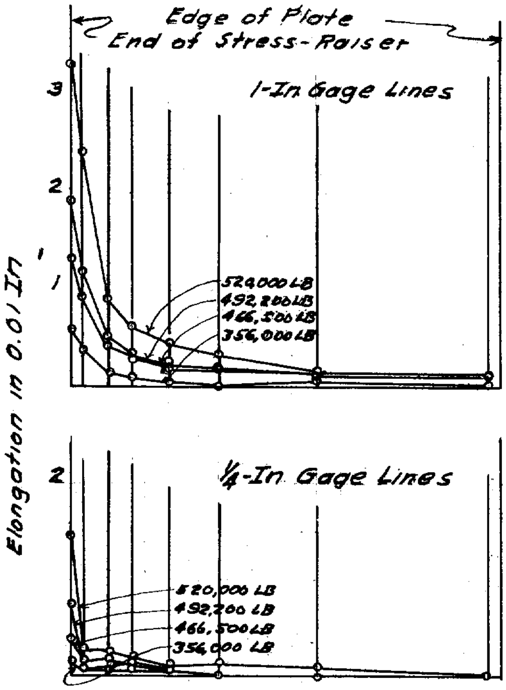
Strain Distribution Across Half of 24-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 20A-7
Steel E As-Rolled
Fig. 121a.



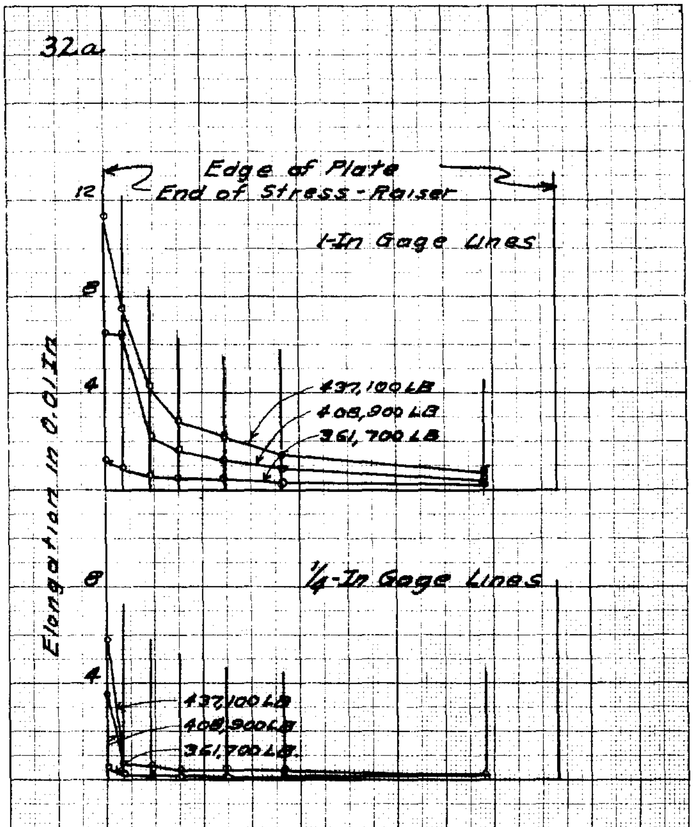
Strain Distribution Across Half of 24-In Plate from ¼-In and 1-In Gage Lines
Specimen 20-13
Steel E As-Rolled
Fig. 122a.



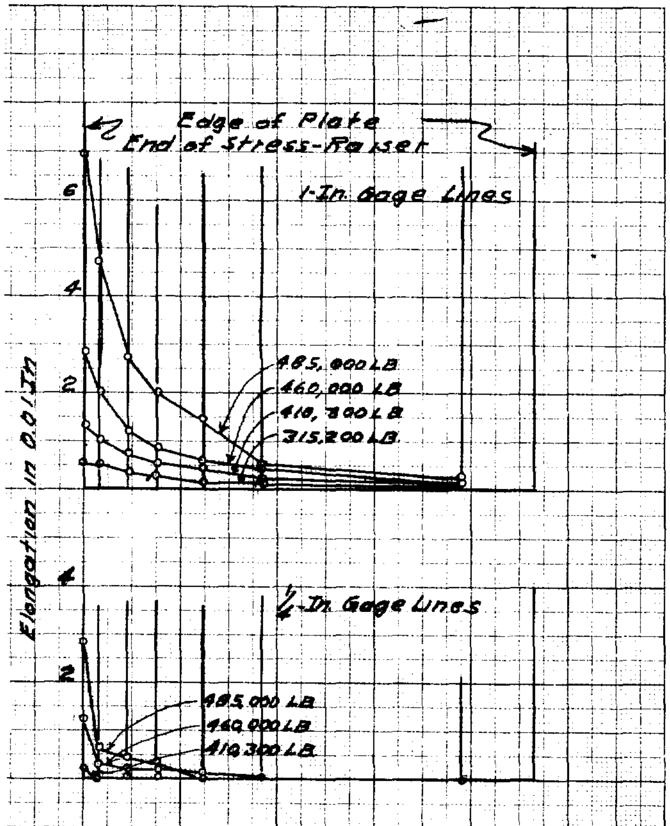
Strain Distribution Across Half of 24-In Plate from ¼-In and 1-In Gage Lines
Specimen 20A-8
Steel E As-Rolled
Fig. 123a.



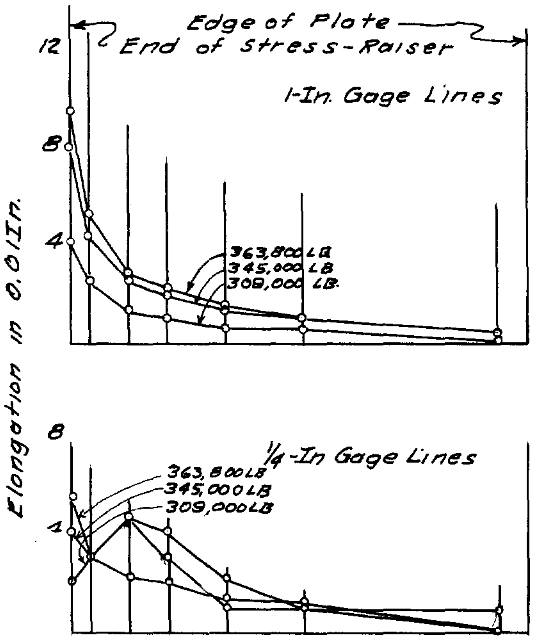
Strain Distribution Across Half of 24-In. Plate from ¼-In. and 1-In. Gage Lines
Specimen 20-14
Steel E As Rolled
Fig. 124a.



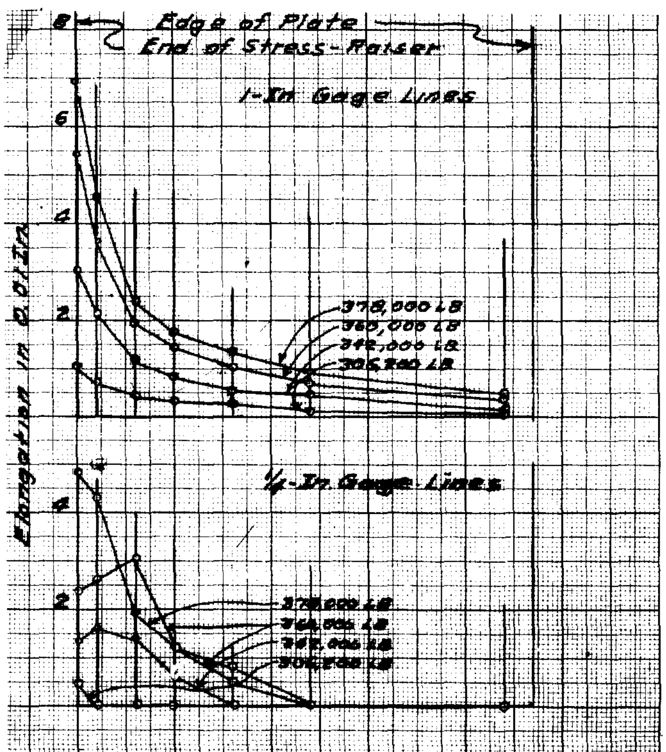
Strain Distribution Across Half of 24-In
Plate from 1/4-In and 1-In Gage Lines
Specimen 20A-9
Steel E As-Rolled
Fig. 125a.



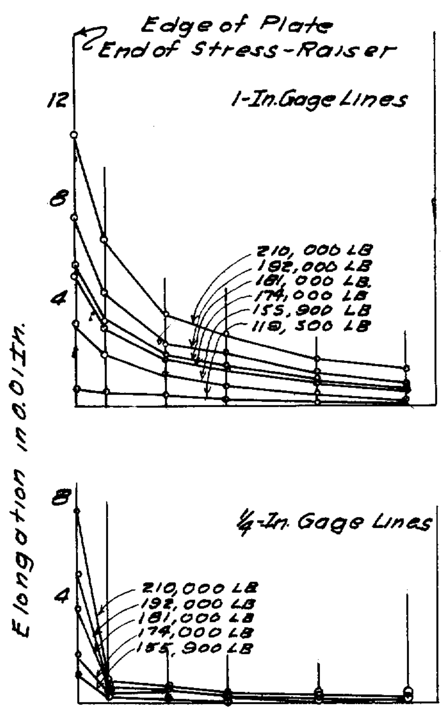
Strain Distribution Across Half of 24-In
Plate from 1/4-In and 1-In Gage Lines
Specimen 20-15
Steel E As-Rolled
Fig. 126a.



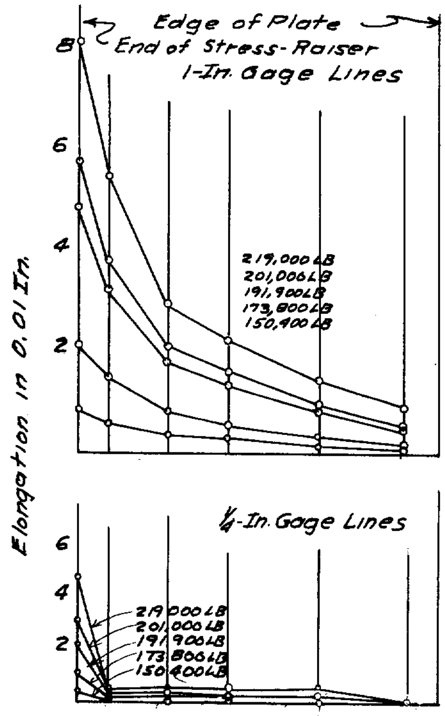
Strain Distribution Across Half of 24-In
Plate from 1/4-In. and 1-In. Gage Lines
Specimen 20A-10
Steel E As Rolled
Fig. 127a.



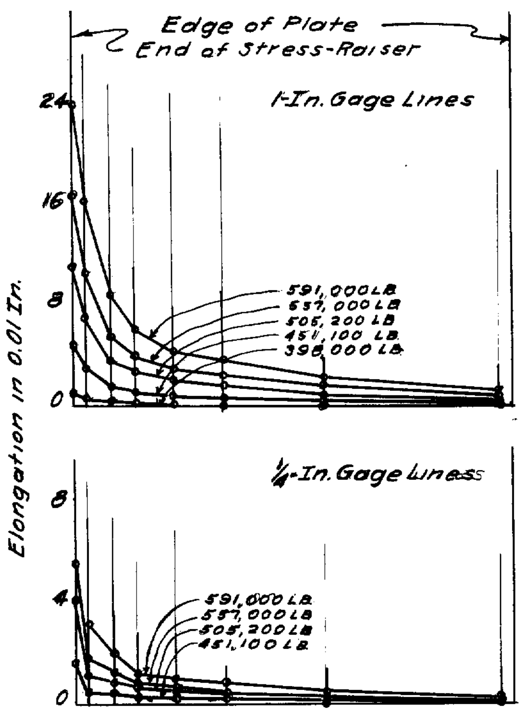
Strain Distribution Across Half of 24-In
Plate from 1/4-In and 1-In Gage Lines
Specimen 20-7
Steel E As-Rolled
Fig. 128a.



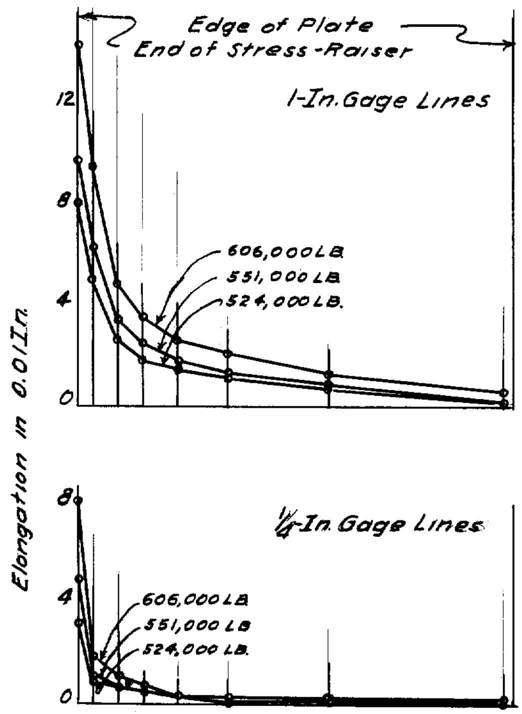
Strain Distribution Across Half of 24-In Plate from 1/4-In and 1-In Gage Lines
Specimen 20A-15
Steel E As-Rolled
Fig. 129a.



Strain Distribution Across Half of 24-In Plate from 1/4-In and 1-In Gage Lines
Specimen 20A-11
Steel E As Rolled
Fig. 130a.

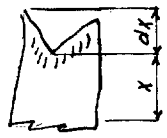


Strain Distribution Across Half of 24-In. Plate from 1/4-In. and 1-In. Gage Lines
Specimen 22A-9
Fig. 131a.

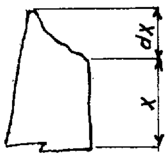


Strain Distribution Across Half of 24-In Plate from 1/4-In and 1-In. Gage Lines
Specimen 20A-14
Fig. 132a.

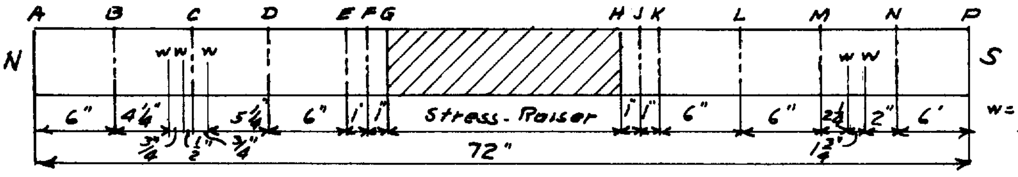
Sec.	Distance from Fracture x								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	←Flame Cut			→	.762	.763	.761	.759	0
B	←Flame Cut			→	.742	.742	.740	.739	0
C	.575	.592	.606	.635	.659	.731	.703	.710	1/32"
D	.647	.661	.668	.678	.683	.690	.701	—	9/16"
E	.660	.687	.695	.707	.716	.789	.746	—	21/32"
F	.686	.705	.714	.728	.737	.747	.759	—	21/32"
G	.738	.752	.756	.762	.763	.768	.768	.768	1/4"
H	.766	.761	.762	.764	.766	.768	.770	.771	5/32"
J	.685	.705	.715	.731	.740	.750	.762	—	19/32"
K	.667	.688	.695	.710	.721	.735	.750	—	21/32"
L	.643	.659	.669	.681	.690	.695	.707	—	5/8"
M	.635	.650	.658	.672	.681	.689	.698	—	9/16"
N	.627	.646	.654	.665	.671	.679	.691	—	15/32"
P	.658	.662	.670	.675	.677	.682	.693	.699	5/8"



Sketch A
Profile of Sec. C



Sketch B
Profile of Secs D, E, F, G, H, J, K, L, M, N, P

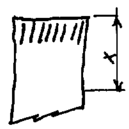


E As Rolled

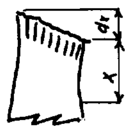
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 18A-1[R]

Fig. 133a.

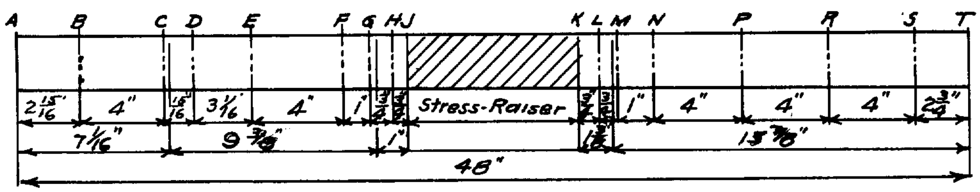
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	—	—	—	.757	.758	.756	.755	.753	0
B	—	—	—	.733	.734	.734	.733	.732	0
C	—	—	—	.669	.677	.686	.699	—	0
D	.591	.615	.640	.654	.665	.678	.700	—	15/32"
E	.632	.645	.657	.668	.679	.694	.711	—	5/8"
F	.668	.679	.691	.701	.709	.719	.734	—	5/8"
G	.674	.686	.705	.716	.728	.733	.743	—	9/16"
H	.675	.710	.728	.733	.735	.739	.746	.751	0
J	.675	.704	.724	.736	.742	.748	.752	.754	0
K	.666	.706	.726	.737	.743	.748	.752	.753	0
L	.678	.713	.731	.732	.733	.736	.744	.749	0
M	.631	.662	.689	.710	.725	.735	.742	.747	0
N	.660	.678	.691	.702	.710	.723	.736	—	5/8"
P	.632	.652	.661	.673	.682	.693	.705	—	5/8"
R	.629	.643	.663	.661	.668	.680	.697	—	5/8"
S	.625	.640	.650	.659	.666	.676	.692		5/8"
T	.670	.681	.692	.701	.707	.710	.668	—	7/16"



Sketch A
Profile of Secs. A, B, C, G, H, J, K



Sketch B
Profile of Secs. D, E, F, L, M, N, P, R S, T

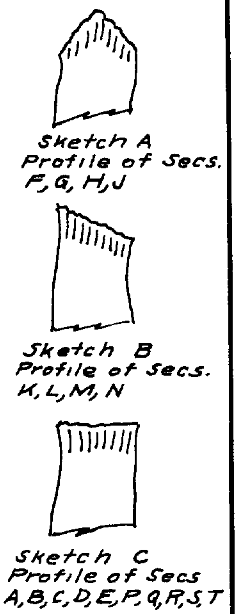


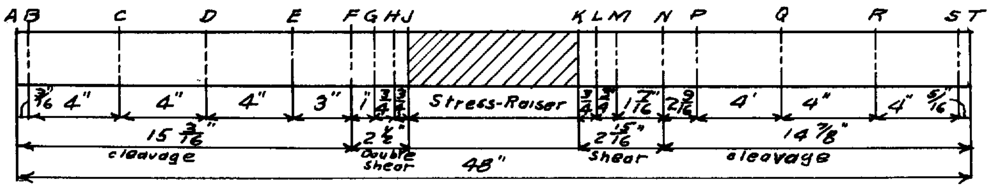
E As Rolled

Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 13-7

Fig. 134-a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	6/8"	5/8"	1 1/8"	1 5/8"	dX
A	.751	.759	.762	.764	.765	.766	.768	.768	0
B	.756	.760	.761	.763	.764	.765	.767	.768	0
C	.747	.760	.757	.760	.761	.762	.763	.765	0
D	.737	.748	.749	.752	.753	.755	.755	.757	0
E	.728	.735	.736	.739	.741	.741	.742	.744	0
F	.644	.651	.656	.667	.678	.696	.722	.737	9/32"
G	.659	.666	.668	.679	.689	.708	.737	.750	5/16"
H	.658	.668	.672	.683	.697	.724	.751	.761	5/16"
J	.715	.732	.749	.752	.759	.761	.768	.768	0
K	.724	.731	.750	.755	.757	.760	.764	.766	0
L	.688	.709	.719	.733	.740	.749	.760	–	11/16"
M	.678	.700	.709	.722	.730	.740	.751	–	23/32"
N	.649	.656	.677	.680	.699	.716	.734	.744	25/64"
P	.721	.731	.733	.736	.738	.741	.743	.744	0
Q	.735	.744	.746	.749	.751	.752	.755	.758	0
R	.740	.751	.754	.756	.758	.759	.762	.763	0
S	.745	.753	.754	.756	.758	.759	.763	.765	0
T	.732	.733	.735	.738	.739	.742	.744	.744	0

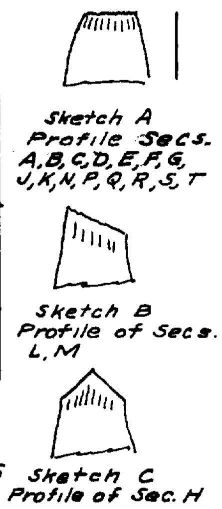


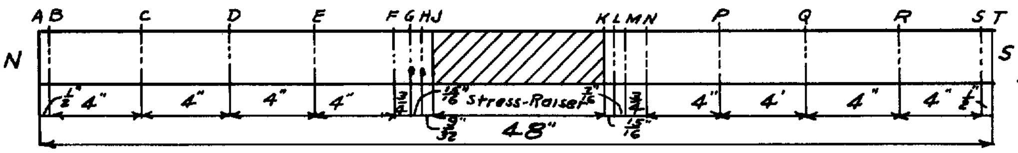


D As Rolled
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 17B-7

Fig. 135a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.730	.749	.751	.753	.754	.753	.756	.755	0
B	.735	.740	.743	.745	.747	.749	.752	.756	0
C	.728	.739	.745	.746	.748	.750	.752	.754	0
D	.725	.740	.742	.744	.744	.745	.748	.753	0
E	.728	.741	.743	.743	.745	.747	.747	.747	0
F	.710	.720	.722	.723	.725	.727	.732	.741	0
G	.676	.684	.690	.696	.706	.721	.739	.746	0
H	.647	.663	.674	.691	.710	.733	.744	.748	3/16"
J	.724	.733	.735	.740	.742	.746	.749	.752	0
K	.683	.708	.717	.734	.742	.745	.749	.751	0
L	.637	.663	.679	.710	.725	.736	.745	.748	1/4"
M	.682	.689	.694	.703	.715	.725	.741	.747	3/32"
N	.709	.718	.720	.722	.723	.726	.734	.741	0
P	.728	.738	.740	.742	.742	.744	.744	.747	0
Q	.722	.739	.741	.743	.746	.748	.750	.752	0
R	.723	.736	.737	.739	.741	.745	.748	.754	0
S	.725	.742	.749	.751	.752	.752	.748	.751	0
T	.715	.719	.718	.721	.717	.719	.713	.713	0

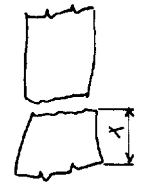




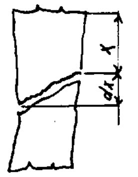
D As Rolled
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 18-2

Fig. 136a.

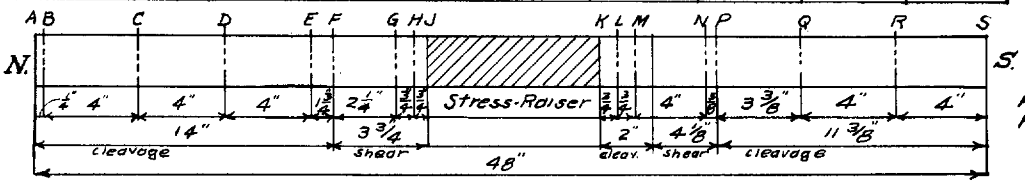
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.739	.749	.753	.754	.755	.756	.758	.759	0
B	.742	.751	.752	.752	.754	.755	.756	.757	0
C	.739	.746	.746	.748	.750	.750	.752	.752	0
D	.751	.736	.737	.738	.739	.741	.743	.744	0
E	.694	.706	.708	.711	.712	.714	.718	.724	0
F	.622	.636	.643	.656	.674	.694	.716	.725	11/16"
G	.662	.681	.692	.707	.717	.728	.741	—	43/64"
H	.674	.696	.707	.722	.731	.741	.754	—	5/8"
J	← Edge	Bruised	→	.751	.754	.758	.759	.760	0
K	Edge Bruised		.752	.755	.758	.763	.767	.767	0
L	Edge Bruised →			.756	.756	.757	.758	.762	0
M	Edge Bruised →			.764	.762	.762	.758	.760	0
N	.639	.661	.669	.683	.693	.708	.723	—	11/16"
P	.586	.617	.621	.641	.665	.687	.711	.725	11/16"
Q	.717	.723	.725	.727	.730	.733	.732	.736	0
R	.733	.738	.740	.743	.745	.746	.747	.748	0
S	.745	.754	.755	.756	.757	.758	.758	.760	0



Sketch A
Profile of Secs.
A, B, C, D, E, K, L, M, Q, R, S



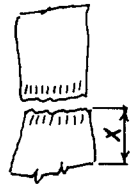
Sketch B
Profile of Secs.
F, G, H, J, N, P



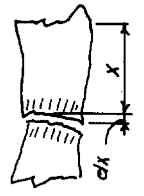
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 5-4
D As-Rolled

Fig. 137a.

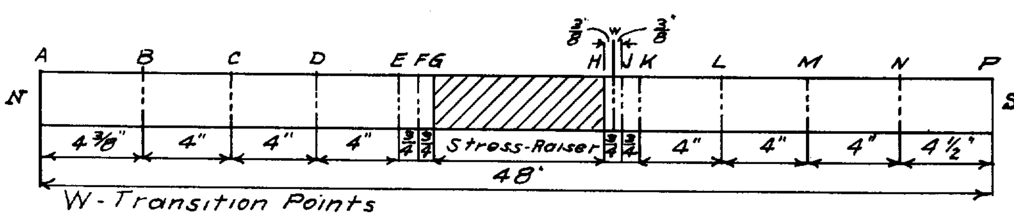
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.751	.753	.754	.754	.755	.754	.754	.754	0
B	.739	.744	.747	.747	.749	.750	.705	.756	0
C	.739	.741	.742	.745	.748	.749	.751	.753	0
D	.745	.746	.748	.749	.750	.752	.752	.753	0
E	.726	.728	.733	.732	.733	.734	.739	.745	0
F	.714	.712	.714	.718	.722	.738	.744	.749	0
G	.739	.737	.739	.742	.745	.747	.751	.754	0
H	.711	.725	.737	.740	.745	.748	.752	.753	1/4"
J	.708	.709	.712	.714	.720	.730	.744	.749	0
K	.728	.729	.732	.721	.731	.734	.739	.745	0
L	.743	.745	.745	.747	.747	.748	.749	.750	0
M	.739	.743	.745	.747	.747	.748	.750	.752	0
N	.737	.738	.741	.743	.743	.746	.748	.754	0
P	.726	.731	.732	.734	.734	.735	.737	.739	0



Sketch A
Profile of Secs.
A, B, C, D, E, F, G, J, K, L, M, N, P



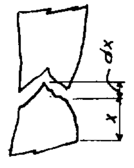
Sketch B
Profile of Sec. H



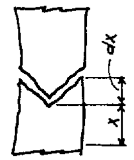
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 18-1
D As Rolled

Fig. 138a.

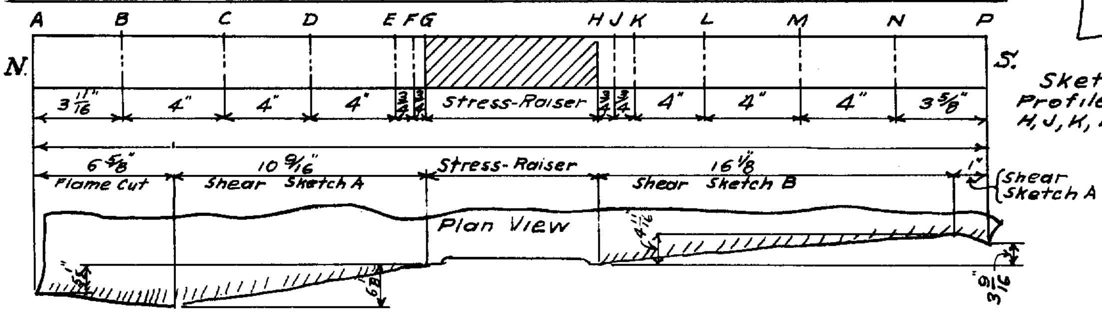
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	← Flame-Cut		→	.740	.741	.741	.744	.736	0
B	← Flame-Cut		→	.703	.701	.702	.698	.697	0
C	.581	.597	.603	.606	.614	.632	.655	.671	1/4"
D	.565	.589	.596	.606	.616	.638	.665	.682	13/64"
E	.588	.596	.607	.624	.643	.671	.702	.720	15/64"
F	.590	.613	.624	.640	.658	.687	.718	.732	13/64
G	.661	.686	.713	.725	.730	.736	.740	.740	0
H	.680	.724	.733	.735	.737	.740	.743	.743	0
J	.592	.610	.625	.649	.668	.697	.725	.734	7/32"
K	.567	.611	.618	.629	.647	.673	.705	.723	13/64"
L	.567	.594	.599	.608	.622	.642	.669	.685	15/64"
M	.568	.593	.604	.609	.615	.635	.659	.674	7/32
N	.590	.615	.616	.616	.619	.631	.650	.663	17/64
P	.521	.548	.561	.582	.598	.615	.618	.633	1/4"



Sketch A
Profile of Secs.
C, D, E, F, G, P



Sketch B
Profile of Secs.
H, J, K, L, M, N

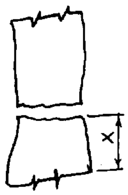


D Normalized

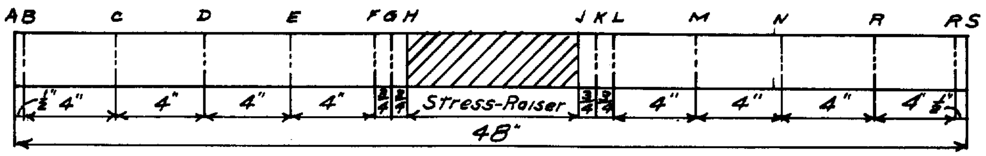
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 15A-1-KN

Fig. 139a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.697	.680	.682	.681	.680	.683	.675	.676	0
B	.734	.741	.744	.742	.746	.739	.745	.747	0
C	.738	.757	.759	.760	.763	.766	.767	.768	0
D	.741	.754	.757	.759	.760	.761	.761	.764	0
E	.739	.756	.759	.759	.761	.761	.761	.760	0
F	.730	.740	.741	.743	.744	.746	.750	.755	0
G	.721	.730	.731	.734	.737	.740	.751	.758	0
H	.666	.692	.721	.737	.745	.752	.761	.764	0
J	.663	.703	.726	.739	.746	.754	.763	.767	0
K	.721	.732	.736	.737	.740	.743	.753	.759	0
L	.720	.744	.746	.748	.749	.749	.752	.756	0
M	.717	.746	.760	.766	.766	.766	.764	.764	0
N	.732	.759	.766	.767	.768	.766	.769	.770	0
P	.741	.760	.764	.767	.767	.769	.770	.770	0
R	.753	.758	.760	.762	.763	.763	.765	.764	0
S	.753	.756	.755	.759	.755	.757	.764	.765	0



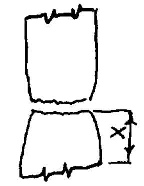
Sketch A
Profile of all Sections

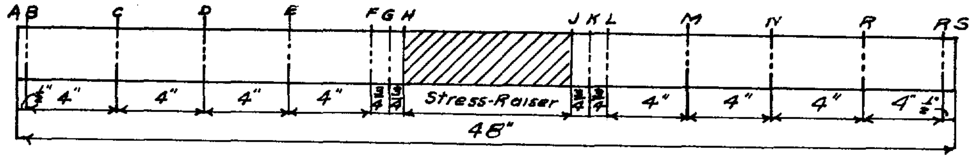


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 5A-2
D Normalized

Fig. 140a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.705	.698	.693	.691	.696	.693	.692	.687	0
B	.741	.743	.744	.748	.749	.752	.755	.750	0
C	.749	.760	.762	.765	.766	.768	.769	.769	0
D	.746	.755	.757	.760	.761	.762	.765	.764	0
E	.740	.755	.757	.760	.759	.761	.762	.764	0
F	.735	.728	.729	.732	.735	.739	.750	.757	0
G	.715	.728	.729	.732	.735	.739	.750	.757	0
H	.660	.680	.706	.731	.741	.751	.759	.763	0
J	.661	.686	.717	.746	.752	.757	.762	.765	0
K	.746	.737	.739	.740	.742	.744	.753	.759	0
L	.736	.748	.749	.750	.750	.749	.752	.758	0
M	.741	.758	.761	.761	.762	.765	.763	.762	0
N	.722	.757	.761	.765	.767	.767	.769	.767	0
P	.738	.758	.759	.765	.767	.768	.768	.769	0
R	.749	.761	.758	.759	.761	.761	.761	.764	0
S	.751	.761	.766	.768	.770	.762	.765	.770	0

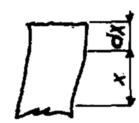


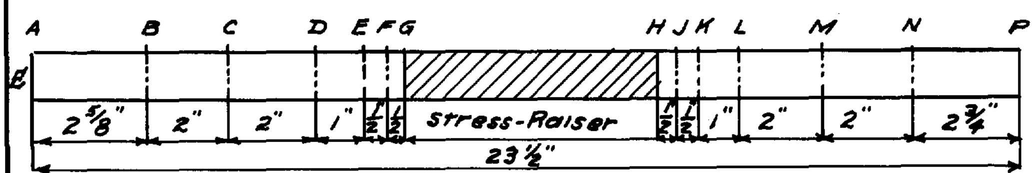


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 5A-5
D Normalized

Fig. 141a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	.703	.721	.734	.757	.762	.765	.764	.763	0
B	.687	.726	.750	.760	.763	.762	.762	.764	0
C	.704	.739	.749	.750	.751	.752	.757	.763	0
D	.707	.739	.750	.752	.752	.753	.757	.764	0
E	.679	.706	.712	.722	.736	.750	.765	.770	0
F	.654	.691	.723	.744	.754	.763	.771	.773	0
G	.726	.751	.756	.764	.768	.773	.776	.777	0
H	.705	.741	.754	.761	.767	.772	.775	.777	0
J	.669	.691	.703	.721	.740	.759	.772	.774	0
K	.707	.735	.738	.741	.745	.751	.764	.772	0
L	.726	.753	.760	.761	.760	.760	.764	.767	0
M	.714	.742	.747	.749	.752	.757	.764	.768	0
N	.745	.764	.766	.765	.766	.765	.766	.767	0
P	.771	.775	.775	.776	.776	.776	.777	.775	0



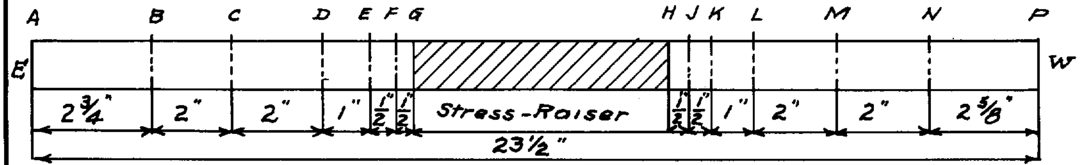


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 20A-13
E As-Rolled

Fig. 142a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.758	.769	.760	.762	.762	.764	.767	.772	0
B	.751	.754	.756	.757	.760	.761	.763	.764	0
C	.750	.753	.755	.757	.758	.759	.760	.762	0
D	.747	.748	.749	.750	.752	.752	.756	.759	0
E	.736	.739	.740	.743	.744	.747	.755	.760	0
F	.717	.721	.724	.732	.738	.748	.759	.763	0
G	.735	.743	.749	.754	.758	.761	.763	.766	0
H	.684	.701	.729	.750	.757	.760	.773	.766	0
J	.722	.727	.740	.734	.739	.749	.760	.763	0
K	.741	.742	.743	.744	.745	.747	.755	.762	0
L	.745	.752	.753	.754	.754	.754	.756	.758	0
M	.753	.760	.762	.762	.762	.763	.763	.764	0
N	.757	.760	.763	.764	.765	.765	.768	.767	0
P	.759	.760	.762	.762	.764	.764	.762	.763	0

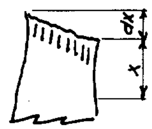
Sketch A
Profile of All Sections



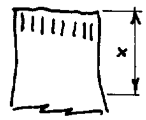
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 17B-6
D As-Rolled

Fig. 143a.

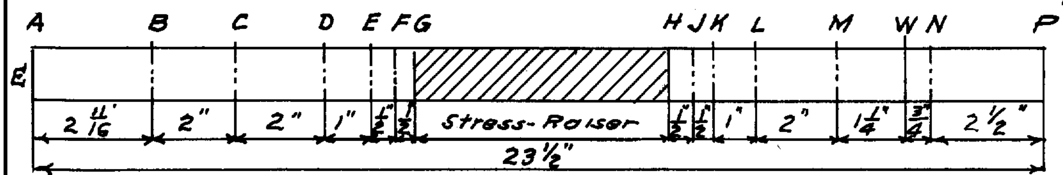
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.667	.676	.682	.687	.690	.696	.707	.716	11/16"
B	.654	.663	.672	.680	.688	.699	.715	—	3/4"
C	.664	.675	.684	.692	.700	.712	.727	—	13/16"
D	.675	.688	.697	.705	.715	.724	.738	—	3/4"
E	.698	.708	.716	.724	.732	.741	.752	—	3/4"
F	.703	.719	.727	.736	.742	.751	.756	—	5/8"
G	.741	.745	.749	.752	.752	.756	.769	.760	3/16"
H	.720	.741	.753	.755	.759	.761	.759	.763	1/8"
J	.705	.718	.729	.738	.745	.753	.759	—	9/16"
K	.702	.714	.721	.730	.735	.744	.754	—	5/8"
L	.689	.698	.704	.715	.720	.731	.742	—	3/4"
M	.667	.679	.687	.695	.702	.712	—	—	3/4"
N	.677	.681	.685	.689	.692	.699	.713	.725	0
P	.747	.748	.760	.750	.750	.749	.744	.737	0



Sketch A
Profile of Secs. A, B, C, D, E, F, G, H, J, K, L, M



Sketch B
Profile of Secs P, N.

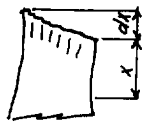


W- Change in Profile

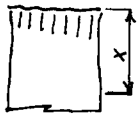
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 17-B-4
D As Rolled

Fig. 144a.

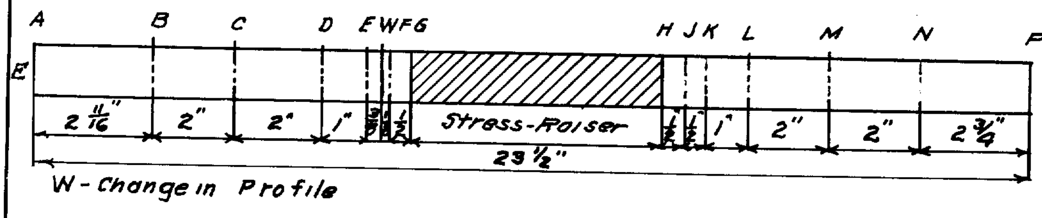
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.753	.755	.757	.760	.760	.762	.765	.766	0
B	.753	.755	.756	.756	.756	.757	.758	.759	0
C	.745	.749	.750	.752	.753	.754	.756	.756	0
D	.739	.741	.742	.742	.743	.744	.749	.754	0
E	.712	.715	.719	.722	.728	.736	.753	.758	0
F	.669	.676	.694	.722	.737	.750	.759	.762	3/16"
G	.730	.741	.747	.752	.756	.759	.762	.764	1/8"
H	.701	.715	.735	.748	.756	.760	.764	.765	0
J	.676	.685	.704	.719	.734	.747	.759	.764	0
K	.721	.722	.725	.729	.734	.740	.753	.758	0
L	.742	.745	.725	.746	.749	.750	.752	.756	0
M	.750	.751	.753	.754	.756	.758	.759	.760	0
N	.751	.754	.756	.760	.761	.765	.765	.764	0
P	.759	.759	.761	.763	.765	.764	.766	.766	0



Sketch A
Profile of Secs. F, G.



Sketch B
Profile of Secs. A, B, C, D, E, H, J, K, L, M, N, P



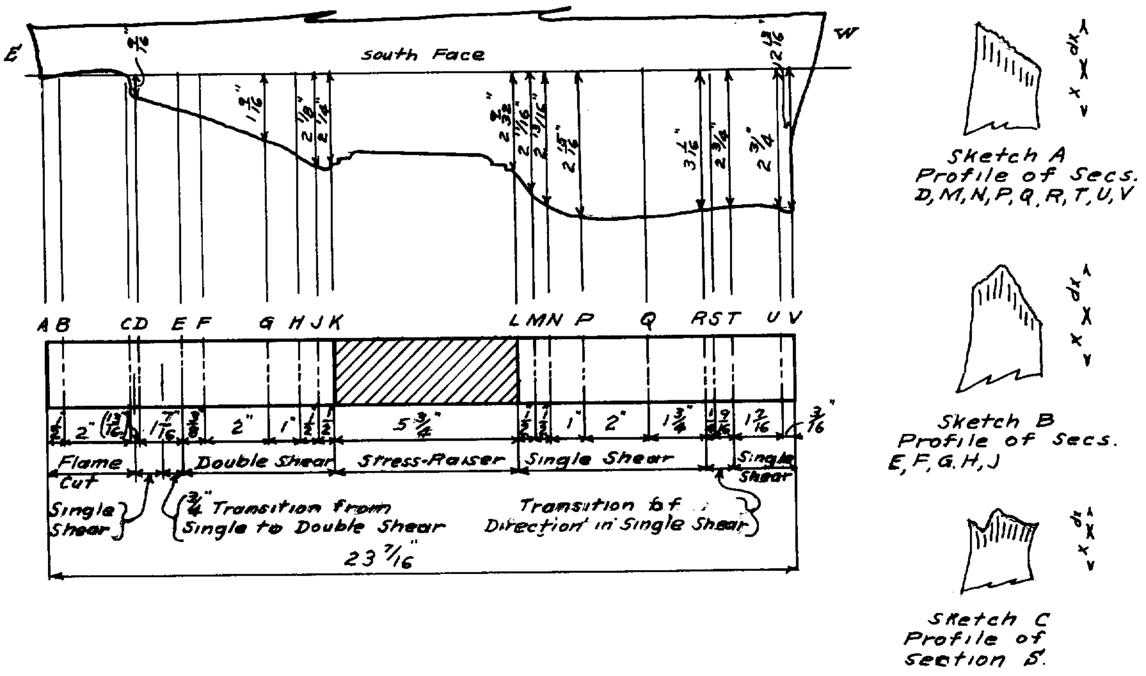
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 17B-5
D As-Rolled

Fig. 145a.

Sec.	Distance from Fracture X								
	0	1/16	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	—	—	—	.759	.759	.758	.748	.739	0
B	—	—	—	.752	.751	.750	.745	.739	0
C	—	—	—	.688	.684	.681	.720	.727	0
D	.646	.675	.686	.700	.706	.713	.723	.748	21/32"
E	.612	.637	.645	.654	.665	.686	.712	.727	1/4"
F	.610	.635	.642	.653	.665	.686	.714	.730	9/32"
G	.605	.633	.643	.659	.673	.698	.730	.747	7/32"
H	.601	.631	.647	.669	.687	.716	.750	.766	9/32"
J	.612	.650	.664	.688	.710	.737	.767	.774	3/16"
K	.751	.757	.761	.766	.771	.775	.777	.779	0
L	.750	.758	.766	.771	.775	.777	.779	.778	0
M	.686	.710	.724	.742	.754	.765	.774	.776	19/32"
N	.675	.698	.709	.726	.738	.752	.767	—	23/32"
P	.652	.680	.692	.705	.720	.732	.751	—	3/4"
Q	.642	.662	.673	.688	.699	.712	.732	—	3/4"
R	.603	.616	.630	.656	.678	.698	.720	.732	23/32"
S	.584	.597	.608	.636	.665	.687	.713	.729	1/8"
T	.605	.635	.650	.668	.683	.700	.720	.731	3/4"
U	.641	.657	.674	.690	.701	.700	.720	.730	5/8"
V	.656	.666	.678	.694	.699	.706	.718	.730	7/16"

Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 3-1
D Normalized

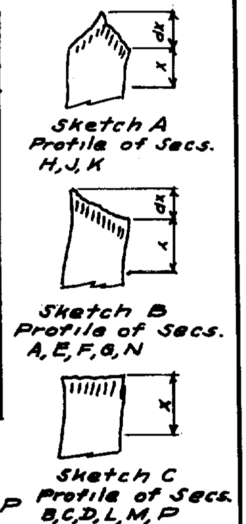
Fig. 146a.

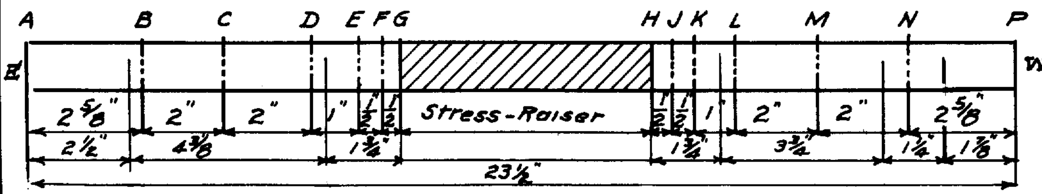


Sketch of Plate Showing Location of Sections for Thickness Measurements Specimen 3-1
D Normalized

Fig. 147a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.756	.759	.759	.759	.760	.760	.759	.764	3/16"
B	.742	.744	.745	.747	.748	.749	.750	.759	3/16"
C	.727	.729	.731	.731	.732	.733	.735	.741	0
D	.644	.651	.659	.672	.688	.707	.731	.746	0
E	.672	.690	.701	.715	.727	.738	.752	–	5/8"
F	.689	.707	.719	.731	.741	.751	.758	–	1/2"
G	.723	.743	.749	.754	.757	.760	.762	.765	0
H	.717	.734	.742	.751	.756	.758	.760	.761	0
J	.646	.657	.664	.681	.702	.732	.753	.757	5/16"
K	.628	.691	.643	.661	.678	.709	.740	.751	5/16"
L	.636	.636	.642	.656	.675	.694	.725	.737	0
M	.719	.721	.721	.722	.723	.724	.724	.730	0
N	.732	.734	.734	.737	.737	.739	.738	.737	1/8"
P	.737	.741	.742	.742	.743	.744	.747	.744	0

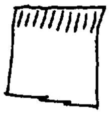




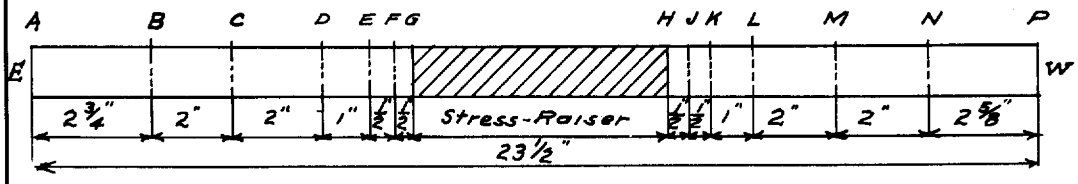
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 3-2
D Normalized

Fig. 148a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.772	.774	.775	.776	.774	.780	.784	.784	0
B	.766	.771	.772	.773	.773	.774	.775	.776	0
C	.765	.768	.769	.780	.770	.771	.771	.773	0
D	.763	.764	.765	.766	.766	.766	.767	.769	0
E	.750	.756	.757	.757	.757	.758	.766	.770	0
F	.733	.740	.741	.746	.747	.759	.770	.773	0
G	.698	.728	.745	.755	.763	.768	.773	.776	0
H	.691	.720	.740	.755	.762	.767	.772	.776	0
J	.736	.738	.741	.743	.749	.767	.770	.774	0
K	.751	.753	.754	.755	.756	.758	.766	.771	0
L	.762	.765	.764	.765-	.767	.766	.768	.770	0
M	.767	.769	.771	.771	.772	.773	.774	.774	0
N	.771	.773	.774	.774	.774	.773	.773	.774	0
P	.730	.738	.738	.773	.741	.740	.737	.750	0



Sketch A
Profile of All Sections

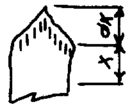


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 3-3
D Normalized

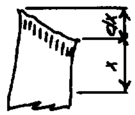
Fig. 149a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.659	.669	.674	.680	.684	.693	.709	.720	9/16"
B	.635	.649	.659	.670	.681	.695	.715	—	23/32"
C	.633	.652	.664	.676	.688	.702	.724	—	23/32"
D	.656	.672	.684	.691	.711	.724	.746	—	23/32"
E	.678	.697	.709	.723	.735	.748	.762	—	10/32"
F	.693	.713	.726	.741	.752	.763	.771	—	15/32"
G	.710	.741	.753	.762	.767	.773	.777	x.776	7/32"
H	.707	.728	.737	.762	.768	.772	.775	.775	3/16"
J	.645	.661	.672	.696	.719	.747	.767	.758	1/4"
K	.637	.643	.650	.667	.686	.718	.751	.764	1/4"
L	.617	.629	.635	.655	.673	.693	.729	.746	1/4"
M	.633	.632	.634	.640	.651	.673	.705	x.690	5/32
N	.668	.669	.670	.670	.673	x.644	x.665	x.684	0
P	.748	.749	.748	.749	.747	.796	.740	.732	0

x Measurement from one-half

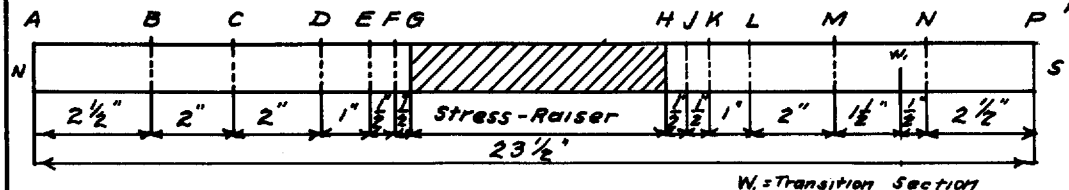


Sketch A
Profile of Secs. H, J, K, L, M



Sketch B
Profile of Secs A, B, C, D, E, F, G

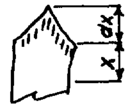
Sketch C
Profile of Secs. N, M.



Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen A-2
F As-Rolled

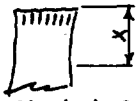
Fig. 150a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.752	.754	.753	.757	.757	.758	.755	.766	3/16"
B	.756	.760	.761	.762	.763	.764	.765	.765	3/16"
C	.744	.747	.748	.750	.751	.752	.753	.755	3/64"
D	.727	.729	.730	.732	.733	.734	.737	.742	0
E	.643	.649	.654	.663	.681	.701	.729	.745	3/32"
F	.619	.631	.644	.671	.691	.711	.735	.750	1/2"
G	.651	.676	.689	.707	.721	.736	.752	—	5/8"
H	.669	.693	.706	.725	.739	.751	.760	—	1/2"
J	.711	.741	.748	.757	.759	.764	.765	.768	0
K	.728	.747	.753	.756	.760	.761	.762	.764	0
L	.630	.648	.655	.673	.701	.729	.759	.759	1/4"
M	.608	.625	.632	.649	.668	.703	.738	.752	1/4"
N	.595	.607	.617	.635	.653	.683	.719	.736	1/4"
P	.626	.636	.637	.651	.666	.682	.718	.737	0
Q	.715	.719	.720	.721	.723	.723	.725	.729	0
R	.729	.733	.735	.736	.737	.738	.738	.738	0
S	.736	.741	.742	.742	.744	.746	.747	.748	0
T	.738	.740	.744	.745	.744	.745	.751	.747	0

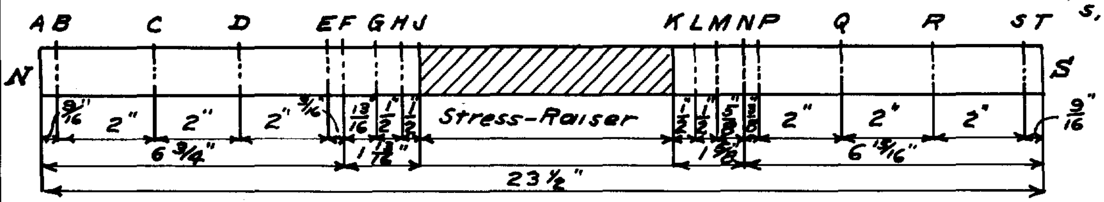


Sketch A
Profile of Secs. K, L, M, N

Sketch B
Profile of Secs. F, G, H, J



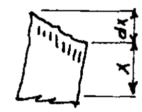
Sketch C
Profile of Secs A, B, C, D, E, P, Q, R S, T



Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen A-1 F As Rolled

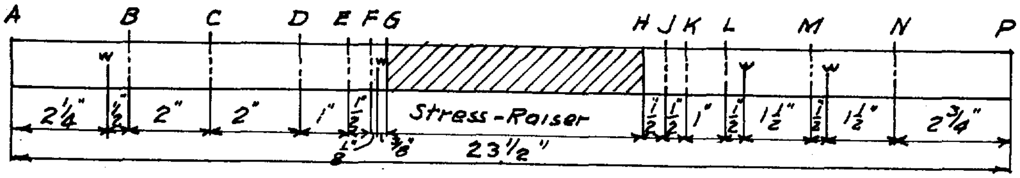
Fig. 151a.

Sec	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.774	.775	.775	.775	.774	.774	.774	.775	3/16"
B	.767	.768	.769	.770	.770	.770	.772	.773	0
C	.764	.764	.765	.766	.766	.766	.769	.770	0
D	.755	.757	.758	.759	.760	.761	.763	.767	1/16"
E	.744	.745	.746	.748	.749	.753	.762	.769	0
F	.719	.722	.725	.733	.741	.755	.766	.771	0
G	.719	.737	.749	.755	.761	.768	.771	.772	1/8"
H	.703	.719	.730	.746	.755	.761	.765	.768	0
J	.715	.717	.720	.727	.737	.748	.761	.766	0
K	.740	.741	.743	.744	.746	.749	.757	.762	0
L	.754	.755	.756	.756	.757	.757	.758	.761	0
M	.758	.759	.760	.761	.760	.762	.762	.762	1/8"
N	.760	.761	.762	.762	.761	.763	.764	.762	0
P	.754	.755	.758	.758	.762	.763	.765	.764	0



Sketch A
Profile of Secs. A, G, M

Sketch B
Profile of Secs. B, C, D, E, F, H, J, K, L, N, P

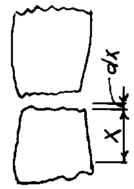


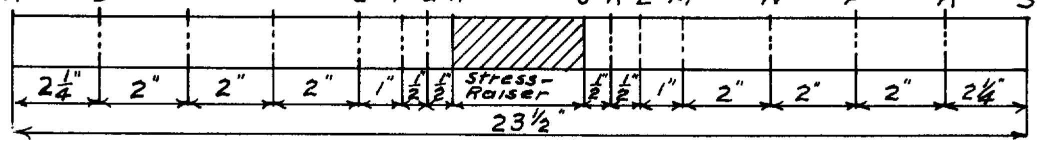
W = Transition Sections

Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen A-3 F As-Rolled

Fig. 152a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	.749	.754	.755	.756	.756	.756	.758	.759	0
B	.752	.755	.756	.758	.758	.759	.759	.762	0
C	.753	.756	.757	.758	.758	.759	.759	.761	0
D	.754	.757	.758	.758	.759	.759	.759	.761	0
E	.750	.752	.754	.754	.754	.755	.756	.759	0
F	.743	.745	.746	.748	.749	.751	.756	.763	0
G	.722	.728	.731	.736	.741	.751	.761	.764	0
H	.683	.706	.725	.750	.759	.763	.765	.768	0
J	.672	.702	.717	.747	.757	.763	.767	.769	0
K	.718	.729	.732	.736	.742	.752	.763	.767	0
L	.739	.746	.747	.748	.749	.751	.758	.764	0
M	.748	.757	.758	.758	.759	.758	.760	.762	0
N	.729	.755	.761	.763	.764	.765	.765	.766	0
P	.758	.765	.765	.767	.767	.767	.768	.768	0
R	.760	.766	.767	.767	.768	.769	.769	.769	0
S	.761	.765	.767	.768	.768	.769	.770	.770	0

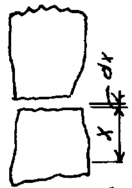


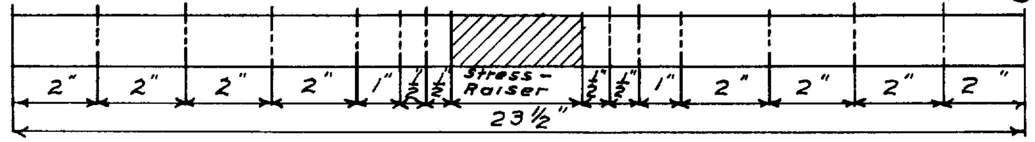


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 20A-7
E As-Rolled

Fig. 153a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.739	.741	.745	.747	.748	.746	.745	.746	0
B	.763	.765	.767	.767	.767	.767	.767	.769	0
C	.765	.767	.768	.768	.768	.768	.768	.769	0
D	.766	.769	.770	.769	.768	.770	.768	.769	0
E	.762	.766	.766	.768	.768	.767	.764	.766	0
F	.756	.757	.759	.759	.759	.761	.763	.767	0
G	.748	.749	.750	.752	.755	.760	.763	.768	0
H	.717	.730	.745	.755	.760	.765	.767	.770	0
J	.713	.736	.750	.758	.762	.766	.768	.770	0
K	.742	.743	.746	.749	.752	.759	.768	.769	0
L	.752	.754	.754	.756	.757	.759	.764	.769	0
M	.760	.761	.763	.765	.765	.766	.767	.770	0
N	.765	.767	.768	.769	.770	.770	.769	.768	0
P	.771	.774	.776	.777	.775	.774	.770	.771	0
R	.770	.773	.775	.775	.775	.776	.774	.771	0
S	.768	.772	.772	.773	.773	.773	.777	.775	0

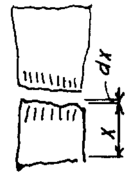




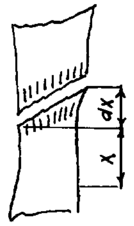
Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimem 20-13
E As-Rolled

Fig. 154a.

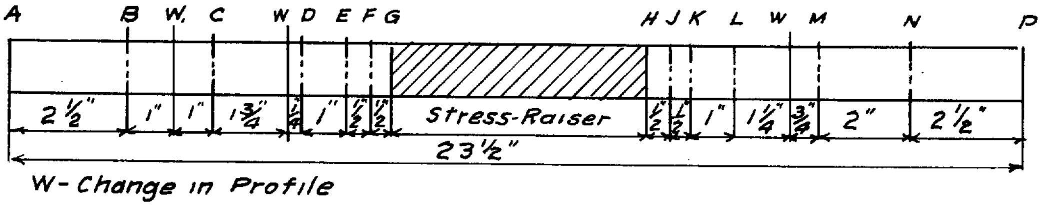
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	.749	.762	.765	.766	.766	.764	.758	.759	0
B	.703	.706	.708	.711	.715	.721	.727	.736	0
C	.664	.677	.689	.698	.708	.722	.739	—	3/4"
D	.654	.684	.708	.729	.747	.756	.761	.766	0
E	.743	.753	.755	.756	.756	.758	.762	.769	0
F	.734	.740	.742	.746	.751	.758	.767	.772	0
G	.682	.704	.735	.751	.760	.768	.770	.772	0
H	.689	.726	.745	.762	.767	.771	.773	.774	0
J	.732	.739	.740	.745	.749	.758	.768	.772	0
K	.734	.752	.755	.756	.756	.757	.764	.769	0
L	.729	.754	.764	.765	.764	.764	.766	.767	0
M	.679	.692	.703	.715	.724	.737	.752	—	11/16"
N	.652	.660	.670	.663	.684	.709	.727	—	23/32"
P	.671	.680	.687	.690	.697	.704	.716	.727	3/4"



Sketch A
Profile for Secs.
A, B, D, E, F, G, H, J.



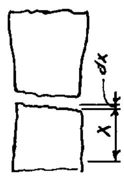
Sketch B
Profile for Secs.
C, M, N, P



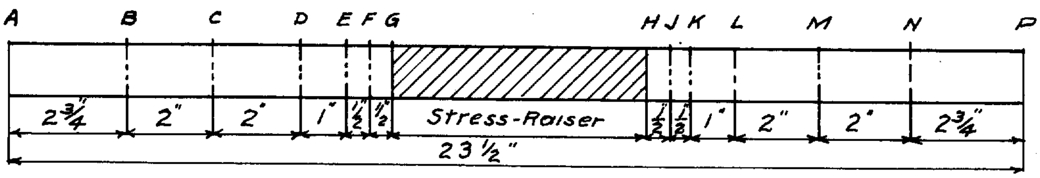
Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 20A-8
E As-Rolled

Fig. 155a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	.767	.770	.771	.771	.773	.771	.776	.777	0
B	.768	.770	.771	.773	.773	.773	.777	.777	0
C	.768	.769	.770	.770	.771	.770	.771	.772	0
D	.765	.766	.768	.767	.767	.767	.768	.770	0
E	.760	.761	.761	.761	.761	.762	.766	.772	0
F	.751	.752	.752	.754	.757	.762	.769	.772	0
G	.722	.734	.753	.762	.766	.771	.773	.775	0
H	.720	.742	.752	.761	.767	.770	.774	.775	0
J	.754	.755	.756	.758	.759	.765	.770	.773	0
K	.760	.762	.763	.764	.765	.766	.768	.772	0
L	.768	.768	.770	.770	.770	.770	.770	.772	0
M	.770	.774	.774	.775	.775	.775	.775	.773	0
N	.769	.772	.773	.776	.776	.776	.775	.776	0
P	.768	.773	.775	.778	.779	.778	.776	.776	0



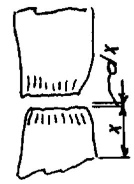
Sketch A
Profile of all
Sections



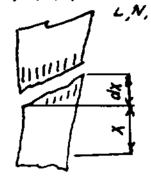
Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 20-14
E As-Rolled

Fig. 156a.

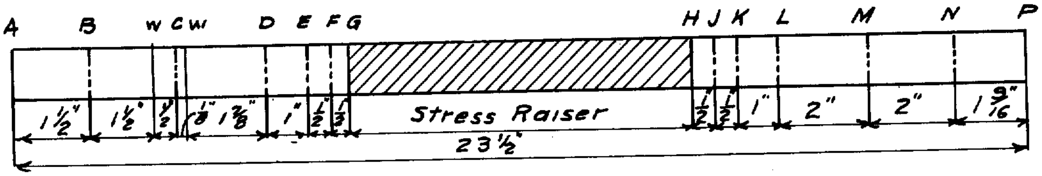
Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.763	.767	.768	.773	.777	.778	.769	.770	0
B	.757	.761	.762	.763	.762	.764	.762	.765	0
C	.749	.749	.751	.752	.751	.751	.752	.757	0
D	.632	.663	.689	.724	.741	.752	.760	.764	0
E	.722	.746	.754	.756	.755	.757	.762	.768	0
F	.733	.741	.744	.746	.750	.746	.767	.769	0
G	.692	.711	.735	.747	.757	.765	.769	.772	0
H	.689	.714	.731	.752	.758	.764	.766	.767	0
J	.728	.733	.735	.739	.744	.753	.762	.765	0
K	.744	.748	.748	.750	.751	.753	.758	.762	0
L	.736	.756	.760	.758	.760	.758	.760	.760	0
M	.691	.714	.731	.750	.753	.758	.764	.765	1/4"
N	.738	.739	.740	.740	.740	.741	.741	.746	0
P	.740	.743	.743	.742	.743	.739	.739	.737	0



Sketch A
Profile of Secs.
A, B, C, D, E, F, G, H, J, K, L, N, P

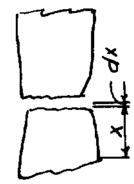


Sketch B
Profile of
Section M

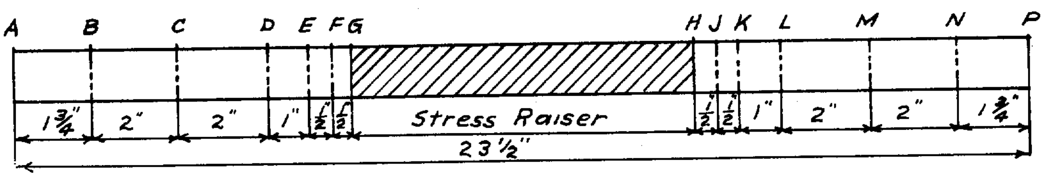


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 20A-9
E As Rolled
Fig. 157a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.770	.772	.773	.773	.773	.773	.774	.778	0
B	.768	.771	.771	.772	.772	.773	.773	.775	0
C	.770	.771	.772	.772	.773	.772	.771	.771	0
D	.764	.766	.766	.767	.767	.767	.767	.770	0
E	.761	.763	.764	.764	.764	.764	.767	.771	0
F	.753	.754	.754	.755	.758	.763	.769	.771	0
G	.728	.744	.753	.761	.766	.769	.771	.776	0
H	.726	.738	.749	.757	.762	.766	.768	.772	0
J	.746	.747	.748	.751	.754	.759	.765	.771	0
K	.754	.756	.758	.755	.757	.759	.764	.767	0
L	.757	.760	.763	.764	.765	.764	.765	.766	0
M	.767	.767	.767	.768	.771	.769	.767	.770	0
N	.763	.766	.767	.769	.768	.768	.771	.771	0
P	.764	.766	.767	.768	.768	.769	.769	.768	0

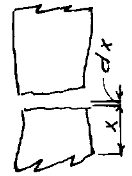


Sketch A
Profile of all
Sections

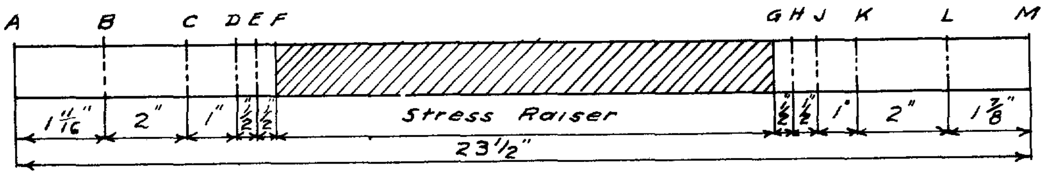


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 20-15
E As Rolled
Fig. 158a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	.753	.754	.755	.756	.758	.757	.757	.760	0
B	.740	.751	.753	.734	.755	.758	.760	.765	0
C	.728	.734	.758	.759	.758	.759	.760	.764	0
D	.737	.750	.751	.752	.752	.754	.758	.764	0
E	.722	.734	.737	.740	.744	.752	.761	.766	0
F	.682	.702	.731	.751	.758	.763	.766	.769	0
G	.695	.723	.746	.756	.763	.769	.772	.774	0
H	.733	.740	.743	.747	.751	.759	.769	.772	0
J	.750	.754	.757	.756	.757	.759	.765	.770	0
K	.735	.761	.766	.766	.767	.767	.767	.770	0
L	.705	.736	.765	.769	.770	.774	.771	.773	0
M	.768	.770	.771	.773	.772	.770	.769	.772	0

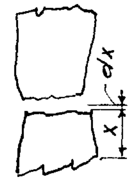


Sketch A
Profile of all
Sections

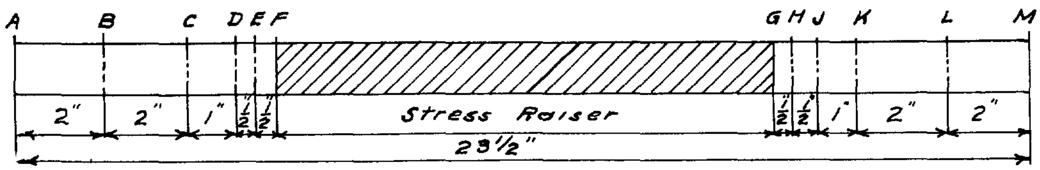


Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 20A-10
E As-Rolled
Fig. 159a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	.751	.753	.753	.754	.753	.752	.751	.750	0
B	.759	.758	.759	.761	.762	.762	.764	.764	0
C	.753	.754	.755	.756	.758	.756	.758	.762	0
D	.748	.749	.750	.751	.753	.754	.758	.763	0
E	.742	.743	.744	.745	.749	.753	.758	.763	0
F	.727	.740	.746	.751	.756	.759	.762	.768	0
G	.726	.733	.739	.754	.759	.765	.768	.770	0
H	.750	.751	.752	.753	.755	.758	.764	.768	0
J	.757	.758	.758	.758	.758	.760	.764	.766	0
K	.763	.765	.765	.765	.766	.766	.766	.766	0
L	.765	.768	.769	.769	.770	.769	.772	.769	0
M	.771	.773	.772	.771	.771	.776	.778	.774	0

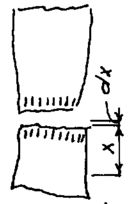


Sketch A
Profile of all
Sections

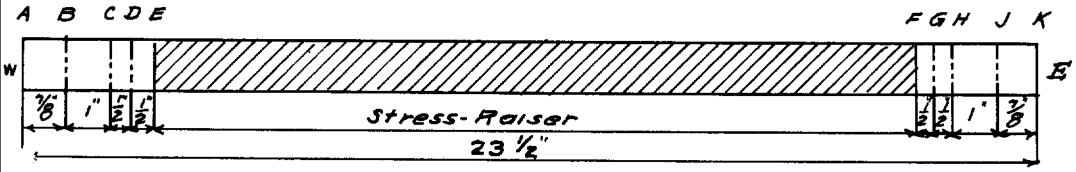


Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 20-7
E As-Rolled
Fig. 160a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.767	.771	.771	.772	.771	.766	.773	.774	0
B	.738	.762	.767	.769	.769	.769	.770	.773	0
C	.760	.764	.770	.770	.770	.773	.769	.775	0
D	.774	.741	.750	.748	.754	.764	.770	.778	0
E	.696	.740	.754	.774	.738	.773	.770	.778	0
F	.678	.707	.726	.756	.763	.771	.772	.776	0
G	.728	.733	.736	.740	.747	.756	.767	.773	0
H	.716	.750	.752	.753	.754	.757	.763	.769	0
J	.745	.762	.762	.762	.763	.763	.764	.766	0
K	.757	.758	.758	.761	.760	.760	.760	.759	0

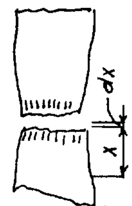


Sketch A
Profile of All
Sections

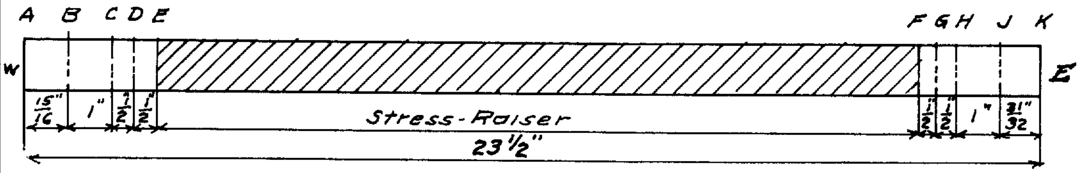


Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 20A-15
E As Rolled
Fig. 161a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.772	.772	.772	.773	.774	.774	.774	.775	0
B	.769	.770	.771	.772	.773	.772	.772	.775	0
C	.763	.764	.765	.765	.764	.765	.769	.774	0
D	.753	.755	.754	.756	.760	.764	.771	.775	0
E	.721	.737	.755	.763	.769	.772	.774	.777	0
F	.725	.739	.758	.763	.768	.772	.775	.777	0
G	.753	.753	.754	.757	.759	.766	.771	.775	0
H	.761	.762	.763	.763	.764	.765	.770	.773	0
J	.769	.770	.770	.770	.770	.770	.770	.772	0
K	.771	.773	.773	.773	.772	.773	.772	.773	0

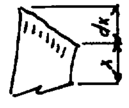


Sketch A
Profile of All
Sections



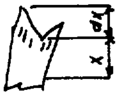
Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 20A-11
E As-Rolled
Fig. 162a.

Sec	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.698	.718	.727	.731	.723	.712	.710	.721	1/8"
B	.627	.639	.648	.671	.686	.702	.719	.731	0
C	.640	.661	.672	.687	.698	.710	.727	.737	5/8"
D	.649	.672	.684	.698	.709	.721	.737	.744	21/32"
E	.639	.664	.678	.700	.715	.730	.747	.754	7/16"
F	.622	.652	.670	.699	.720	.740	.752	.756	3/16"
G	.628	.674	.695	.723	.740	.750	.755	.657	1/8"
H	.721	.741	.747	.751	.754	.756	.757	.758	0
J	.725	.738	.747	.752	.754	.756	.757	.759	0
K	.674	.709	.719	.737	.746	.751	.756	.758	5/32"
L	.668	.695	.706	.726	.736	.747	.754	.756	7/16"
M	.636	.649	.666	.697	.713	.730	.747	.755	1/2"
N	.620	.633	.648	.677	.694	.712	.732	.742	1/2"
P	.645	.665	.677	.690	.699	.711	.726	.737	5/8"
R	.652	.662	.675	.687	.695	.703	.713	.724	17/32"

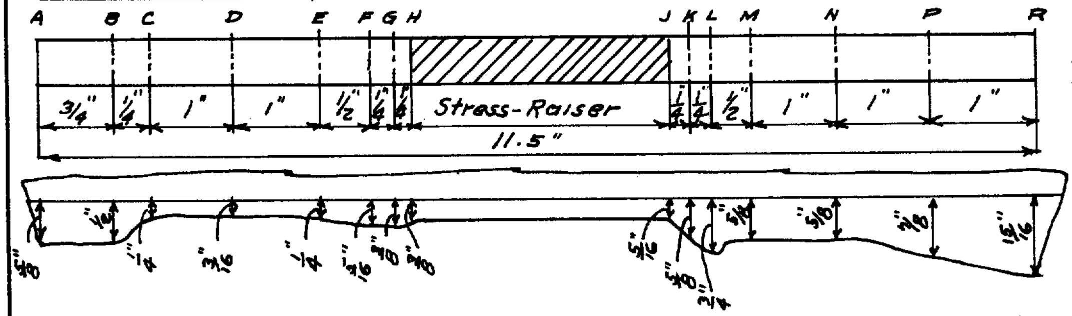


Sketch A
Profile of Secs.
A, C, D, E, K, L, P, R

Sketch B
Profile of Secs
B, H, J

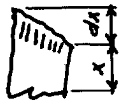


Sketch C
Profile of Secs.
F, G, M, N



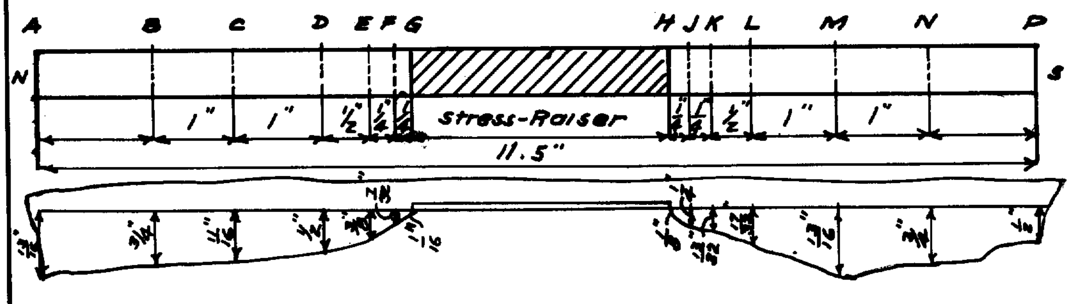
Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 23-3B
E As Rolled
Fig. 163a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dx
A	.629	.637	.652	.670	.676	.691	.701	.711	19/32"
B	.632	.653	.663	.675	.688	.707	.719	.732	11/16"
C	.638	.654	.666	.681	.696	.709	.729	—	23/32"
D	.659	.680	.690	.705	.716	.730	.745	* .750	21/32"
E	.657	.687	.699	.717	.728	.738	.751	.762	1/2"
F	.659	.692	.708	.724	.733	.741	.751	.753	5/16"
G	.729	.737	.739	.741	.742	.745	.751	.756	0
H	.710	.727	.734	.741	.745	.748	.751	.754	0
J	.663	.690	.707	.725	.737	.740	.750	.751	11/32"
K	.656	.686	.698	.716	.726	.737	.748	.751	17/32"
L	.655	.676	.687	.703	.714	.728	.743	.749	11/16"
M	.629	.657	.667	.685	.695	.710	.730	* .738	23/32"
N	.634	.658	.668	.681	.694	.704	.721	.730	21/32"
P	← Flame Cut		→	.705	.700	.695	.706	.712	0



Sketch A
Profile of Secs.
A, B, C, D, E, F,
J, K, L, M, N

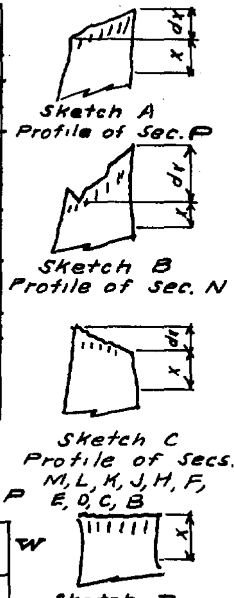
Sketch B
Profile of secs
G, H

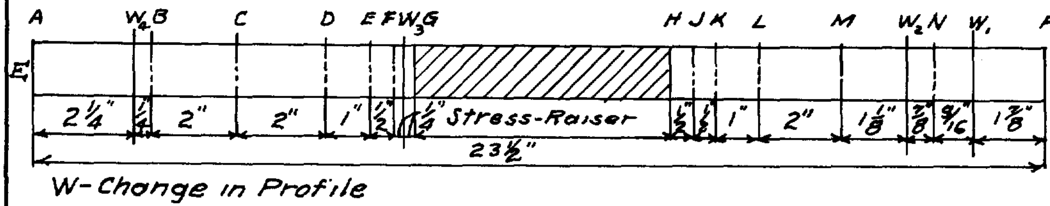


Thickness of Plate at Specified Distances from Fracture
on Various Sections Normal to the Fracture Specimen 23-3A
E Normalized

Fig. 164a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.688	.709	.727	.735	.737	.727	.719	.713	0
B	.636	.651	.659	.668	.676	.688	.703	–	3/4"
C	.634	.649	.699	.671	.679	.691	.709	–	1/16"
D	.650	.667	.674	.687	.698	.709	.725	–	3/4"
E	.668	.683	.692	.705	.713	.723	.738	–	11/16"
F	.642	.665	.682	.702	.720	.729	.742	–	3/8"
G	.634	.665	.693	.724	.736	.746	.749	.753	0
H	.717	.724	.732	.735	.746	.747	.749	–	9/16"
J	.632	.654	.677	.699	.714	.729	.742	–	7/16"
K	.662	.674	.685	.699	.708	.720	.735	–	11/16"
L	.659	.668	.680	.693	.700	.709	.725	–	5/8"
M	.641	.652	.661	.671	.680	.692	.709	–	11/16"
N	.590	.605	.622	.645	.659	.675	.693	.708	3/16"
P	.652	.656	.662	.672	.678	.684	.698	.707	5/8"

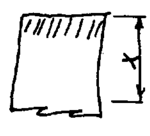


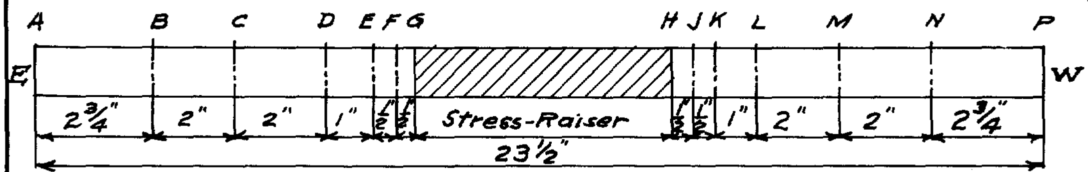


Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 22A-9

Fig. 165a.

Sec.	Distance from Fracture X								
	0	1/16"	1/8"	1/4"	3/8"	5/8"	1 1/8"	1 5/8"	dX
A	.768	.770	.772	.773	.774	.776	.777	.779	0
B	.770	.772	.773	.774	.774	.774	.774	.775	0
C	.768	.770	.771	.771	.772	.772	.772	.773	0
D	.763	.764	.764	.764	.764	.765	.765	.768	0
E	.748	.749	.750	.752	.753	.755	.764	.769	0
F	.729	.731	.734	.739	.745	.757	.768	.773	0
G	.659	.669	.712	.740	.758	.769	.775	.777	0
H	.647	.678	.711	.740	.759	.772	.777	.778	0
J	.728	.731	.733	.738	.743	.755	.768	.774	0
K	.749	.750	.750	.752	.752	.755	.764	.771	0
L	.761	.762	.764	.764	.764	.764	.765	.768	0
M	.766	.768	.769	.770	.771	.771	.771	.773	0
N	.770	.772	.773	.774	.777	.776	.775	.776	0
P	.773	.776	.777	.777	.778	.778	.778	.779	0





Thickness of Plate at Specified Distances from Fracture on Various Sections Normal to the Fracture Specimen 20A-14

Fig. 166a.

APPENDIX B.

MECHANICAL PROPERTIES OF MATERIALS.

From:

University of Illinois
College of Engineering

Report Prepared by:

Wilbur M. Wilson

Robert A. Hechtman

Walter H. Bruckner

APPENDIX B.

MECHANICAL PROPERTIES OF MATERIALS.

Contents.

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LIST OF FIGURES.

APPENDIX B.

ABSTRACT

Coupon tests of the steels used in this investigation have been made as follows:

1. Tensile coupon tests from all plates at room temperature.
2. V-notch impact tests at various temperatures from one plate of each kind of steel, and additional tests of other plates where deemed necessary.
3. Meriam tear tests at various temperatures from Killed-Steel D As-Rolled, Killed-Steel D Normalized, and Rimmed-Steel E As-Rolled.

MECHANICAL PROPERTIES OF MATERIALS.

TENSILE COUPON TESTS.

Tensile coupons were taken from each plate used in this investigation for the purpose of determining the mechanical properties of the material. Duplicate tests were made of 1½-in. x 3/4-in. A.S.T.M. standard flat tensile coupons in the direction of rolling and 0.505-in. diameter A.S.T.M. standard round tensile coupons both parallel and normal to the direction of rolling. The results of these tests are shown in Tables Ib and IIb. The mill chemical analyses of these various steels are given in Table IIIb.

V-NOTCH IMPACT TESTS OF KILLED-STEELS F AND G.

1. Introduction:- The relation between energy and temperature as given by V-notch impact tests was determined for Steels F and G. The tensile properties for these two steels are given in Table IIb and their mill chemical analyses in Table IIIb.

2. Procedure:- All specimens were cut in the direction of rolling of the plate with the notch normal to the rolled surface. The same procedure was employed in making these tests to determine the energy-temperature curve as is described in detail on page 1b of Appendix B of the Final Report, OSRD No. 6457, Serial No. M-614, January 15, 1946.

TABLE Ib.

MECHANICAL PROPERTIES OF MATERIAL.*

Standard A.S.T.M. 1½-in. x 3/4-in. Flat Tensile Coupons Tested in Direction of Rolling.

PLATE NO.	STRENGTH, lb. per sq. in. ULTIMATE	YIELD POINT	ELONGATION IN 8 In. Percent	REDUCTION OF AREA, Percent	CHARPY IMPACT VALUE IN FT.LBS. FOR STANDARD V-NOTCH SPECIMEN FOR TEMPERATURE OF -40	0	+40	+80	+110
			RIMMED-STEEL E AS-ROLLED						
17	56 300	30 150	31.9	56.1					
	56 200	30 000	31.8	56.5					
Av.	56 250	30 075	31.9	56.3					
			KILLED-STEEL D AS-ROLLED						
17B	65 020		29.6	59.2			47		
	65 800	39 000	29.2	55.6					
Av.	65 410		29.4	57.4					
18	65 500	39 000	31.2	58.7					
	64 700	39 100	27.2	58.2			51		
Av.	65 100	39 050	29.2	58.5					
			KILLED-STEEL D NORMALIZED						
5A	60 700	34 400	33.5	59.3					
	60 700	34 700	37.4	60.8					
Av.	60 700	34 550	35.5	60.1					
15A	59 500	34 800	32.4	61.4					
	59 500	35 000	32.3	61.3					
Av.	59 500	34 900	32.4	61.4					
			KILLED-STEEL F AS-ROLLED						
A	61 000	33 650	30.8	62.4	23	53	83	108	115
	60 500	34 450	30.3	62.4					
Av.	60 750	34 050	30.6	62.4					

*Mechanical properties of plates not included in this Table are given in Table 1, page 15a of Appendix A of the Final Report, OSRD No. 6457, No. M-614, January 15, 1946.

Table IIb (contd)
Mechanical Properties of Material.

PLATE NO.	ROLLING DIRECTION	STRENGTH, lb. per sq. in. Ultimate	Yield Point	ELONGATION IN 2 In. Percent	REDUCTION OF AREA Percent
20	P	60 900	33 500	35.5	59.5
	P	60 500	33 300	34.5	62.2
AV.		60 700	33 400	35.0	60.9
20	N	61 500	33 600	38.5	56.3
	N	61 100	36 200	34.0	58.0
AV.		61 300	34 900	36.3	57.2
20A	P	65 000	34 900	35.5	60.6
	P	64 500	36 900	34.5	56.5
AV.		64 800	35 900	35.0	58.6
20A	N	64 400	36 300	35.5	54.7
	N	64 800	34 000	31.0	53.7
AV.		64 600	35 200	33.3	54.2
22	P	65 900	36 200	34.0	57.8
	P	66 700	38 600	33.5	55.8
AV.		66 300	37 400	33.8	56.8
22	N	66 100	37 100	30.0	53.0
	N	66 200	36 200	30.5	54.3
AV.		66 200	36 700	30.3	53.7
22A	P	60 900	33 900	35.0	60.0
	P	60 700	34 000	37.0	57.8
AV.		60 800	34 000	36.0	58.9
22A	N	60 900	34 200	30.5	53.7
	N	61 300	34 200	36.5	56.2
AV.		61 100	34 200	33.5	55.0
23	P	64 600	34 100	33.0	55.8
	P	65 000	31 600	31.5	55.2
AV.		64 800	32 900	32.3	55.5
23	N	65 200	34 600	32.5	52.8

Table IIb. (Contd)

Mechanical Properties of Material.

PLATE NO.	ROLLING DIRECTION	STRENGTH, lb. per sq. in. Ultimate	Yield Point	ELONGATION IN 2 In. Percent	REDUCTION OF AREA Percent
		KILLED-STEEL D	NORMALIZED		
3	P	61 900	39 300	36.5	63.2
	P	61 600	36 000	38.5	62.0
AV.		61 800	37 700	37.5	62.6
3	N	61 900	37 600	35.5	61.1
	N	61 800	38 900	40.0	61.1
AV.		61 900	38 300	37.8	61.1
5	P	63 700	38 900	36.8	61.7
	P	63 300	39 700	39.5	63.3
AV.		63 500	39 300	38.2	62.5
5	N	63 400	38 000	40.0	59.3
	N	63 300	38 400	39.3	62.8
AV.		63 400	38 200	39.7	61.1
5A	P	62 000	36 900	37.0	64.5
	P	62 000	37 100	36.0	65.5
AV.		62 000	37 000	36.5	65.0
5A	N	62 700	36 900	37.0	59.1
	N	62 300	37 800	37.0	60.5
AV.		62 500	37 400	37.0	59.8
11	P	63 200	36 800	35.0	64.7
	P	63 400	36 600	36.0	65.3
AV.		63 300	36 700	35.5	65.0
11	N	63 400	35 300	35.5	60.3
	N	64 000	35 600	36.5	68.9
AV.		63 700	35 500	36.0	64.6
14	P	65 000	38 200	36.0	63.0
	P	64 900	38 400	36.5	62.8
AV.		65 000	38 300	36.3	62.9
14	N	65 500	39 400	38.0	61.5
	N	64 100	39 400	36.0	62.4
AV.		64 800	39 400	37.0	62.0
15	P	62 700	38 000	38.0	62.7
	P	62 400	37 800	42.5	61.9
AV.		62 600	37 900	40.3	62.3
15	N	62 500	37 600	37.0	58.6
	N	62 400	38 600	37.0	58.0
AV.		62 500	38 100	37.0	58.3
15A	P	61 900	37 200	37.5	63.7
	P	62 000	38 200	36.0	65.5
AV.		62 000	37 700	36.8	64.6
15A	N	62 300	38 700	35.5	59.5
	N	62 000	38 600	36.0	62.2
AV.		62 200	38 700	35.8	60.9

Table IIb (Contd)

Mechanical Properties of Material.

PLATE NO.	ROLLING DIRECTION	STRENGTH, lb. per sq. in. Ultimate	Yield Point	ELONGATION IN 2 In. Percent	REDUCTION OF AREA, Percent
		KILLED AS-ROLLED STEEL D			
5	P	65 600	38 400	33.5	64.5
	P	65 500	37 800	34.5	63.0
AV.		65 600	38 100	34.0	63.8
5	N	64 600	38 000	36.5	60.0
	N	64 200	37 200	33.0	61.4
AV.		64 400	37 600	34.8	60.7
17	P	67 500	42 300	35.8	58.9
	P	68 200	39 900	35.8	60.5
AV.		67 900	41 100	35.8	59.7
17	N	67 300	40 000	33.8	55.6
	N	67 700	39 700	37.0	57.2
AV.		67 500	39 900	35.4	56.4
17A	P	68 200	38 900	37.5	63.5
	P	67 500	39 800	35.8	63.5
AV.		67 900	39 400	36.7	63.5
17A	N	67 500	40 100	33.5	56.8
	N	67 100	42 200	35.5	57.8
AV.		67 300	41 200	34.5	57.3
17B	P	65 700	40 600	31.5	63.6
	P	66 800	42 800	35.5	62.5
AV.		66 300	41 700	33.5	63.1
17B	N	67 000	38 800	33.5	56.2
	N	66 600	42 700	29.0	56.7
AV.		66 800	40 800	31.3	56.5
18	P	66 200	39 600	36.5	60.8
	P	66 500	40 500	35.0	62.4
AV.		66 400	40 100	35.8	61.6
18	N	66 500	42 500	35.5	56.6
	N	65 900	39 600	35.5	59.8
AV.		66 200	41 100	35.5	58.2

Table IIb.
(Concluded)

Mechanical Properties of Material.

PLATE NO.	ROLLING DIRECTION	STRENGTH, lb. per sq. in. Ultimate	Yield Point	ELONGATION IN 2 In. Percent	REDUCTION OF AREA Percent
		KILLED-STEEL F AS-ROLLED.			
A	P	61 300	34 800	36.5	62.9
	P	60 800	36 500	37.5	67.5
Av.		61 100	35 700	36.0	65.7
A	N	60 600	34 000	34.0	57.5
	N	70 600	35 600	34.5	58.5
Av.		65 600	34 800	34.3	58.0
		KILLED-STEEL G AS-ROLLED.			
B	P	75 700	42 500	34.0	59.2
	P	72 400	42 900	33.0	62.3
Av.		74 100	42 700	33.5	60.8
B	N	72 400	44 800	30.0	51.1
	N	72 100	43 200	30.0	52.7
Av.		72 300	44 000	30.0	51.9

TABLE IIIb.

CHEMICAL ANALYSES OF PLATE STEELS-

ABSTRACT OF MILL REPORTS.

KIND OF STEEL	CHEMICAL ANALYSIS							
	C	Al	Mn	Si	P	S	Cu	Sn
Rimmed-Steel E As-Rolled	0.23		0.39	0.008	0.019	0.032	0.19	
Killed-Steel D As-Rolled	0.18		0.55	0.23	0.015	0.028	0.20	
Killed-Steel F As-Rolled	0.15	0.041	0.82	0.17	0.014	0.030		0.016
Killed-Steel G As-Rolled	0.20	0.045	0.86	0.19	0.020	0.020		0.012

HEAT TREATMENT OF NORMALIZED STEELS.

Killed-steel D normalized was normalized at the rolling mill at a temperature of 1650 degrees F. The length of time at the normalizing temperature is not known.

Rimmed-steel E normalized was normalized at the University of Illinois. It was held at a temperature of 1650 degrees F. for one hour and then cooled in still air.

3. Data Obtained:- The impact values obtained at the various temperatures are given in Table IVb. The curves of Figs. 1b, 2b, 3b, and 4b show the impact-temperature curves for Steels F and G. In Figs. 1b and 2b the three curves given for Steels F and G show the maximum, average, and minimum V-notch impact values. In Fig. 3b the average V-notch impact values for Steels F and G are compared with the average keyhole-notch impact values for the same steels, as reported by S. Epstein of the Bethlehem Steel Company. In Fig. 4b the average V-notch impact values for Steels F and G are compared with the V-notch impact values for the rimmed and killed steels previously reported.

4. Examination of Fractured Impact Specimens:- Figure 5b is a photograph of the fracture surfaces typical of the impact specimens of killed-steel F. The fracture surfaces shown are for a range of temperature of 110 degrees F. to -100 degrees F. Two specimens are shown for the fractures at 70 degrees F. since two of the four specimens tested had a slightly lower impact value and a larger area of crystalline fracture than the other two specimens from the opposite surface of the plate. The fracture for one specimen broken at 70 degrees F., shown at the left side in Fig. 5b, is typical of the two specimens which had the lower impact value, Specimens 3 and 4, shown in Table IVb. Microexamination of a polished and etched cross-section of the plate revealed no distinguishable difference in microstructure of either side of the plate. A Rockwell B hardness test

TABLE IVb.

IMPACT-ENERGY IN FOOT-POUNDS ABSORBED IN FRACTURE OF STANDARD V-NOTCH SPECIMENS OF KILLED-STEELS F AND G.

KILLED-STEEL F AS-ROLLED

SPEC. NO.	TEMPERATURE IN °F. -100	-60	-40	0	32	70	110	150	215	312
1	5.8	7.9	19.8*	67.8*	82.1*	111.5	116.5	106.0	110.0	94.8
2	5.3	8.9	11.8*	78.2*	91.5*	113.0	114.5	106.0	103.5	98.0
3	4.9	6.2	32.4*	50.2	58.8	91.8*	115.5	116.0	107.0	101.2
4	4.7	14.1	28.5	69.3*	85.5*	99.5	115.5	107.0	111.2	101.2
Av.	5.2	9.3	23.1	66.4	79.5	103.8	115.5	109.0	107.9	98.9

KILLED-STEEL G AS-ROLLED

SPEC. NO.	TEMPERATURE IN °F. -100	-60	-40	0	32	70	120	200
1	3.7	5.1	11.0	24.7	49.8	73.5*	88.8*	88.5
2	4.9	6.9	7.6	13.6	29.2*	70.6*	91.0*	95.6
3	3.5	5.7	8.0	24.0*	39.2*	54.8*	94.8	88.6
4	3.8	3.4	12.6	18.4	65.0	66.0*	94.8*	87.0
Av.	4.0	5.3	9.8	20.2	45.8	66.2	92.3	89.9

* Denotes specimen which was not completely broken after impact test.

Specimens 1 and 2 were removed from the rolled plate surface opposite the rolled surface from which Specimens 3 and 4 were removed.

showed the side of the plate for which the impact test values were lower, to have a one point higher Rockwell B hardness than the opposite side.

Figure 6b is a photograph of the fracture surfaces typical of the impact specimens of killed-steel G. The fracture surfaces shown are for a range of temperature of 200 degrees F. to -100 degrees F.

A micro-examination was made at 200 X of the fracture surfaces shown in Figs. 5b and 6b. The results of the examination are given in the statement that some part of the fracture surface for specimens of killed-steels F and G showed cleavage fracture when tested in impact at temperatures of 70 degrees F. or lower. Impact test specimens broken at higher temperatures, 110 degrees F. and higher for killed-steel F and 120 degrees F. and higher for killed-steel G showed no trace of cleavage on the fracture surface.

Upon completing the micro-examination of the impact fracture surfaces, a polished and etched surface was prepared by cutting the fractured impact specimens shown in Figs. 5b and 6b on a horizontal plane perpendicular to the plane of the paper and through the center of the specimen. An examination at 400 X showed cleavage cracks in the ferrite grains of the specimen of killed-steel F broken at 32 degrees F. The specimen of killed-steel F broken at 0 degrees F. showed cleavage cracks and twins in the ferrite. The examination of specimens of killed-steel G showed cleavage cracks in the specimen broken at 70 degrees F. and both cleavage cracks and twins in the specimen broken at 32 degrees F.

5. Discussion of Data from Impact Tests:- The evidence as to transition temperatures for killed-steels F and G is given in their respective impact-temperature curves in Figs. 1b and 2b. If the transition temperature is defined as the temperature at which the impact value is 10 ft.lbs., then for killed-steel F the transition temperature is approximately -60 degrees F. and for killed-steel G it is approximately -40 degrees F.

The micro-examination of the fractured impact specimens indicated that some parts of the specimens of the two steels had a cleavage fracture when broken at or below 70 degrees F. (room temperature). At the higher testing temperatures of 110 degrees F. for killed-steel F and 120 degrees F. for killed-steel G, there was no evidence of cleavage on the fracture surface. It is probable that at some temperature between 70 degrees F. and approximately 110 degrees F. and at higher temperatures, the V-notch specimens fractured with 100 percent shear deformation. If the transition temperature is defined as the highest temperature at which cleavage occurs in any part of the impact specimen then the transition temperatures for the two steels lies between 70 degrees F. and some higher temperature which is below 110 degrees F. or 120 degrees F. for killed-steels F and G, respectively. This is indicated also by the considerable spread which still remains at 70 degrees F. between the minimum and maximum impact curves for the two steels in Figs. 1b and 2b. A rough estimation of the area of the impact fracture surface represented by the shiny cleavage facets in specimens broken at

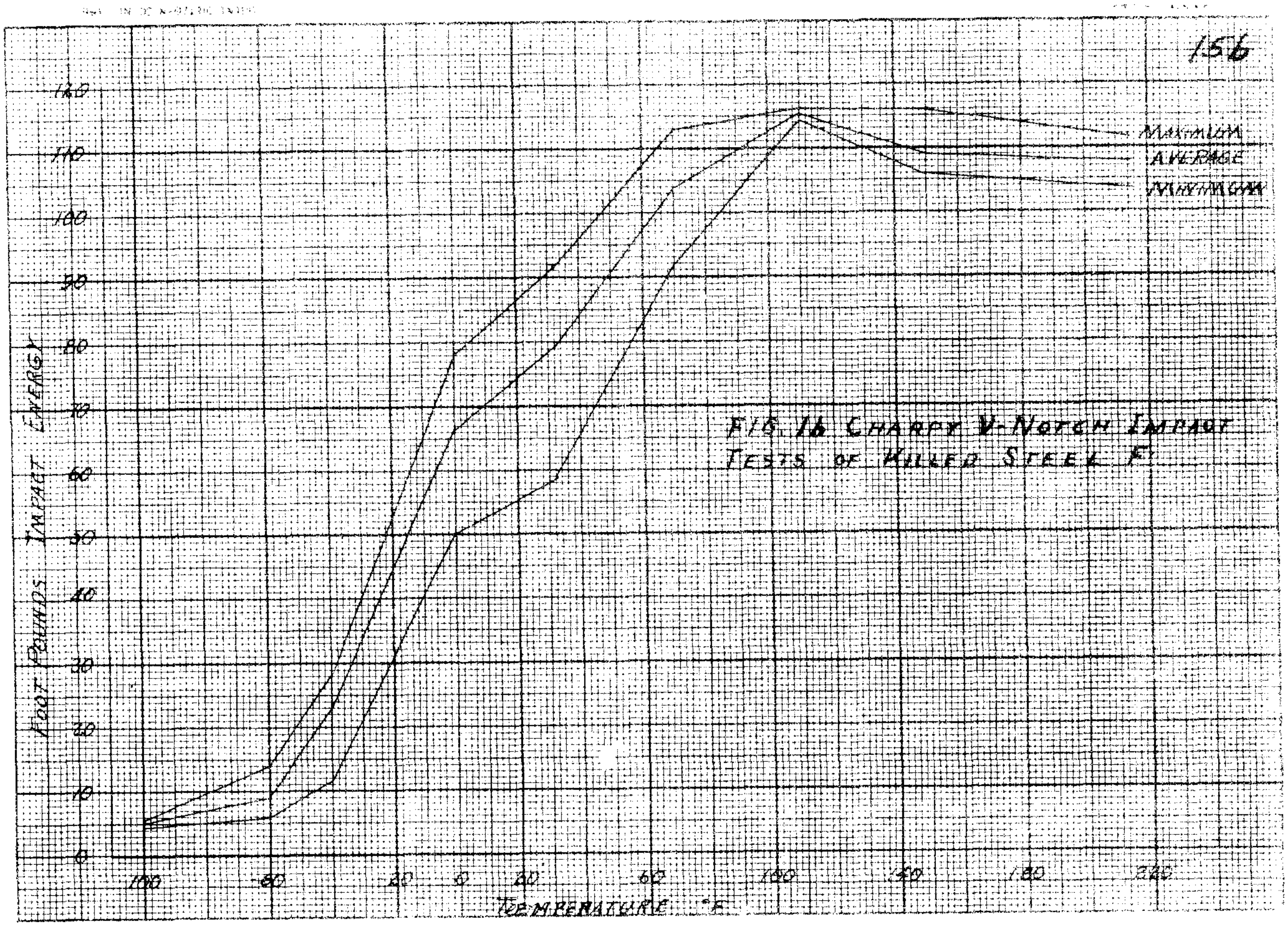
70 degrees F., showed 10 percent to 15 percent for the killed-steel F, and 35 percent to 50 percent for killed-steel G. However, the high impact values for the two steels at 70 degrees F. shows that the simultaneously occurring shear deformation was large.

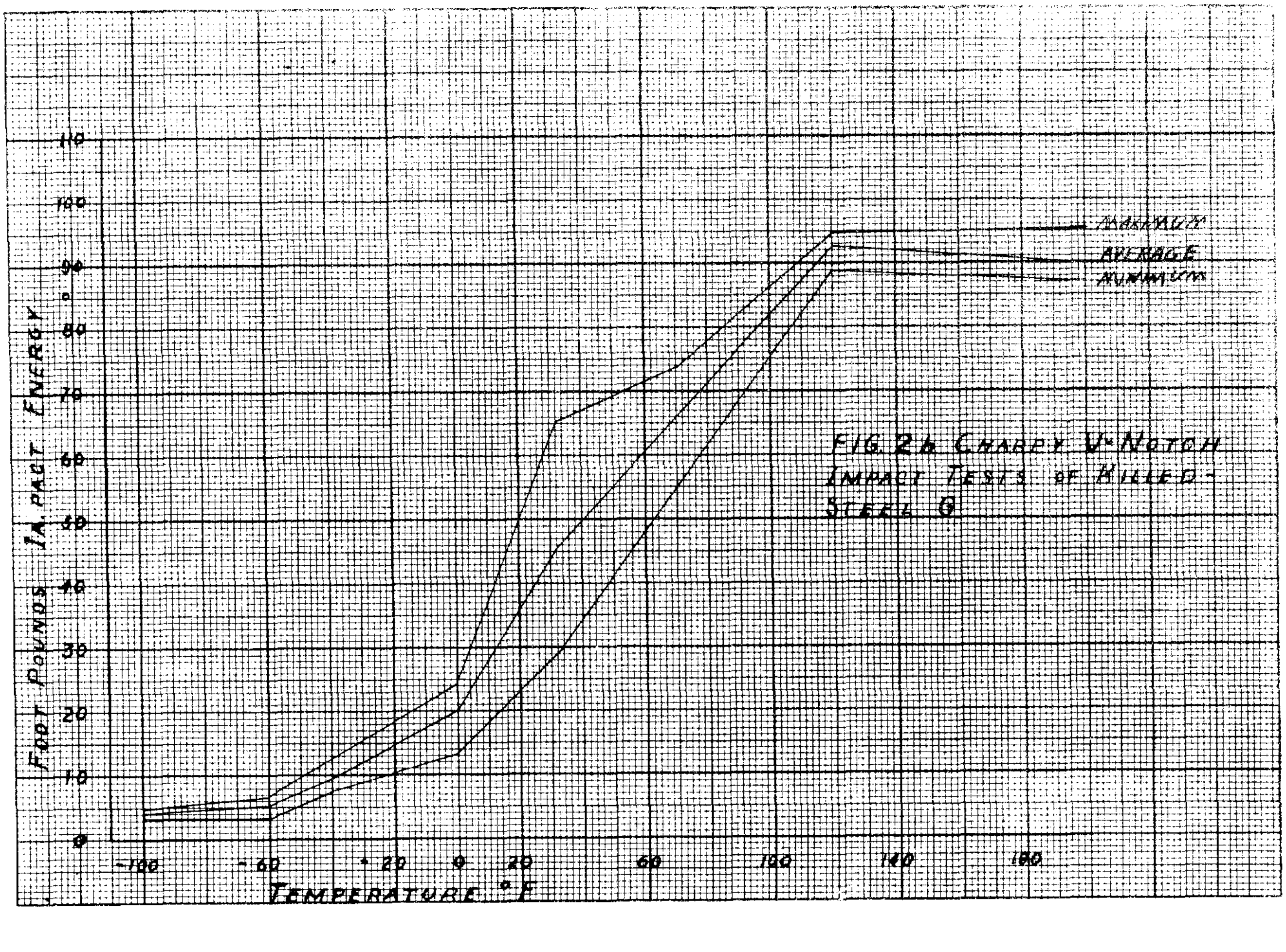
MERIAM TEAR TESTS.

A specimen of the type described on page 15 of the Final Report, NDRC Research Project NRC-92, OSRD No. 6387, Serial No. M-607, "Cleavage Fracture of Ship Plate as Influenced by Design and Metallurgical Factors (NS-336), Part I, Hatch Corner Specimen Tests," dated December 4, 1945, was made from killed-steel D as-rolled, killed-steel D normalized, and rimmed-steel E as-rolled for the purpose of studying with a simple specimen, the change in the nature of the fracture with change in temperature. This specimen is shown in Fig. 7b.

The specimens were mounted directly in the grips of the testing machine. The temperature for each test was kept constant and the nature of the fracture noted. Different tests were made at different temperatures, starting with a temperature, which produced a full cleavage fracture, and increasing in steps to a higher temperature, which produced a full shear fracture. A comparison of the results of these tests with the results of the wide plate tests, having a jeweler's-saw cut stress-raiser, is shown in Fig. 8b.

An examination of Fig. 8b will indicate for both the wide plate tests with a jeweler's-saw cut stress-raiser and the Meriam tear test that there is a temperature band in which the nature of the fracture is one of mixed cleavage and shear. Above or below this temperature band the fracture is wholly of one type, cleavage or shear. Not sufficient wide plate tests have been made so that the upper and lower limits of this temperature band, in which fractures of mixed cleavage and shear appear, may be determined as closely as a few degrees. On the basis of the number of tests made, it appears that the Meriam tear test determines a narrower temperature band of mixed fractures than does the wide plate test with the jeweler's-saw cut stress-raiser. However, the narrower temperature band of mixed fractures determined by the Meriam tear test does fall within the same band determined by the wide plate tests.


MAXIMUM
AVERAGE
MINIMUM
FOOT POUNDS IMPACT ENERGY
TEMPERATURE °F
FIG. 1b CHARPY V-NOTCH IMPACT TESTS OF KILLED STEEL F


MAXIMUM
AVERAGE
MINIMUM
FOOT POUNDS IMPACT ENERGY
TEMPERATURE °F
FIG. 2b CHARPY V-NOTCH IMPACT TESTS OF KILLED-STEEL G

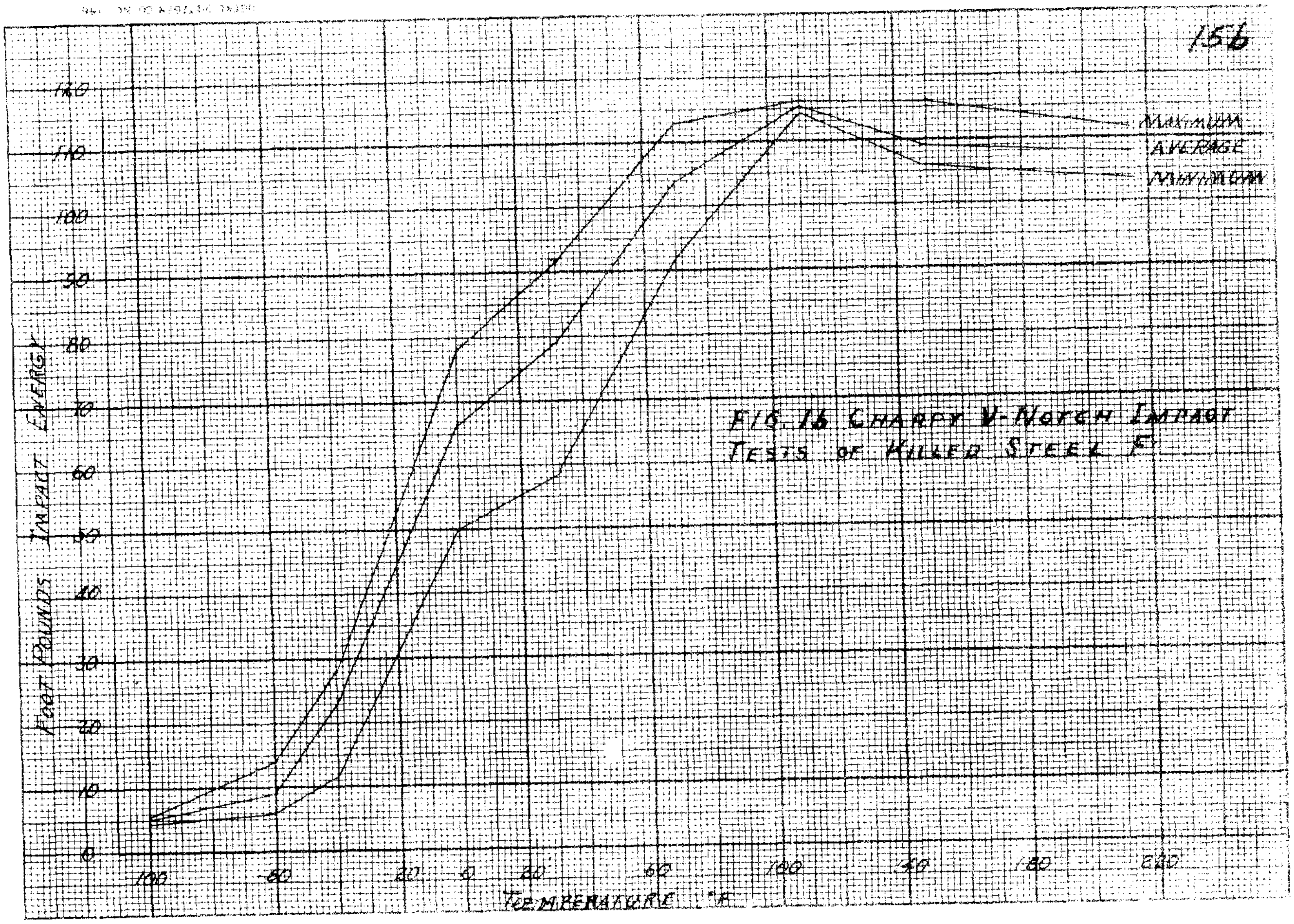


FIG. 1b Charpy V-Notch Impact Tests of Killed Steel F

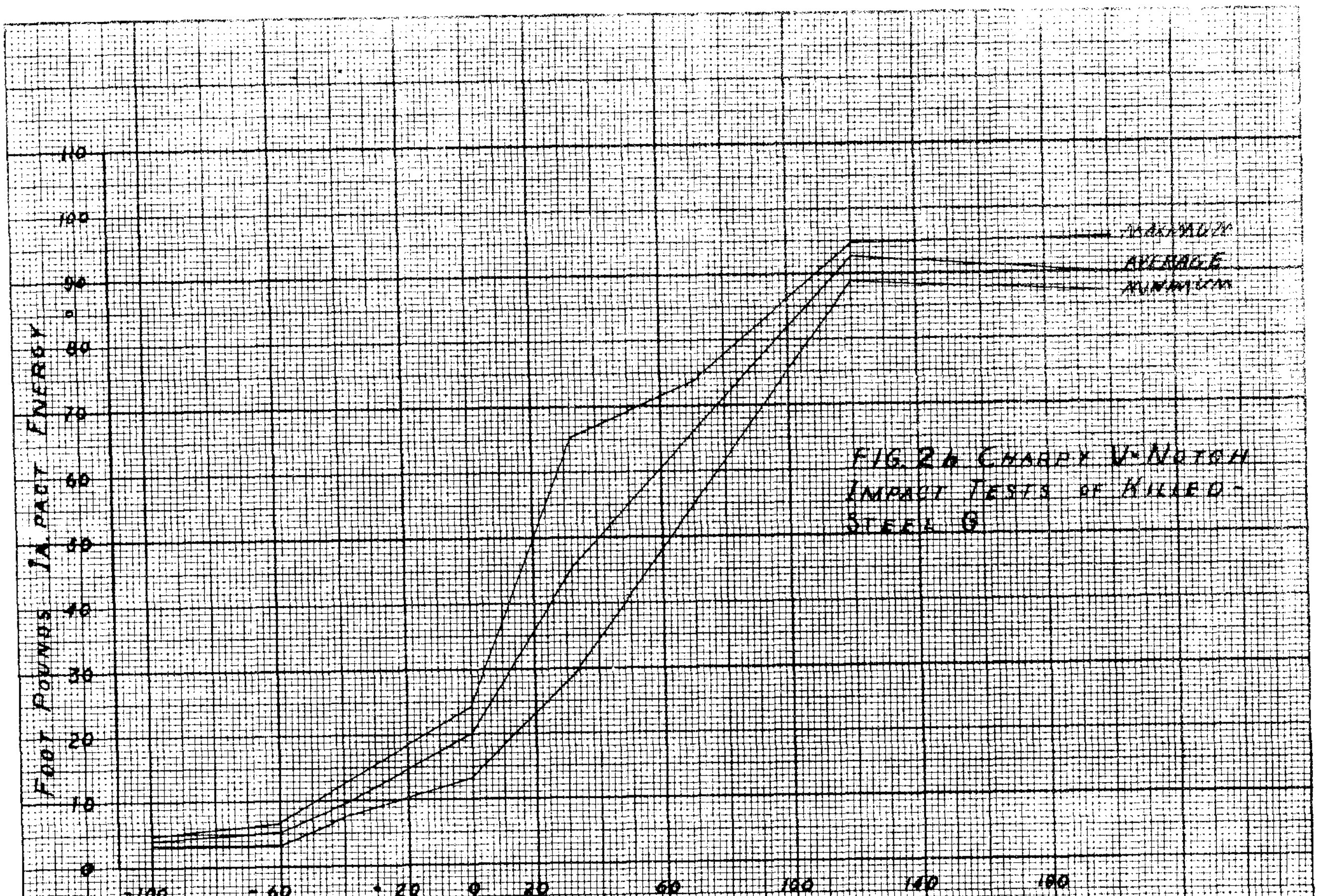


FIG. 2b Charpy V-Notch Impact Tests of Killed Steel G

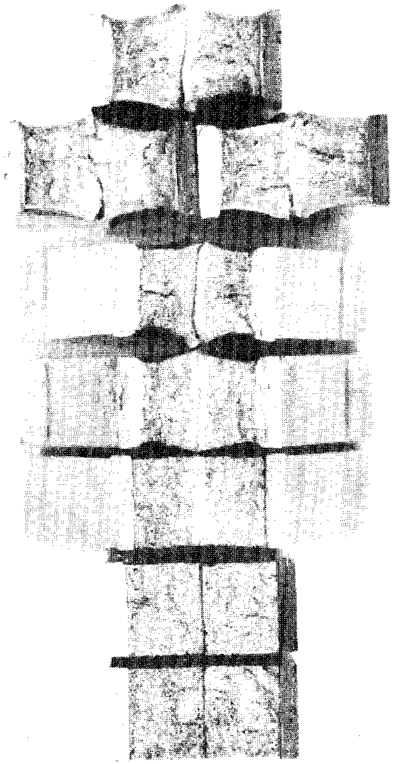


FIG. 5b

FRACTURE SURFACES OF KILLED-STEEL F SPECIMENS

Top to bottom fracture temperatures:

110°, 70°, 32°, -40°, -60°, and -100° F.

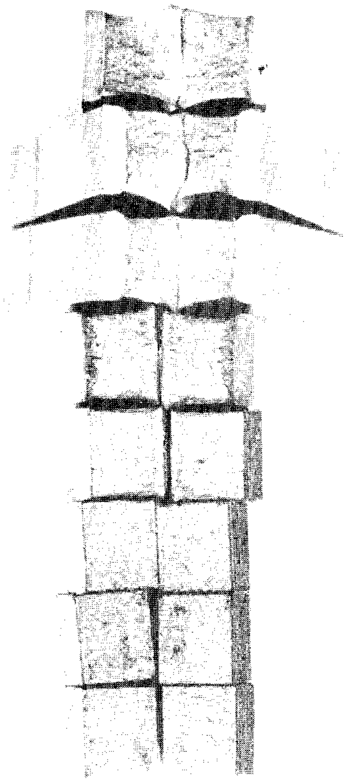


FIG. 6b

FRACTURE SURFACES OF KILLED-STEEL G SPECIMENS

Top to bottom fracture temperatures:

200°, 120°, 70°, 32°, 0°, -40°, -60°, and -100° F.

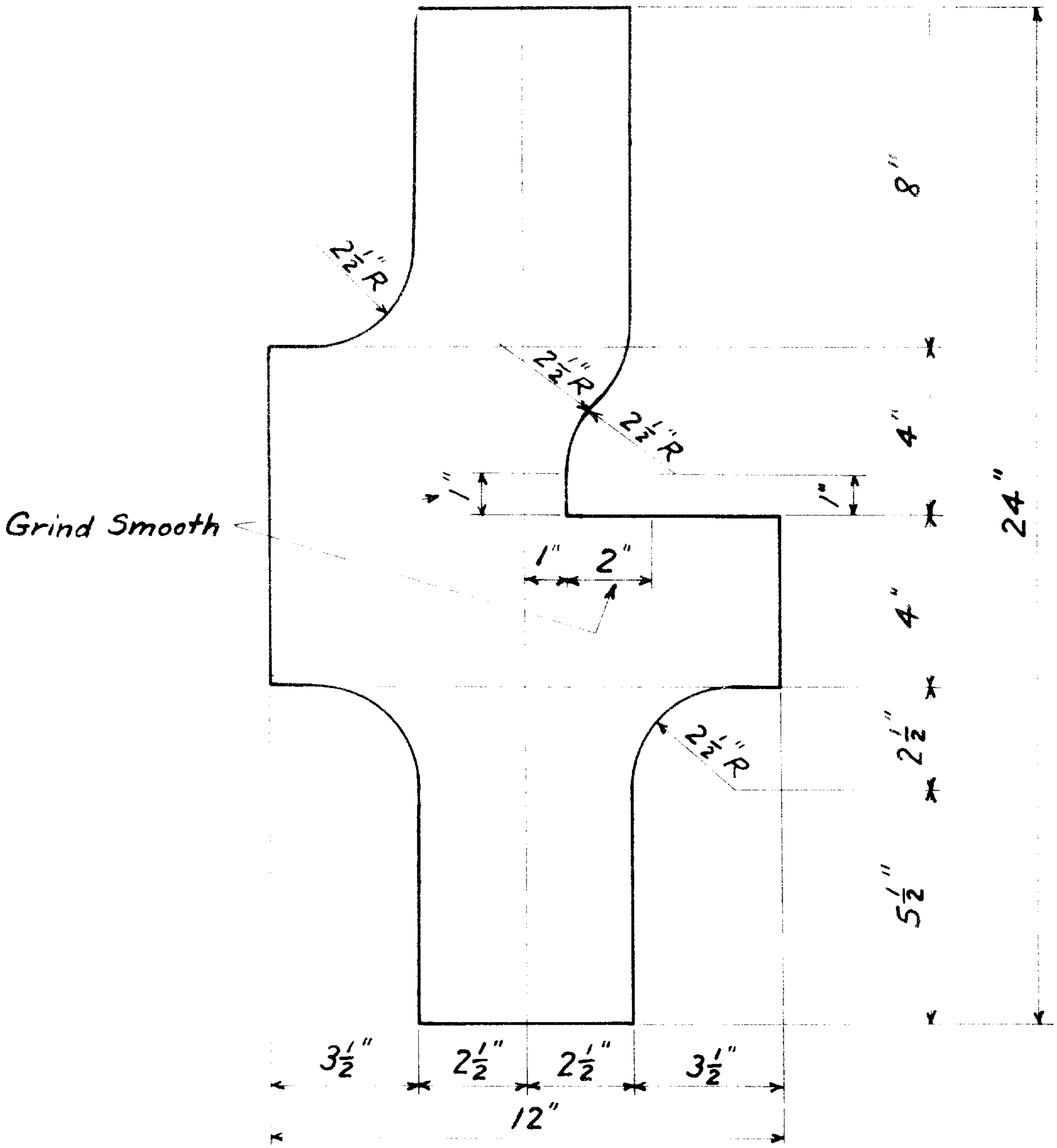


Fig. 7b
Meriam Tear Test Specimen

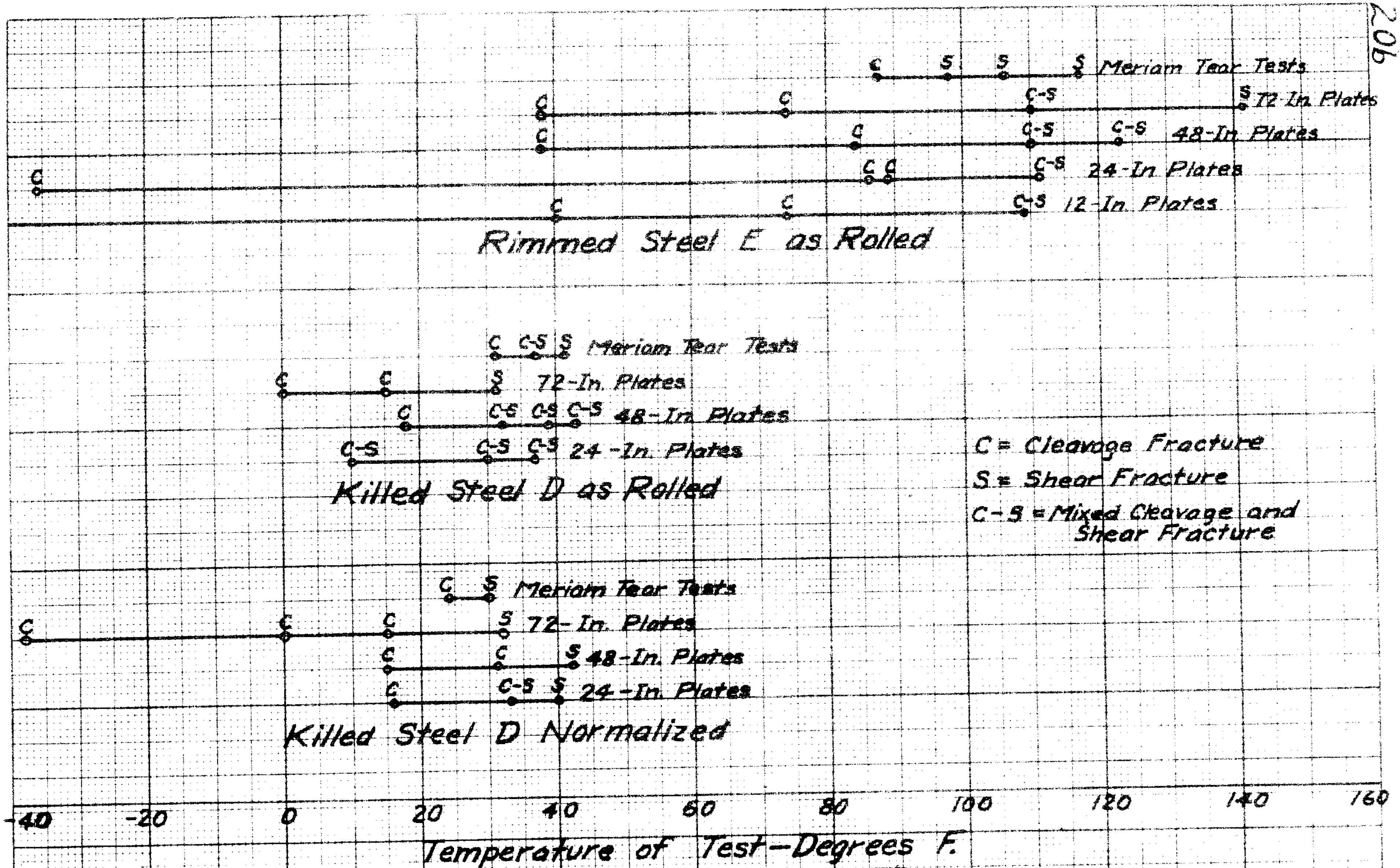


Fig. 8b

Comparison of Type of Fracture for Wide Plate Tests with Jeweler's Saw Cut Stress Raiser and Meriam Tear Tests

NONE
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1. ORIGINATING ACTIVITY *(Corporate author)*	2a. REPORT SECURITY CLASSIFICATION	
Ship Structure Committee	UNCLASSIFIED	
	2b. GROUP	
3. REPORT TITLE		
Cleavage Fracture of Ship Plates As Influenced By Size Effect		
4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*		
Progress Report		
5. AUTHOR(S) *(Last name, first name, initial)*		
W.M Wilson, R.A. Hechtman and W.H. Bruckner		
6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 20, 1946	126	0
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)	
BuShips NObs- 31224	SSC - 3	
b. PROJECT NO.		
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*	
d.		
10. AVAILABILITY/LIMITATION NOTICES		
Unlimited		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY	
	Bureau of Ships, Dept. of the Navy Washington, D.C.	

13. ABSTRACT
This report supplements the Final Report, OSRD No. 6457, Serial No. M-614, "Cleavage Fracture of Ship Plates as Influenced by Size Effect," (NS-336), dated January 15, 1946. It is a Progress Report of tests made subsequent to that date under the direction of the Bureau of Ships, U.S. Navy Department. The report contains a description of tests made to determine why ship plates crack in service The tests were based upon the hypothesis that the cracks begin at points where there are severe geometrical stress-raisers and that the tendency for the plates to crack increased, for specific geometrical characteristics, with an increase in the notch sensitivity of the steel. Plates with nominal widths of 72, 48, 24, and 12 inches were tested. The 72", 48", and 12" plates were made of three kinds of steel, rimmed steel E as-rolled, killed steel as-rolled(D), and killed steel D normalized. The 24" plates were made of four kinds of steel, rimmed steel E as-rolled, killed steel D as-rolled, killed steel D normalized, and a low carbon, high manganese killed steel F as-rolled. All plates of each kind of kind of steel were from the same heat. Tests of both flat and round coupons were made to determine the ultimate strength, yield point, elongation, and reduction of area. Impact values, determined by tests of standard V-notch spevimens, were obtained for all steels throughout the temperature range covered by the tests of the wide plates. The standard stress raiser, which was centrallt located in the plate, was a transverse slot ½" wide with a hacksaw cut at each end which terminated in a jeweler's saw cut 1/8" long. For a few specimens, the hacksaw cut terminated in a No. 47 drill hole. The L/W ratio (length of stress raiser/width of plate) had values of

DD FORM 1 JAN 64 1473

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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0.125, 0.25, 0.33, 0.50, and 0.75 for two series of tests. For all other series L/W was equal to 0.25. The plates were tested at temperatures ranging from -73 to 141° F. The elongation at all loads of the wide plates at midlength was measured by mechanical gauges on a gage length equal to 3/4 of the gross width of the plate. The elastic and early plastic strains in the plate at midlength were measured with electric strain gages having a 13/16" gage length; the plastic strain in the same region was measured with mechanical gages of ¼" and 1" gage lengths at loads up to the initial fracture. All Starins were measured on both sides of the plate. After failure, the thickness of the plate adjacent to the fracture was measured with micrometer calipers and the mode of fracture, percentage of shear and cleavage in the fracture was determined. The tests were planned to determine:

(1) The relative energy absorbing capacity and strength of plates of the four kinds of steel.
(2) The relation between the width of the plates and their strength and energy absorbing capacity.
(3) The relation between the temperature of the plates and their strength and energy absorbing capacity.
(4) The relation between the value of L/W and the strength and energy absorbing capacity of the plates.
(5) The effect of the type of stress raiser upon the strength and energy absorbing capacity of rimmed steel plates
(6) The correlation of V-notch impact test and the wide palte test with the jewleer's saw cut type of stress raiser.

There were a total of 61 wide plates tested. There were also two identical plate failures, not planned but of considerable importance, that have been included in this report. The details of the results are given in Appendix A. The results are discussed on pages 8 to 25, and the conclusions are given on pages 26 to 28.