WADC TECHNICAL REPORT 55-103
SUPPLEMENT 1

DESIGN PROPERTIES OF HIGH-STRENGTH STEELS IN THE PRESENCE OF STRESS-CONCENTRATIONS AND HYDROGEN EMBRITTLEMENT

Effects of a Number of Variables on the Mechanical Properties of Aircraft High-Strength Steels

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WRIGHT AIR DEVELOPMENT CENTER
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WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Carpenter Litho & Prtg. Co., Springfield, O.
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FOREWORD

This report was prepared by Syracuse University under USAF Contract No. AF 33(616)-2362. The contract was initiated under Project No. 7360, "Materials Analysis and Evaluation Techniques", Task No. 73605, "Design and Evaluation Data for Structural Metals" formerly RDO No. 614-13 "Design and Evaluation Data for Structural Metals", and was administered under the direction of the Materials Laboratory, Directorate of Research, Wright Air Development Center, with Mr. A. W. Brisbane as project engineer. This work was performed in the period between March 1954 and June 1955.

ABSTRACT

Supplement 1 of WADC TR 55-103, is a summary of all test results assembled in this investigation. The results are presented in graphs which indicate all the important parameters.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

M. R. Whitmore
Technical Director
Materials Laboratory
Directorate of Research

LIST OF ILLUSTRATIONS

4340 Steel - Heat No. 1 (4-1/4 In. Dia.)

LIST OF ILLUSTRATIONS (Con't.)

LIST OF ILLUSTRATIONS (Con't.)

4340 Steel - Heat No. 3

LIST OF ILLUSTRATIONS (Con't.)

SYMBOLS USED

SYMBOL

K:	Theoretical stress concentration factor as derived by Neuber's theory.
L:	Longitudinal specimens, i.e. specimens taken along the direction of rolling.
Tr:	Transverse specimens, i.e. specimens taken perpendicular to the direction of rolling.
R.L. & C.L:	Longitudinal specimens taken from the rim and from the core of V-Mod. 4330 bar respectively.
R.T. & C.T:	Transverse specimens taken from the rim and from the core of V-Mod. 4330 bar respectively.
e:	Eccentricity, i.e. the distance from the center of the specimen to the line of load application.
D:	Shank diameter of notch-tension or notch-fatigue specimens.
d:	Notch diameter of notch-tension or notch-fatigue specimens.

INTRODUCTION

Appendix A of this report summarizes in graph form all the data obtained in this investigation with the exception of the results of the program covering hydrogen embrittlement which were submitted as separate reports. The results are plotted against all the important parameters studied, and are presented in a manner most suitable for design purposes. Each plot is self-contained indicating all conditions existing during the test.

The data are presented for each steel in the following order: Metallographic, hardenability, tension, hardness, ductility, notch-tension, impact, fatigue and notch-fatigue, and stress-rupture.

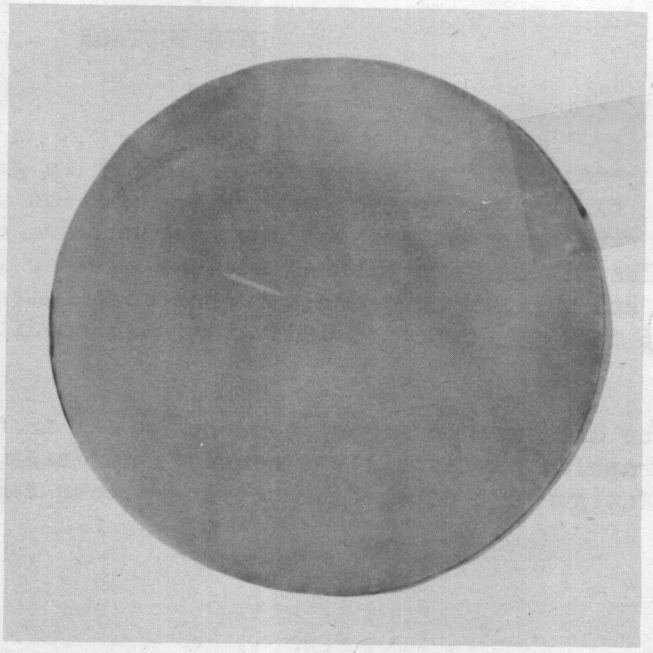
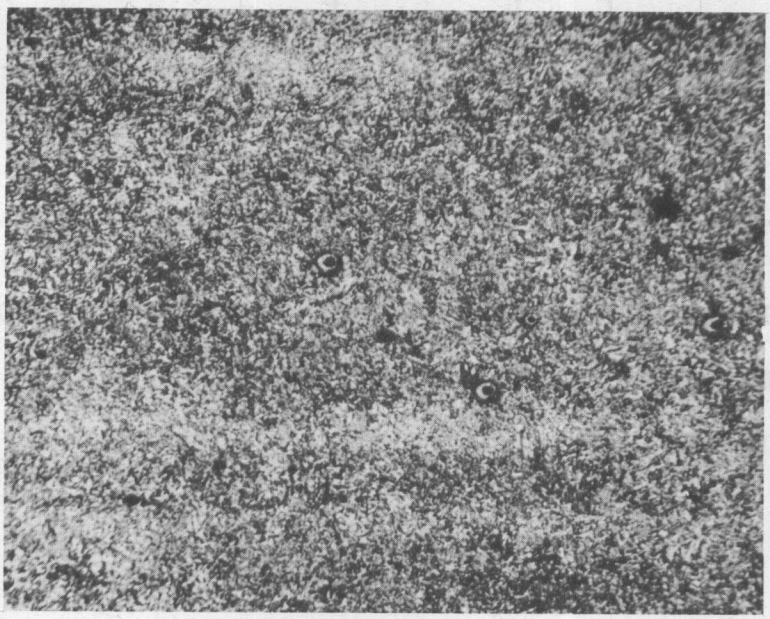


FIG. 1 MACROGRAPH OF 4340 STEEL (HEAT 1) AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.

(a) Transverse Pattern



(b) Longitudinal Pattern

FIG. 2 PHOTOMICROGRAPHS OF 4340 (HEAT 1) STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

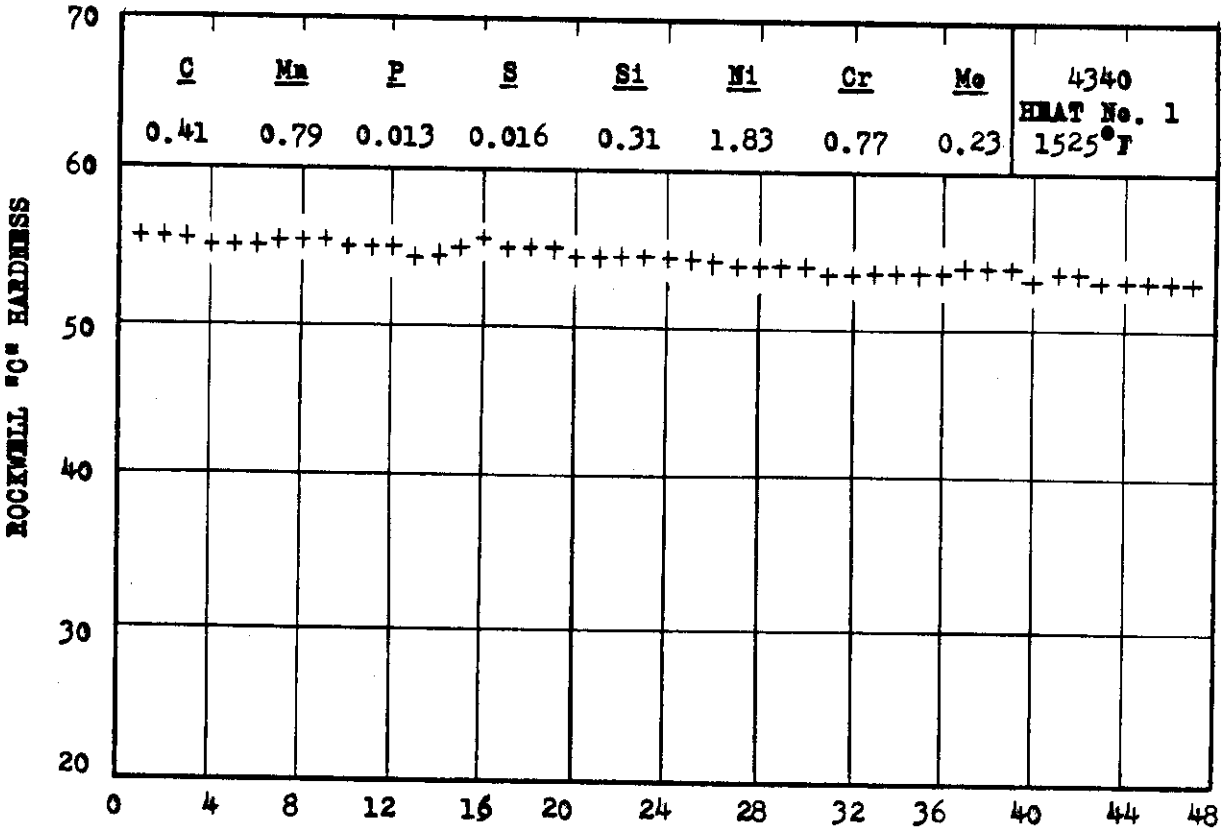


FIG. 3 HARDENABILITY OF JOMINY-QUENCH BAR

SECTION: 4½ IN. DIA.

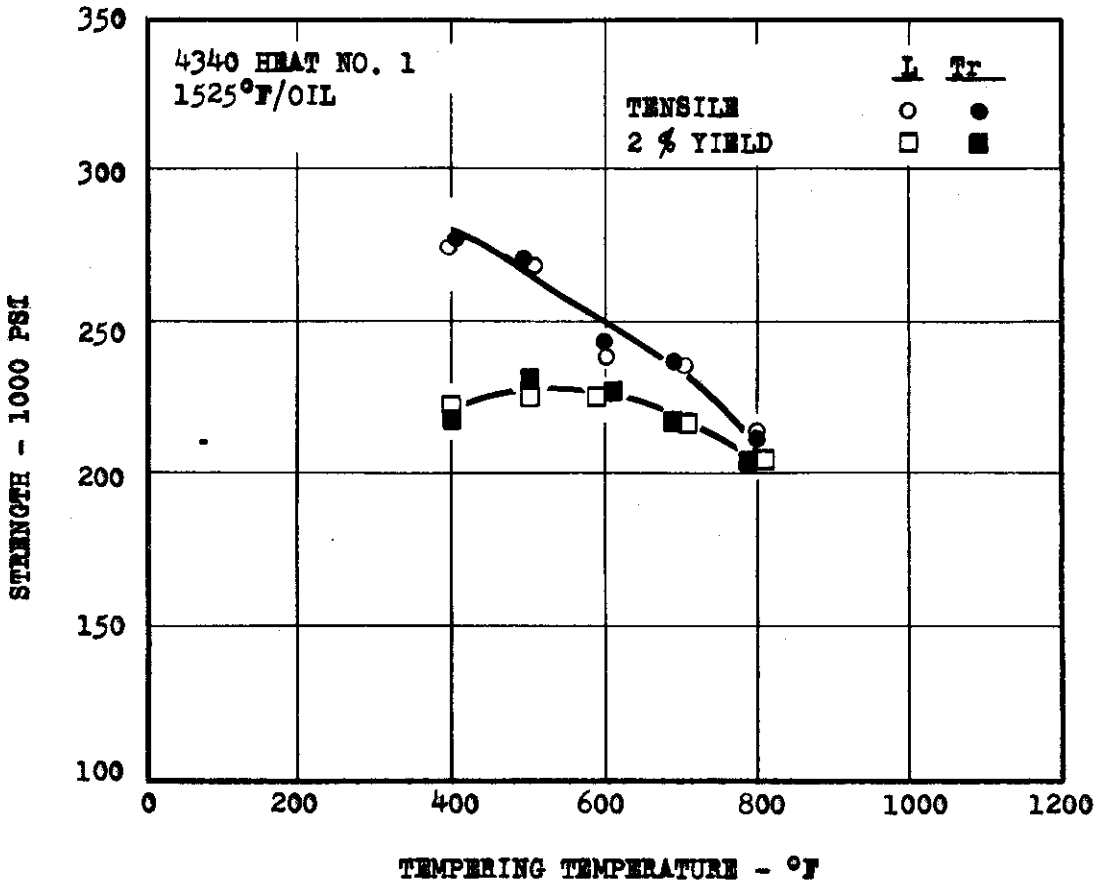


FIG. 4 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4¼ IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

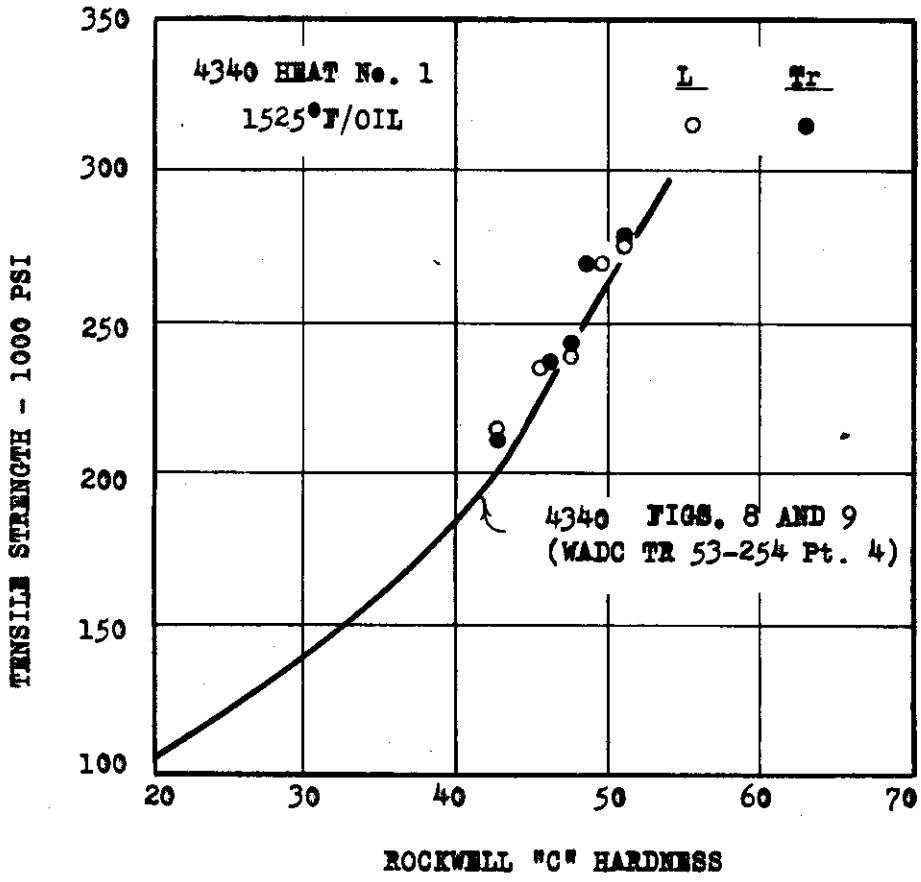


FIG. 5 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

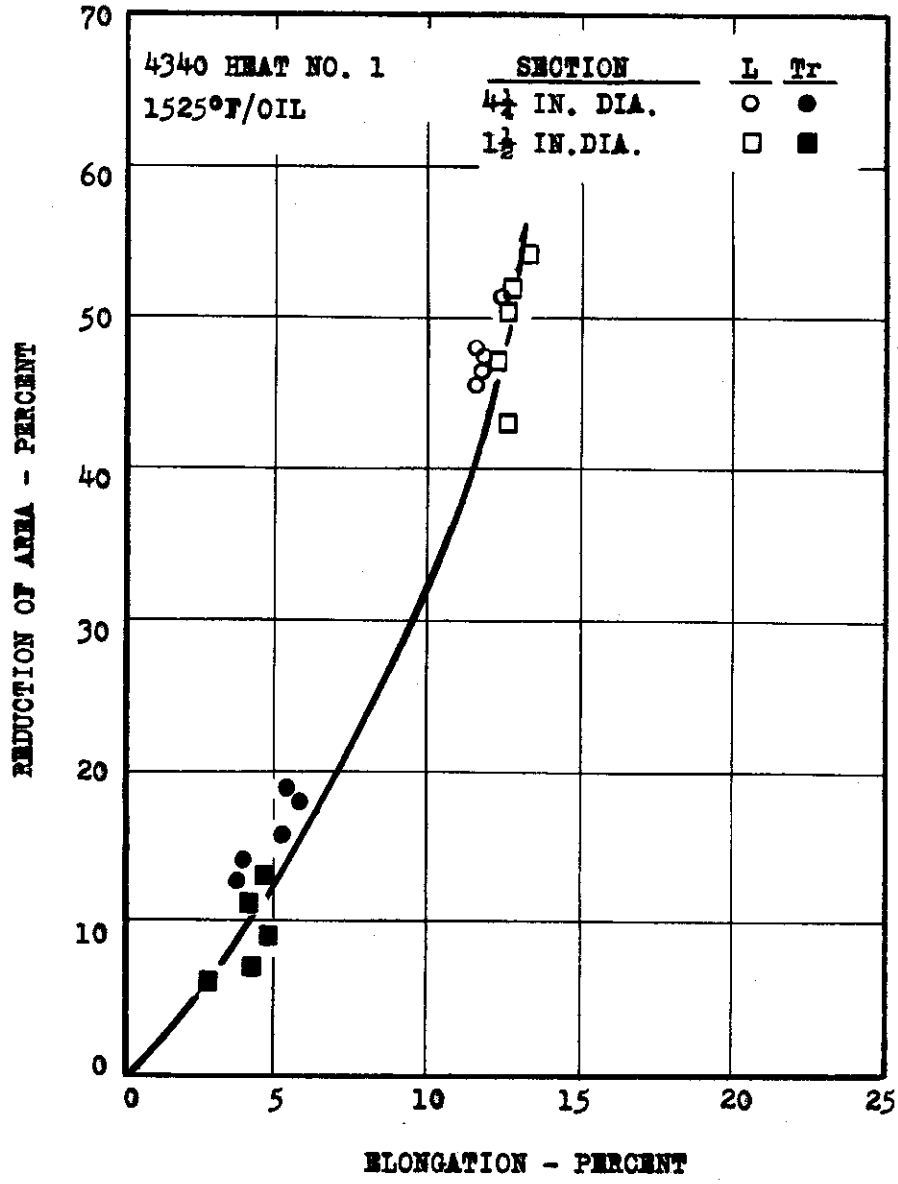


FIG. 6 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 4¼ AND 1½ IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

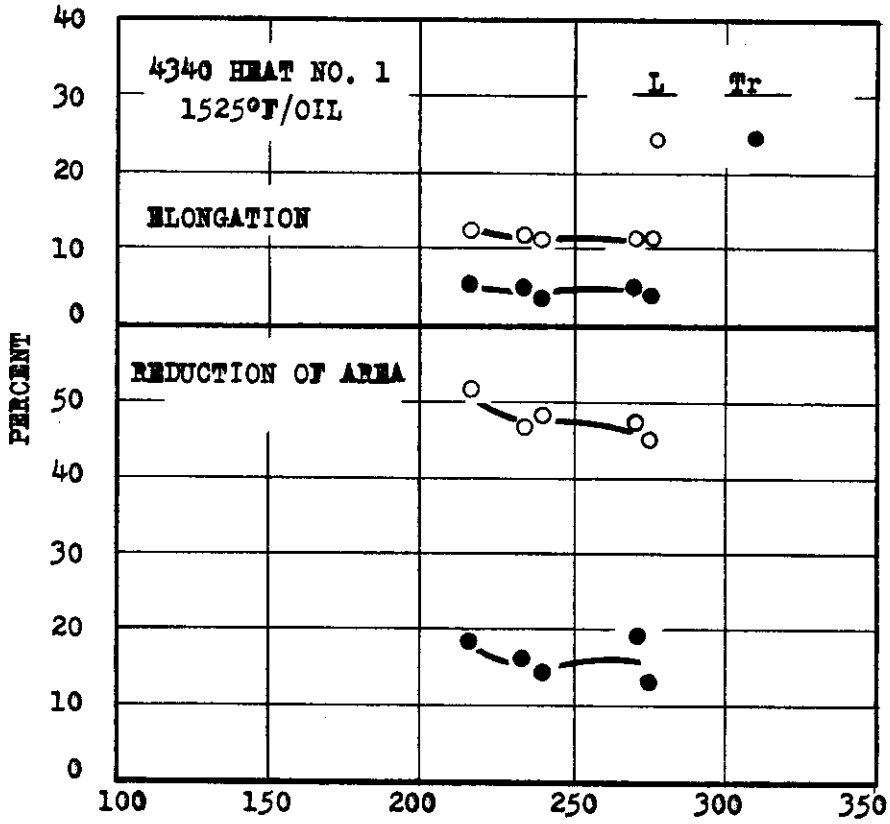


FIG. 7 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: $4\frac{1}{4}$ IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

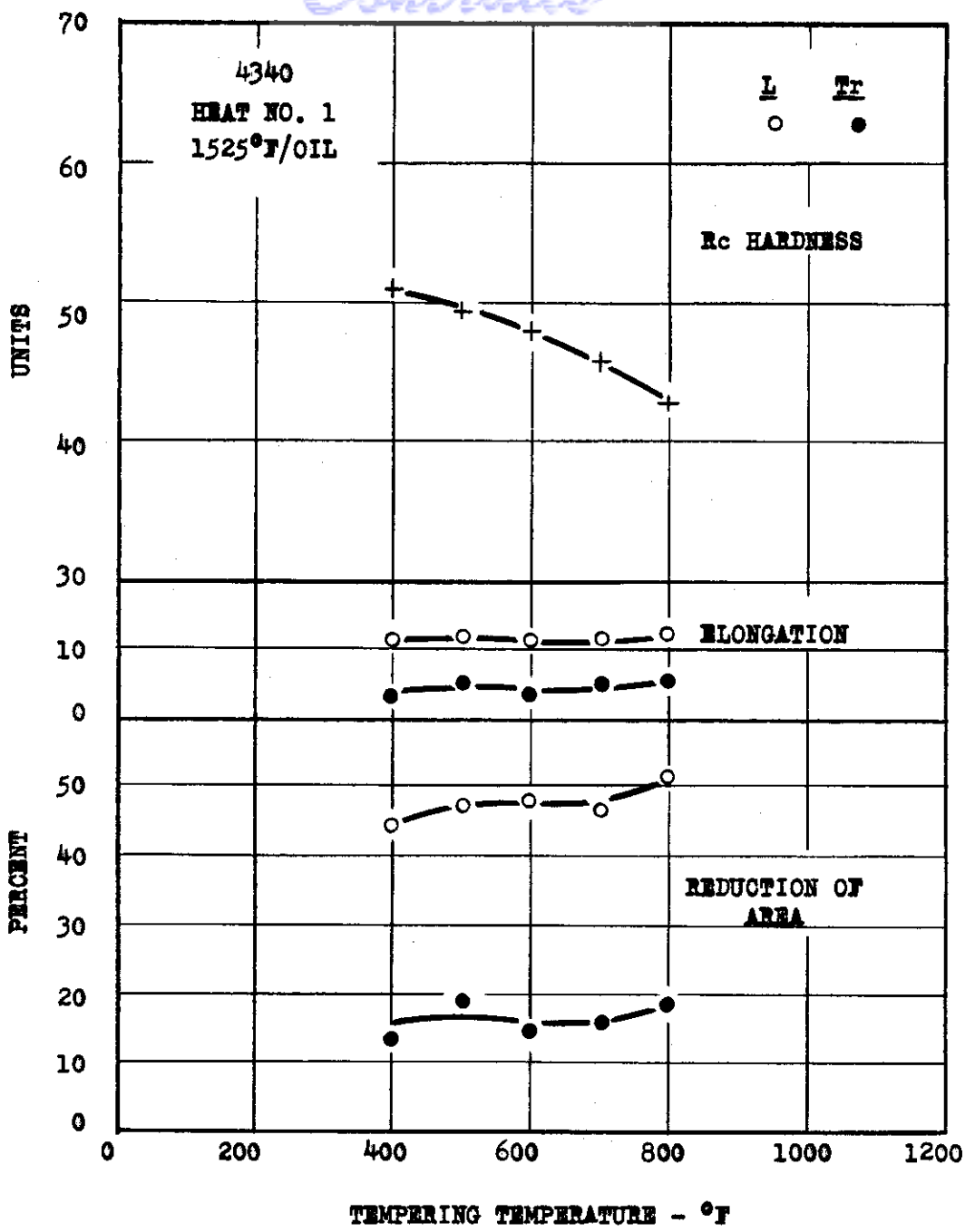


FIG. 8 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: $4\frac{1}{4}$ IN.DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

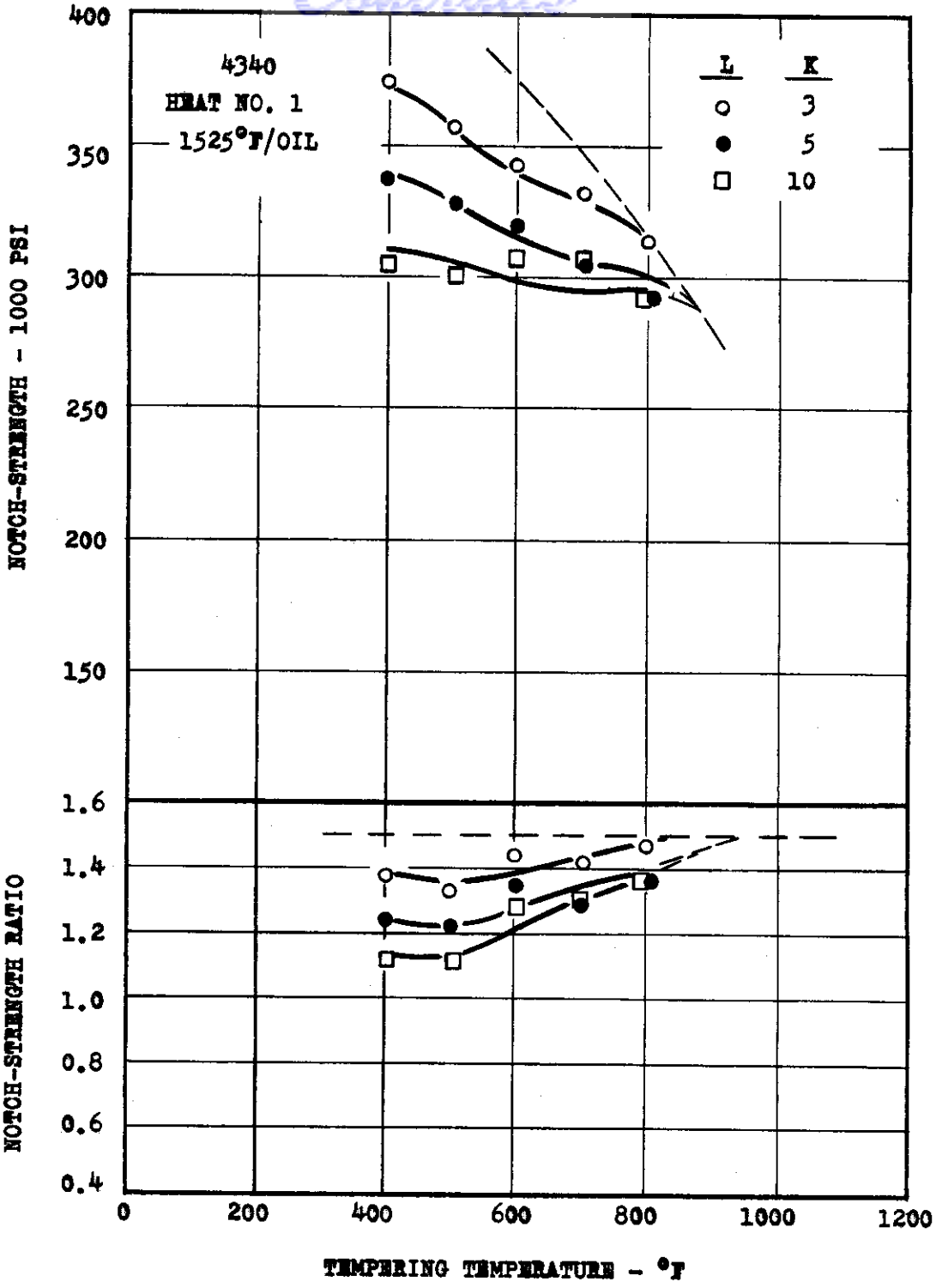


FIG. 9 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

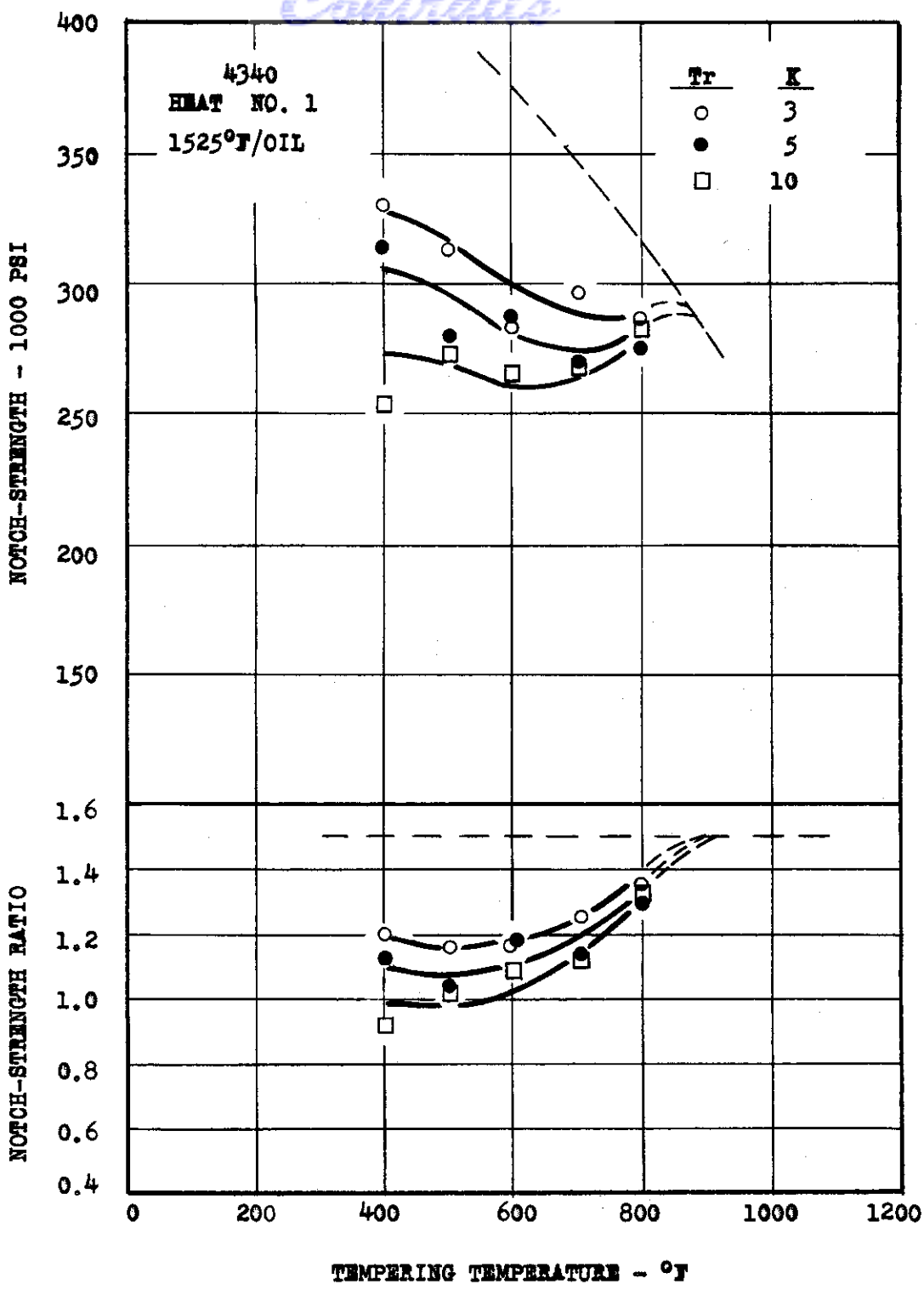


FIG. 10 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

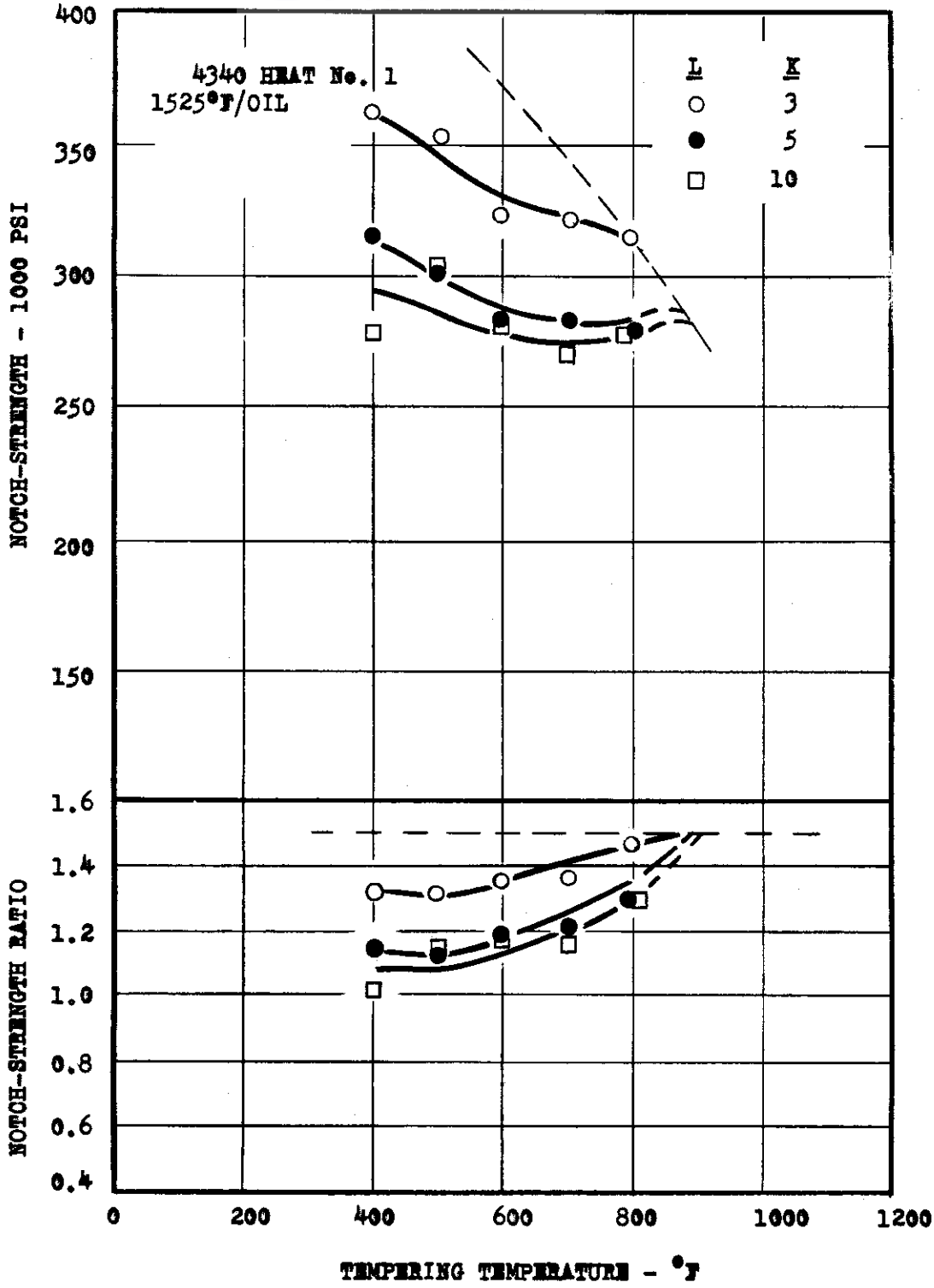


FIG. 11 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: $4\frac{1}{2}$ IN. DIA.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

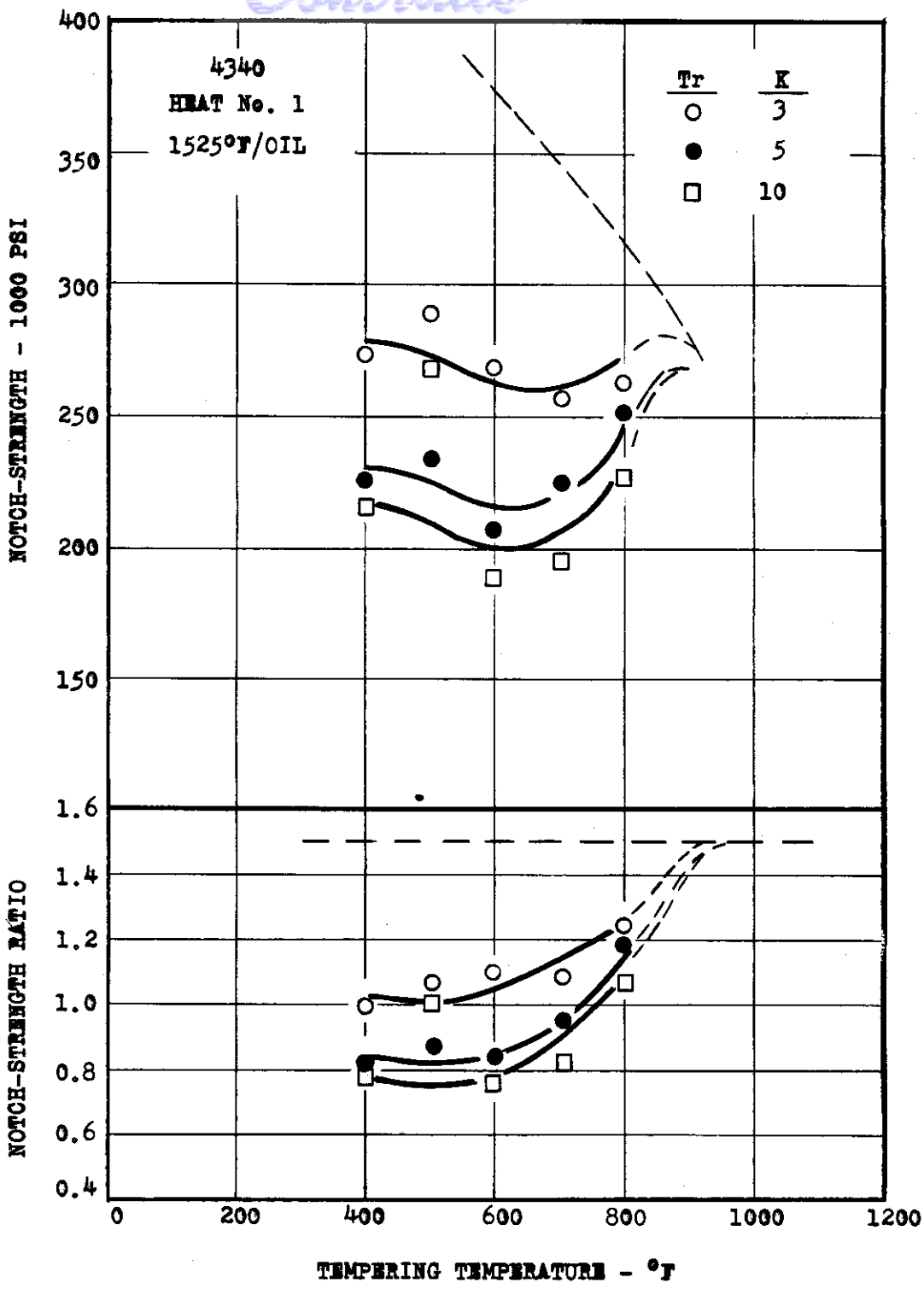


FIG. 12 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN. DIA.

SPECIMEN: 0.5 IN. DIA.

TEST TEMP: R.T.

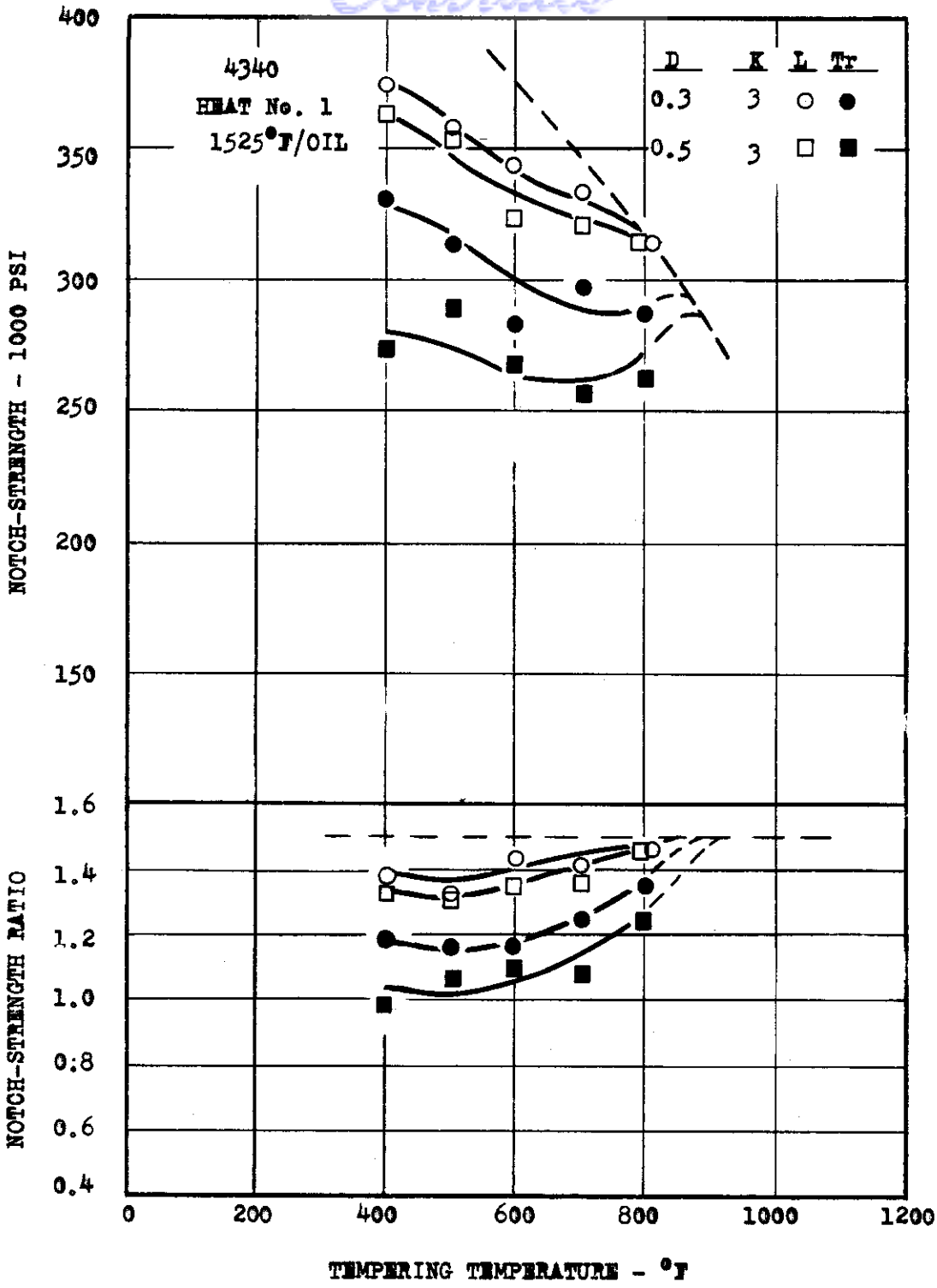


FIG. 13 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: $4\frac{1}{4}$ IN. DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

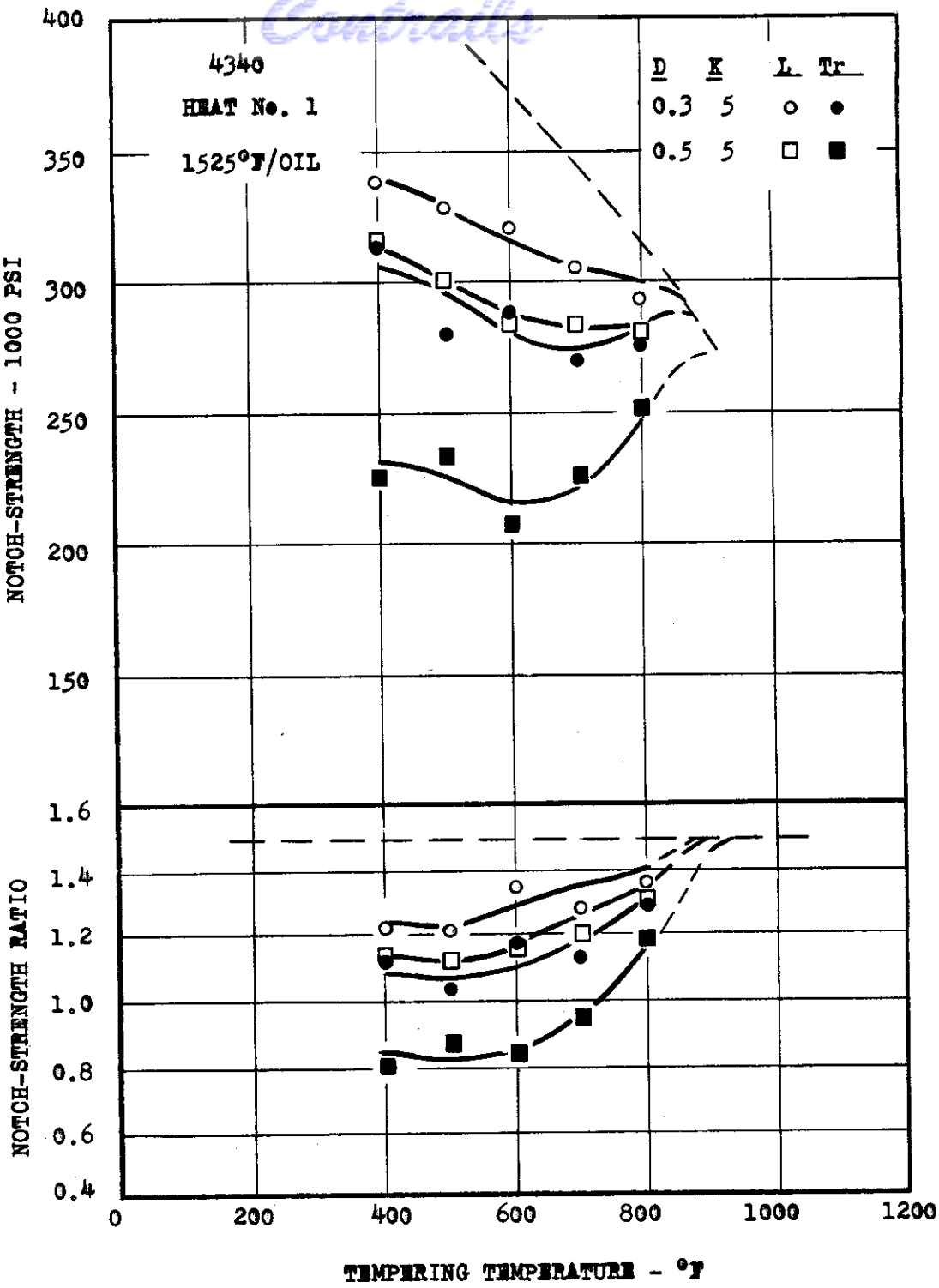


FIG. 14 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN. DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

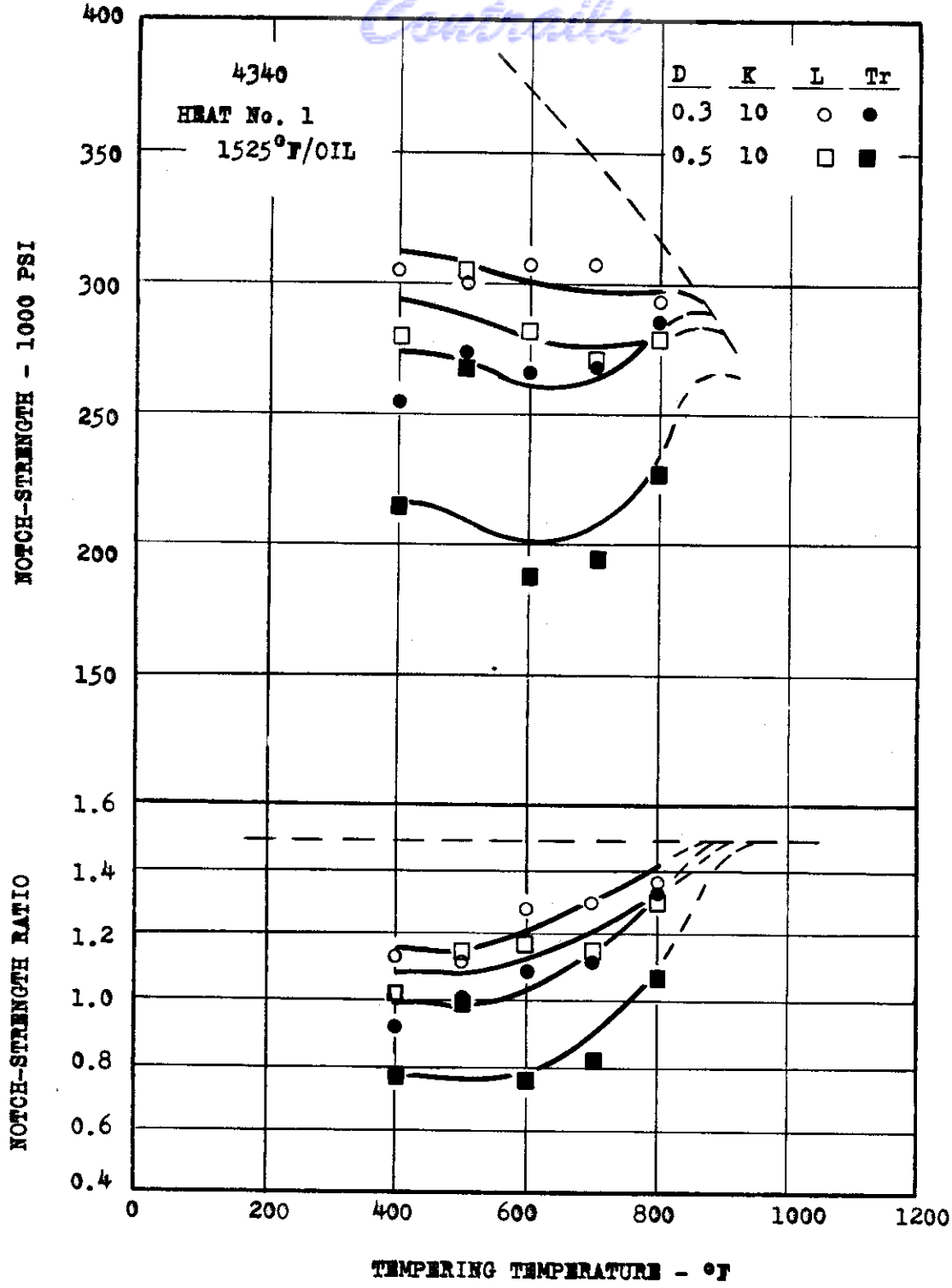


FIG. 15 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

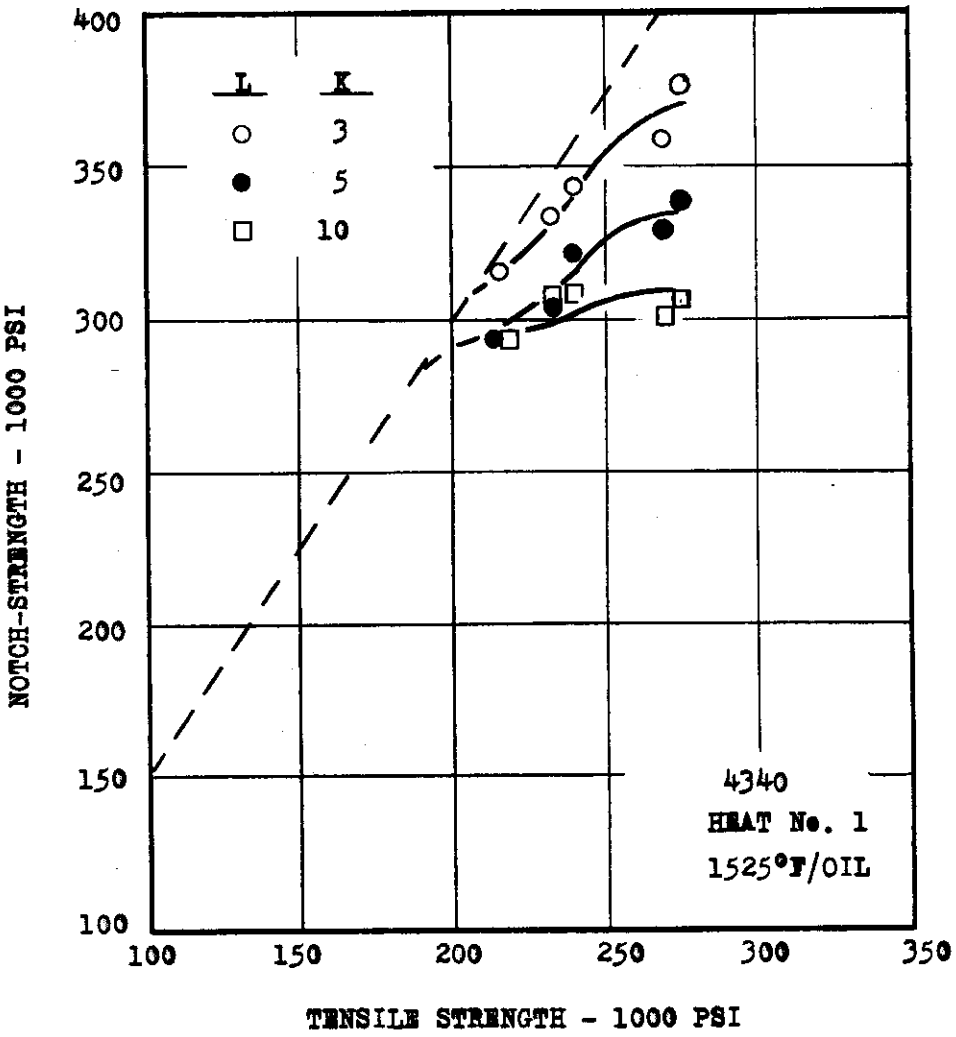


FIG.16 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: $4\frac{1}{4}$ IN.DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

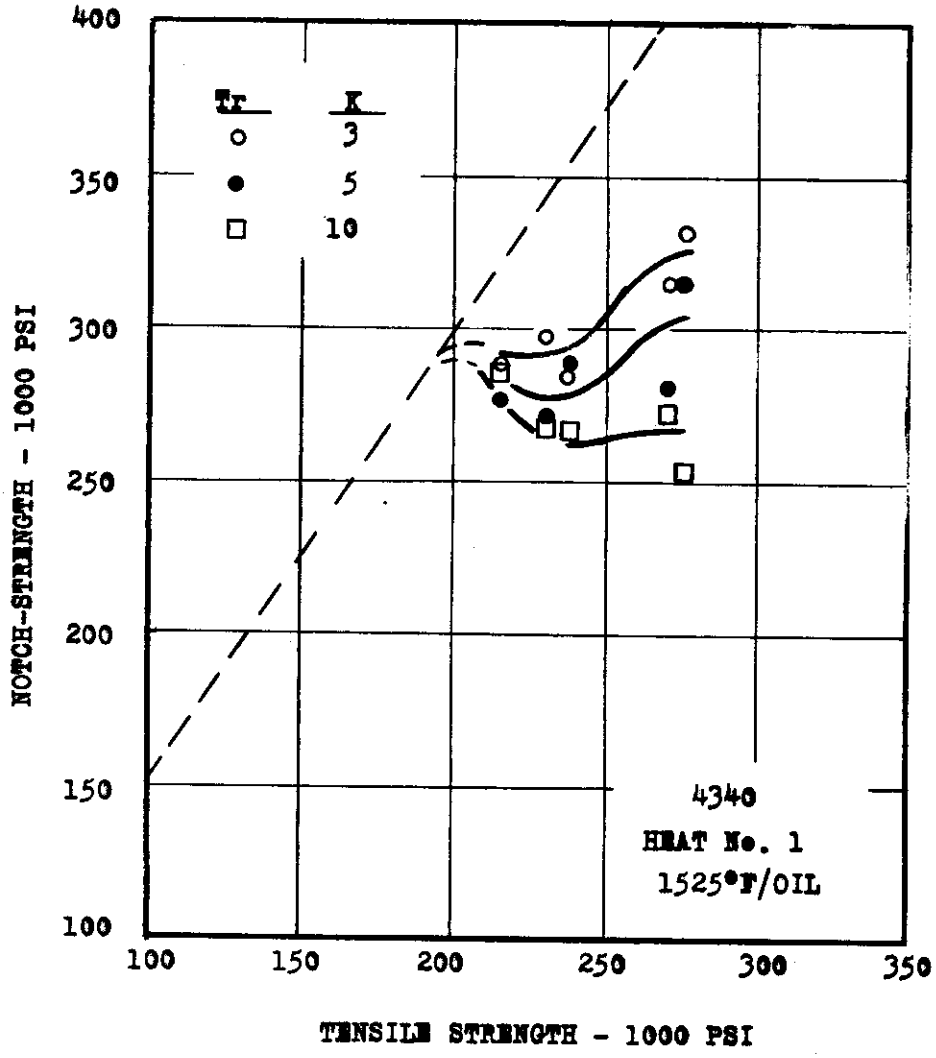


FIG. 17 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

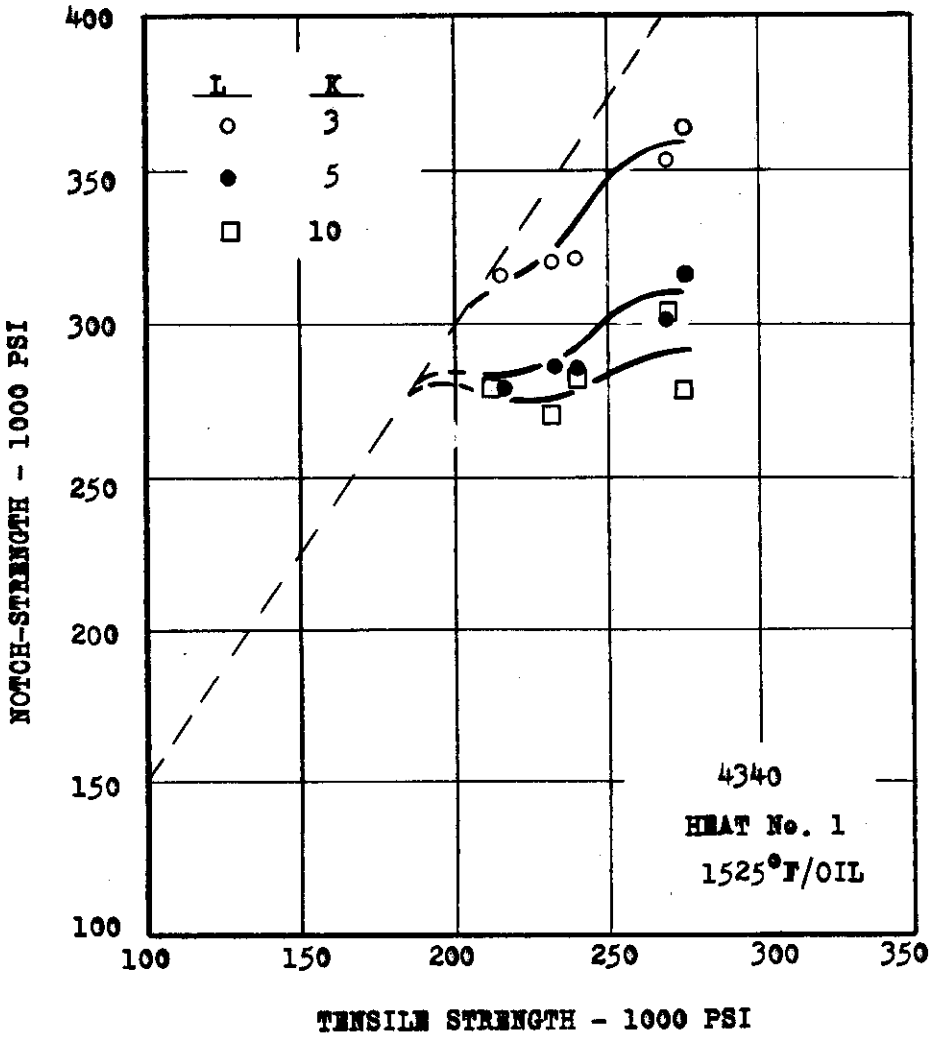


FIG. 18 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

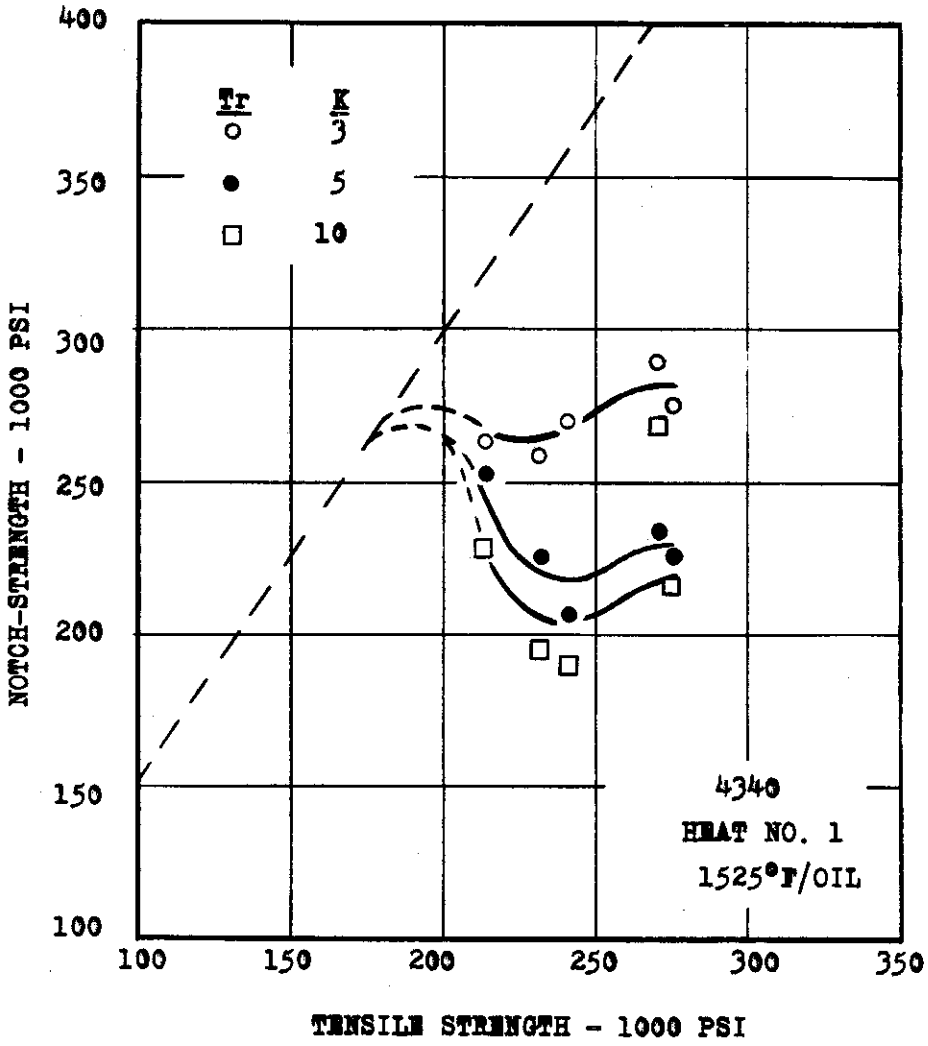


FIG. 19 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: $4\frac{1}{2}$ IN. DIA.

SPECIMEN: 0.5 IN. DIA.

TEST TEMP: R.T.

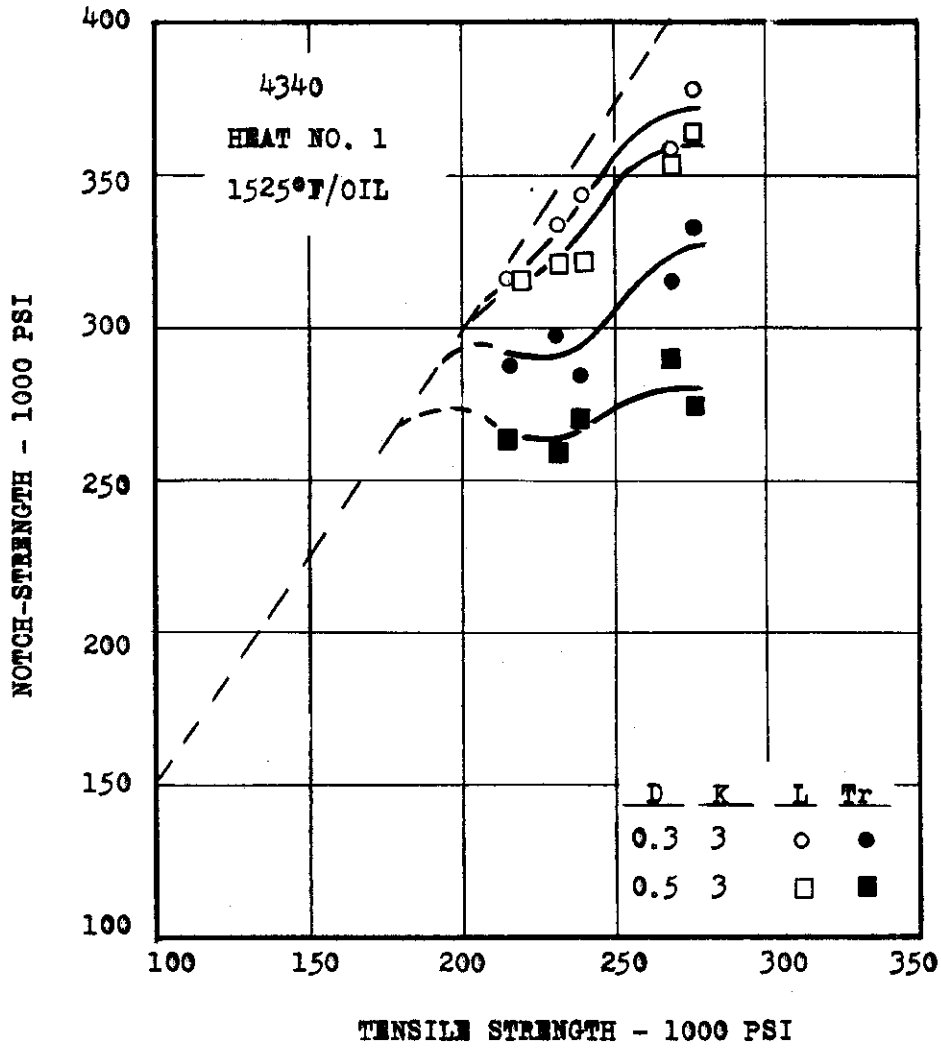


FIG. 20 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4¼ IN.DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

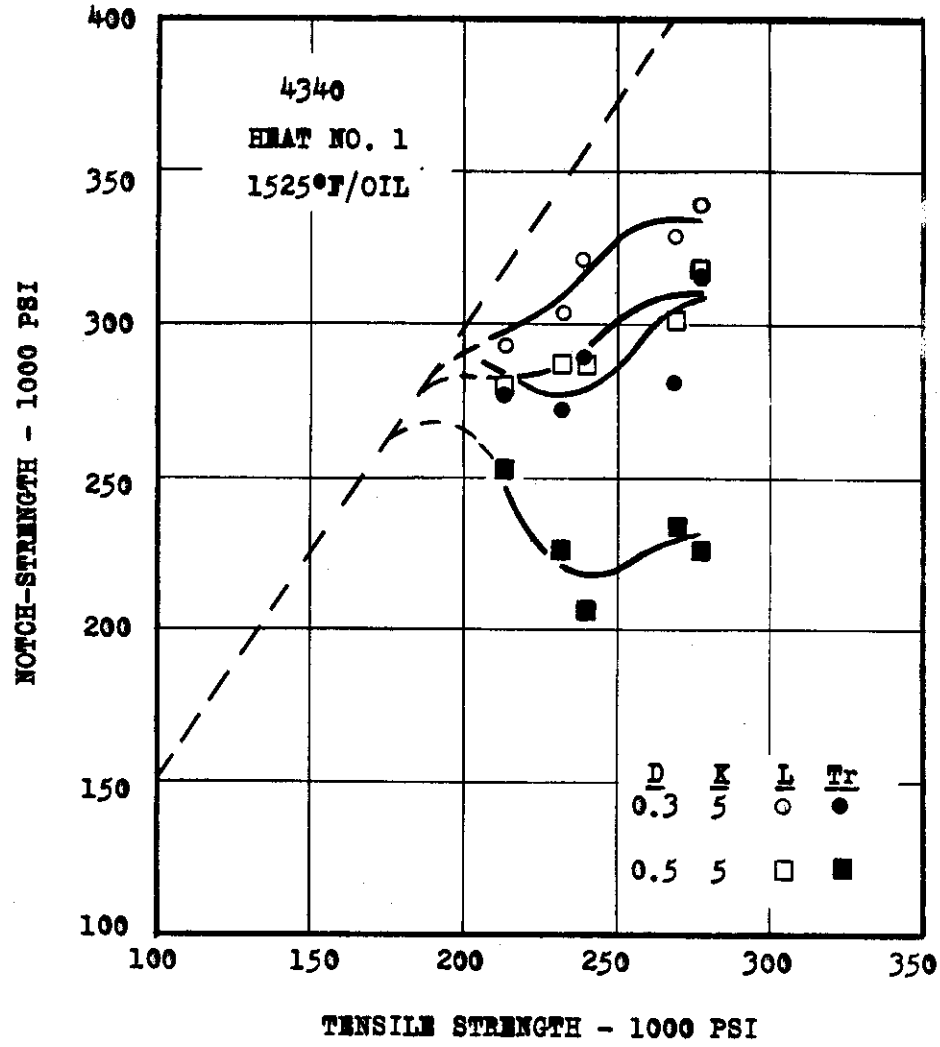


FIG. 21 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4¼ IN. DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

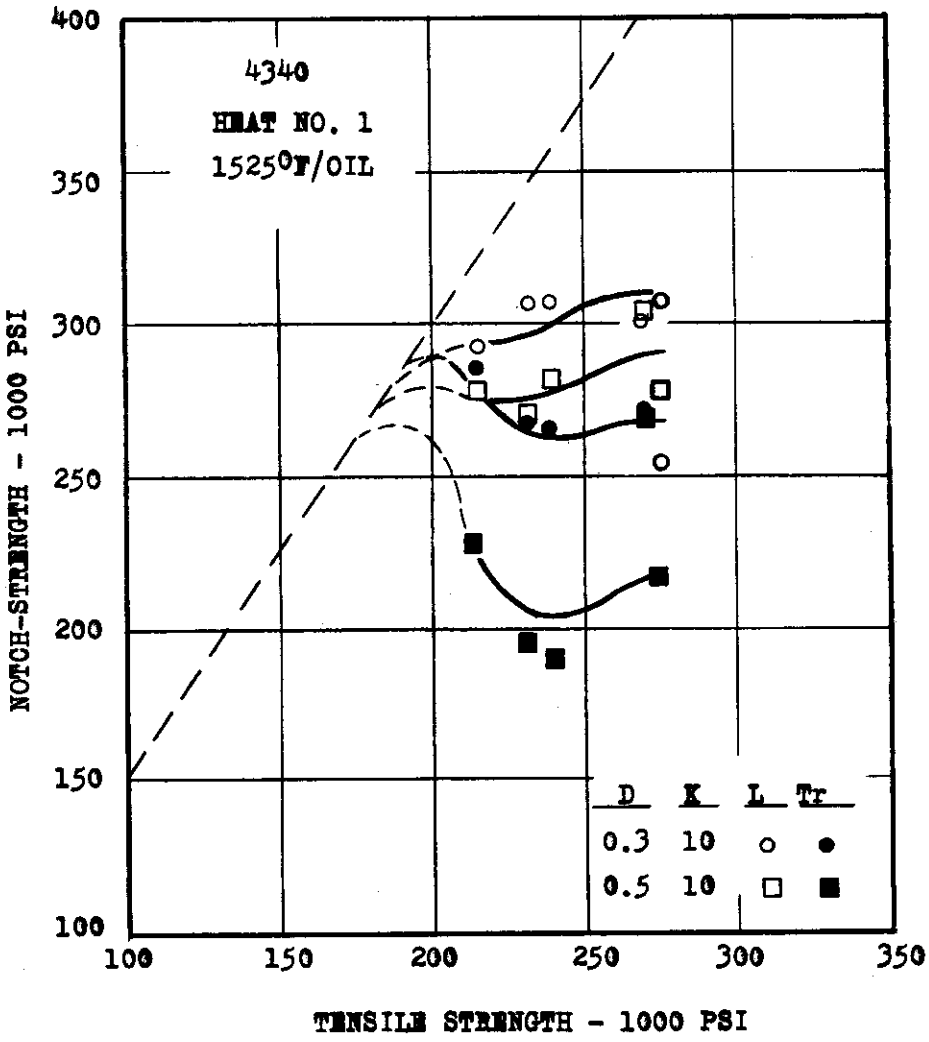


FIG. 22 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: $4\frac{1}{2}$ IN. DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

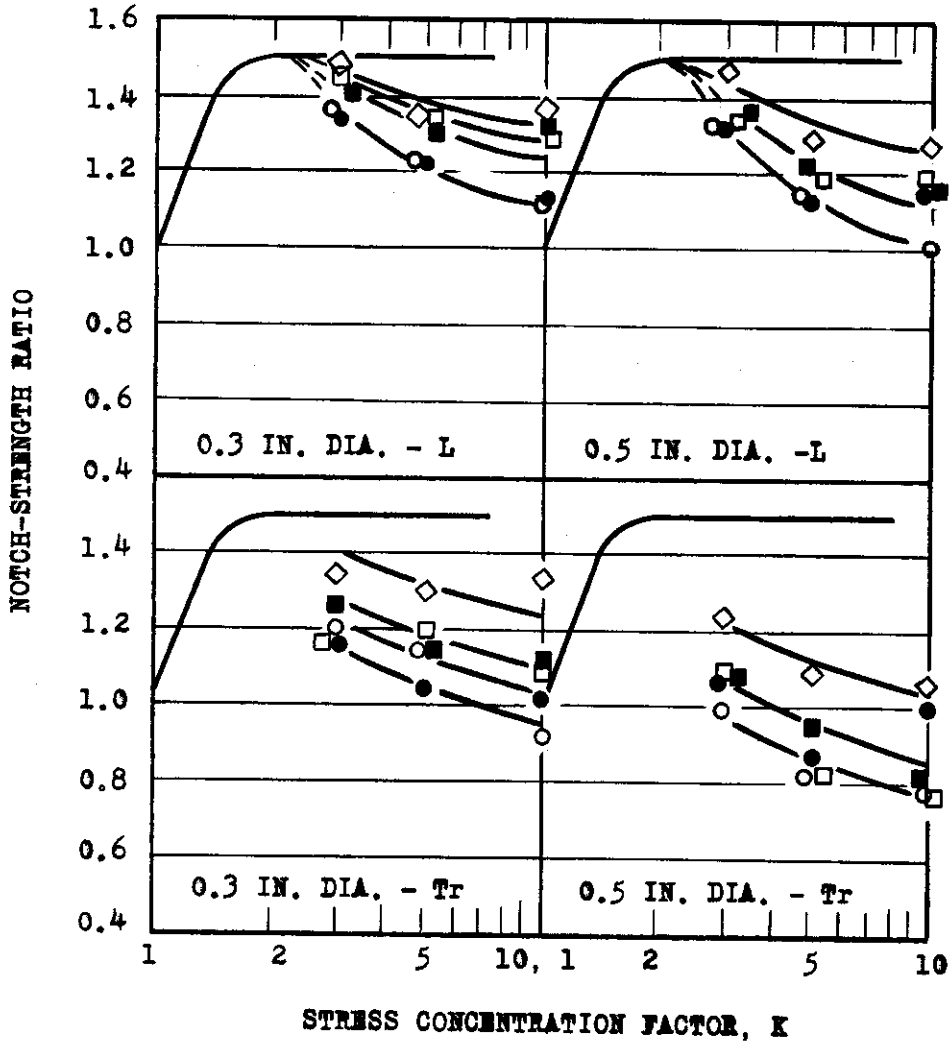


FIG. 23 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 4½ IN. DIA.

TEST TEMP: R.T.

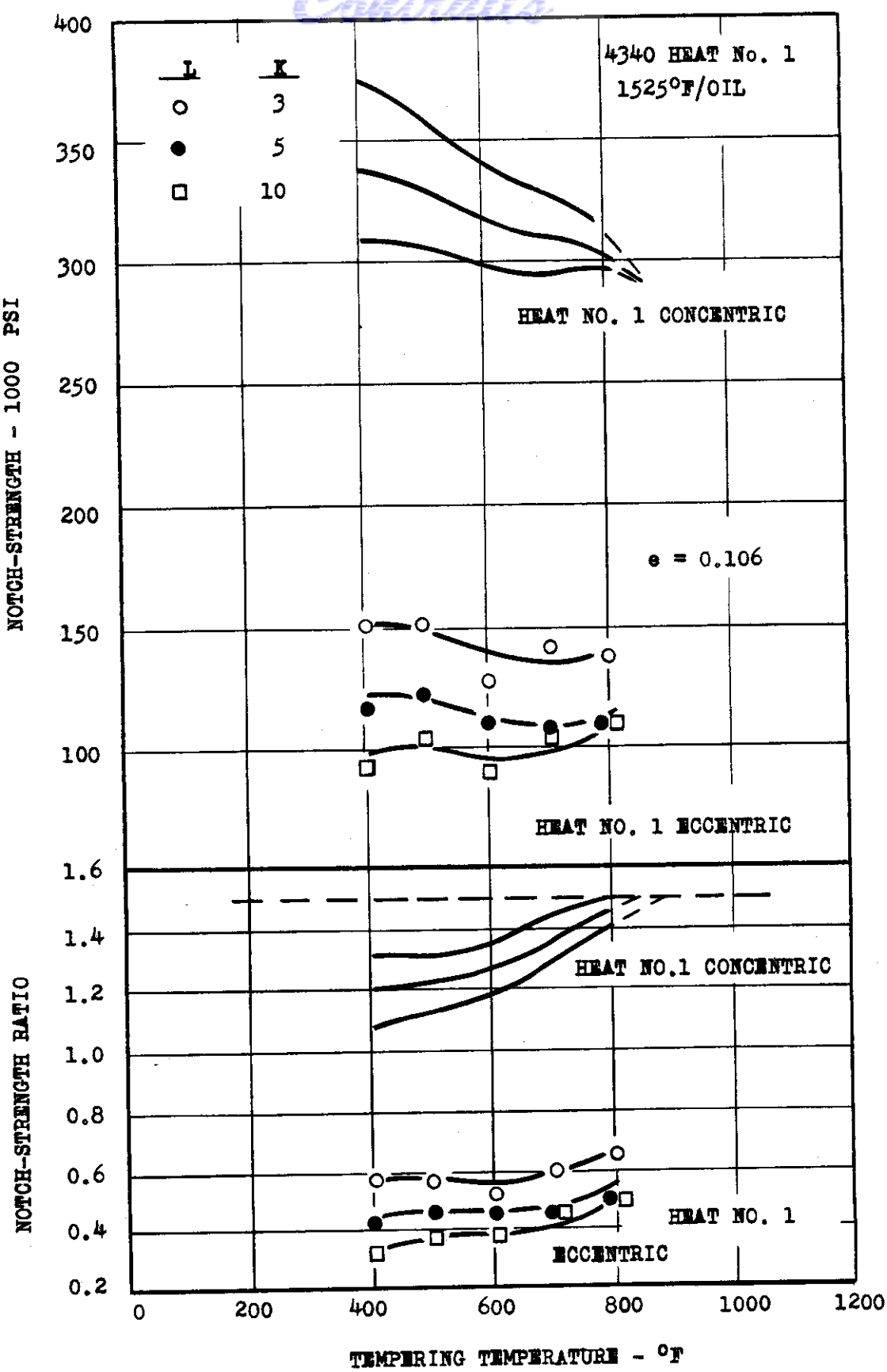


FIG. 24 VARIATION OF ECCENTRIC NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

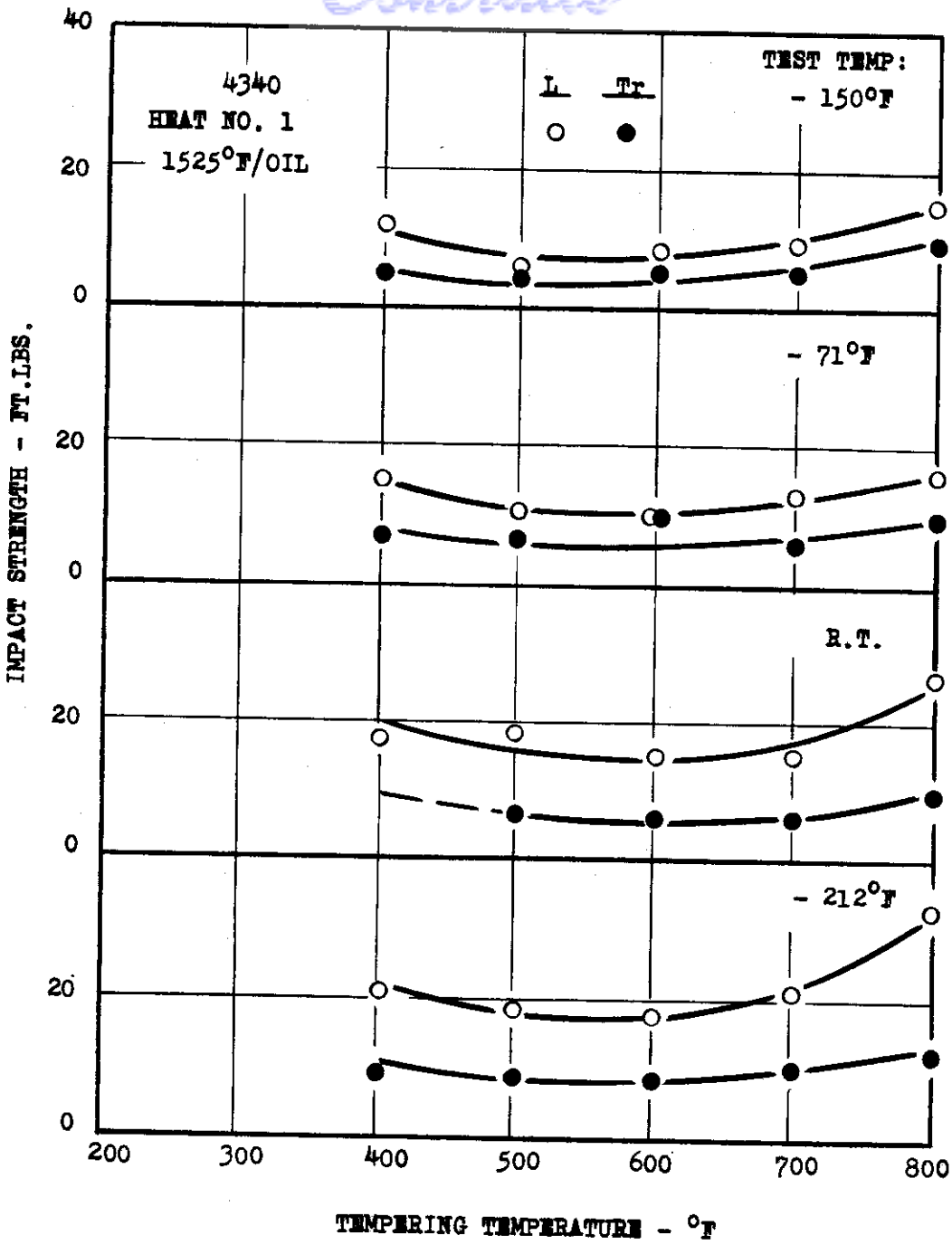


FIG. 25 VARIATION OF IMPACT STRENGTH WITH TEMPERING TEMPERATURE.

SECTION: 4¼ IN. DIA.

SPECIMEN: STD. V-NOTCH CHARPY

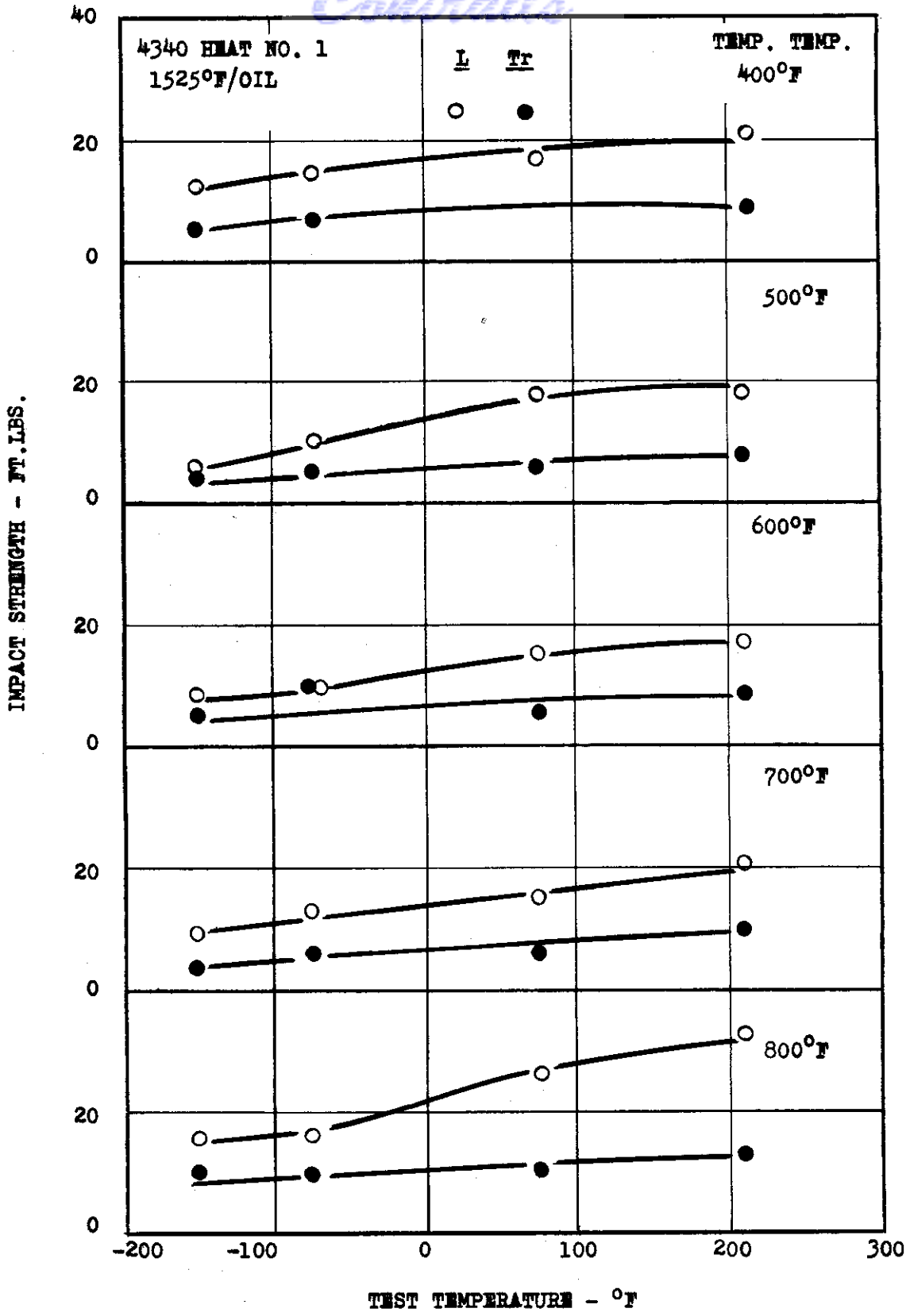


FIG. 26 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 4½ IN. DIA.

SPECIMEN: STD. V-NOTCH CHARPY

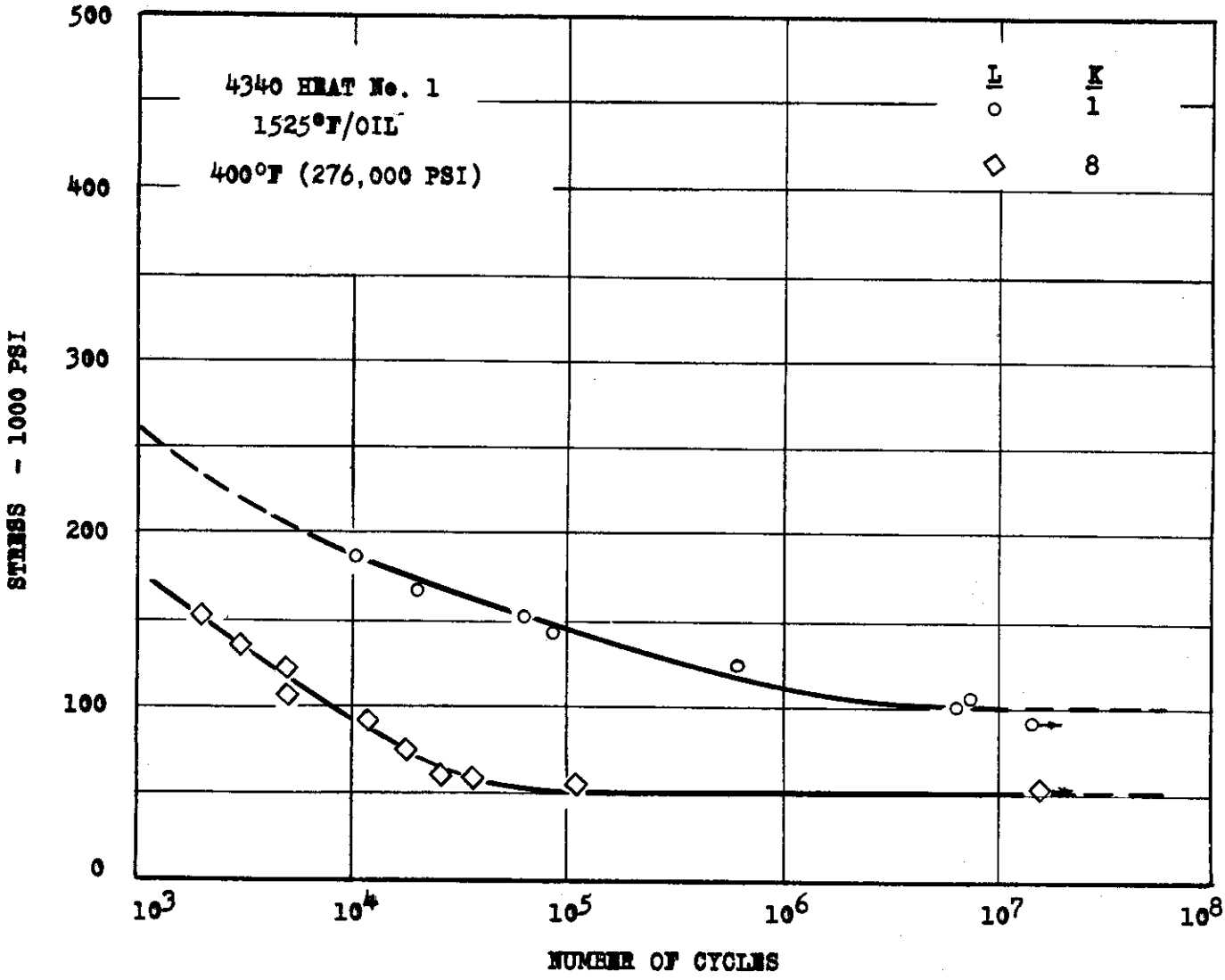


FIG. 27 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4½ IN. DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

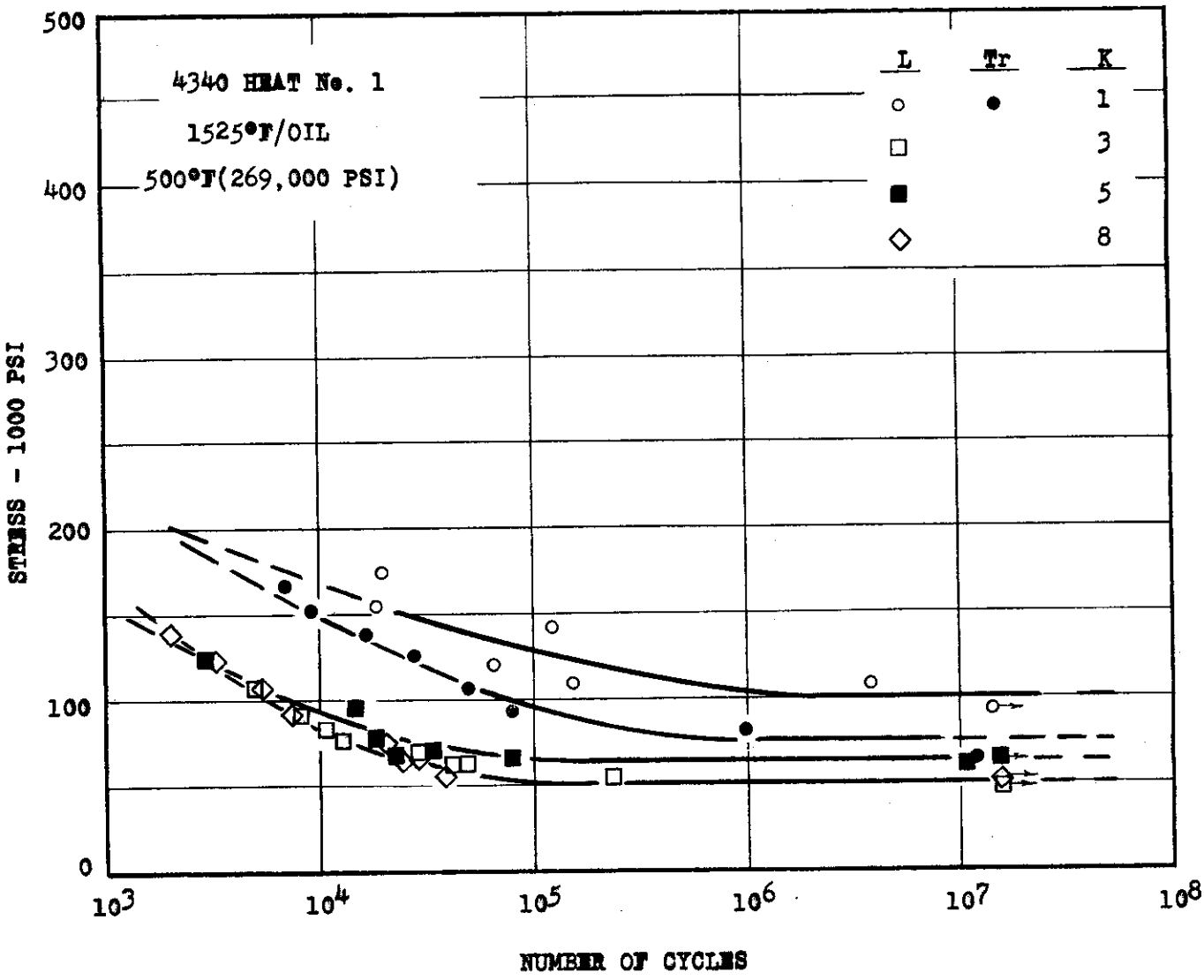


FIG. 28 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4½ IN. DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

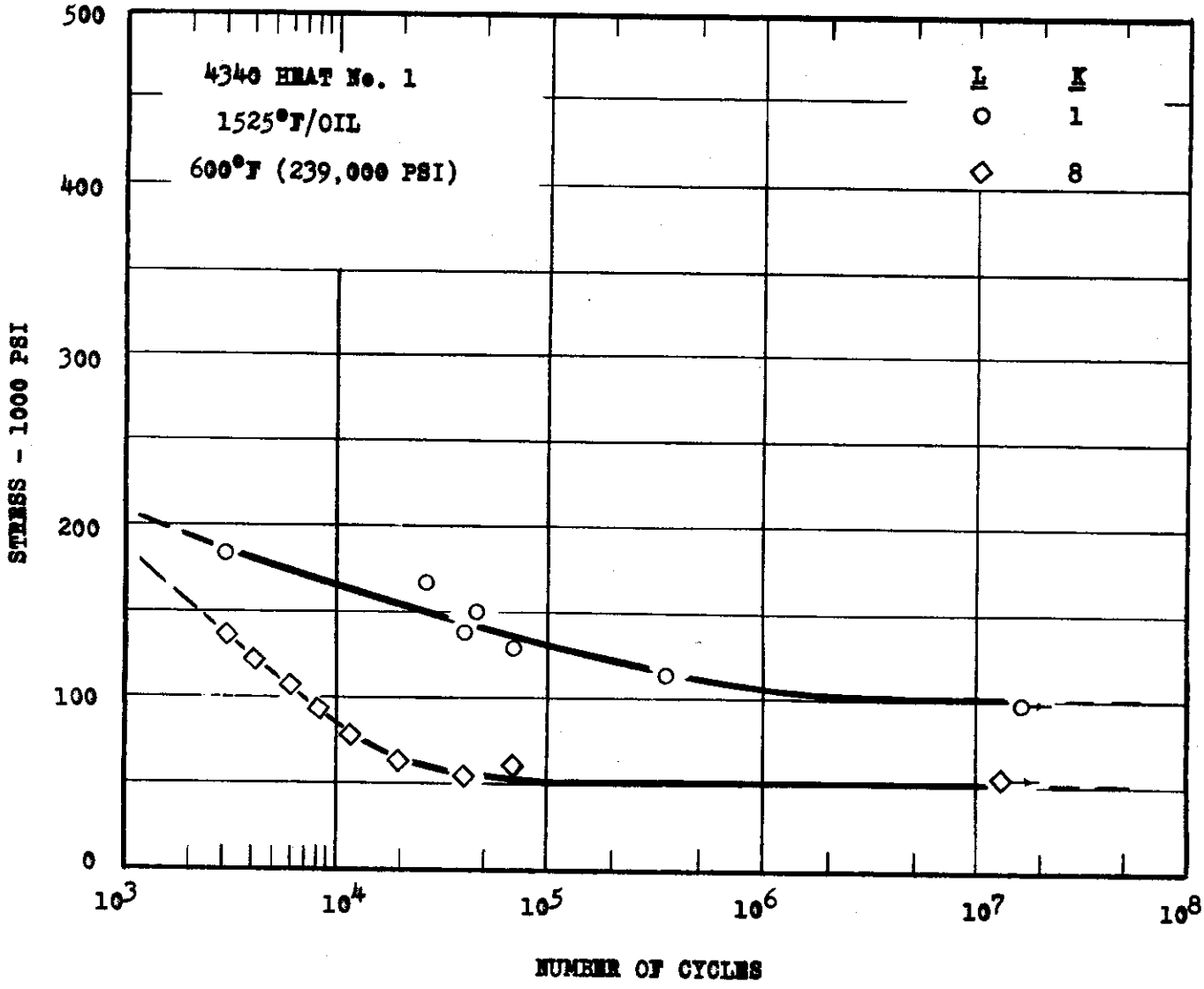


FIG. 29 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4¼ IN. DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

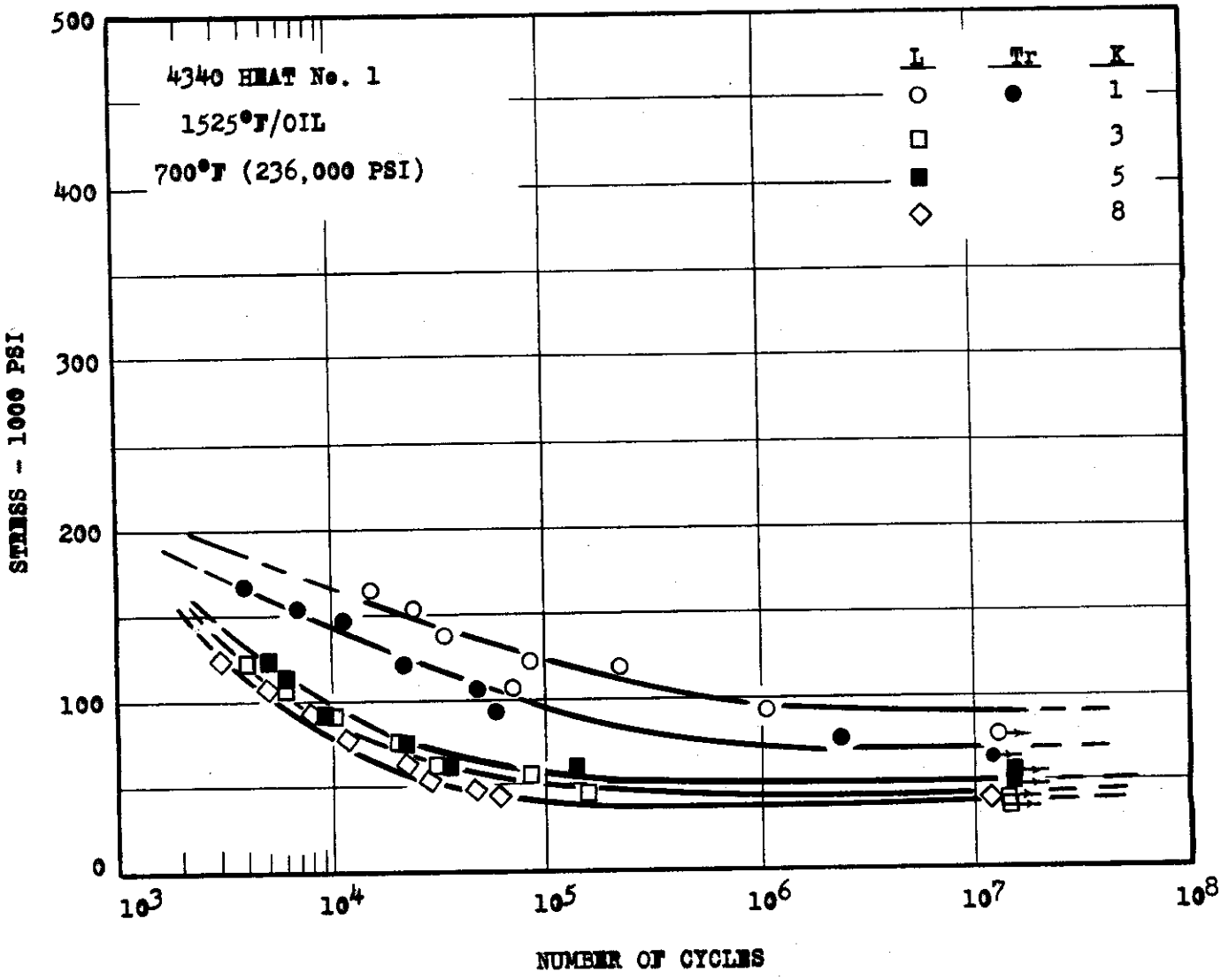


FIG. 30 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4½ IN. DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

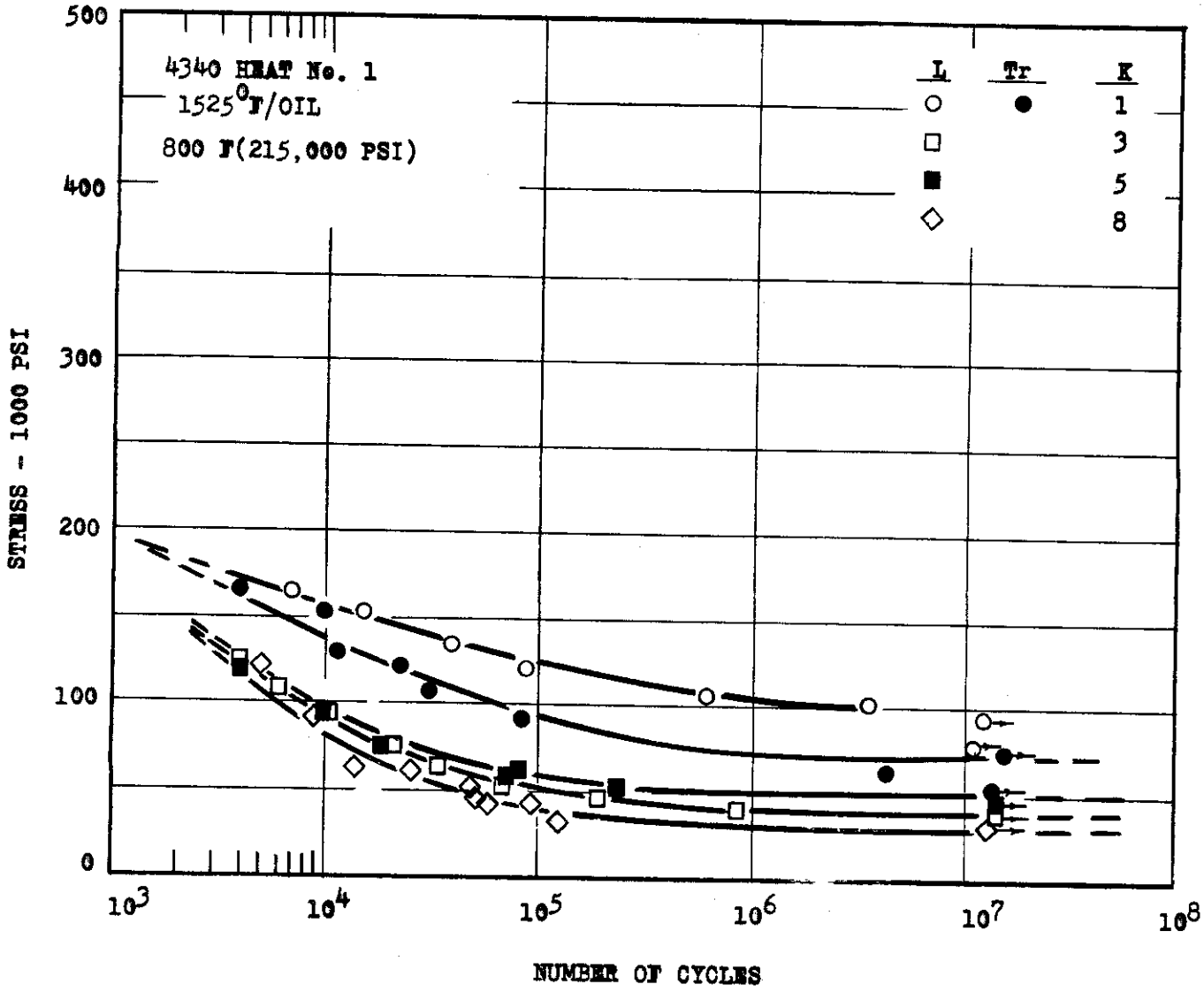


FIG. 31 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4¼ IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

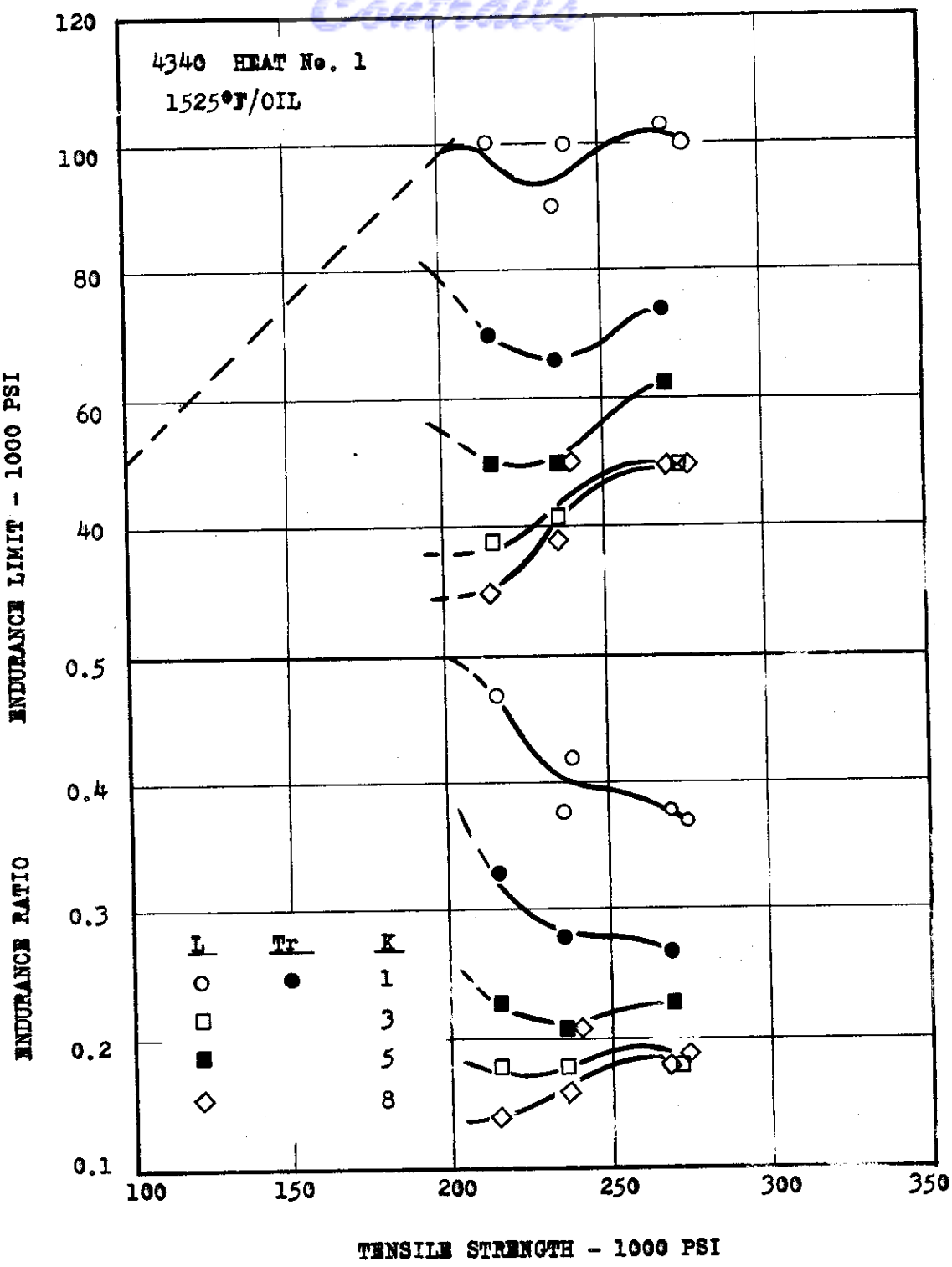


FIG.32 VARIATION OF ENDURANCE LIMIT AND ENDURANCE RATIO WITH TENSILE STRENGTH

SECTION: 4½ IN.DIA.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

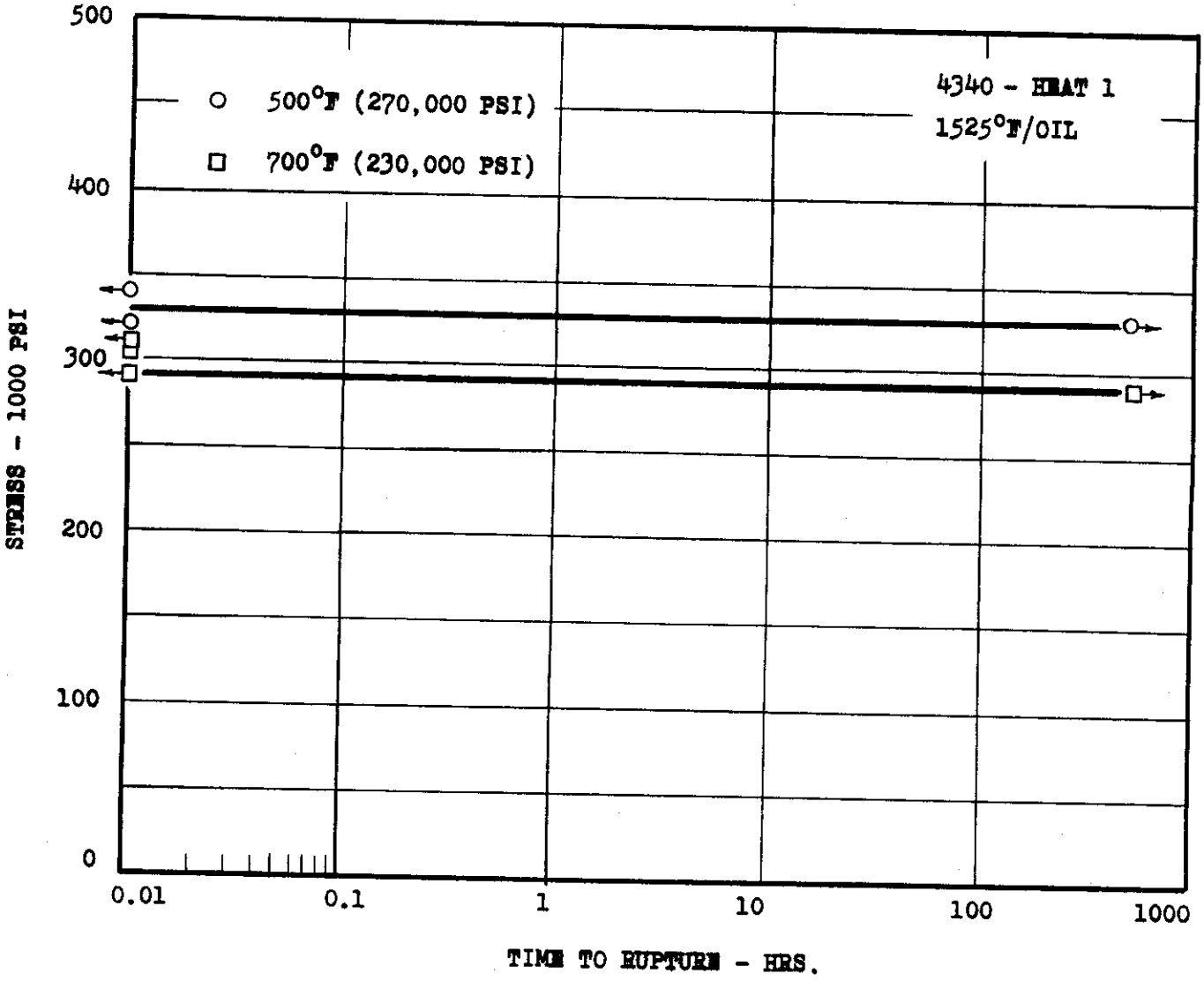


FIG. 33 STRESS-RUPTURE DIAGRAM FOR NOTCHED (K=5) 4340 SPECIMENS AT TWO STRENGTH LEVELS.

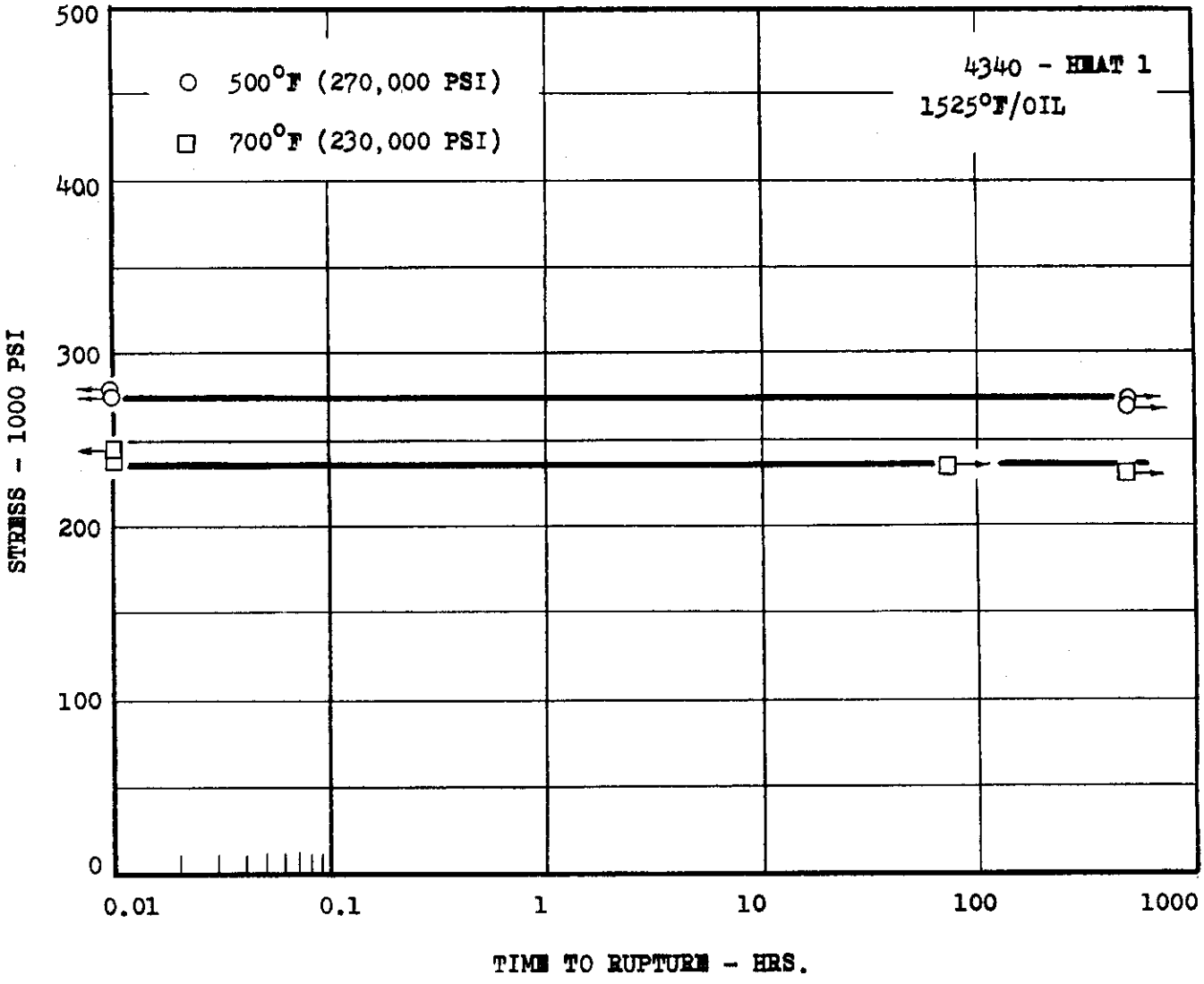


FIG. 34 STRESS-RUPTURE DIAGRAM FOR SMOOTH 4340 SPECIMENS AT TWO STRENGTH LEVELS.

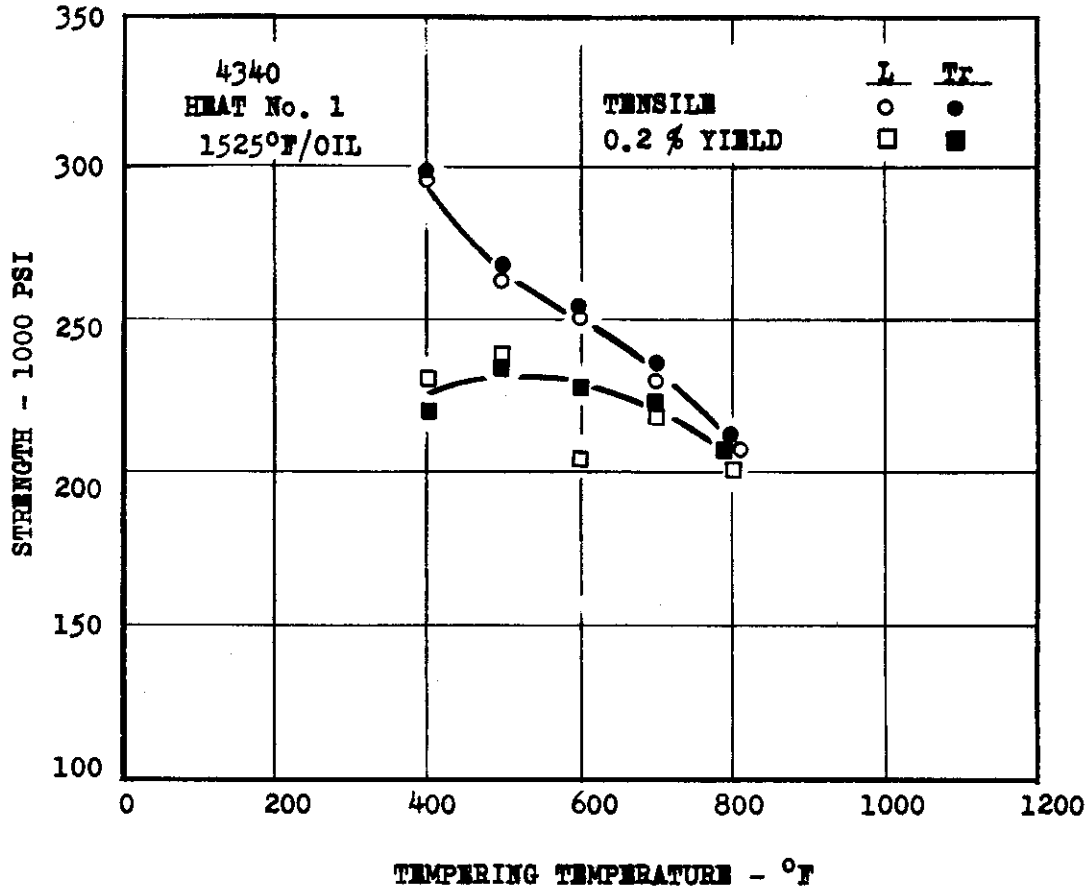


FIG. 35 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 1½ IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

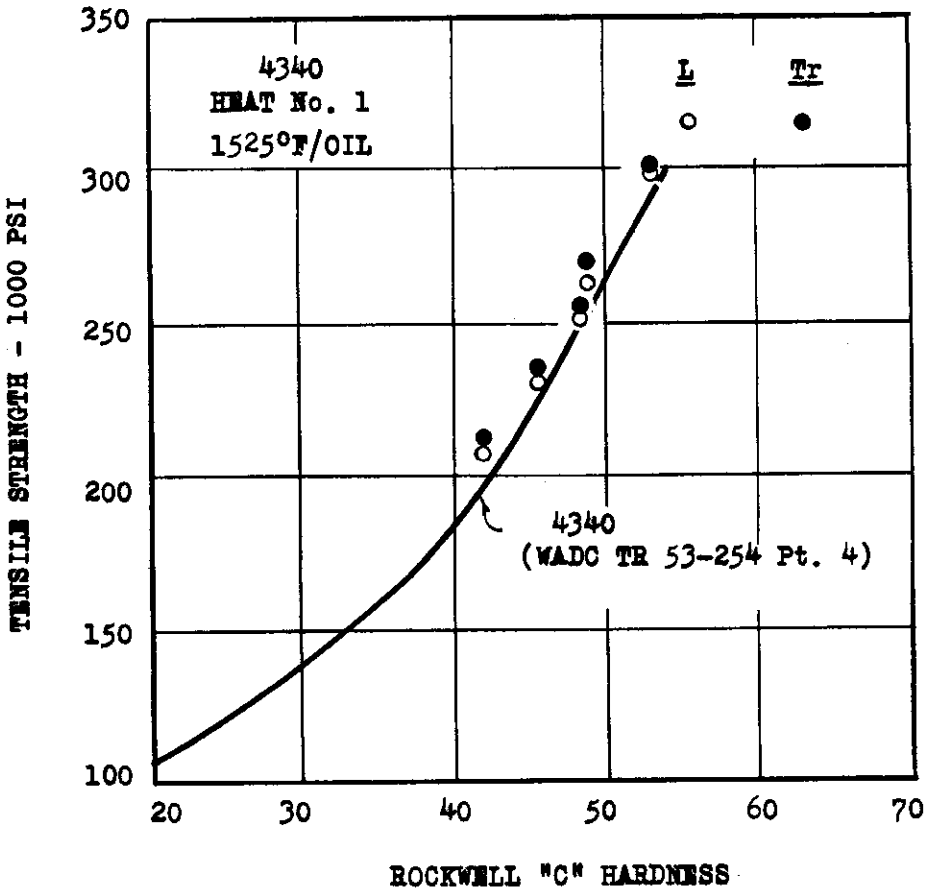


FIG. 36 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 1½ IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

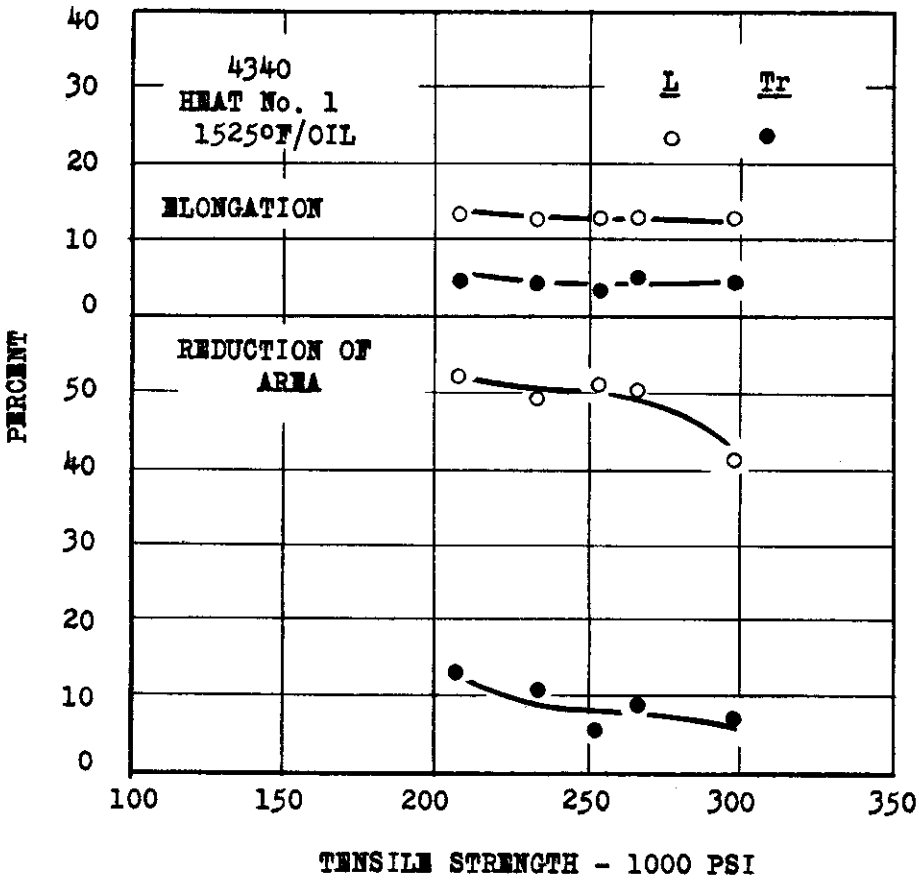


FIG. 37 VAIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: $1\frac{1}{2}$ IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

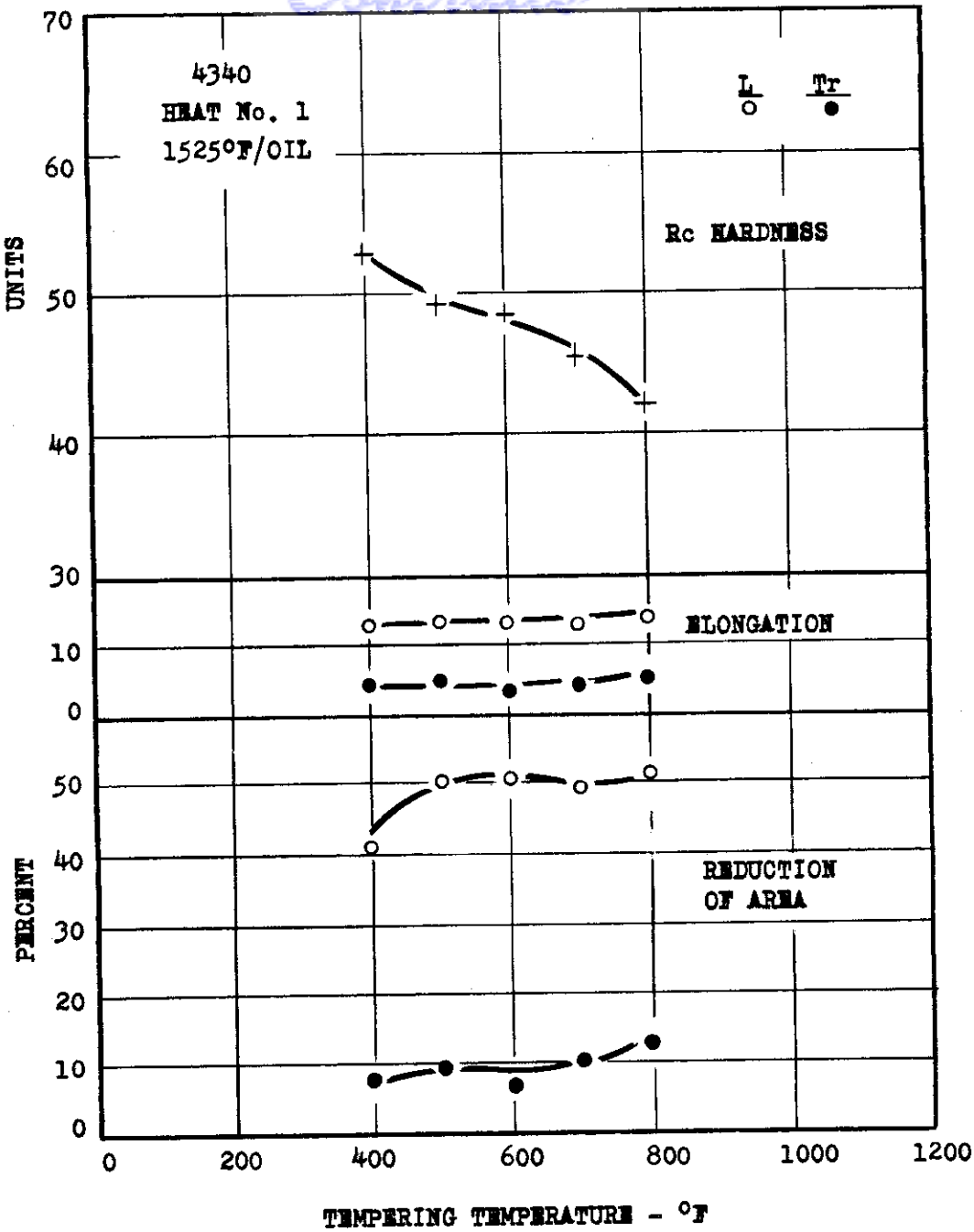


FIG. 38 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 1½ IN.DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

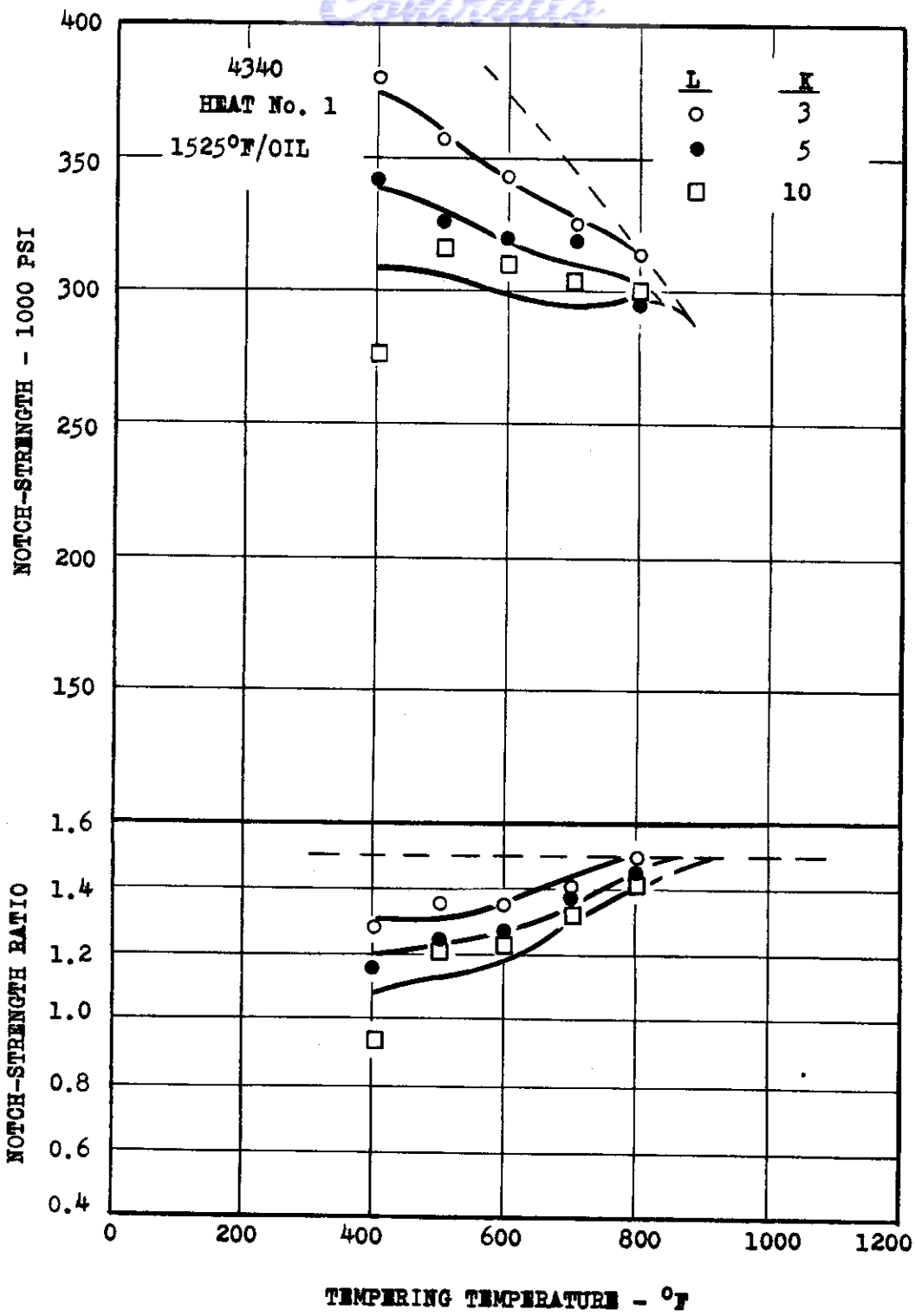


FIG.39 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 1⅛ IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

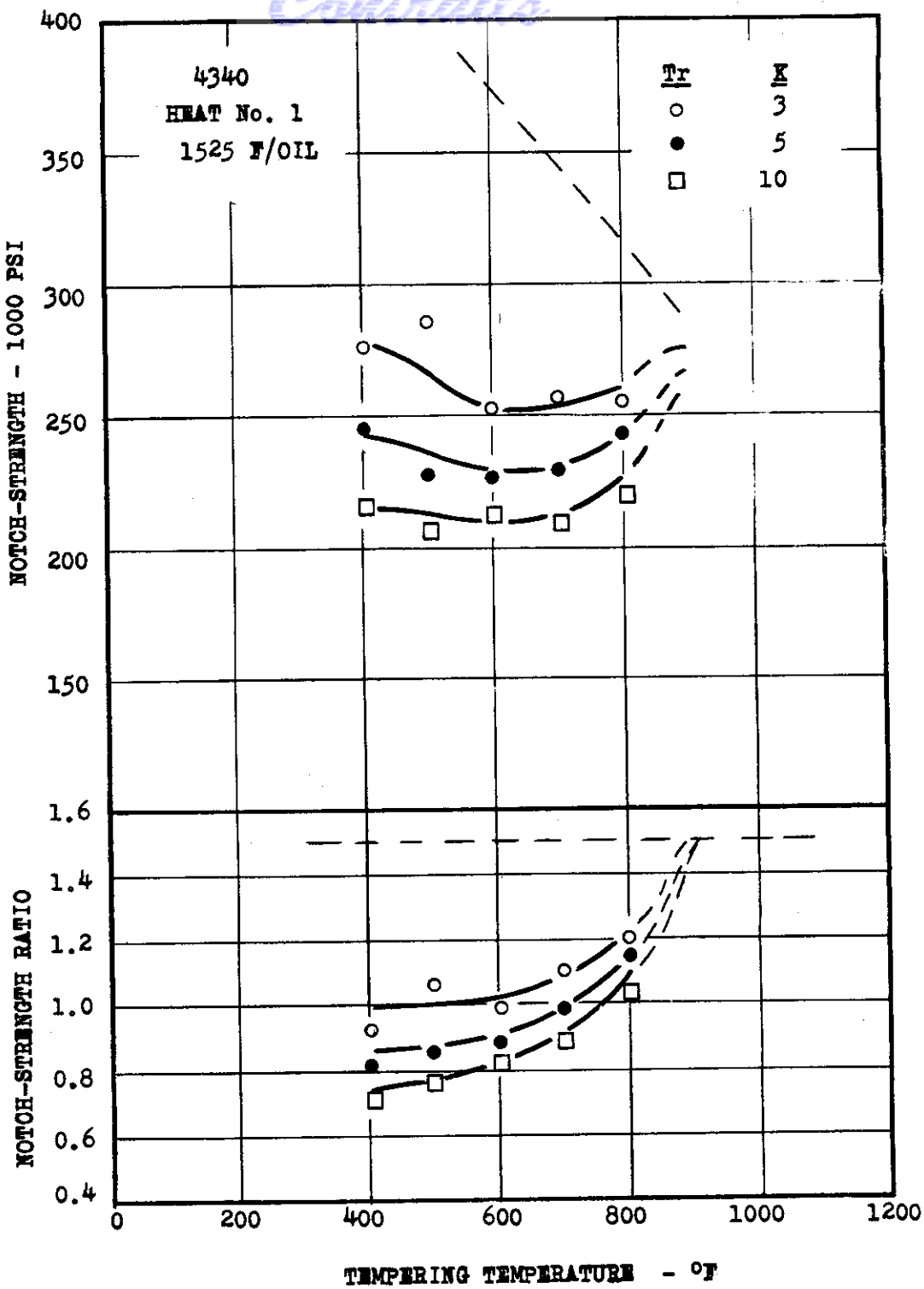


FIG. 40 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: $1\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

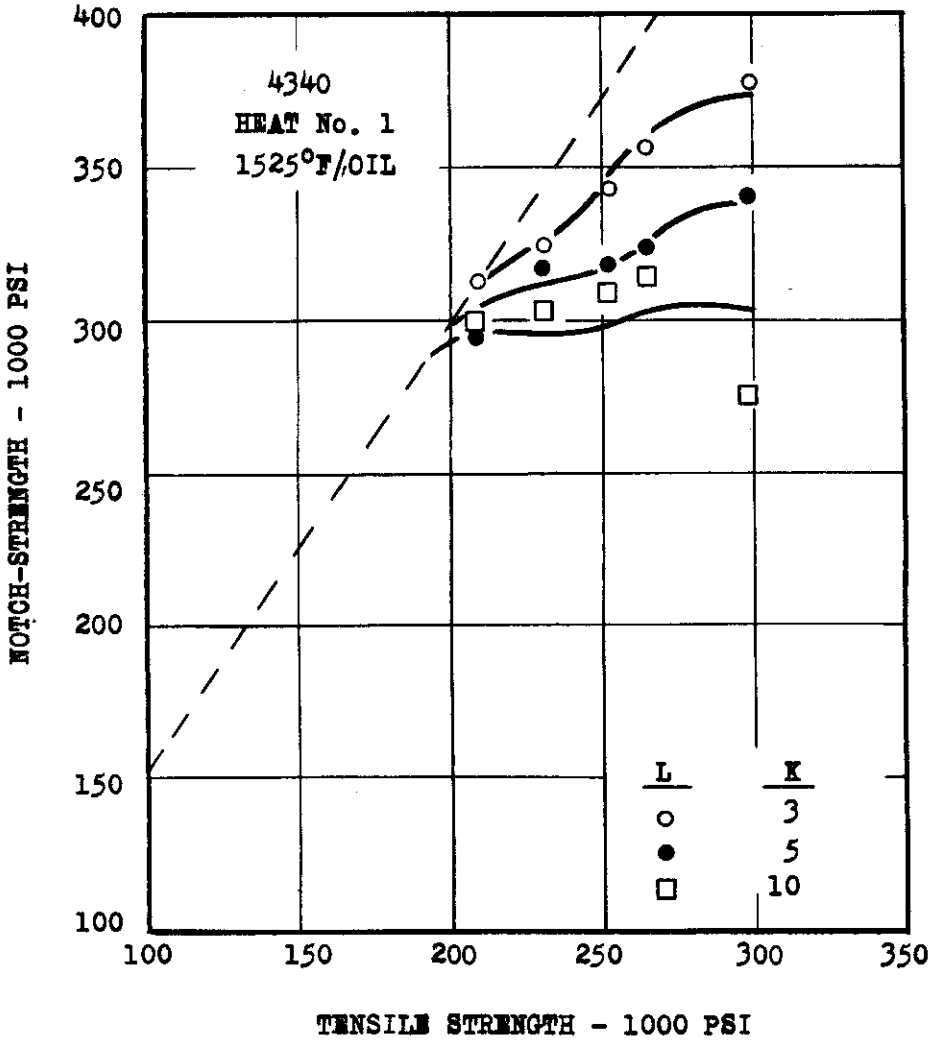


FIG.41 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: $1\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

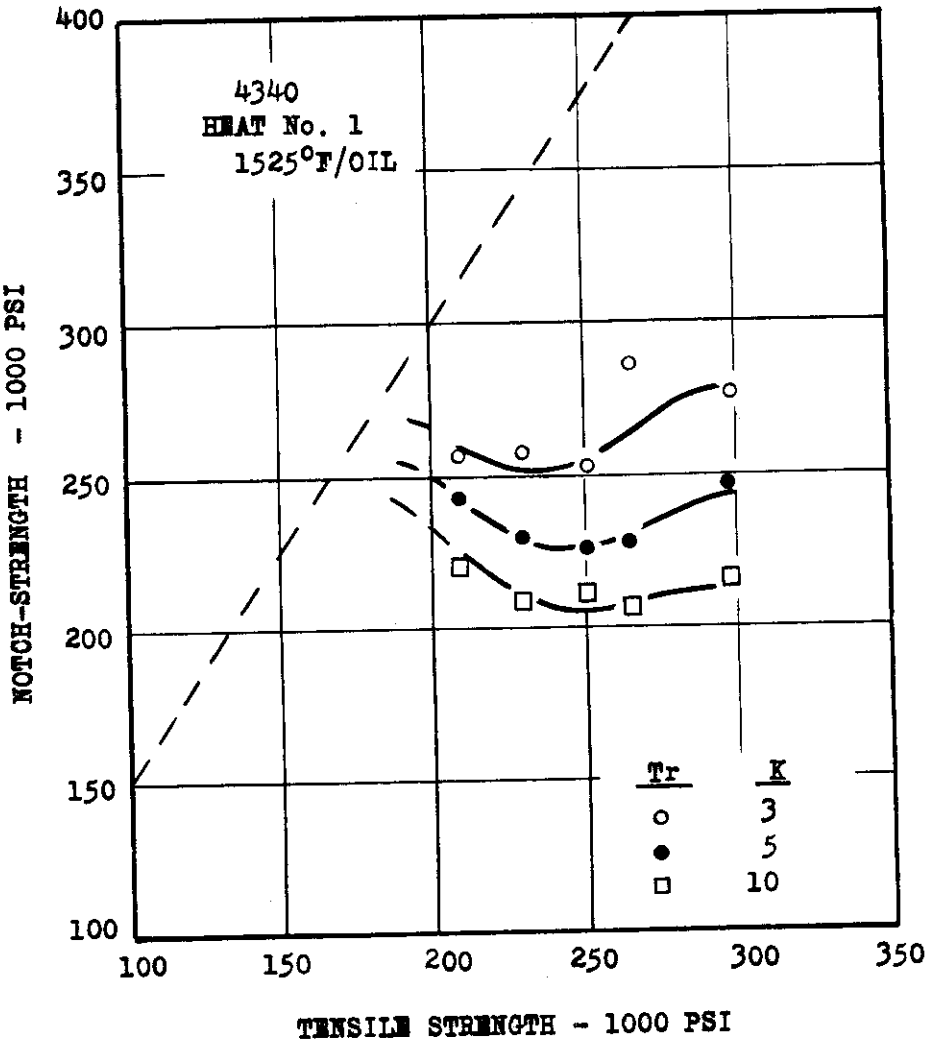


FIG. 42 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 1½ IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

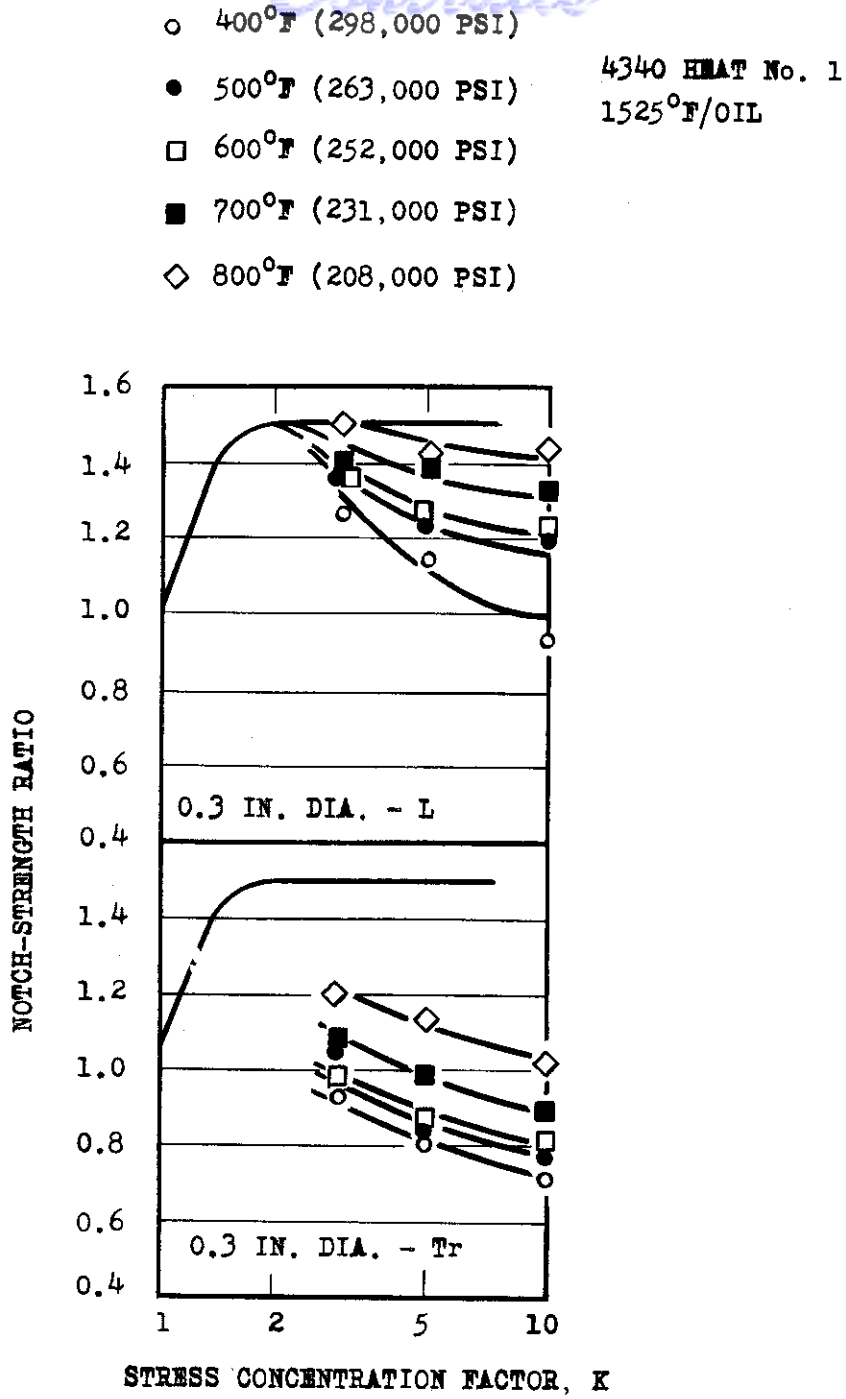


FIG. 43 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: $1\frac{1}{2}$ IN. DIA.

TEST TEMP: R.T.

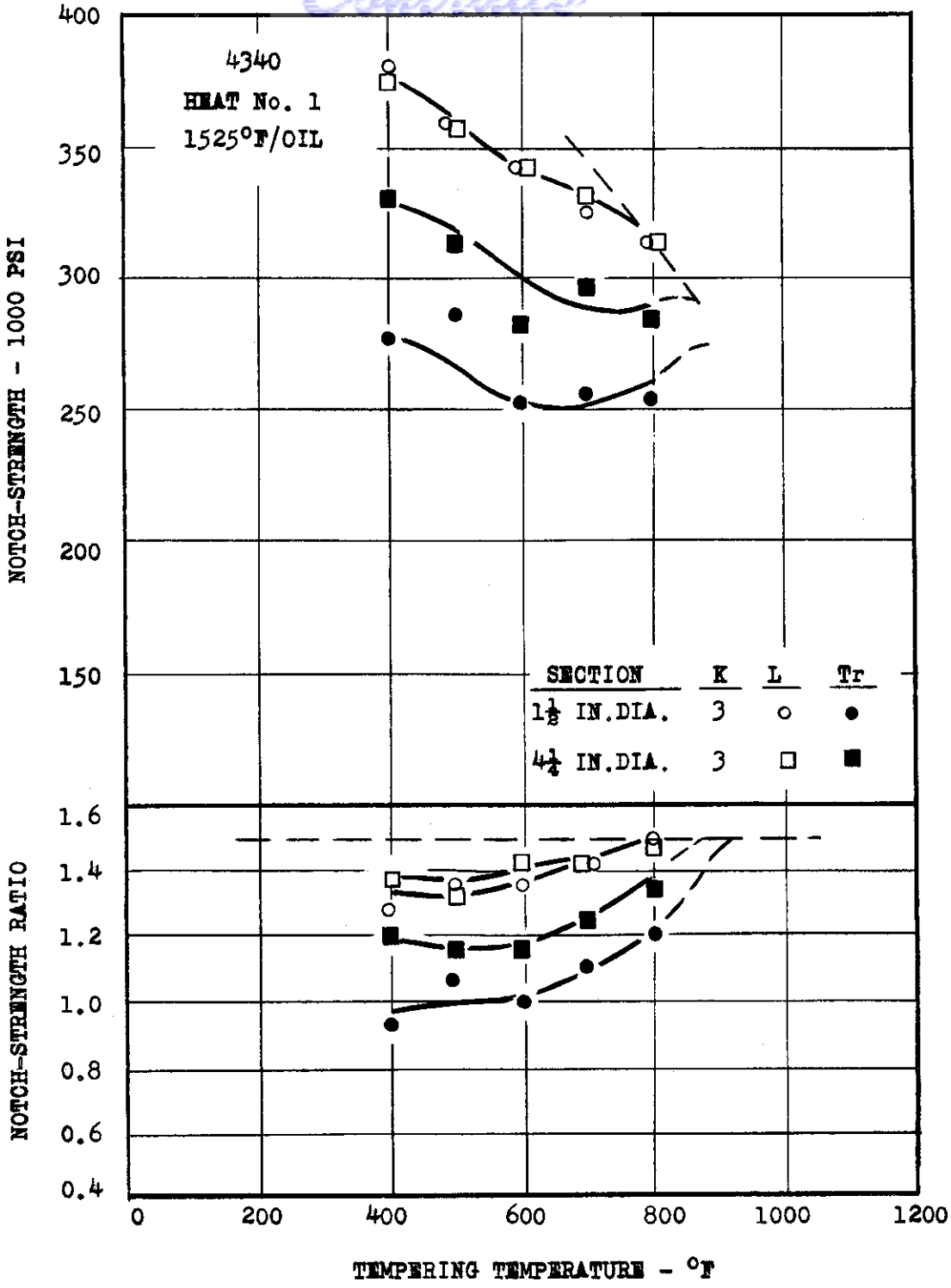


FIG. 44 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 1½ and 4¼ IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

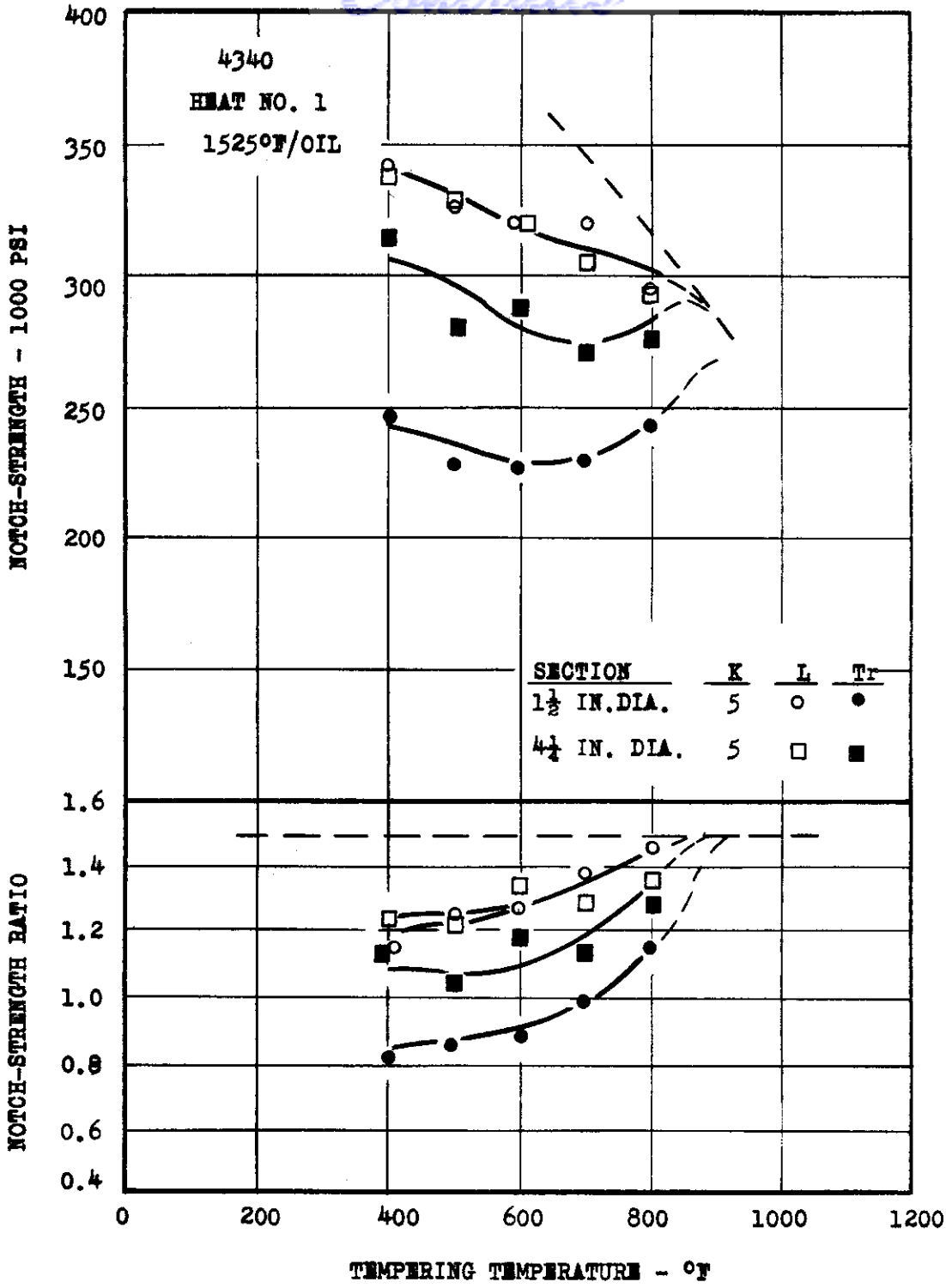


FIG. 45 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 1½ and 4½ IN.DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

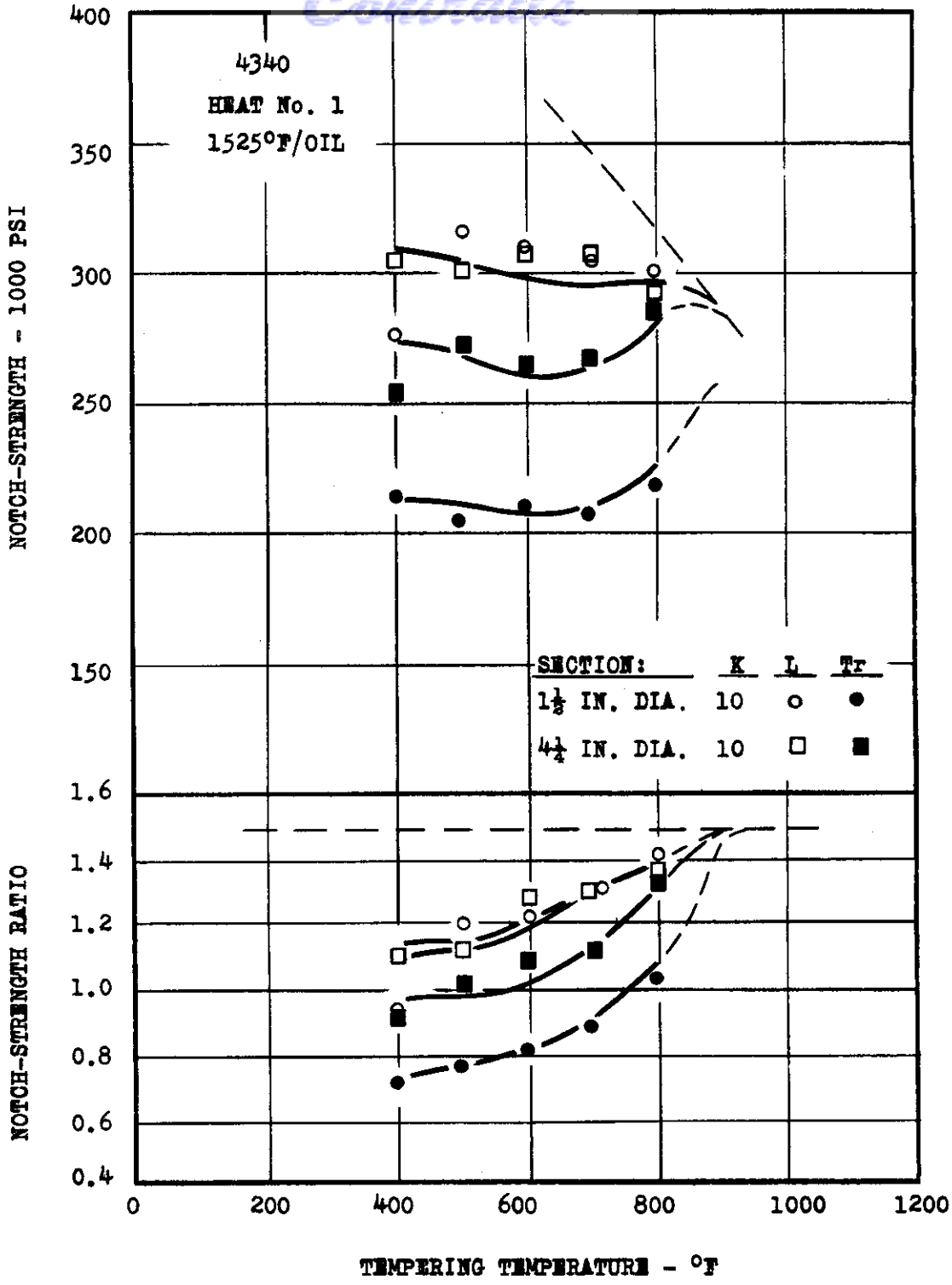


FIG. 46 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 1½ and 4¼ IN. DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

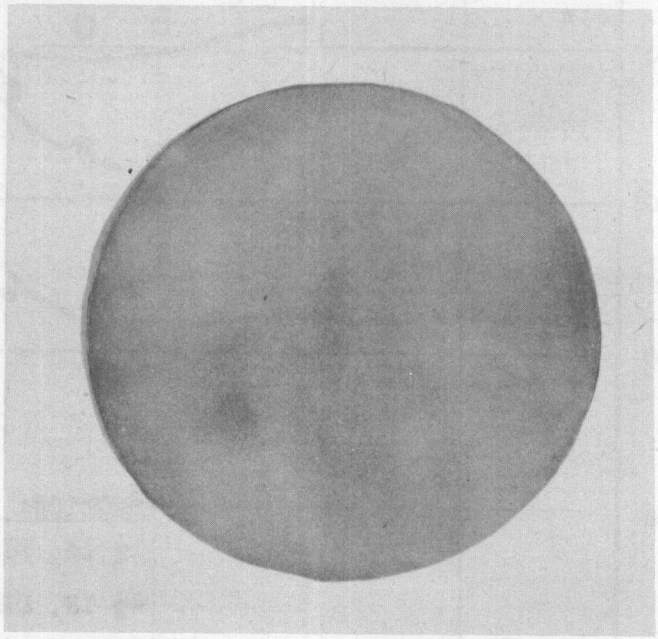
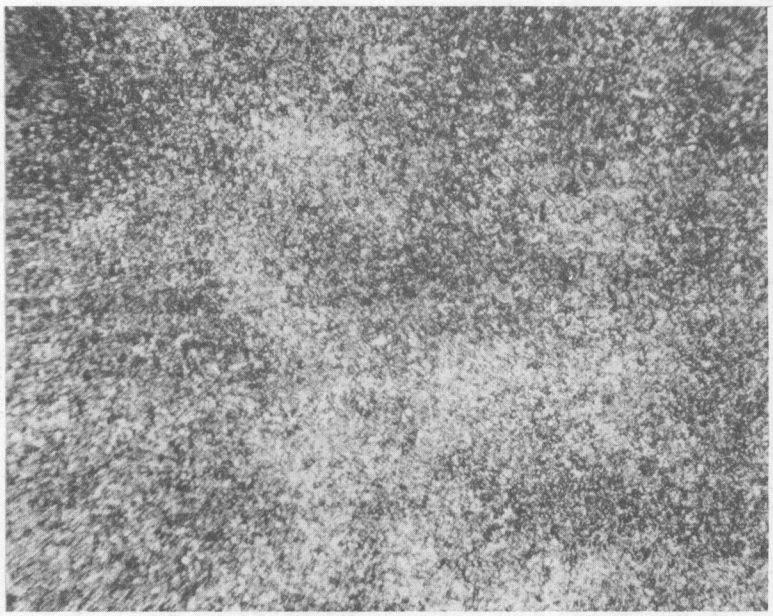
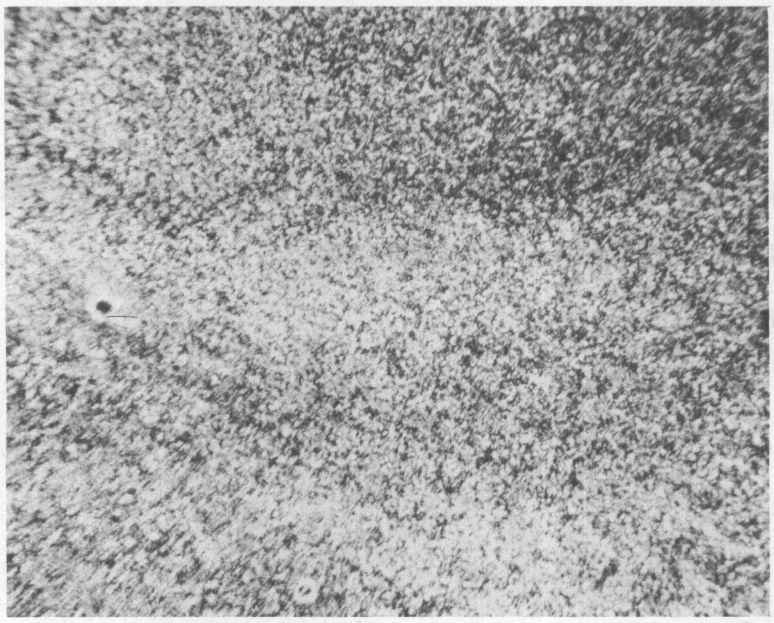


FIG. 47 MACROGRAPH OF 4340 STEEL (HEAT 2) AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) Transverse Pattern



(b) Longitudinal Pattern

FIG. 48 PHOTOMICROGRAPHS OF 4340 (HEAT 2) STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

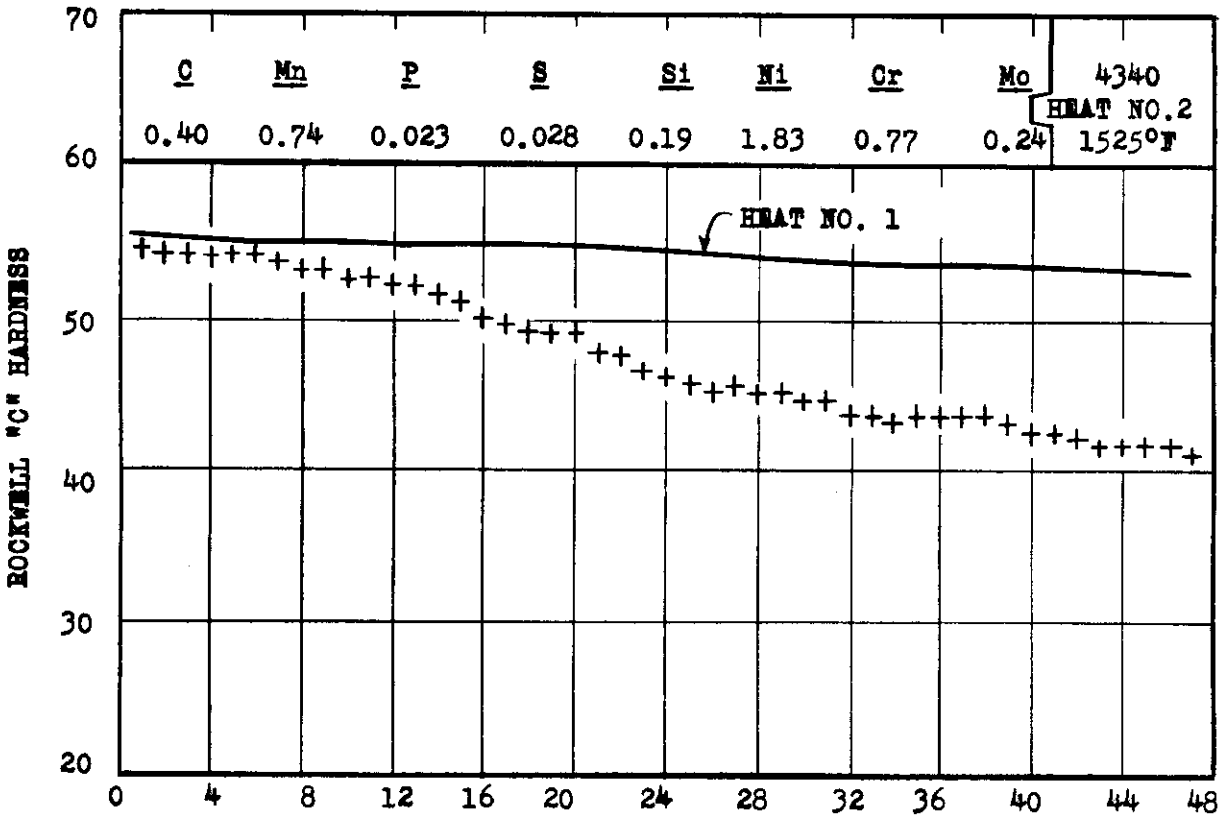


FIG. 49 HARDENABILITY OF JOMINY-QUENCH BAR.

SECTION: 4 IN. DIA.

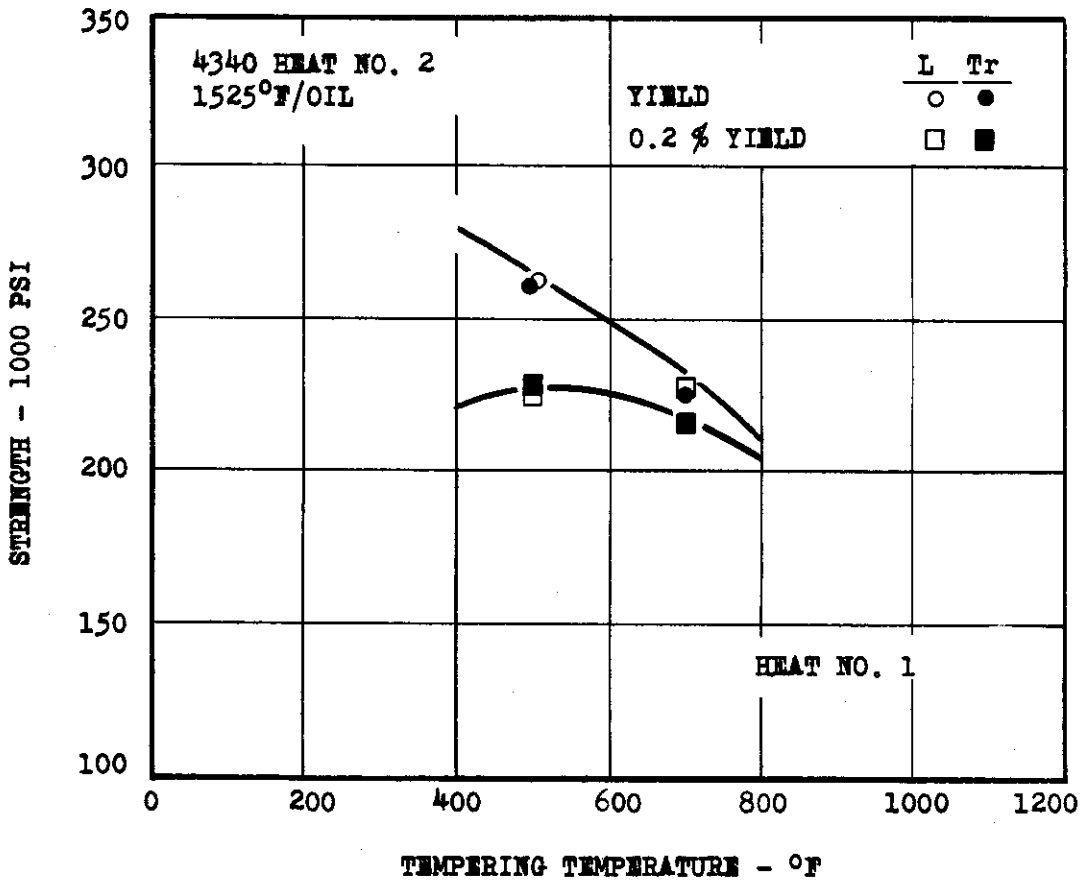


FIG. 50 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

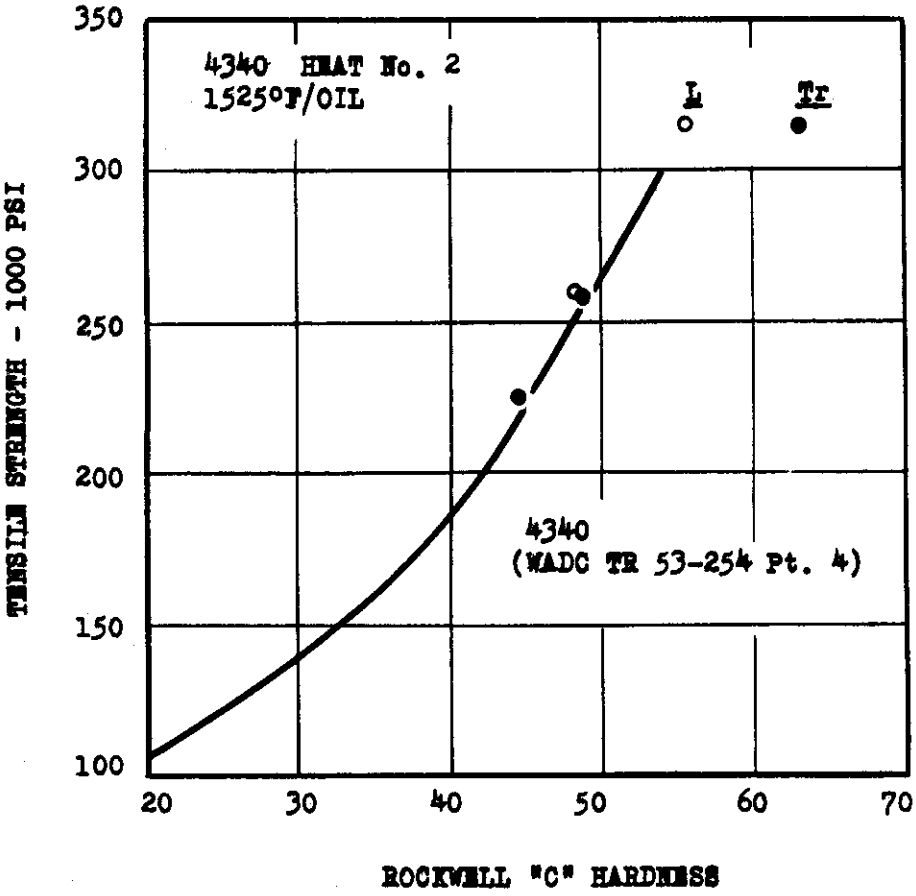


FIG. 51 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 4 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

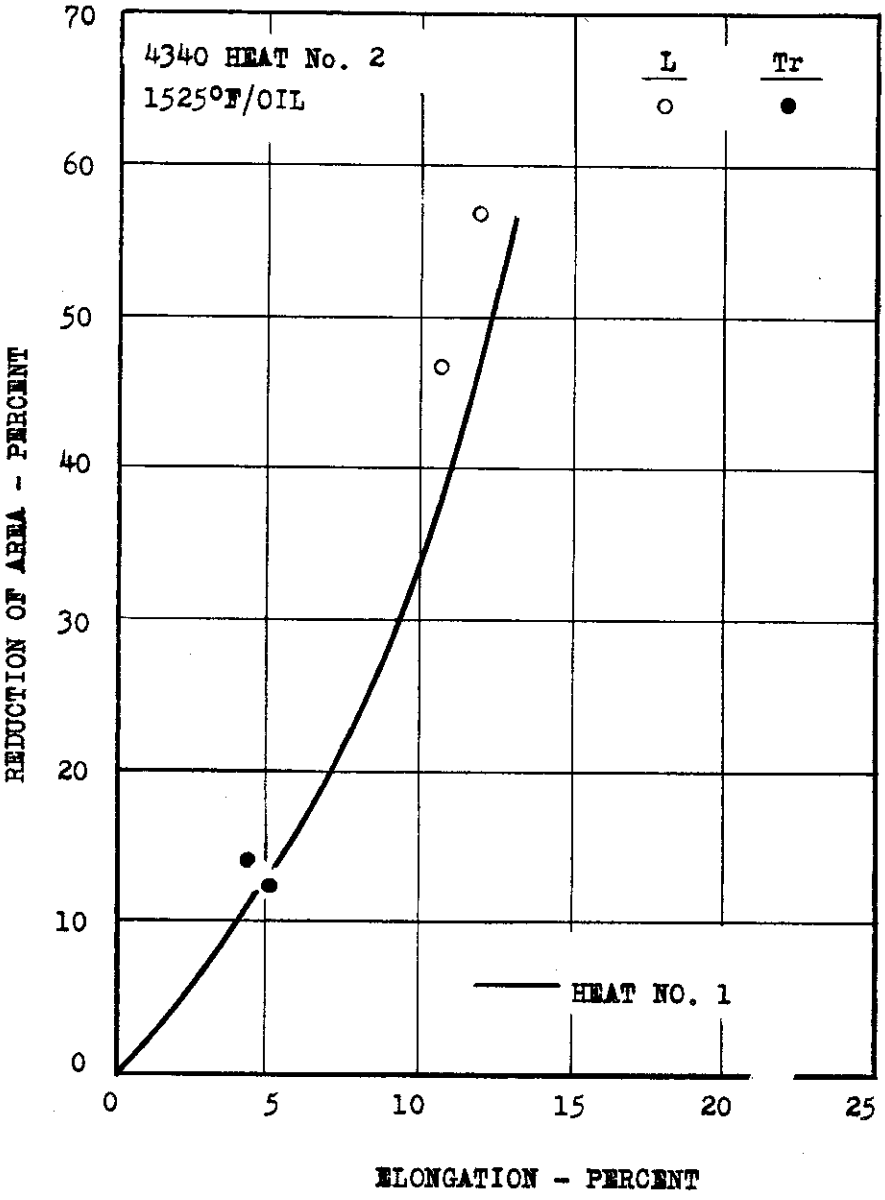


FIG. 52 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 4 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

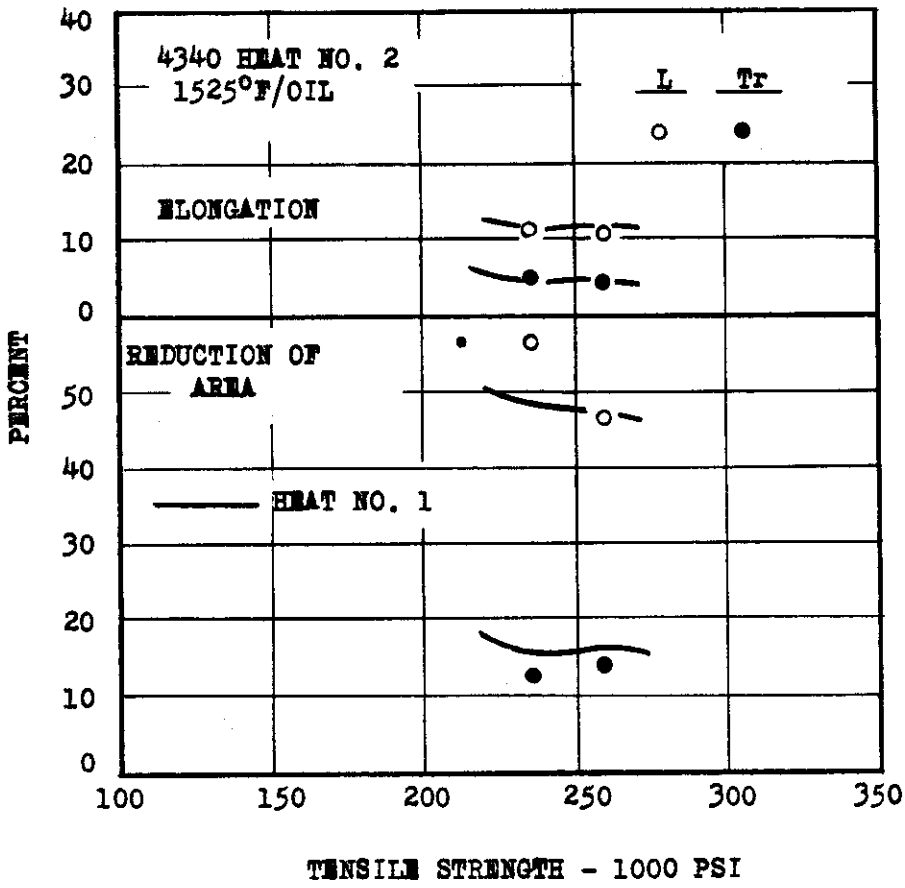


FIG. 53 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 4 IN. DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

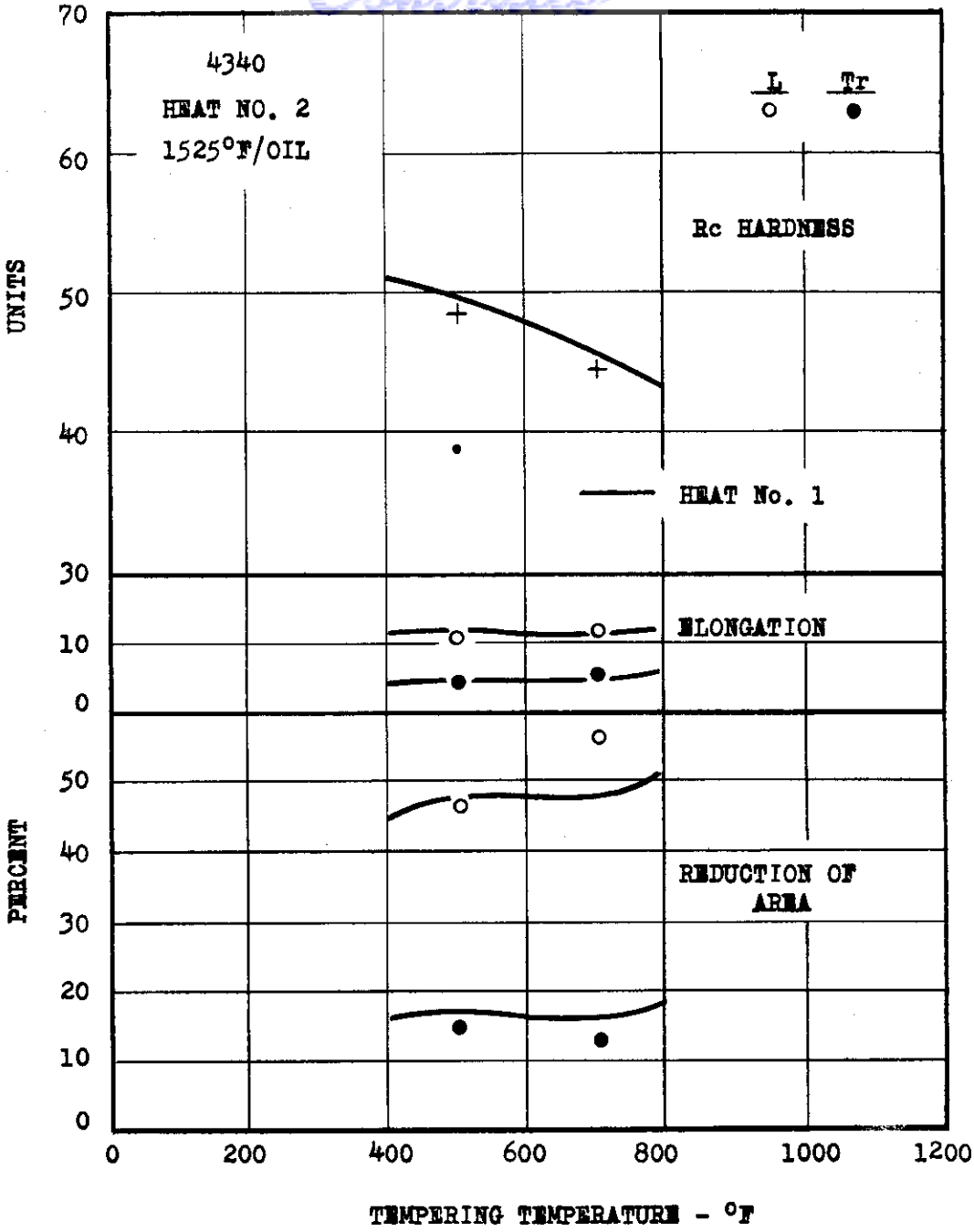


FIG. 54 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

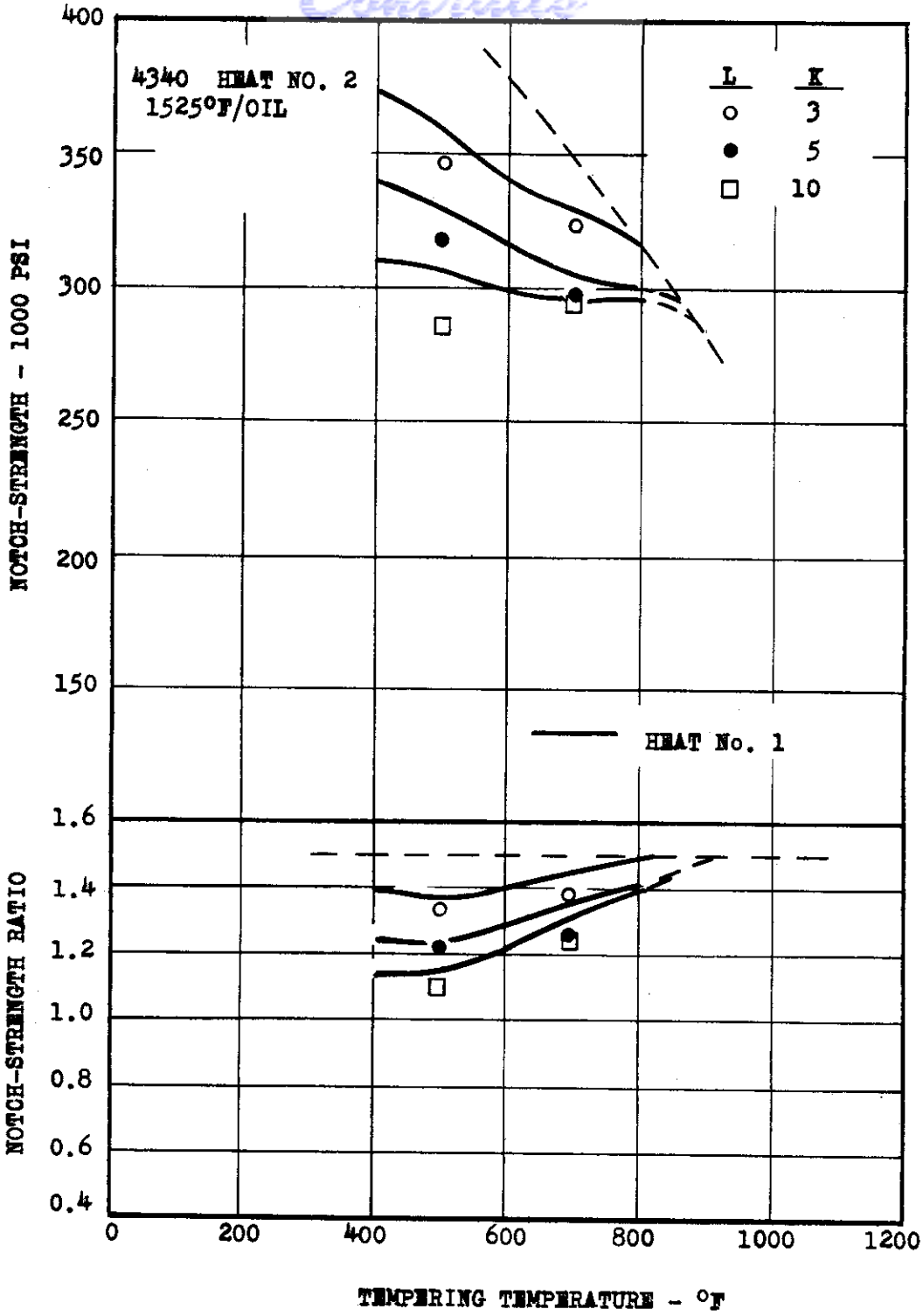


FIG. 55 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

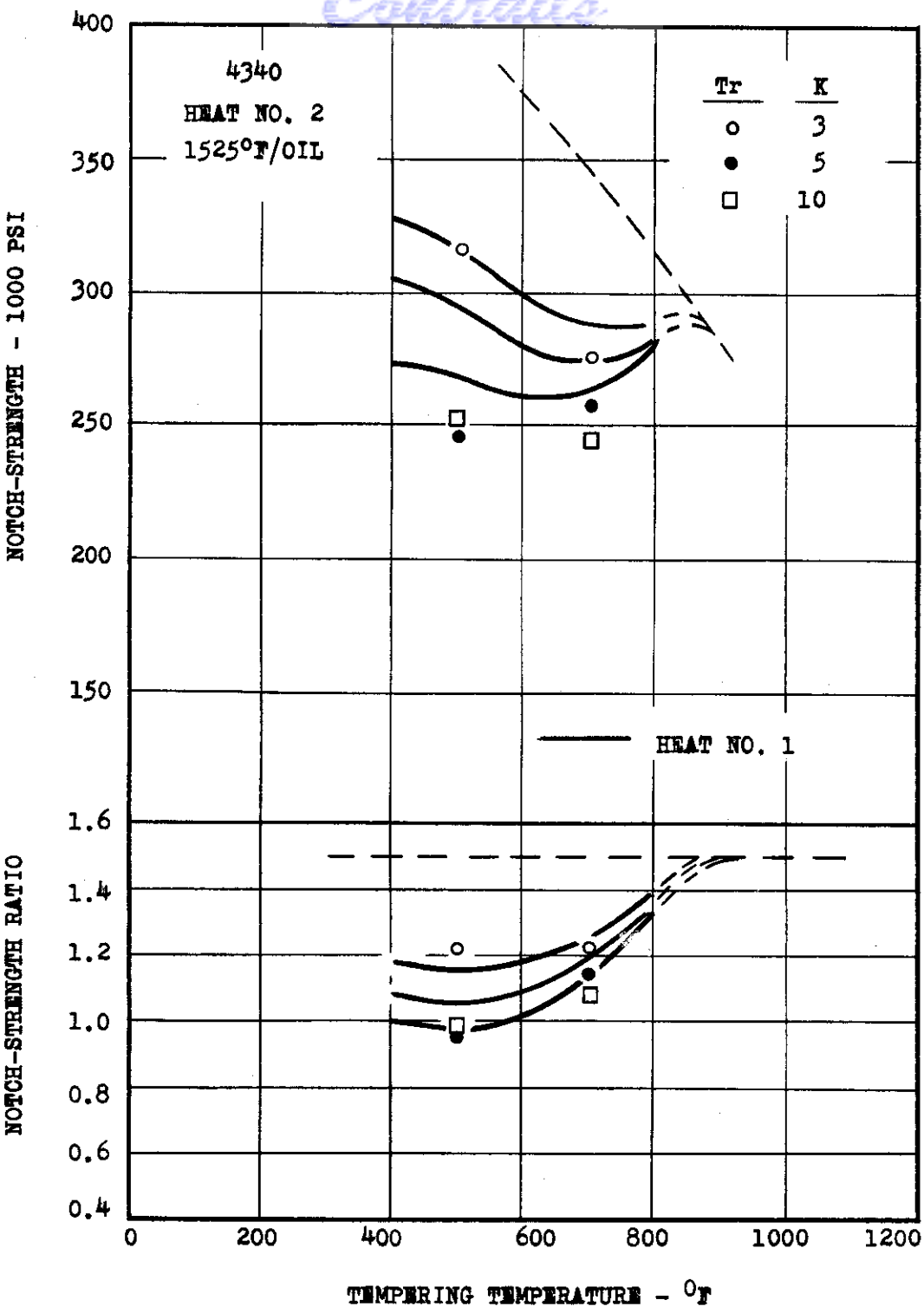


FIG. 56 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

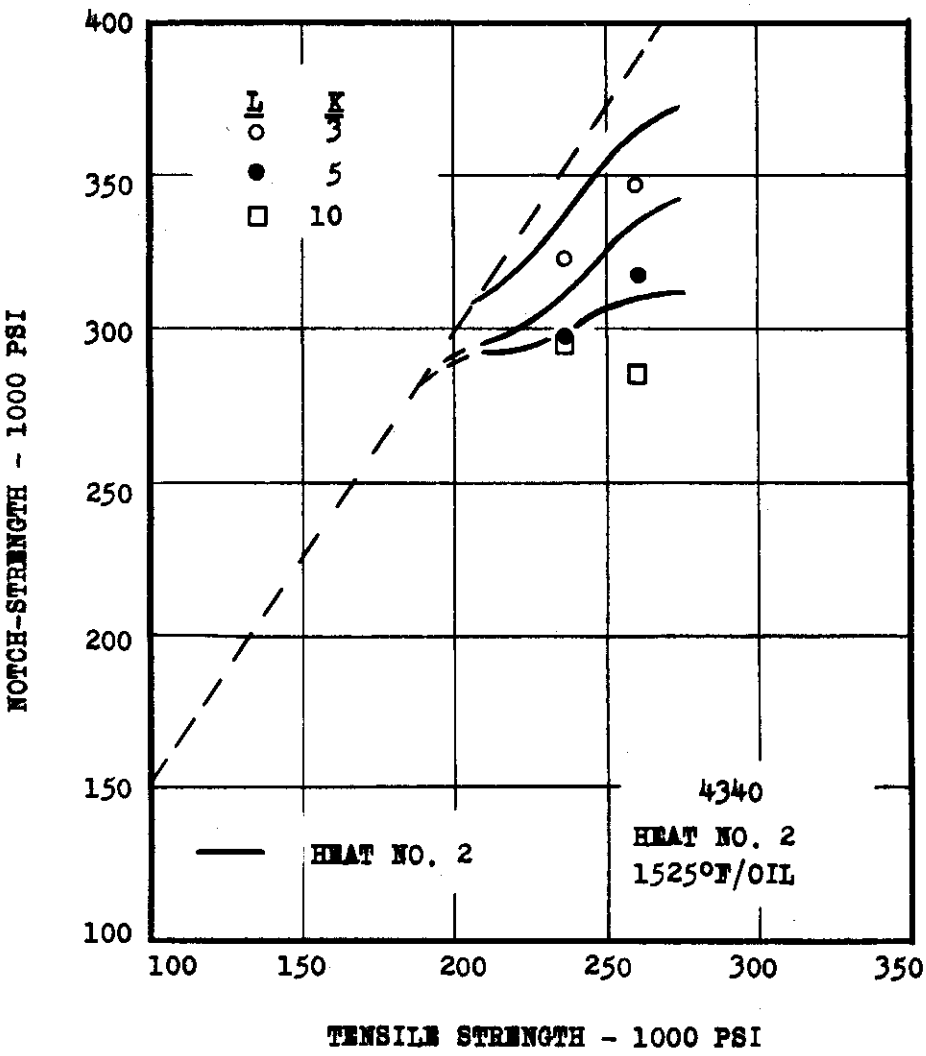


FIG. 57 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN. DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

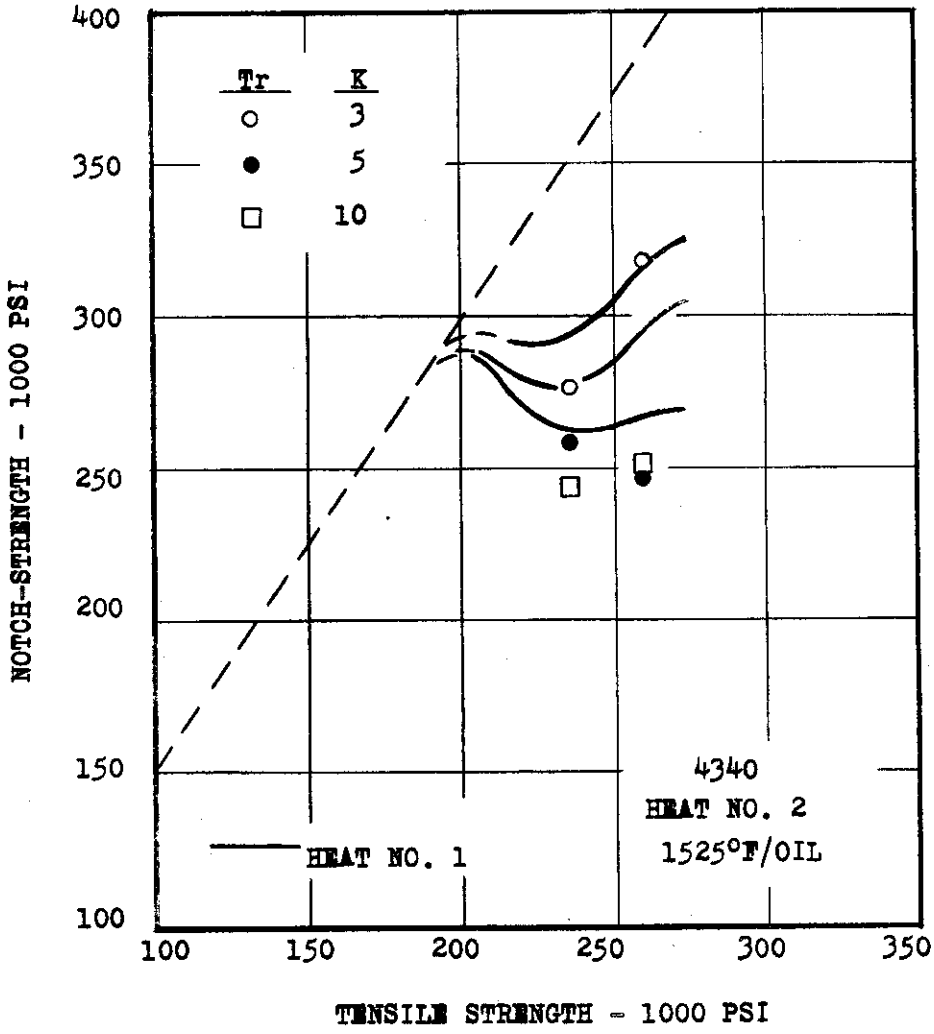


FIG. 58 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN.DIA.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

○ 500 F (260,000 PSI)

● 700 F (236,000 PSI)

* AS OBTAINED IN HEAT No. 1

4340 HEAT No. 2
1525°F/OIL

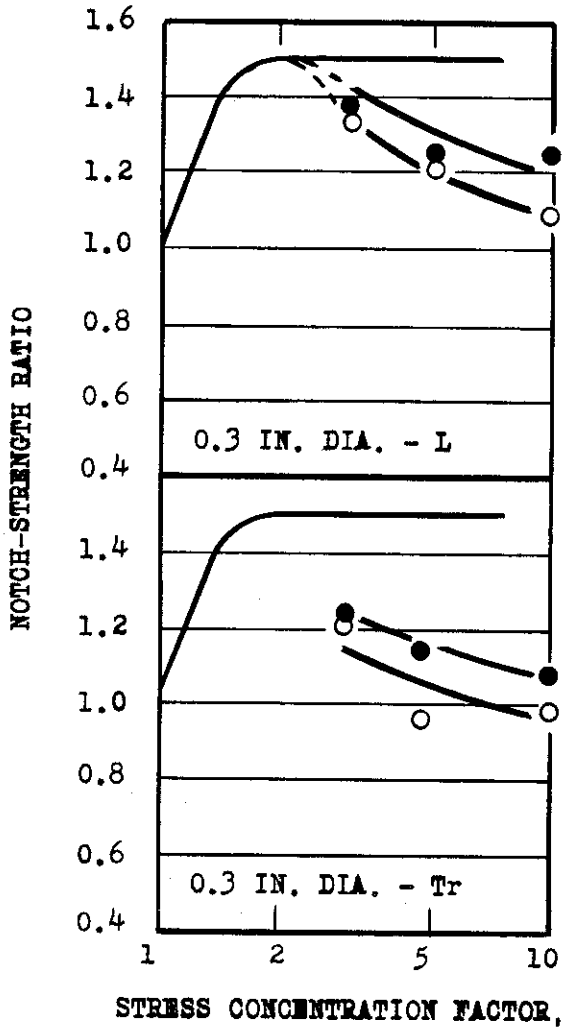


FIG. 59 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 4 IN. DIA.

TEST TEMP: R.T.

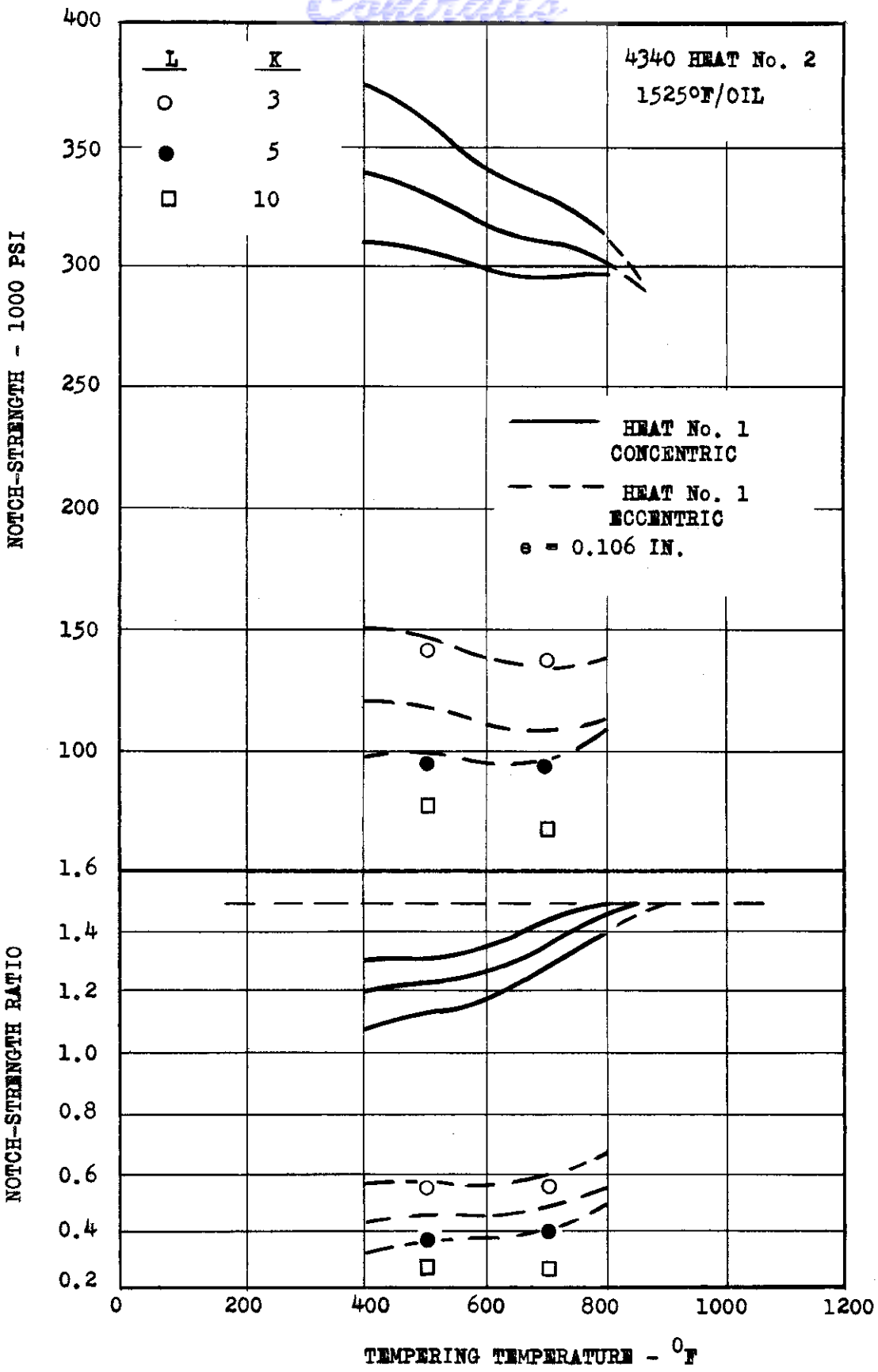


FIG. 60 VARIATION OF ECCENTRIC NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

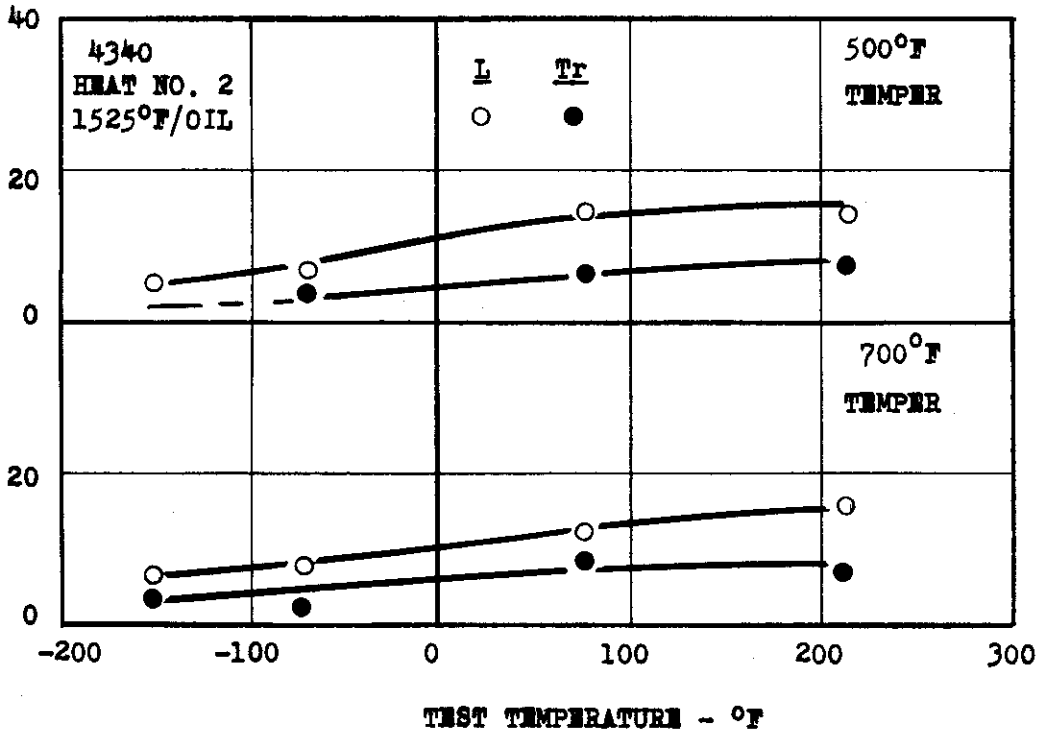


FIG. 61 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 4 IN. SQ.

SPECIMEN: STD. V-NOTCH CHARPY

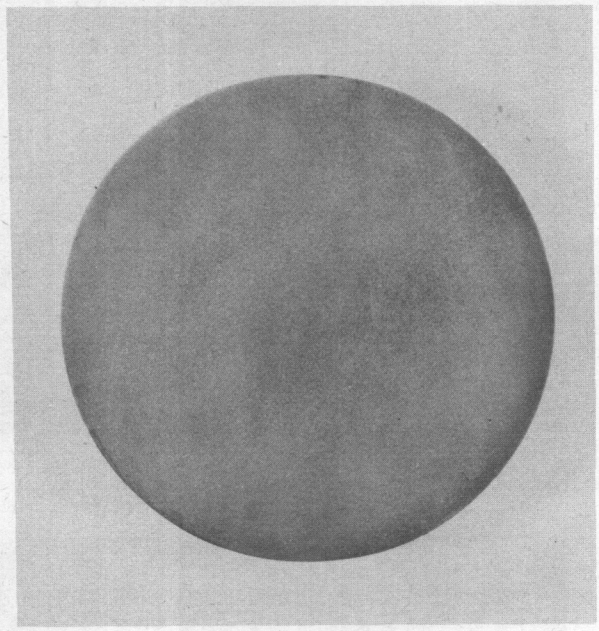
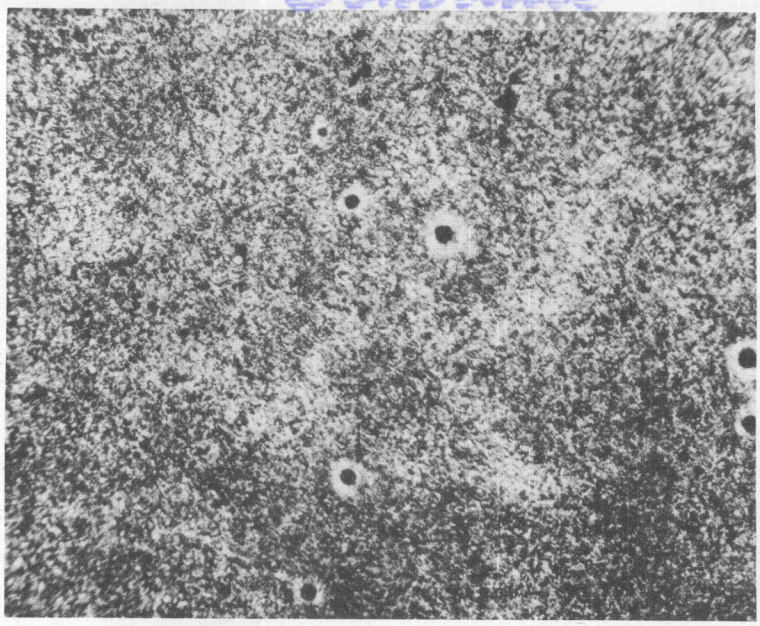
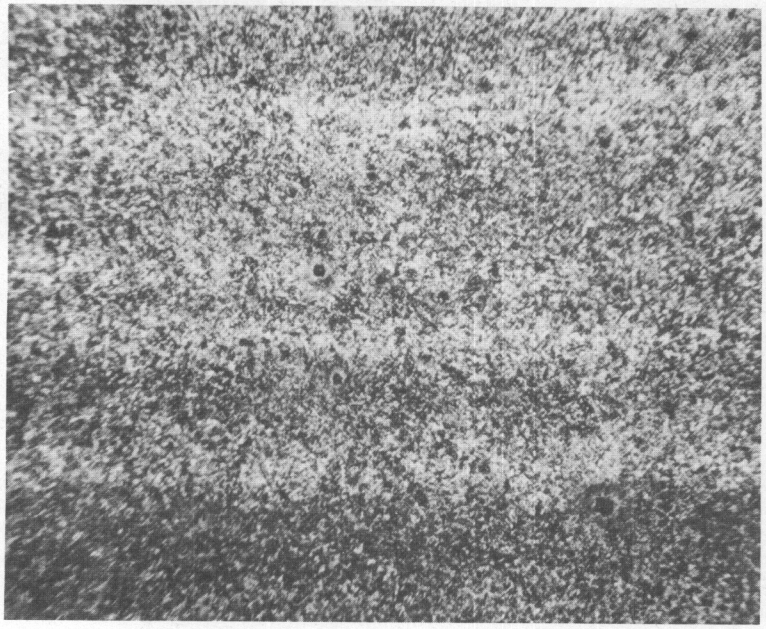


FIG. 62 MACROGRAPH OF 4340 STEEL (HEAT 3) AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) Transverse Pattern



(b) Longitudinal Pattern

FIG. 63 PHOTOMICROGRAPHS OF 4340 (HEAT 3) STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

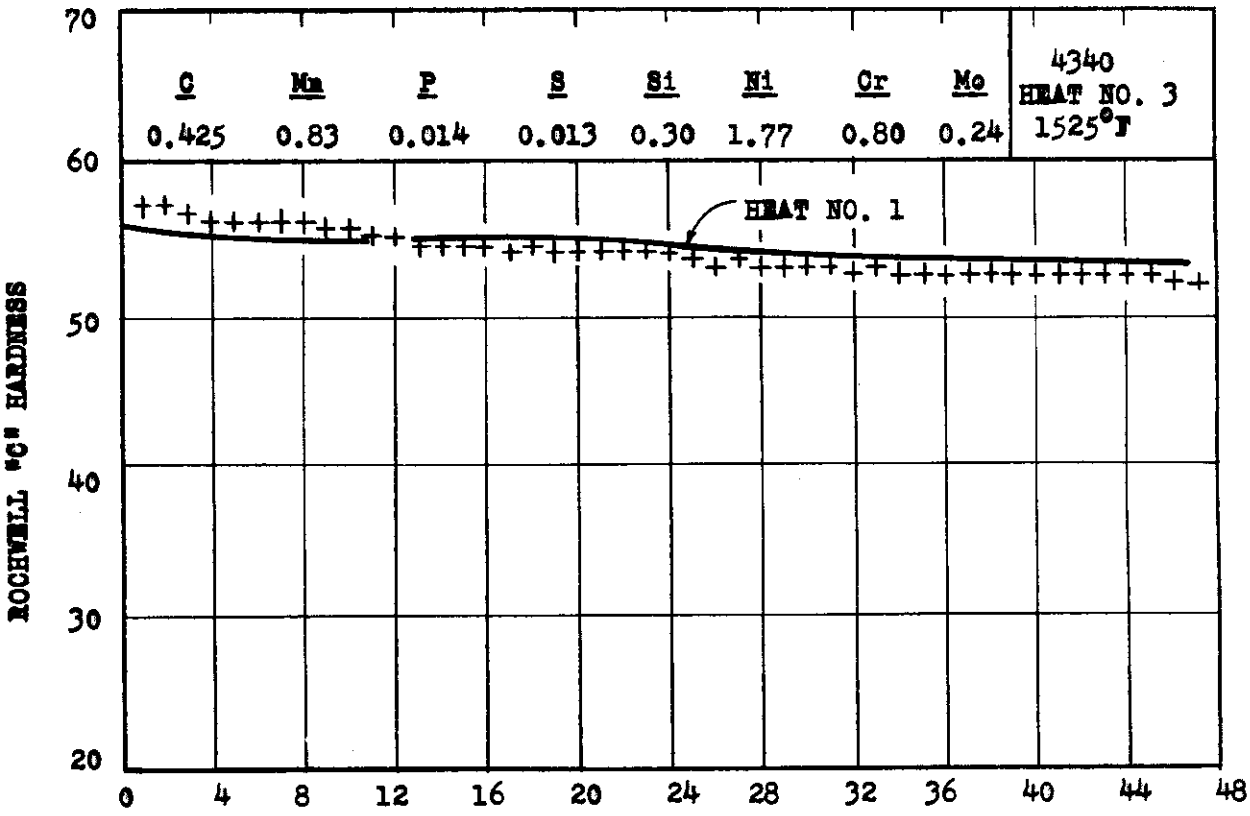


FIG. 64 HARDENABILITY OF JOMINY - QUENCH BAR.

SECTION: 3 1/2 IN.DIA.

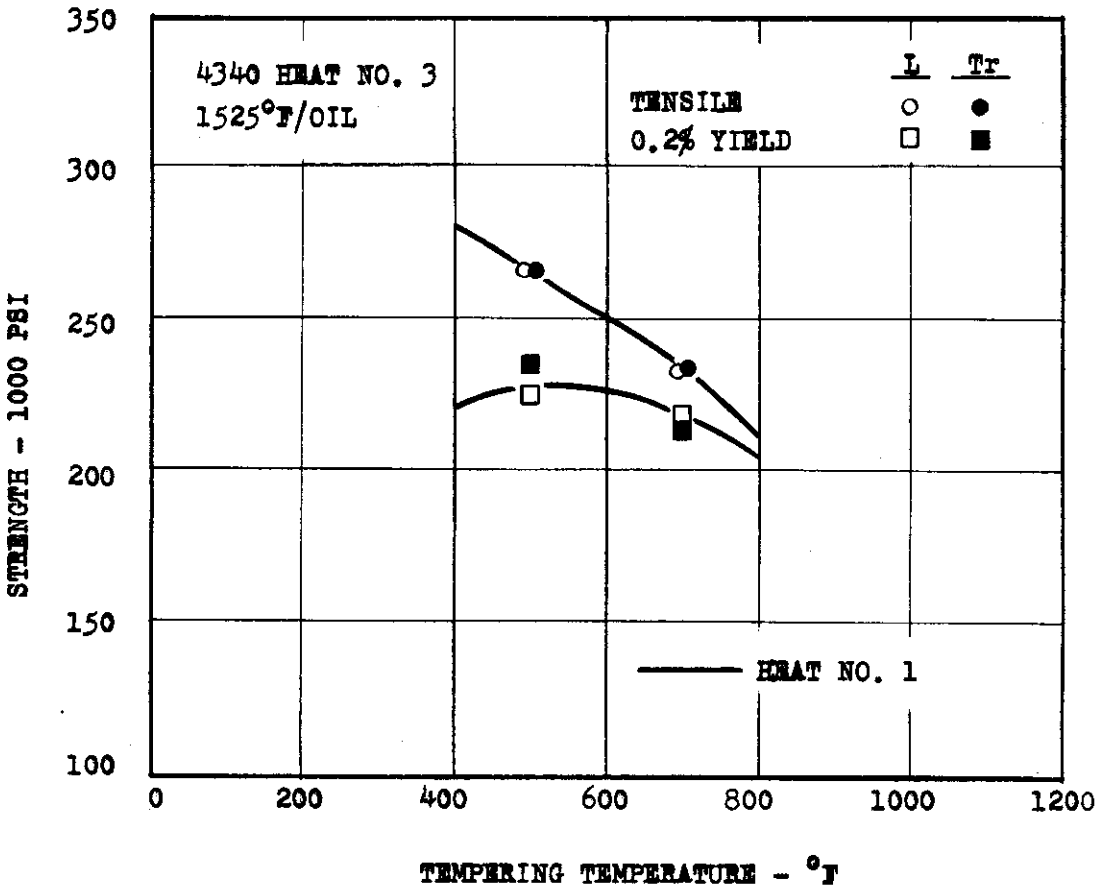


FIG. 65 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

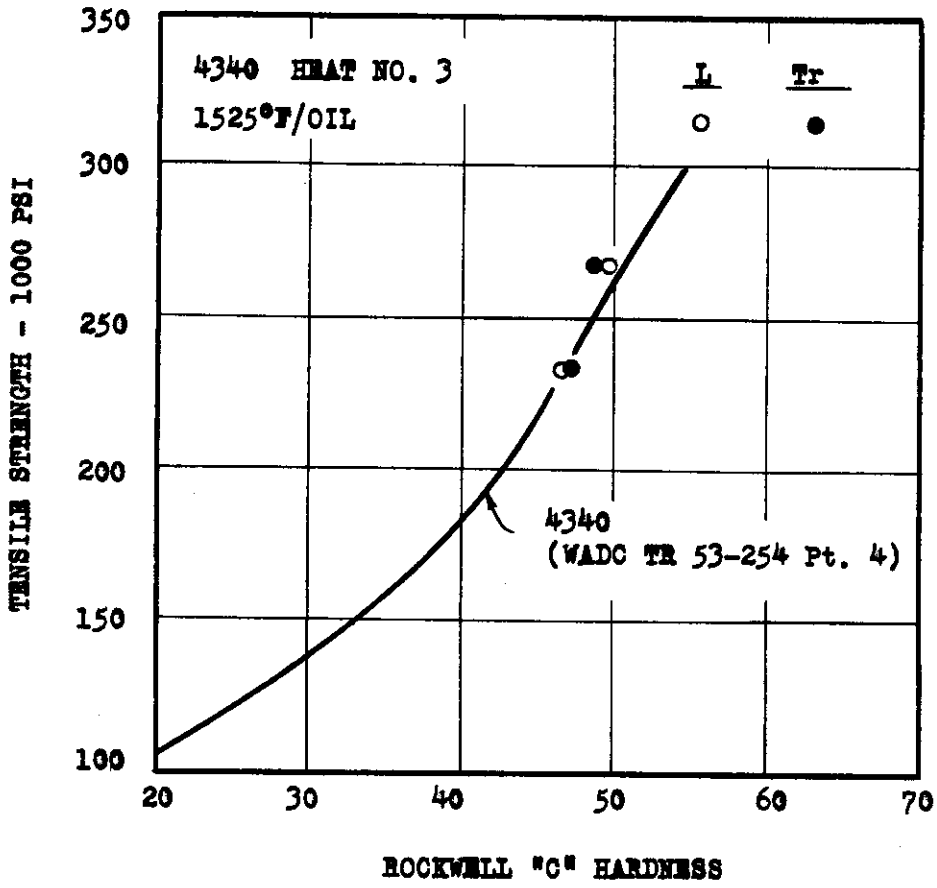


FIG. 66 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

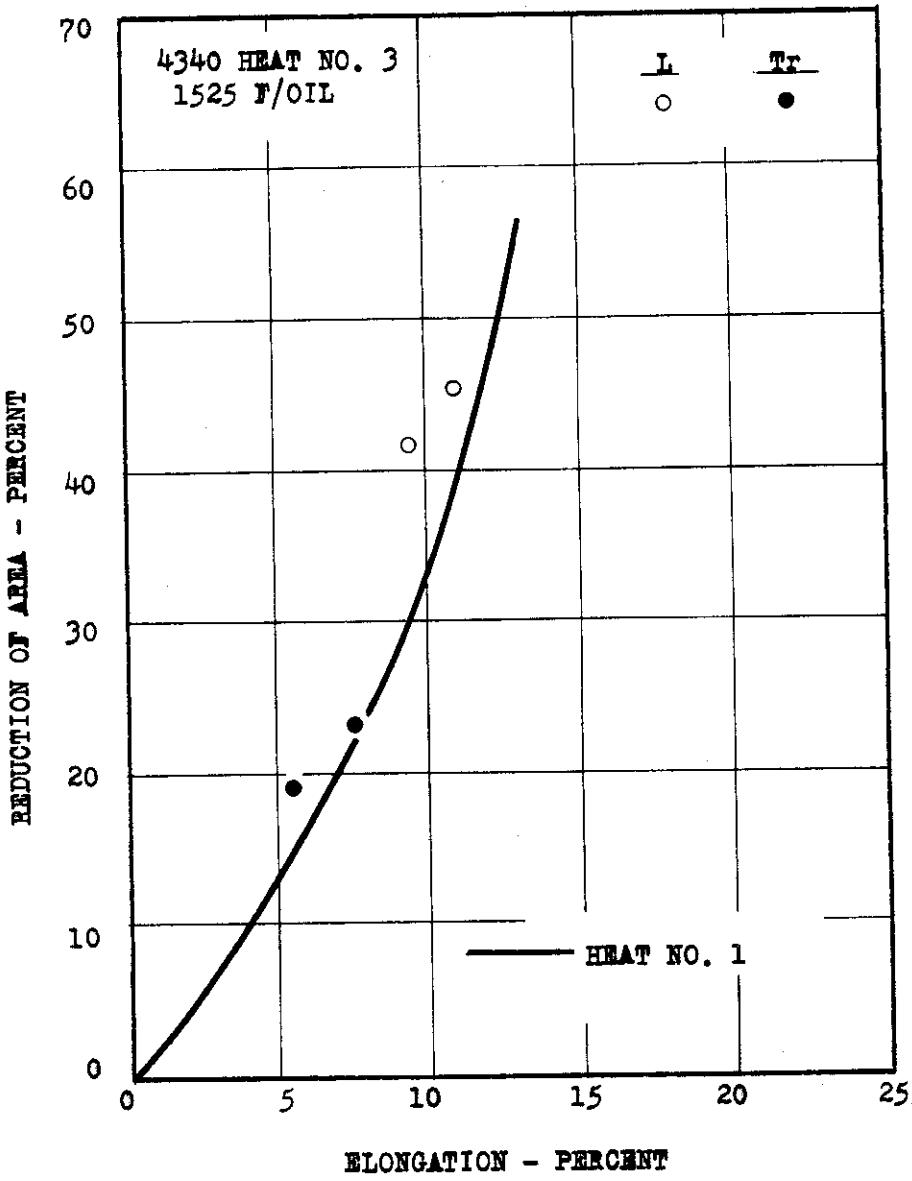


FIG. 67 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

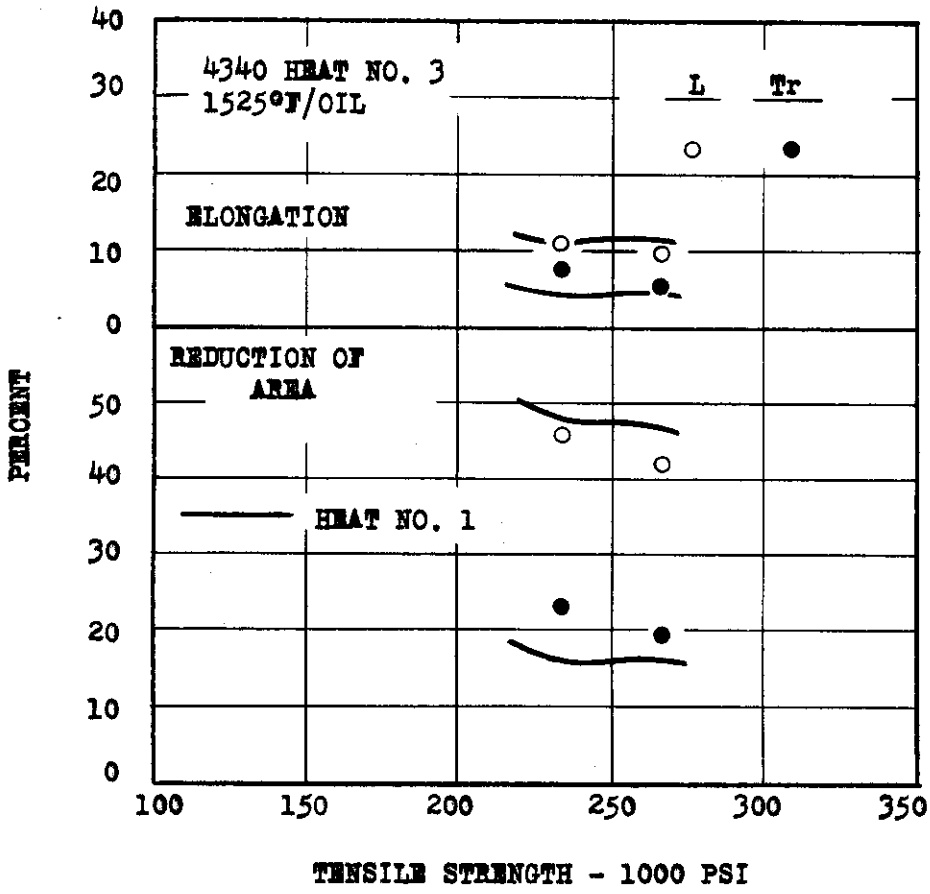


FIG. 68 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.28

TEST TEMP: R.T.

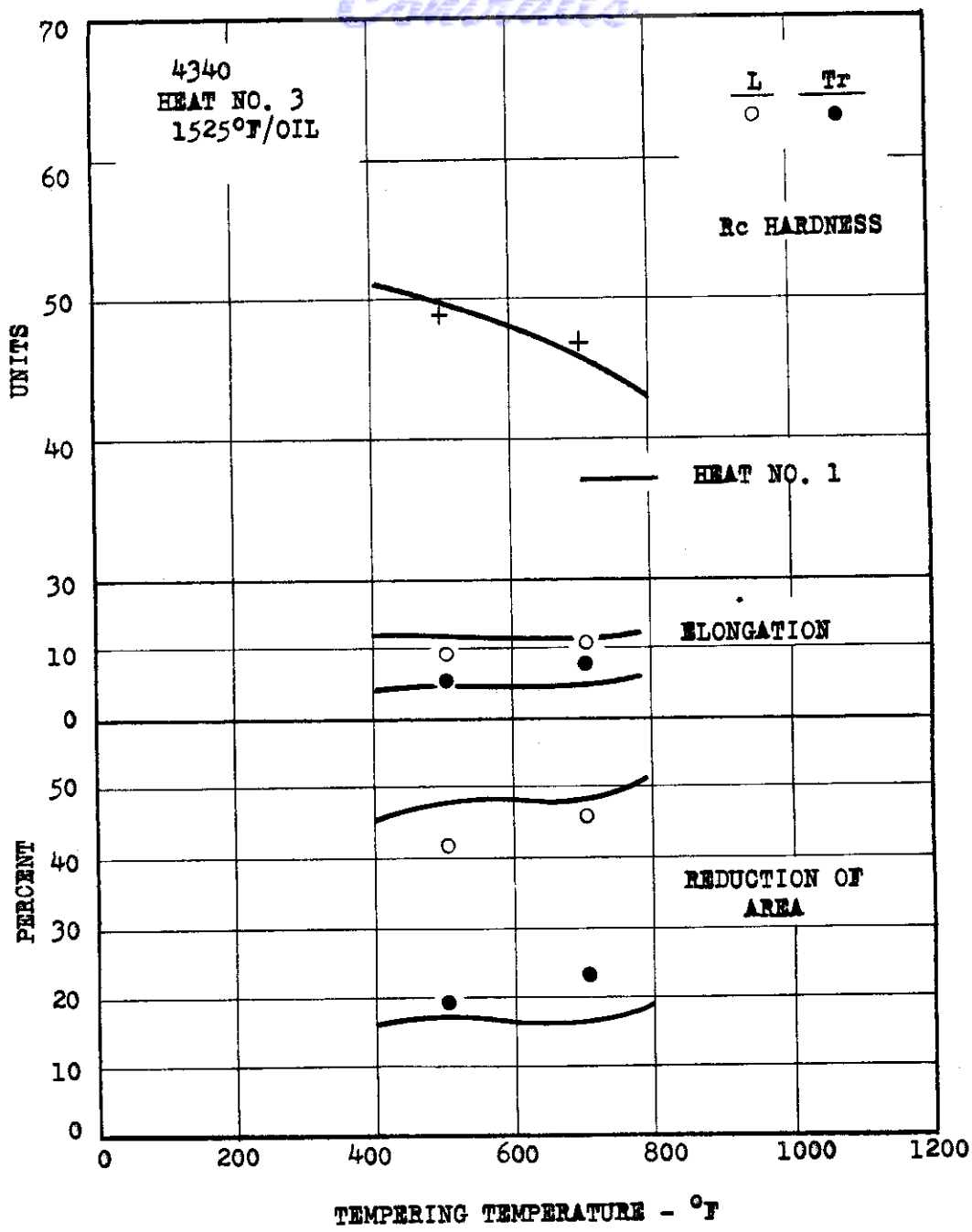


FIG. 69 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

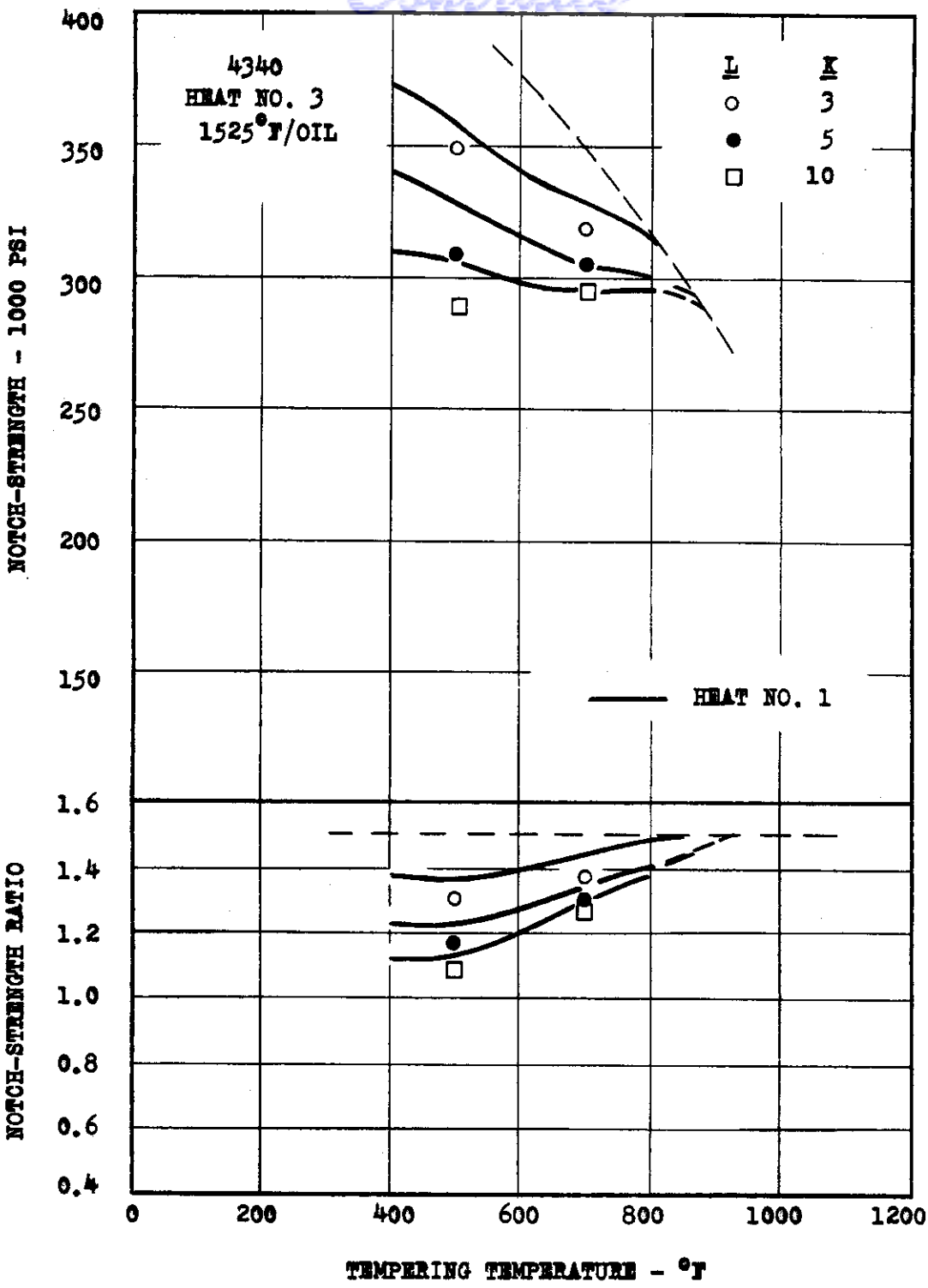


FIG. 70 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

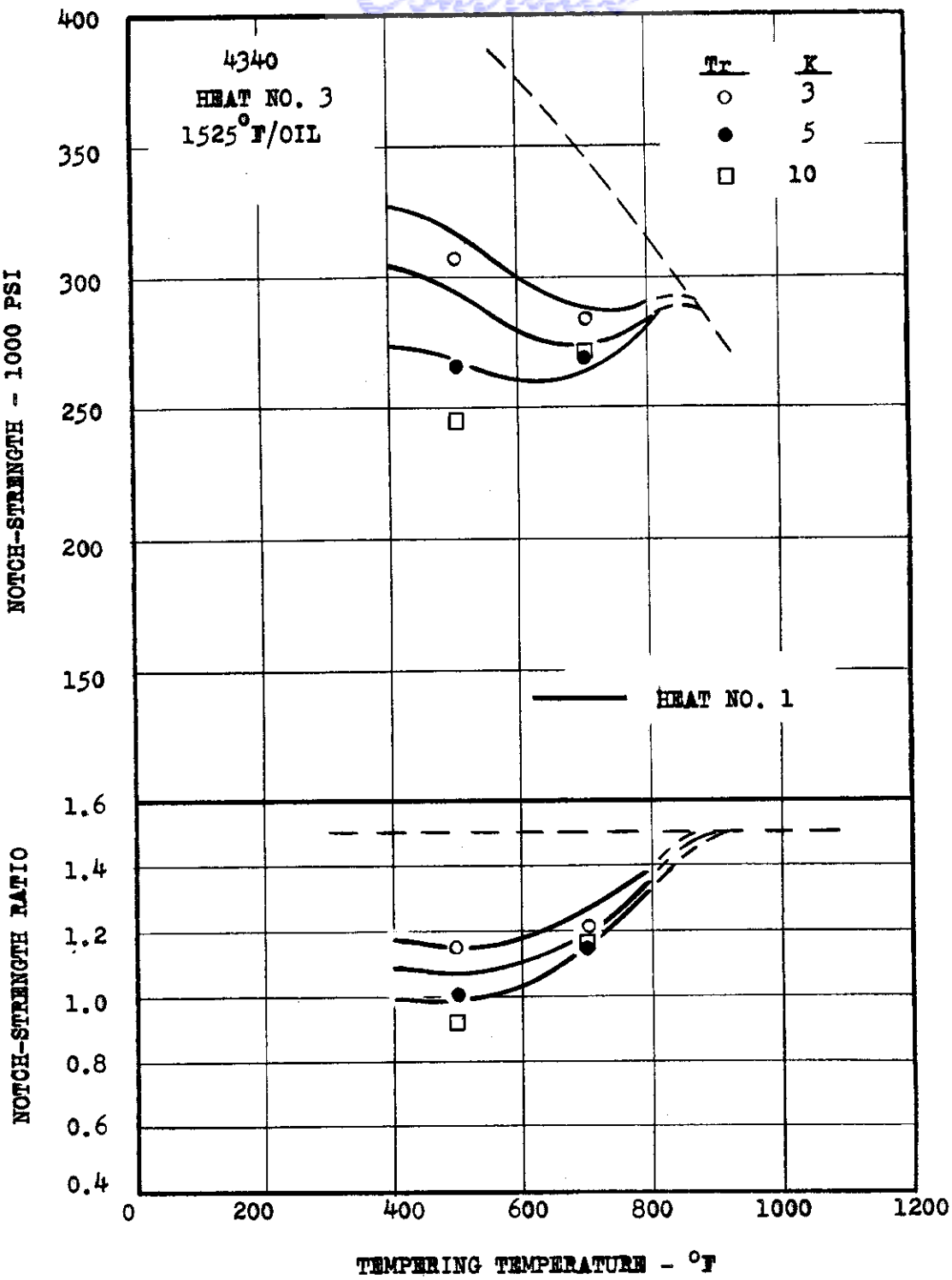


FIG. 71 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

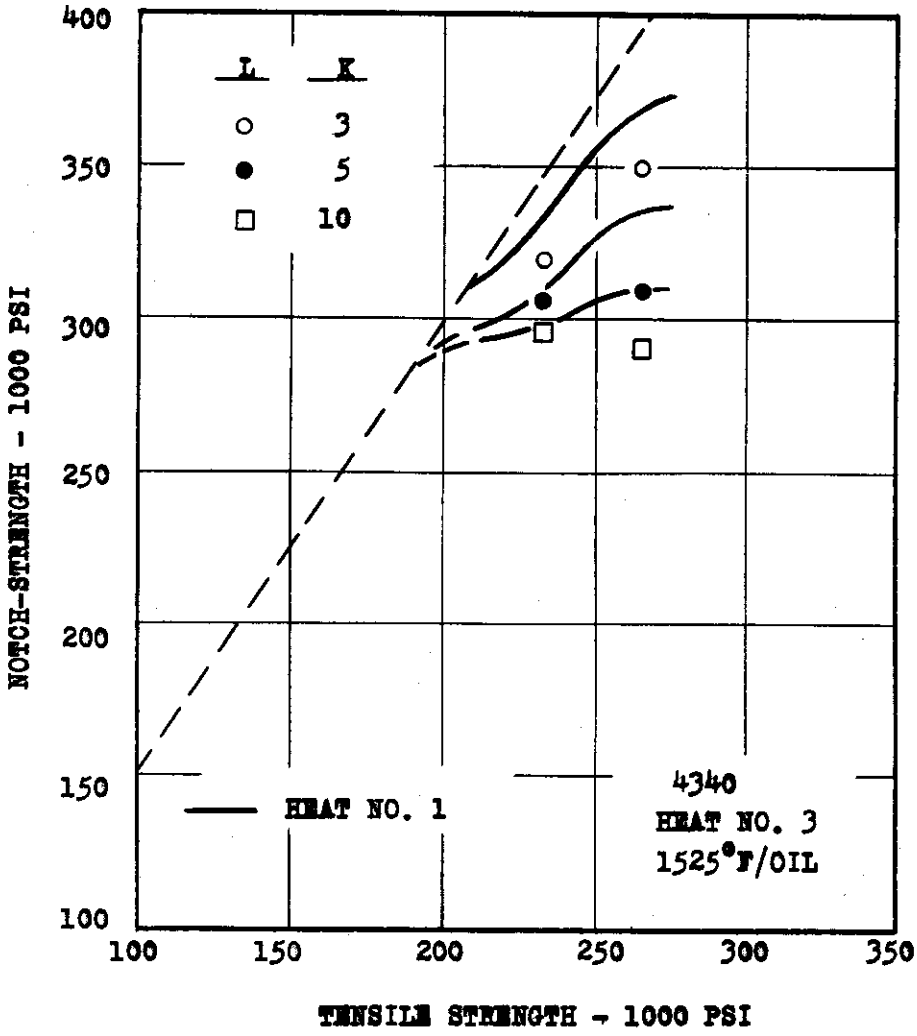


FIG. 72 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

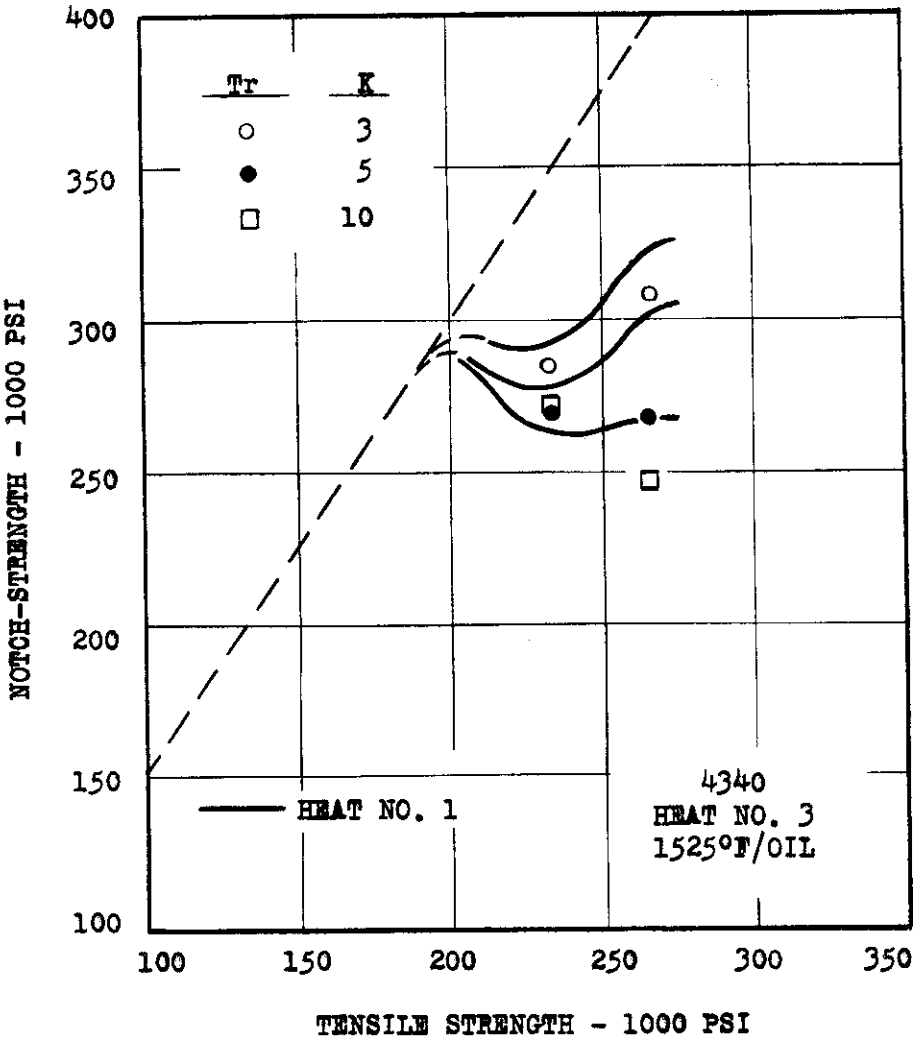


FIG. 73 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 1/2 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

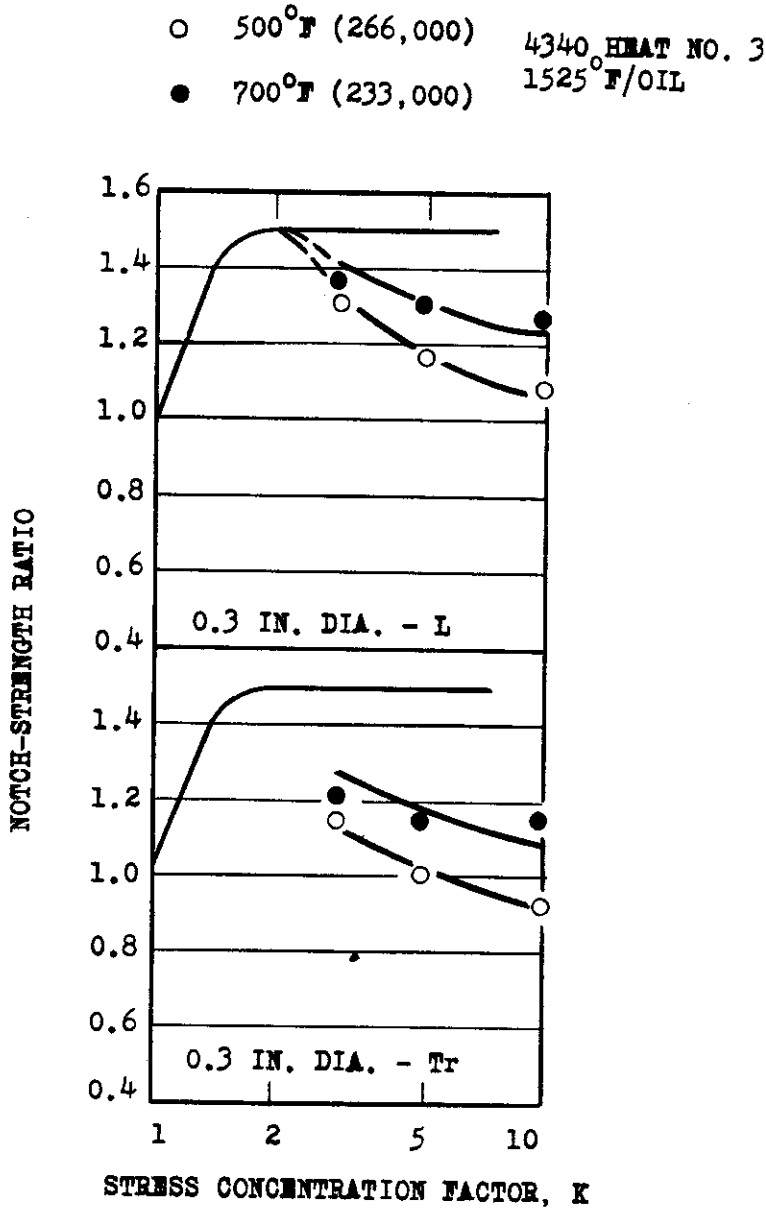


FIG. 74 VARIATION OF NOTCH STRENGTH RATIO WITH K.

SECTION: 3½ IN. DIA.

TEST TEMP: R.T.

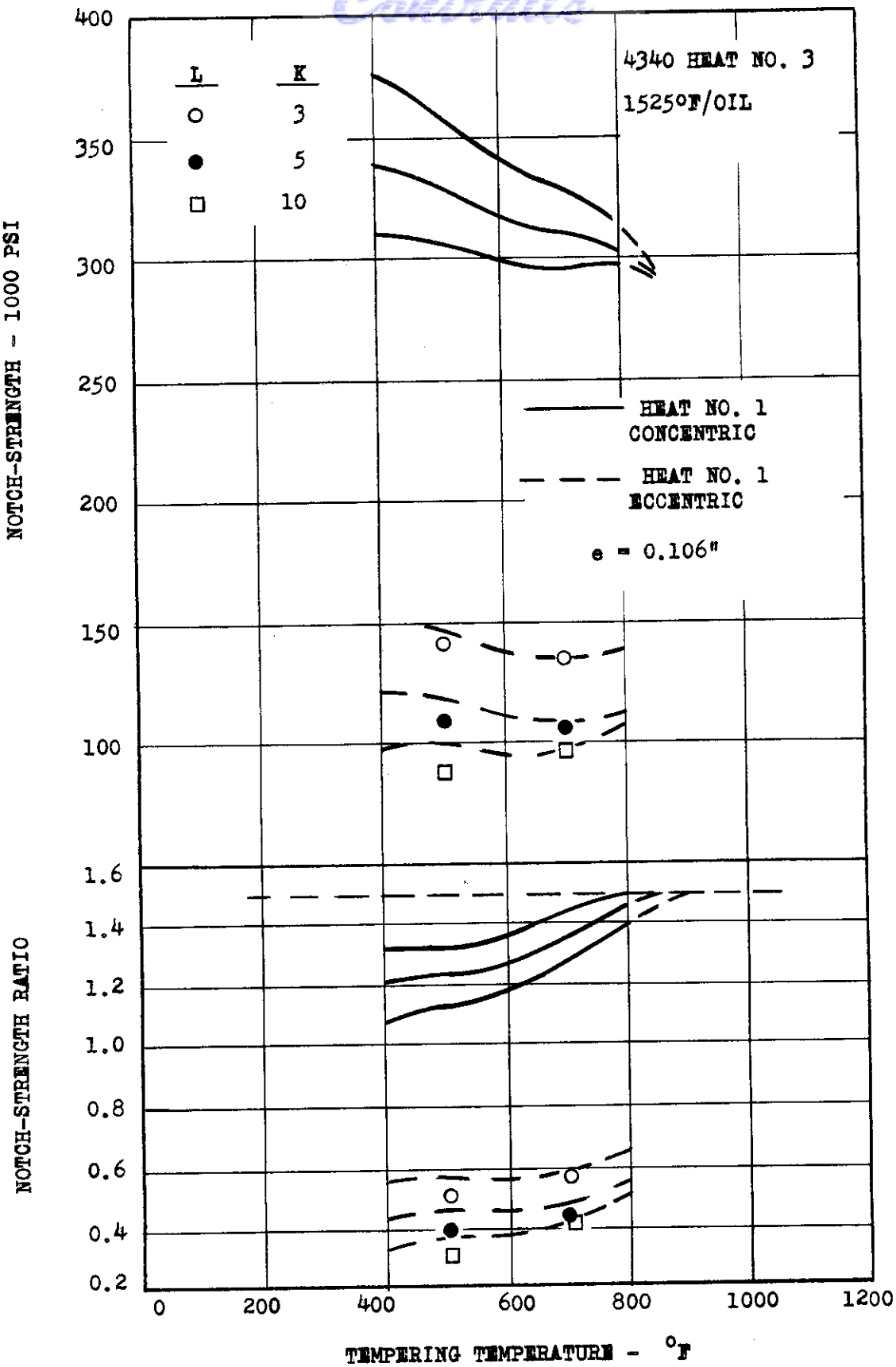


FIG. 75 VARIATION OF ECCENTRIC NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

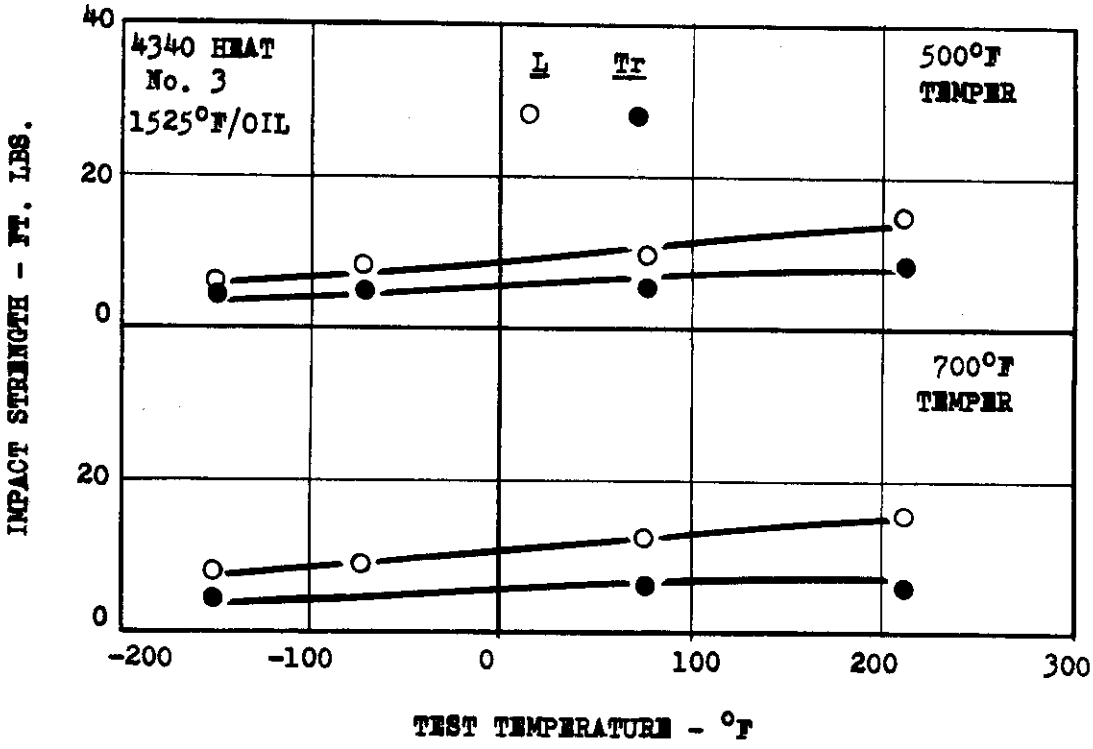


FIG. 76 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 3½ IN. DIA.

SPECIMEN: STD. V-NOTCH CHARPY

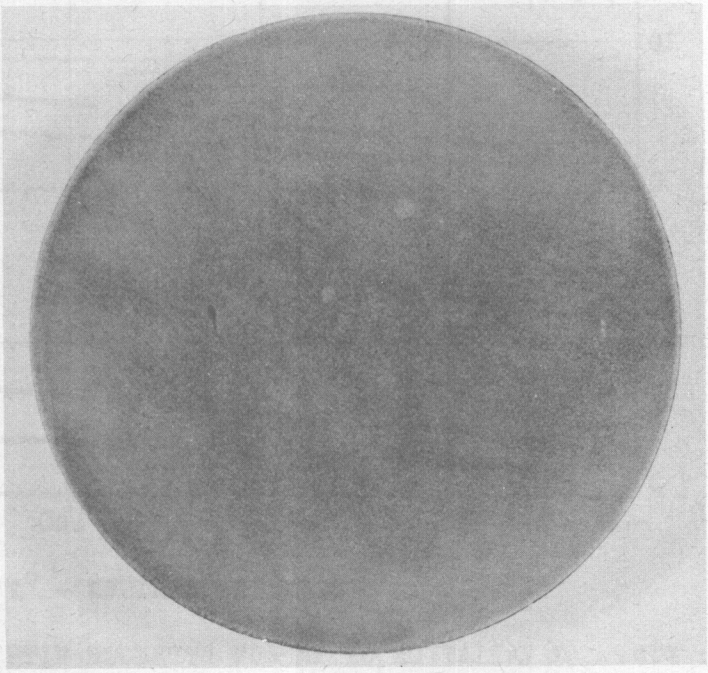
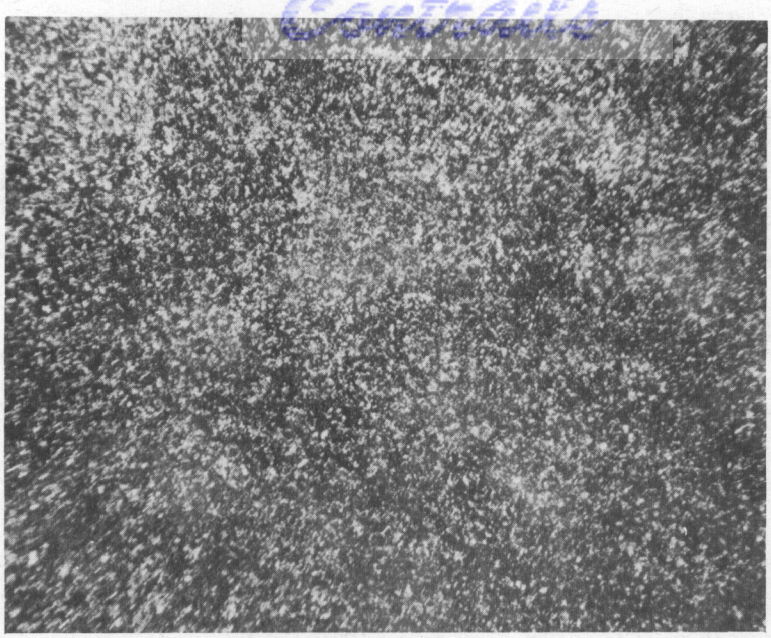
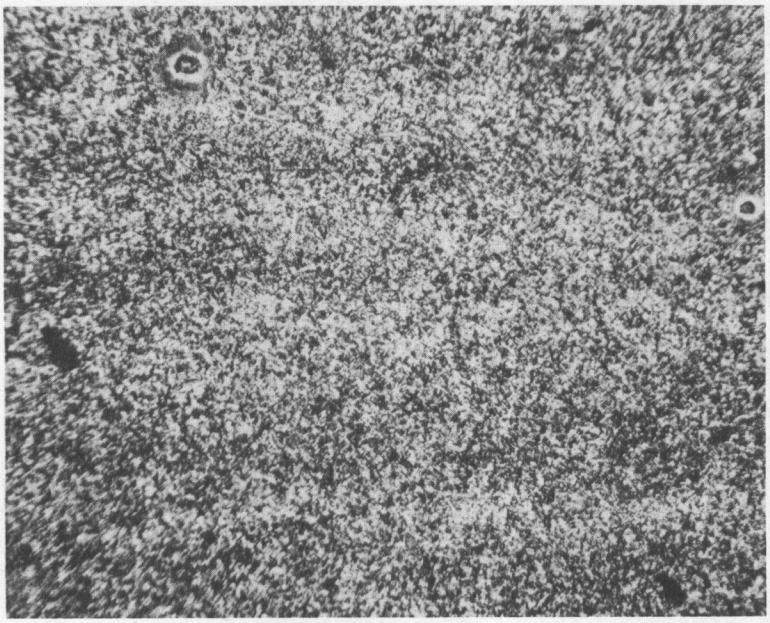


FIG. 77 MACROGRAPH OF 4340 STEEL (HEAT 4) AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) Transverse Pattern



(b) Longitudinal Pattern

FIG. 78 PHOTOMICROGRAPHS OF 4340 (HEAT 4) STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

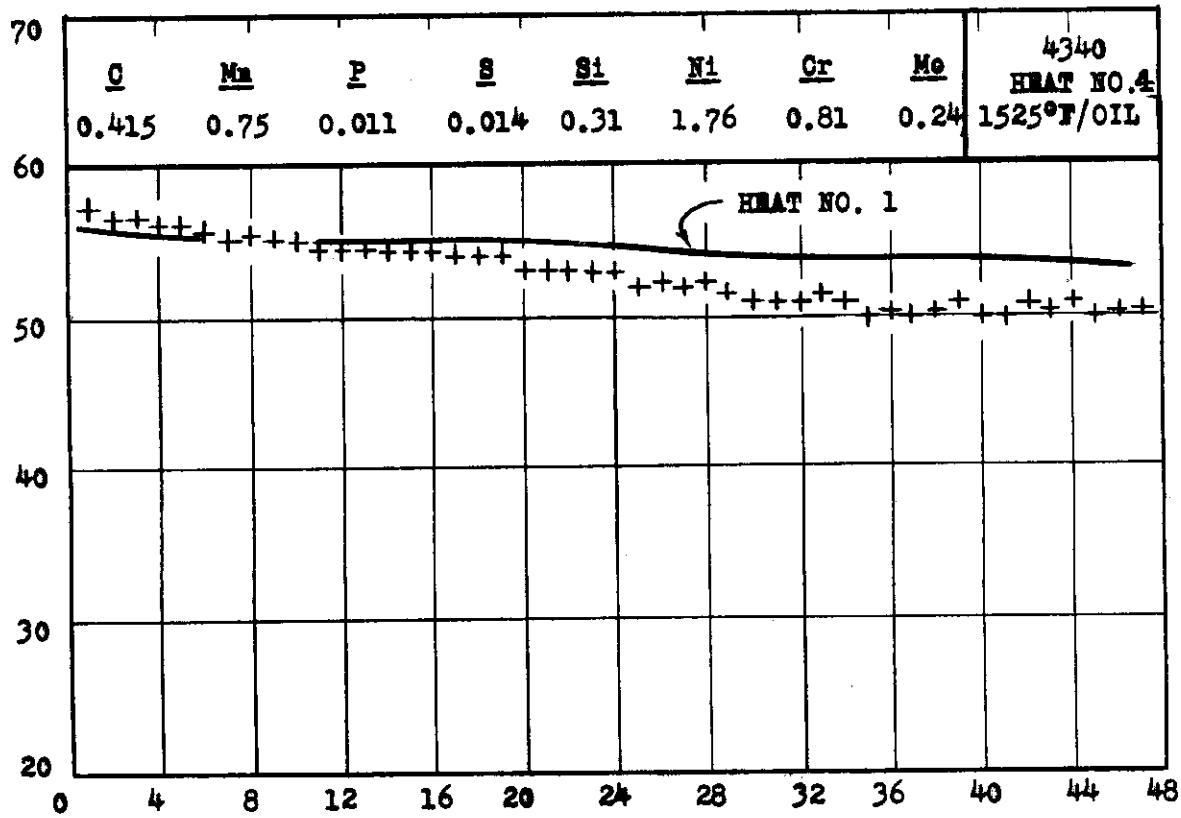


FIG. 79 HARDENABILITY OF JOMINY - QUENCH BAR.

SECTION: 3 1/4 IN.DIA.

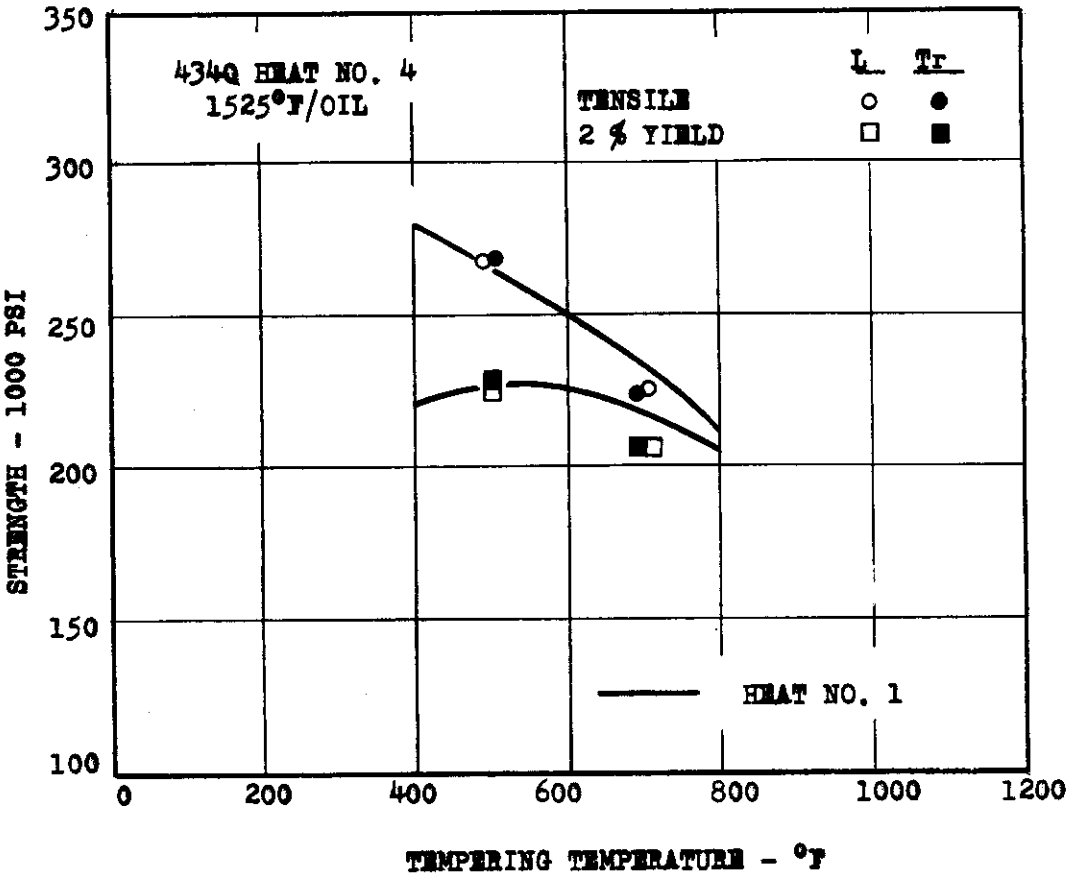


FIG. 80 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

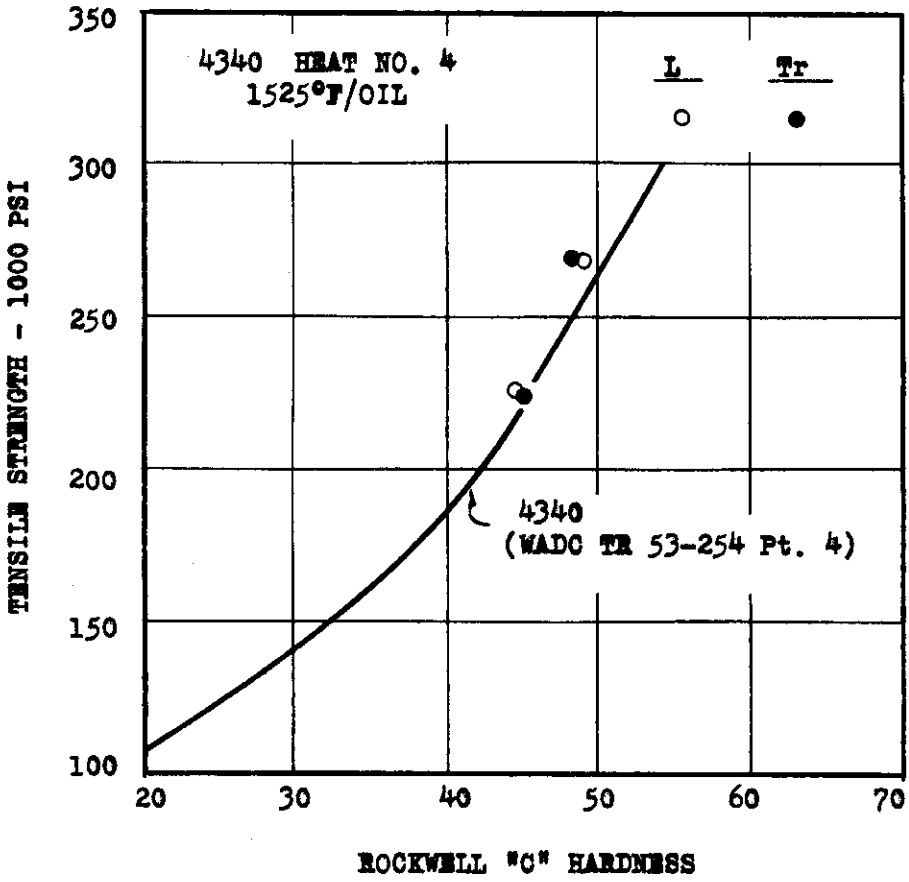


FIG. 81 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

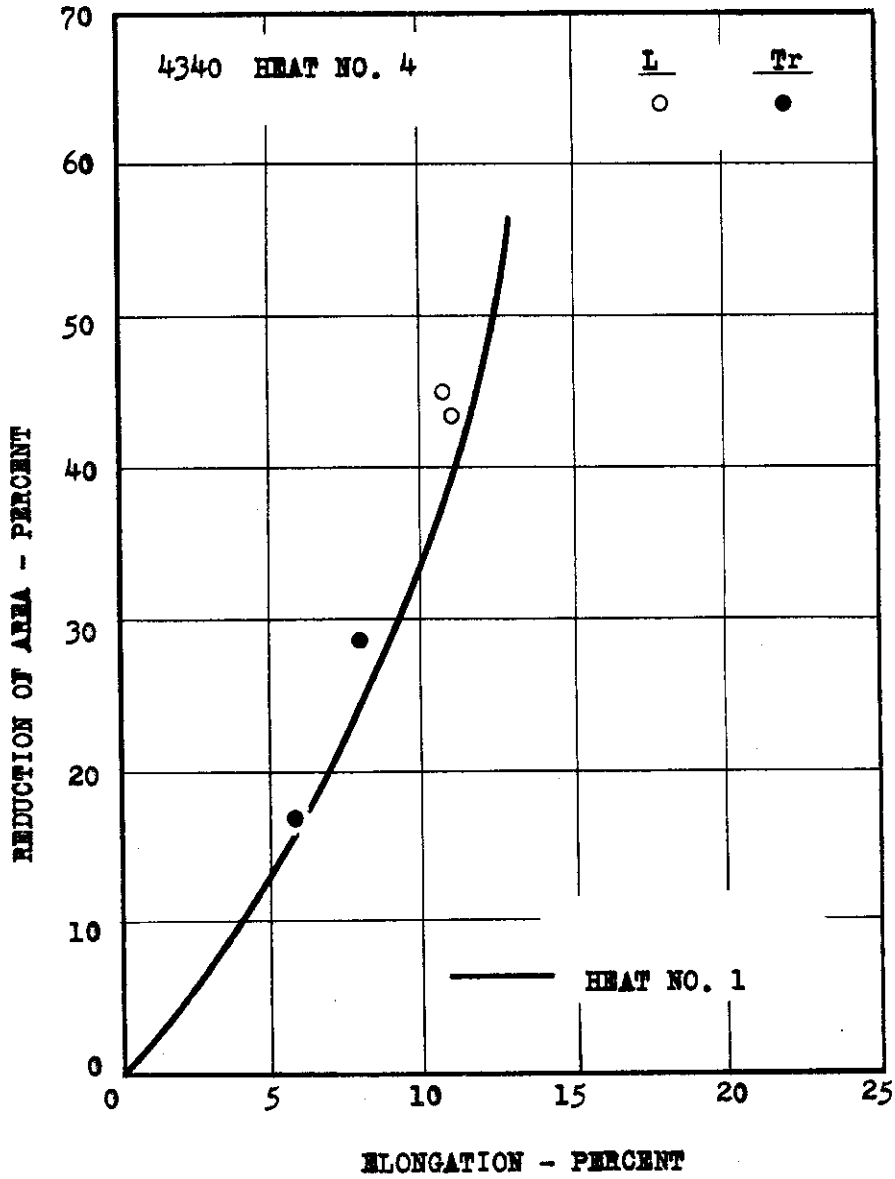


FIG. 82 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

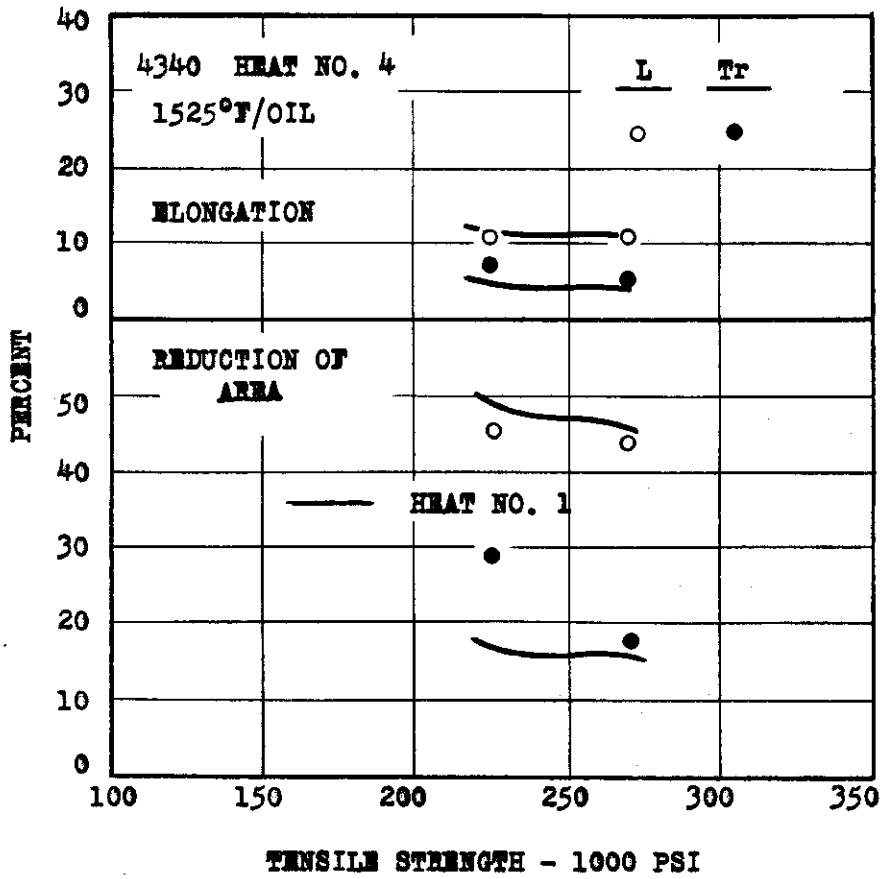


FIG. 83 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

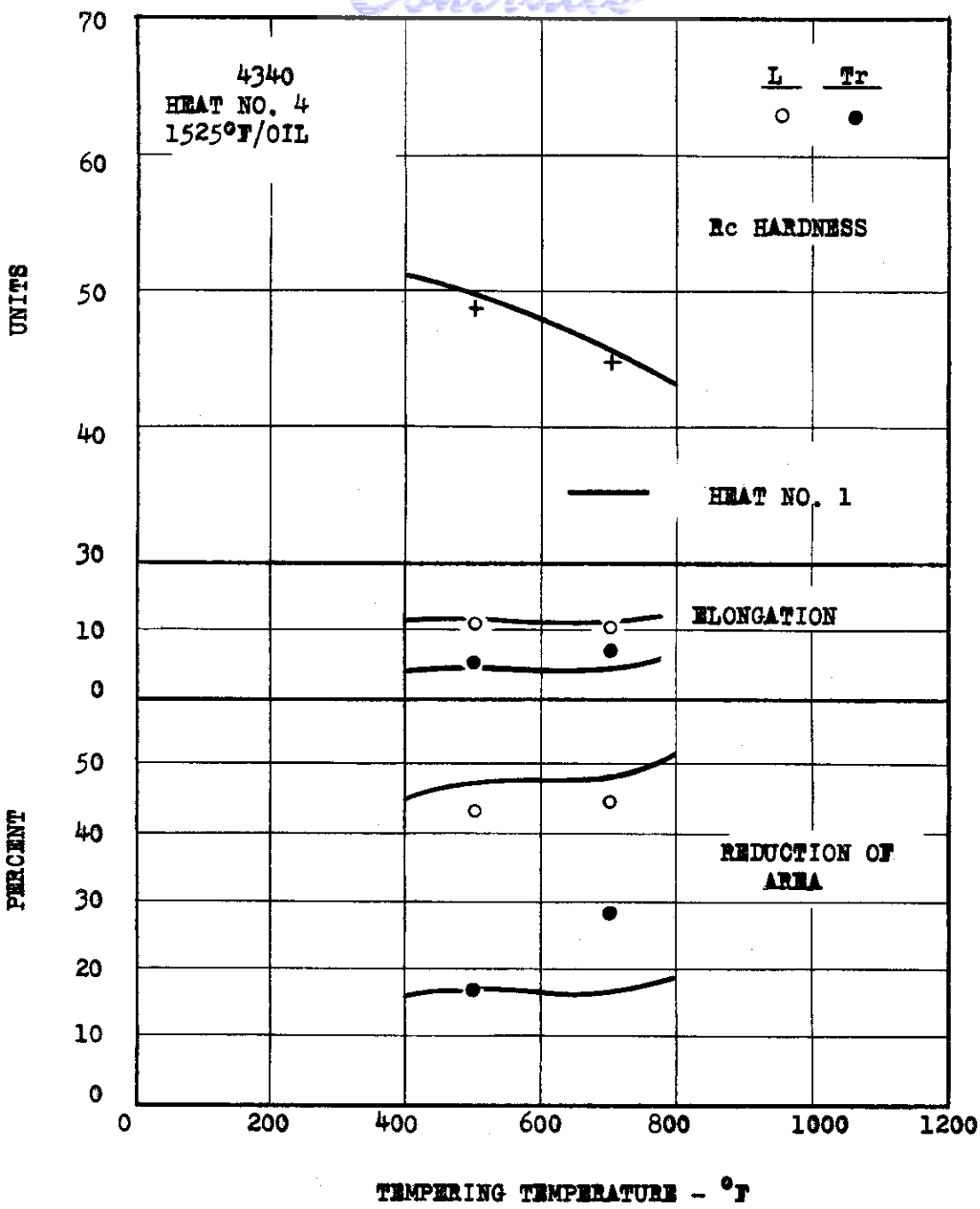


FIG. 84 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

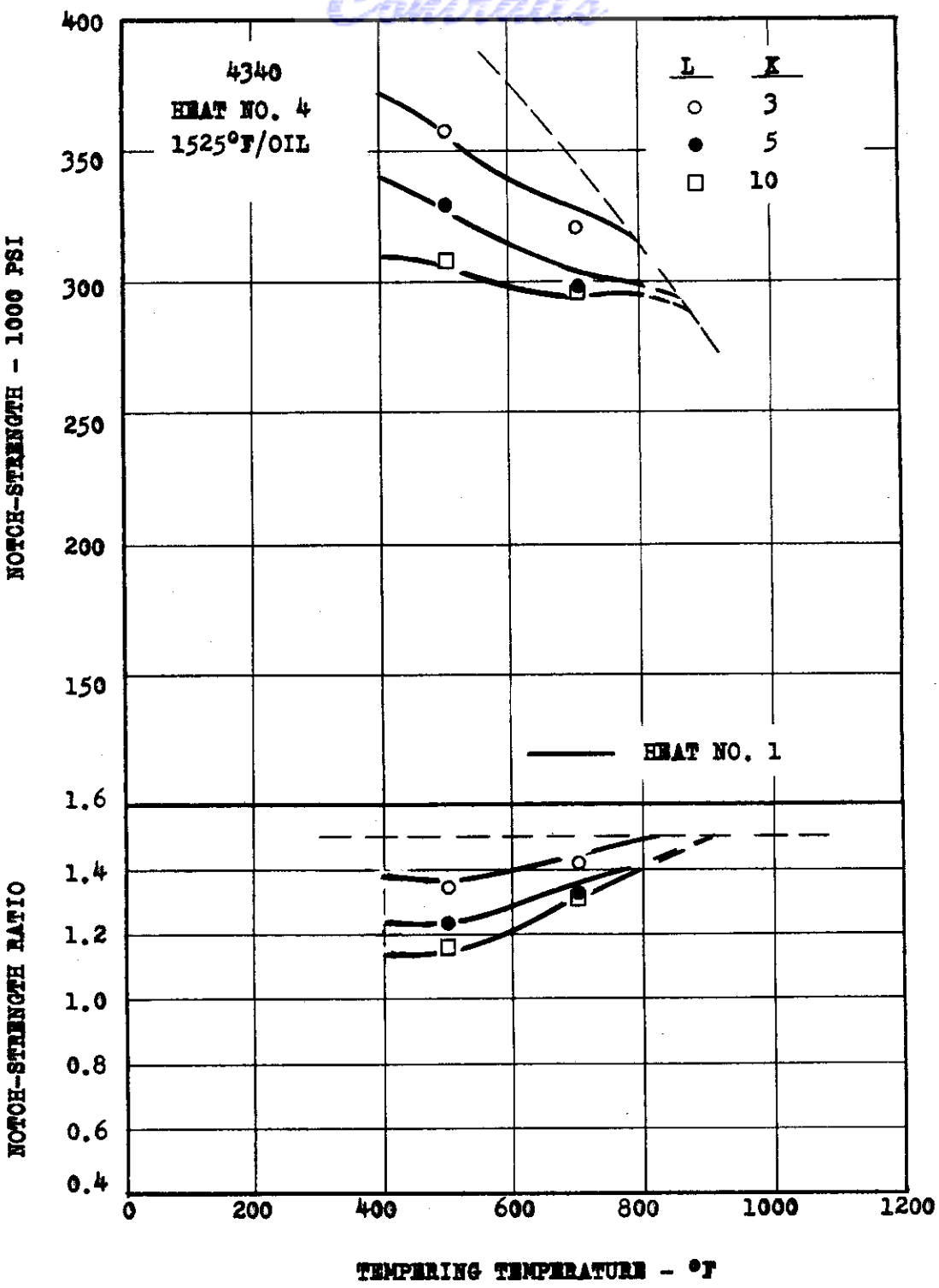


FIG. 85 VAIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

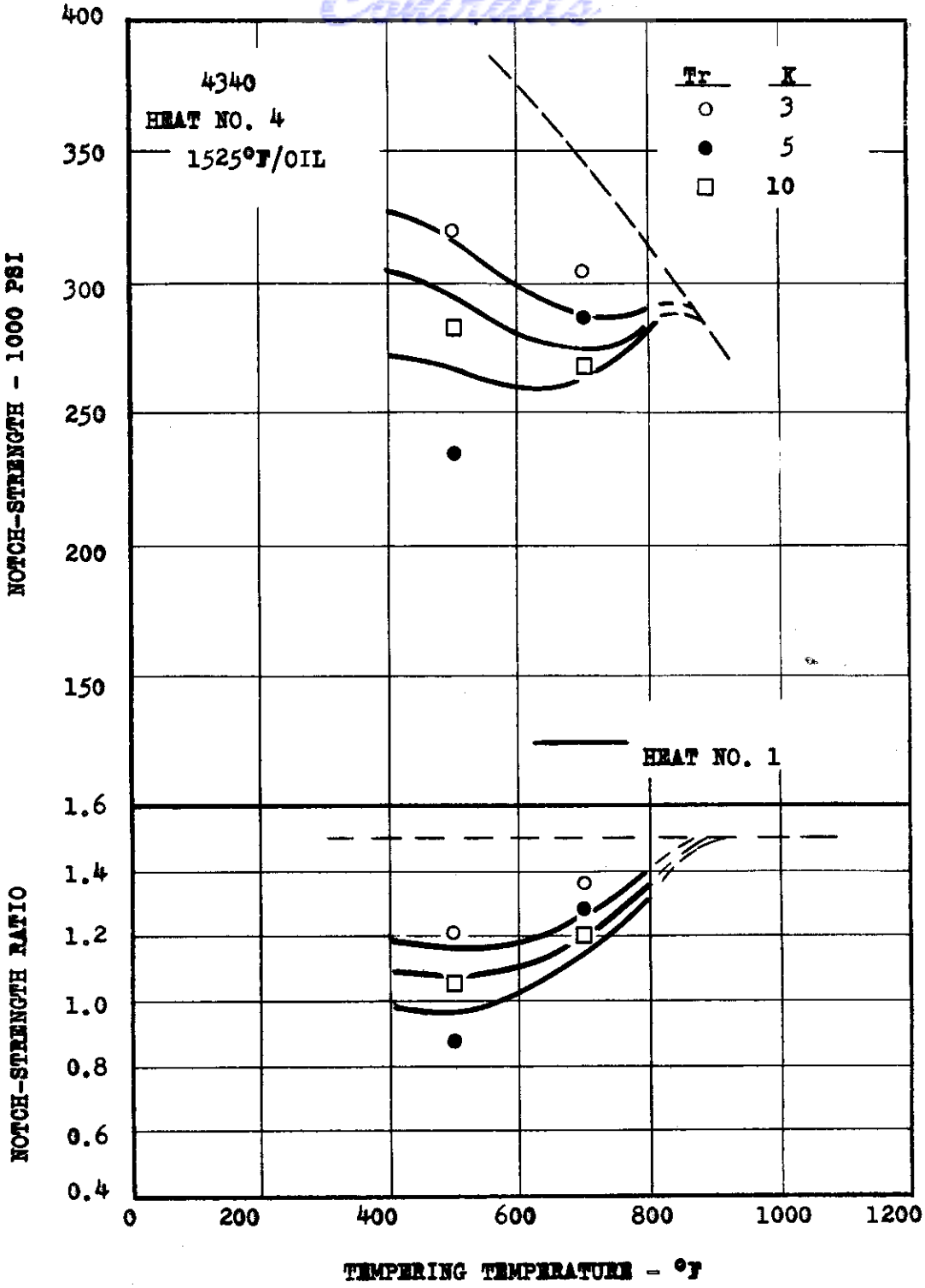


FIG. 86 VARIATION OF NOTCH-STRENGTH AND NOTCH- STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

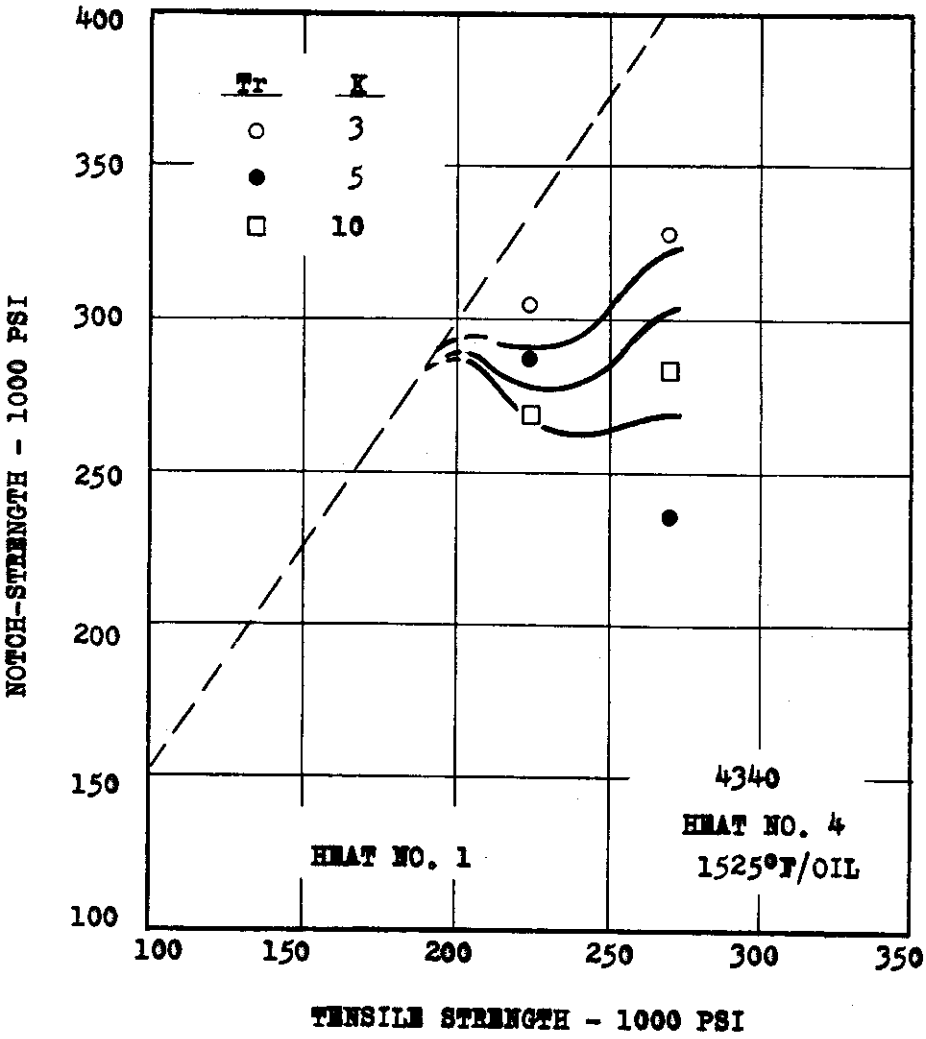


FIG. 87 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

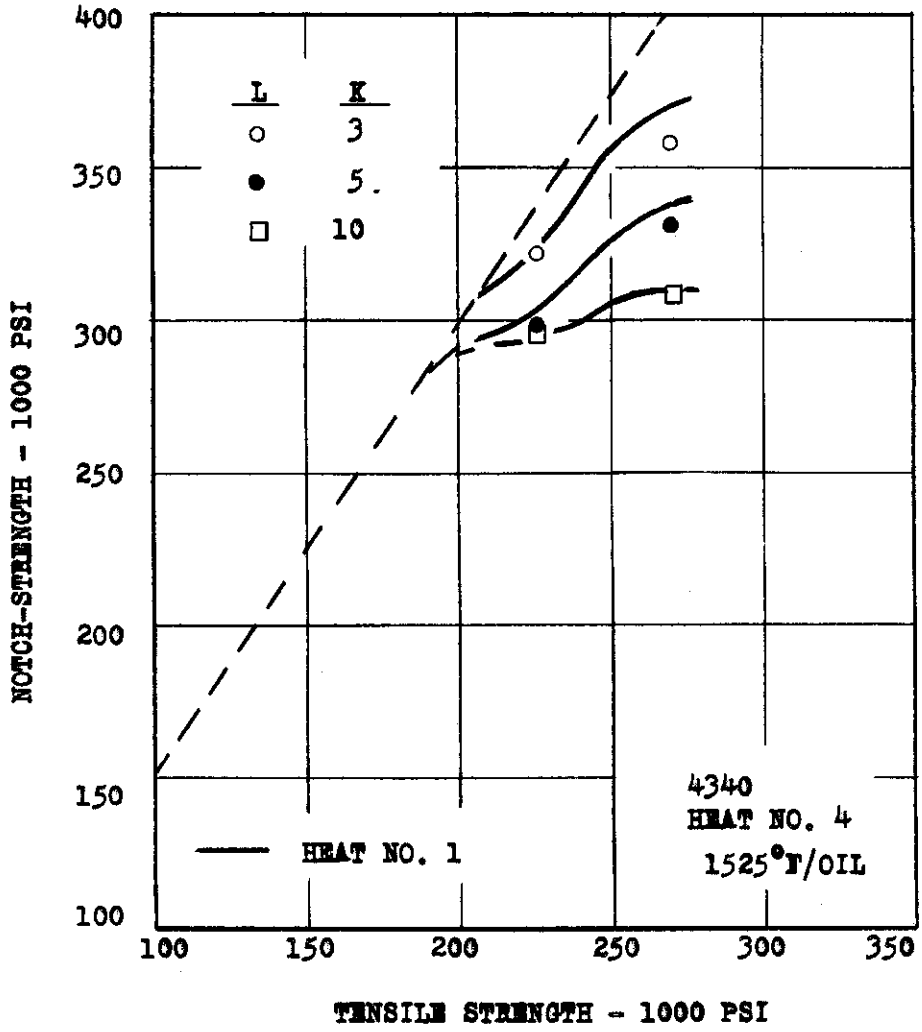


FIG. 88 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 1/4 IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

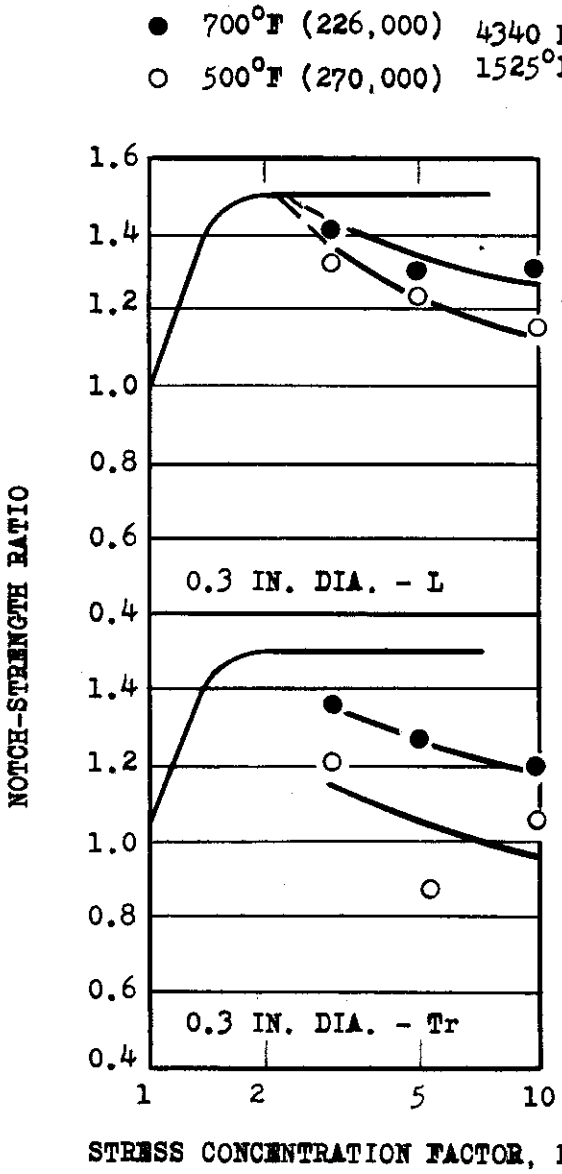


FIG. 89 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 3½ IN. DIA.

TEST TEMP: R.T.

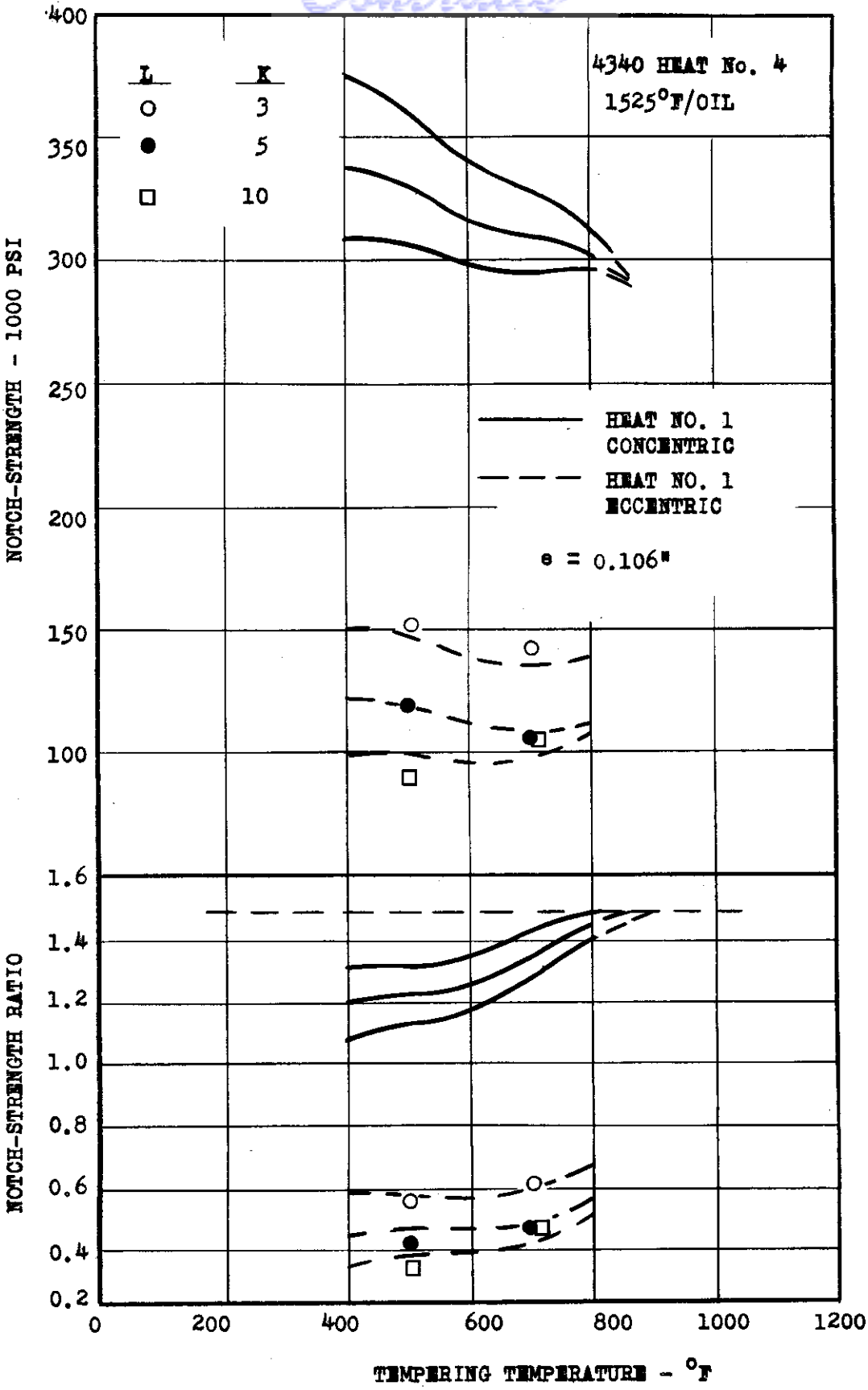


FIG. 90 VARIATION OF ECCENTRIC NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

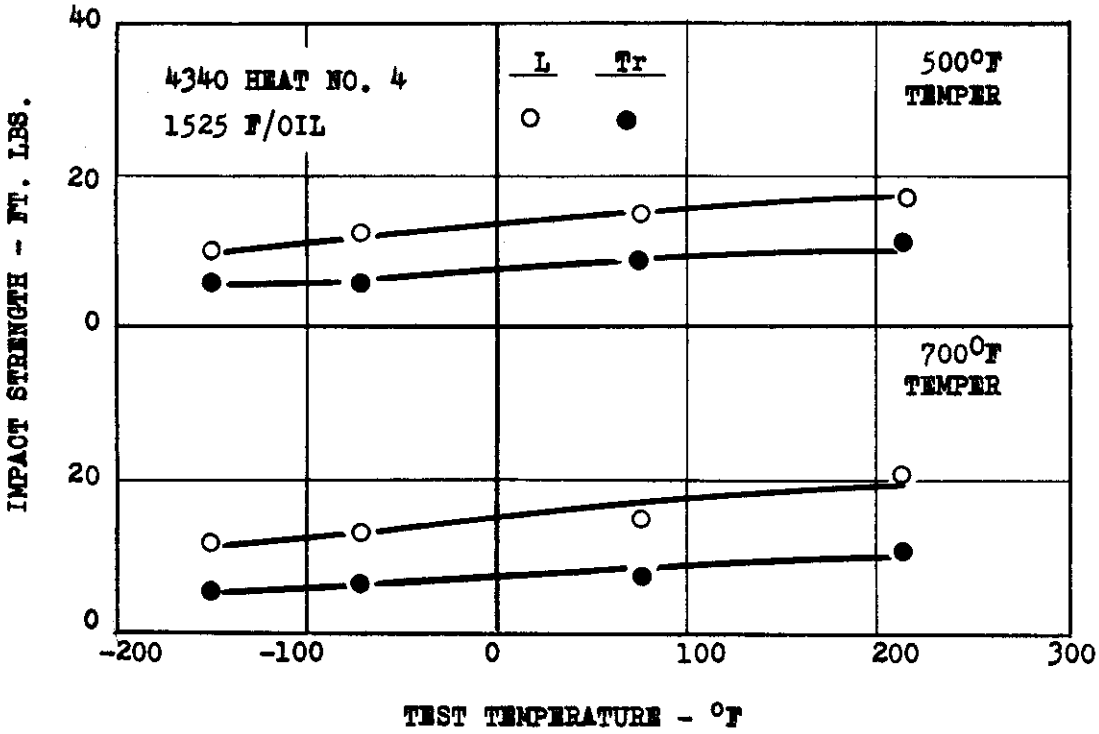


FIG. 91 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 3½ IN. DIA.

SPECIMEN: STD. V-NOTCH CHARPY

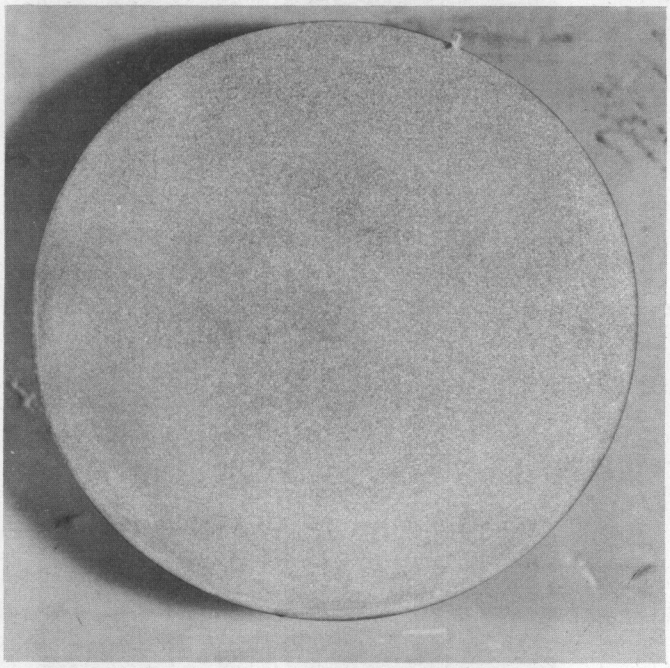
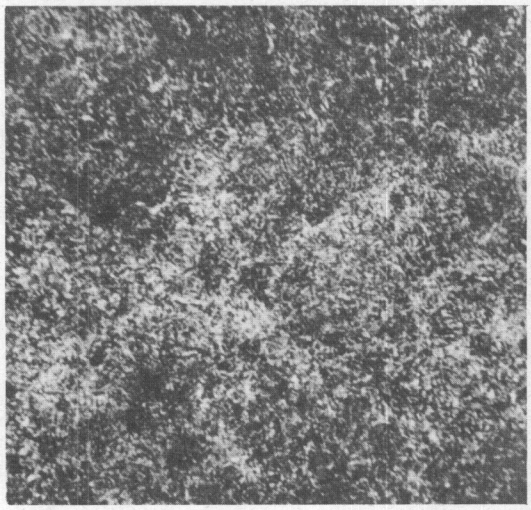
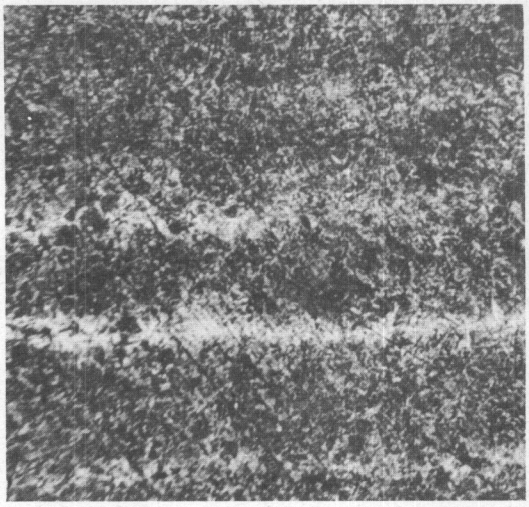


FIG. 92 MACROGRAPH OF 98B40 STEEL AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) Transverse Pattern



(b) Longitudinal Pattern

FIG. 93 PHOTOMICROGRAPHS OF 98B40 STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

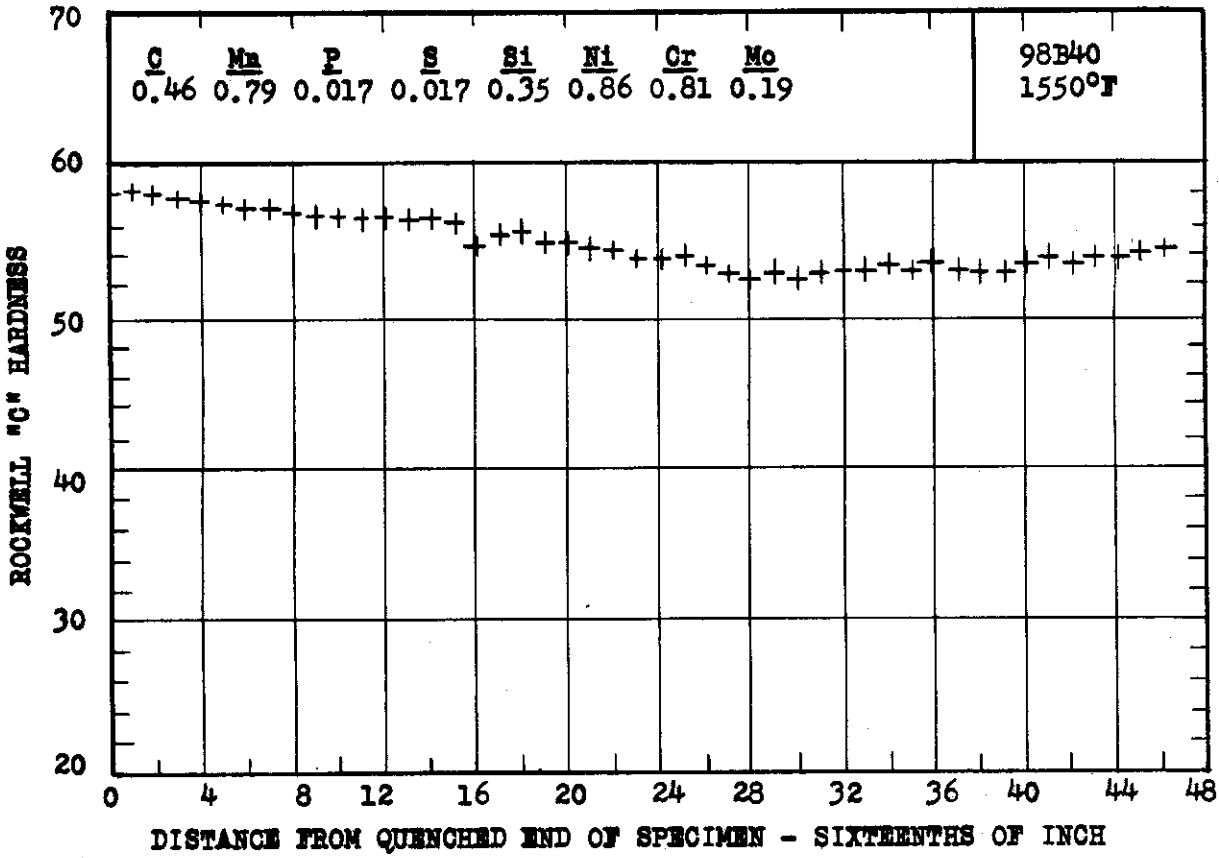


FIG. 94 HARDENABILITY OF JOMINY-QUENCH BAR.

SECTION: $4\frac{1}{2}$ IN. DIA.

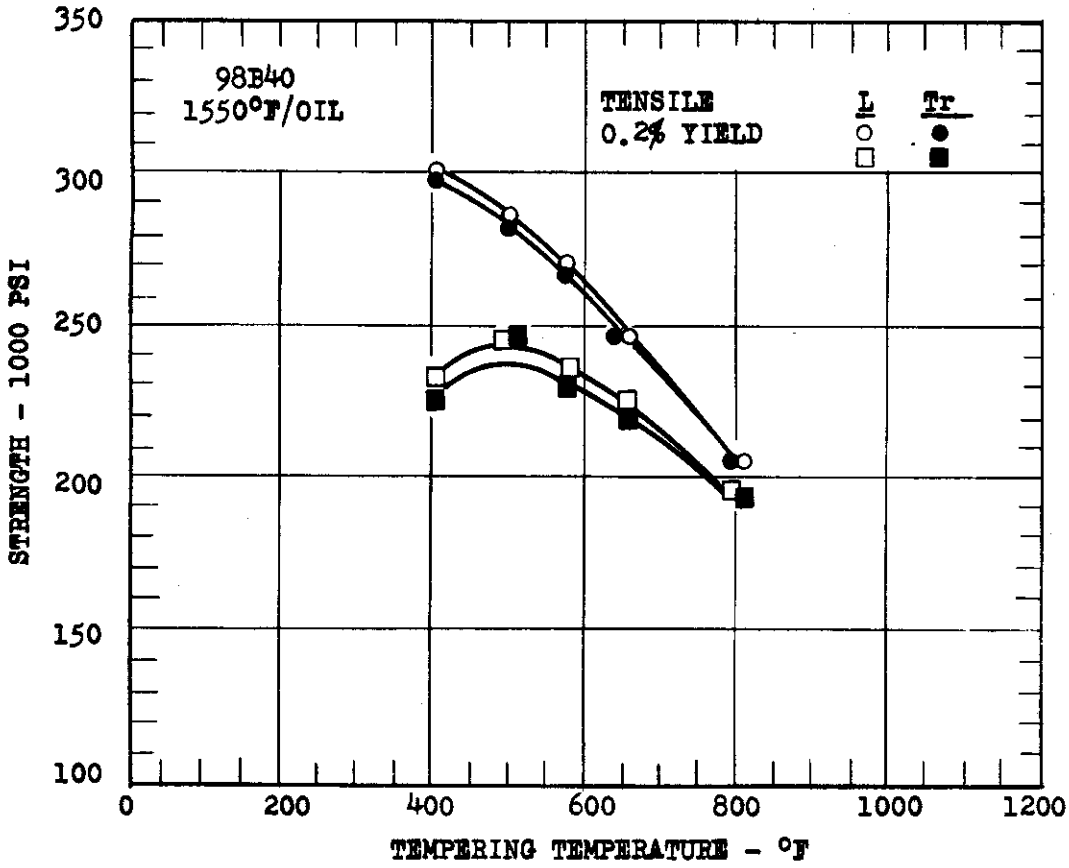


FIG. 95 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4½ IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

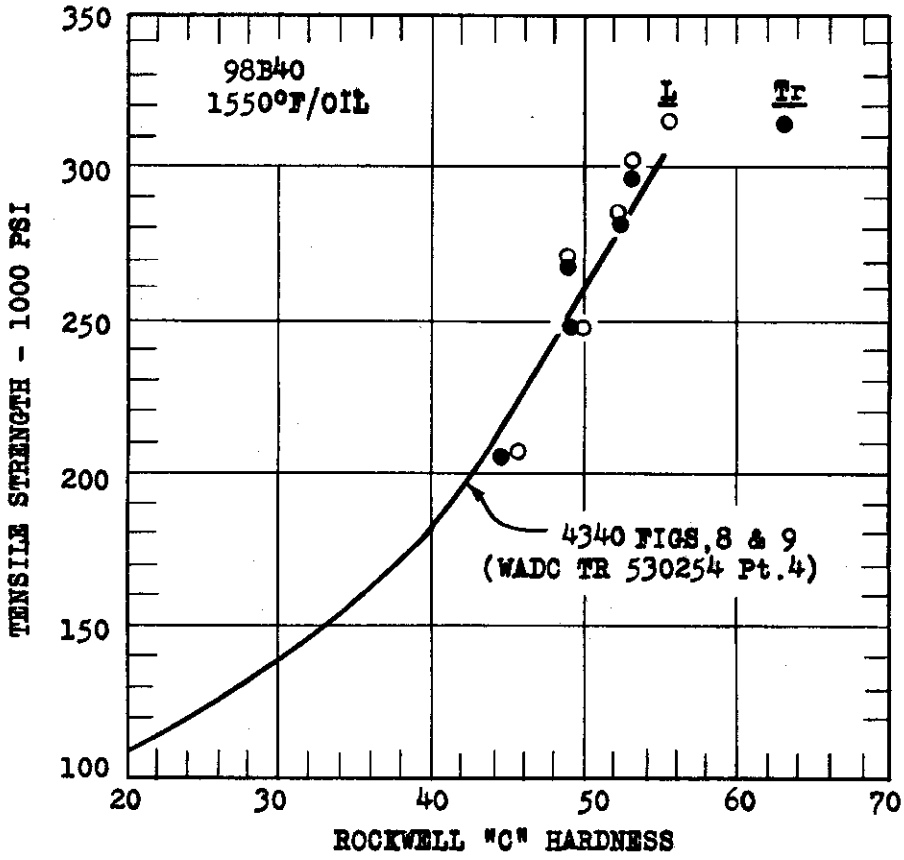


FIG. 96 VARIATION OF TENSILE STRENGTH WITH HARDNESS

SECTION: 4½ IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP. R.T.

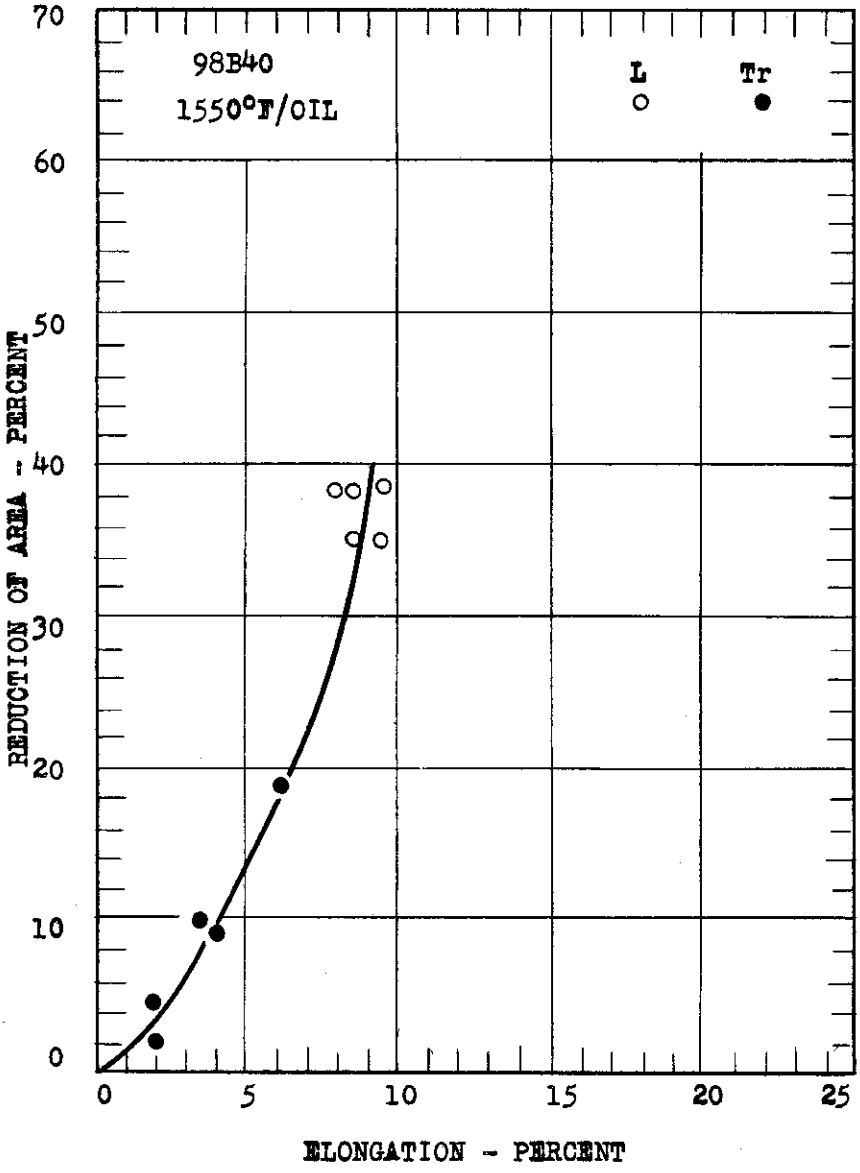


FIG. 97 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: $4\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP:R.T.

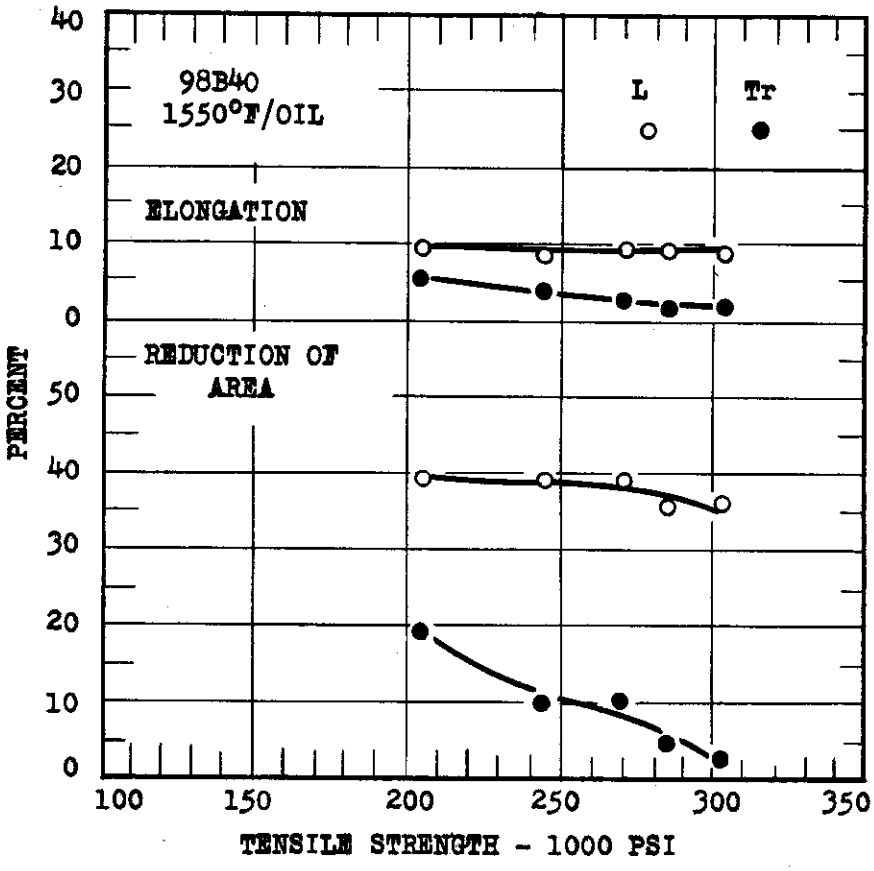


FIG. 98 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: $4\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

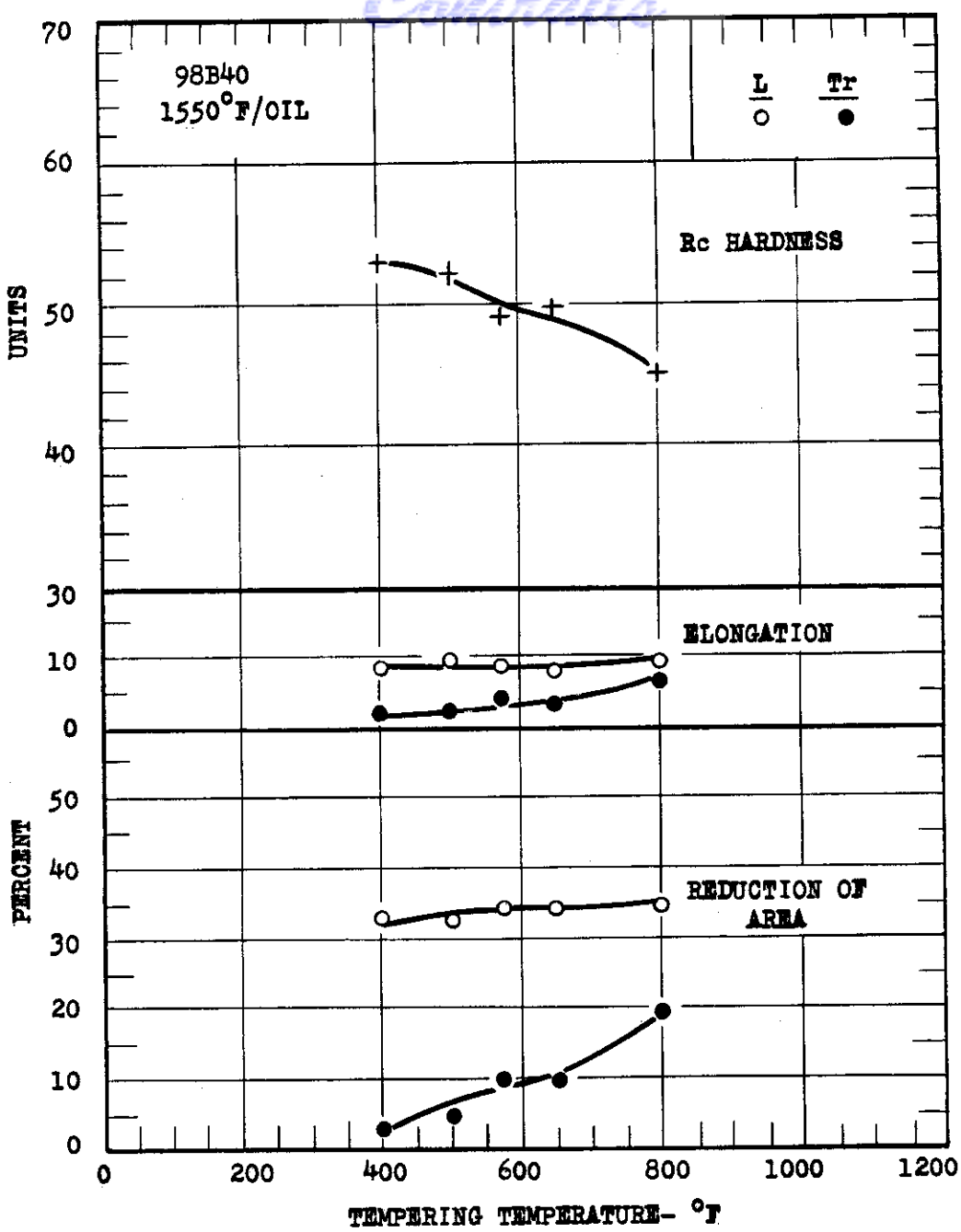


FIG. 99 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

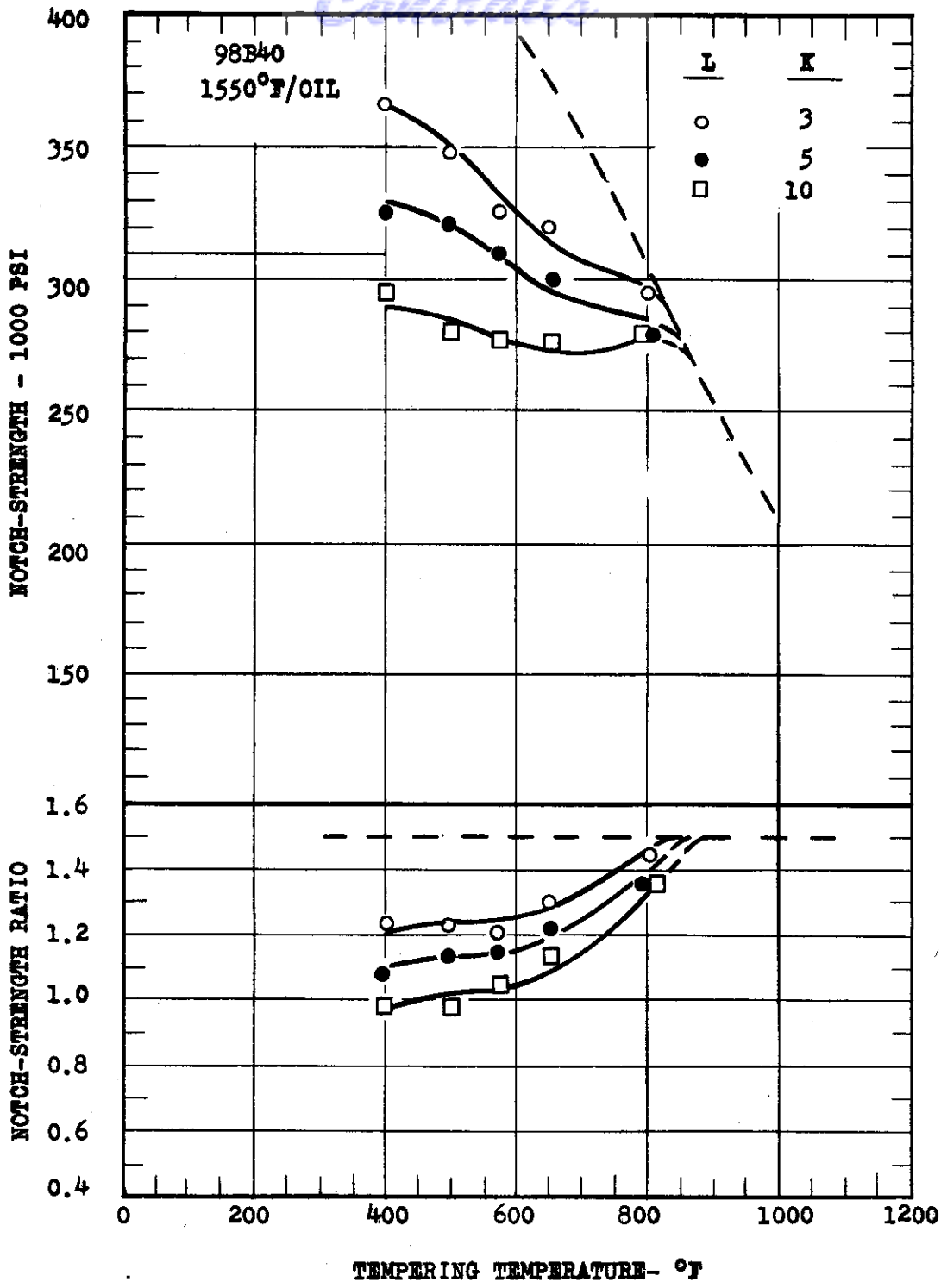


FIG. 100 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION : 4½ IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

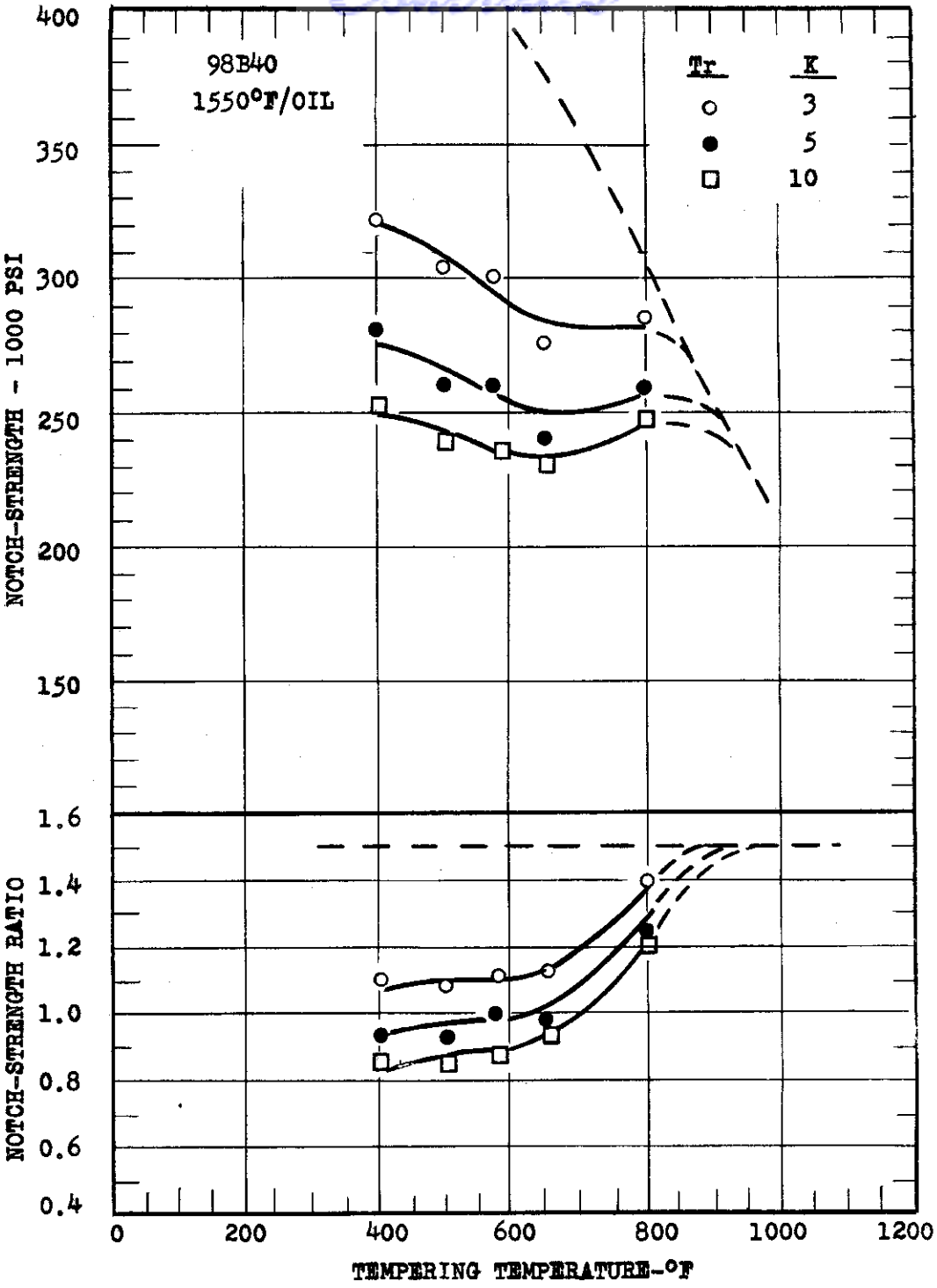


FIG. 101 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: $4\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP. R.T.

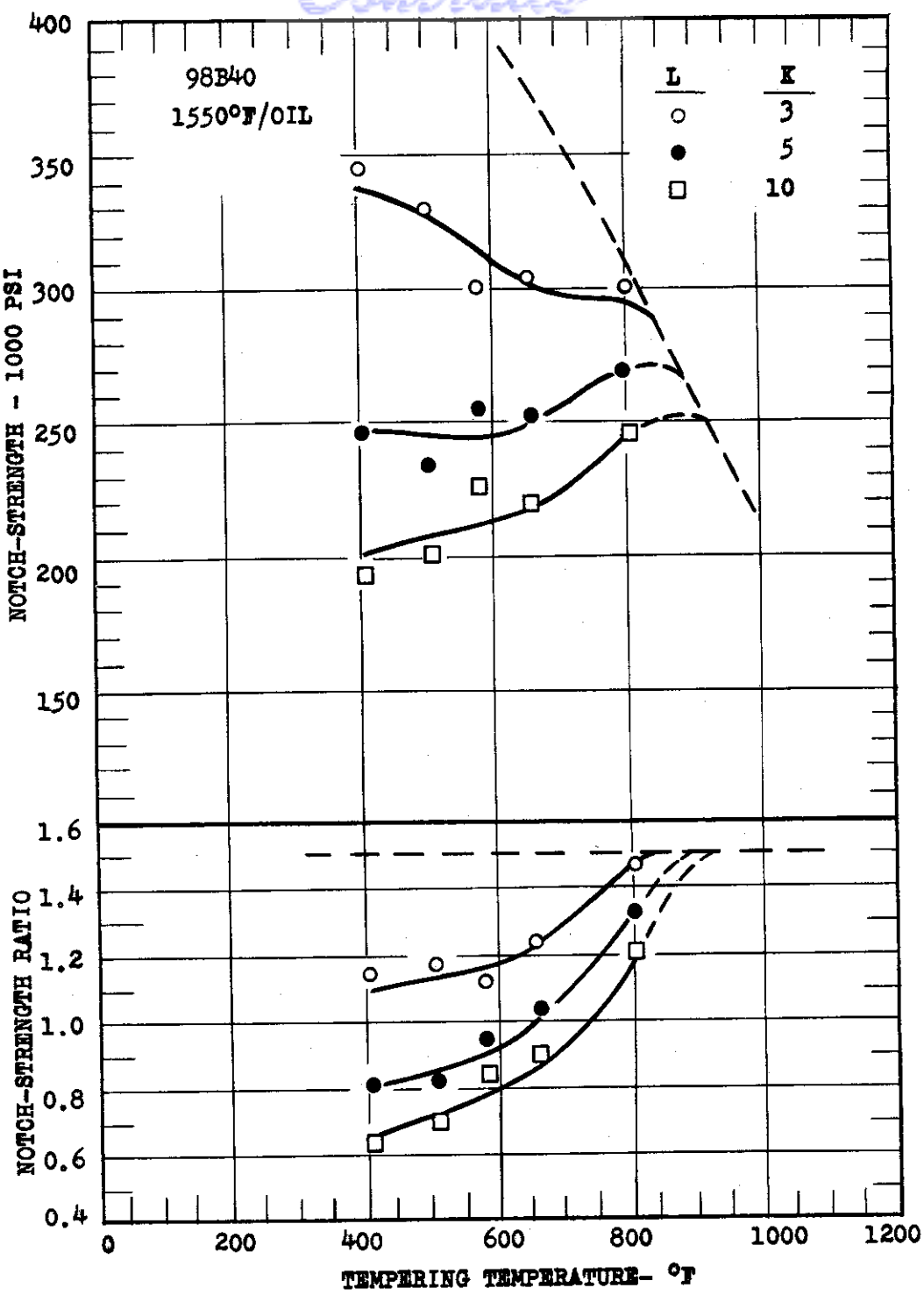


FIG. 102 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: $4\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP:R.T.

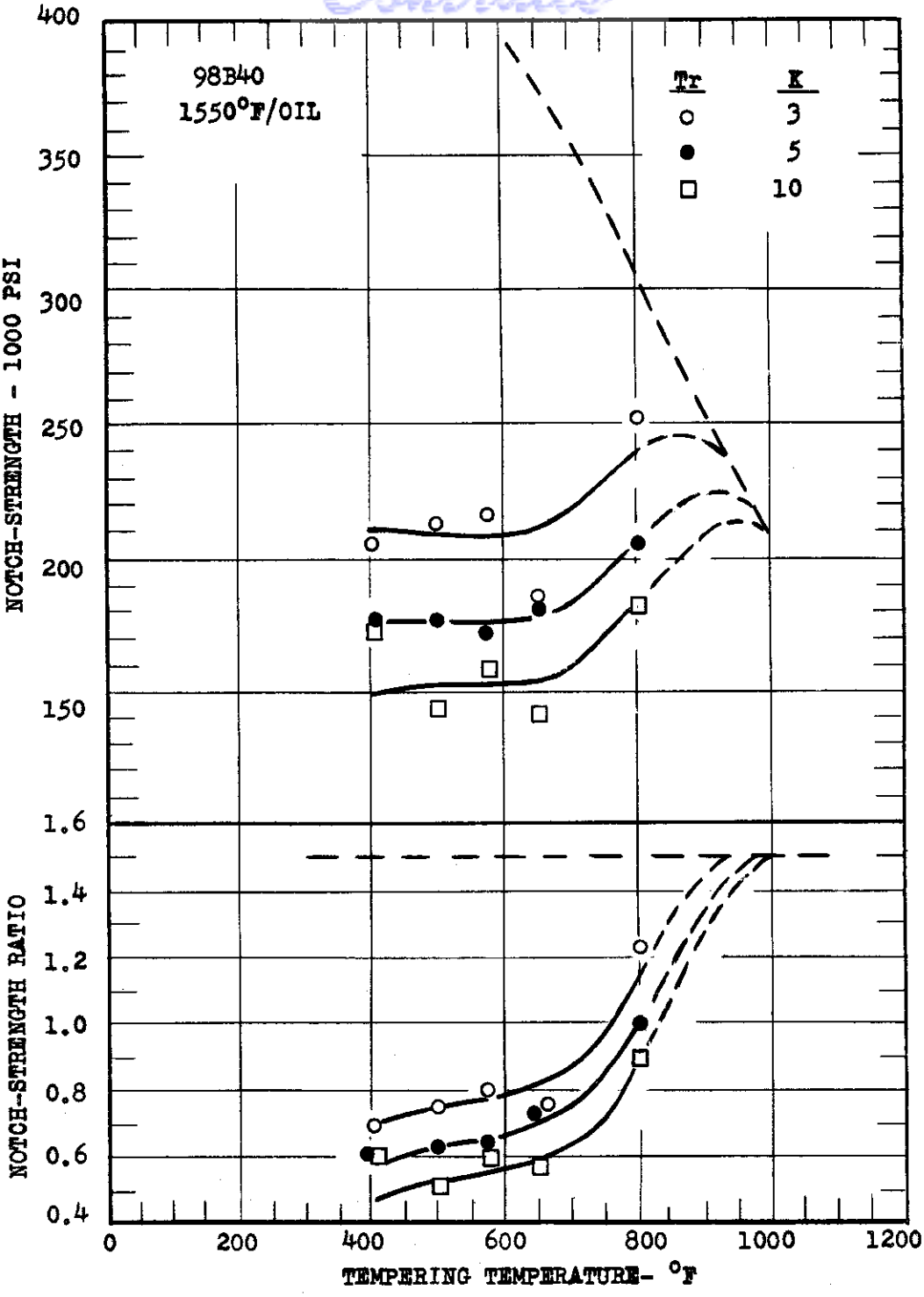


FIG. 103 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: $4\frac{1}{8}$ IN.DIA.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

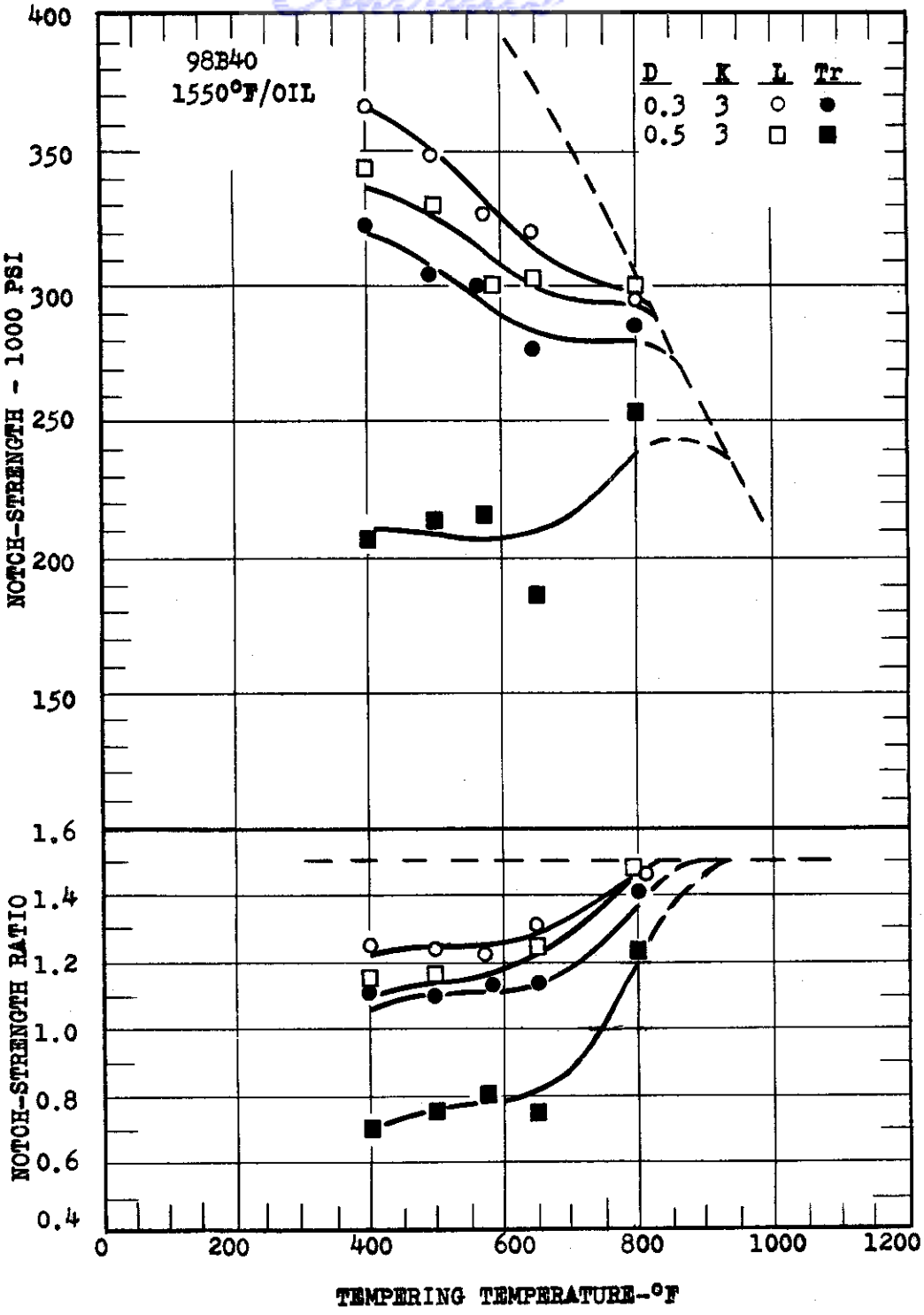


FIG. 104 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: $4\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

TEST TEMP: R.T.

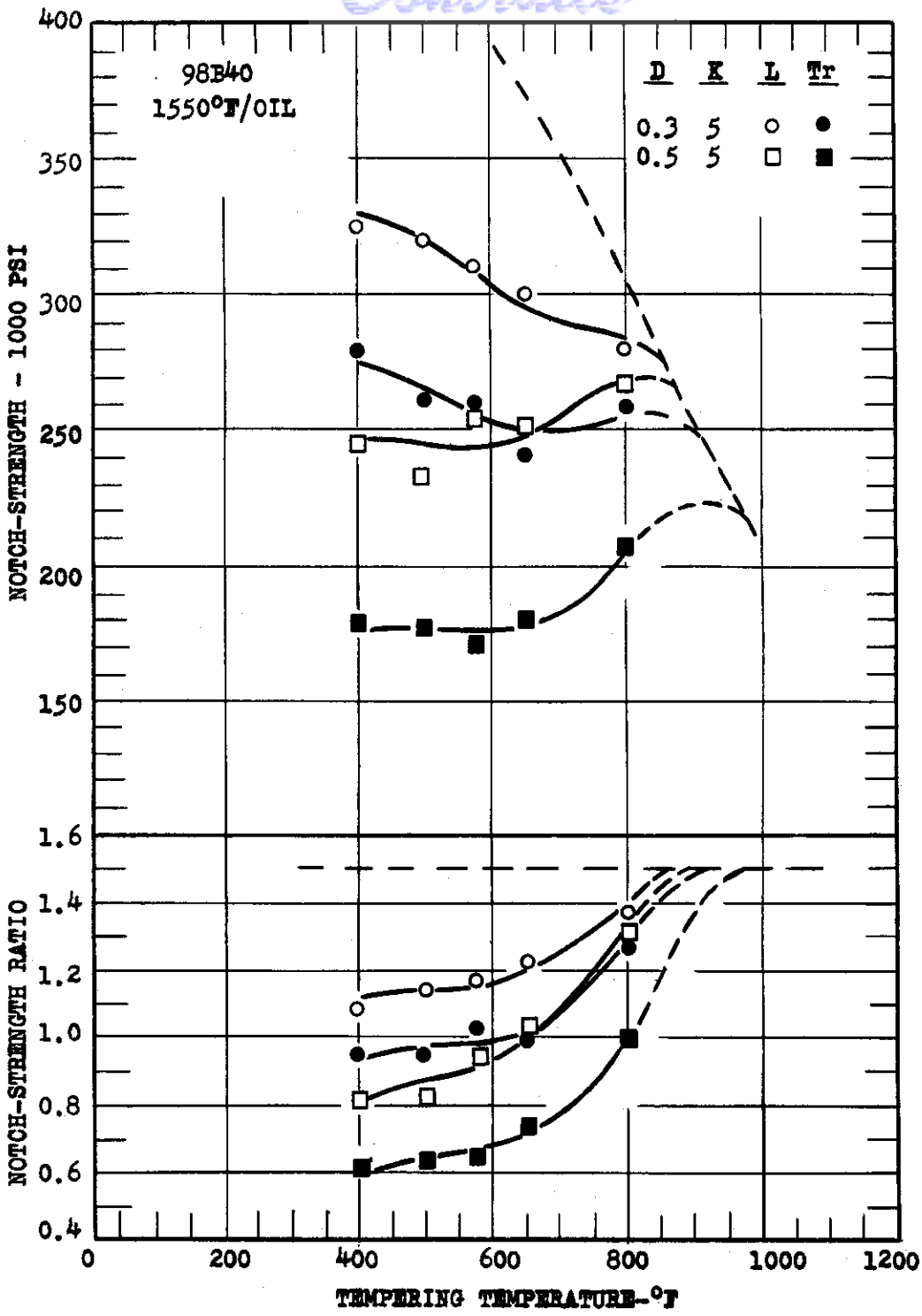


FIG. 105 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4⅛ IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R. T.

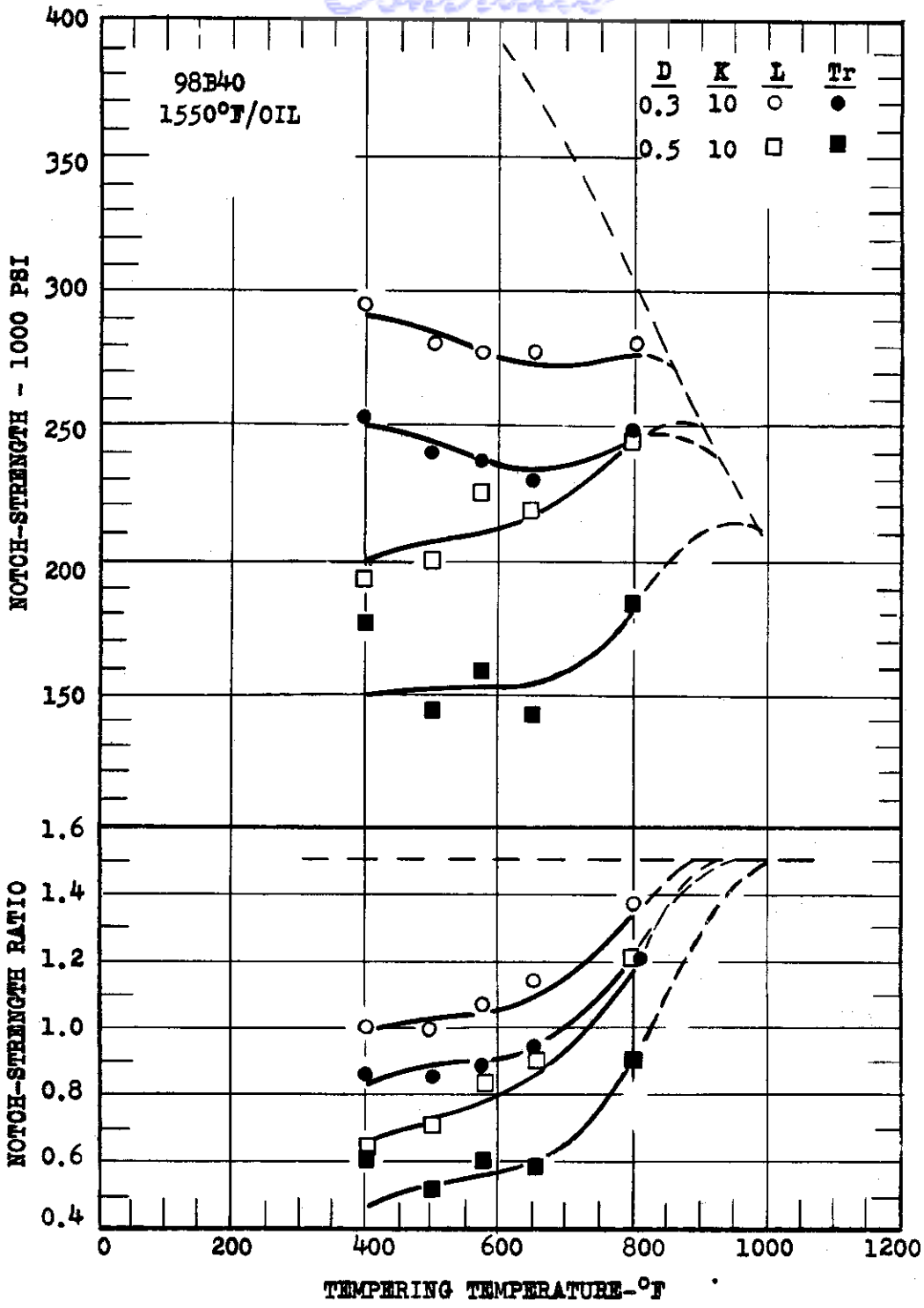


FIG. 106 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

TEST TEMP: R.T.

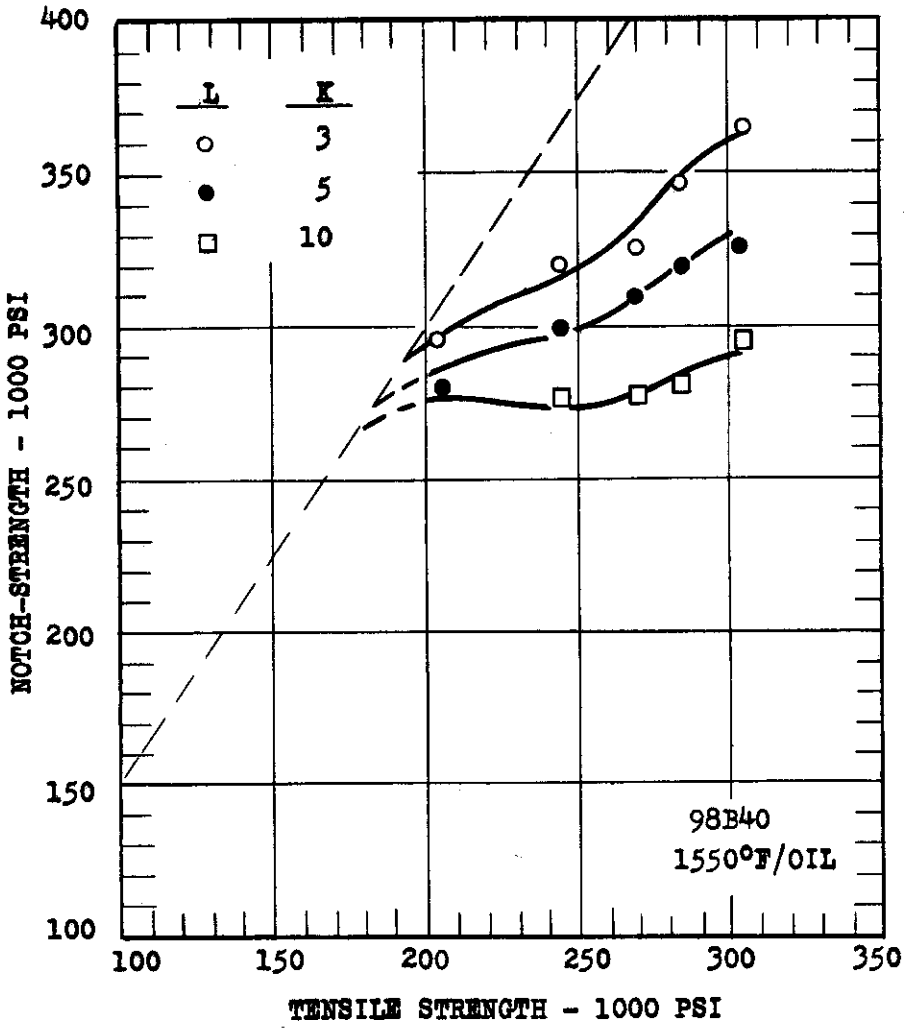


FIG. 107 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP. R.T.

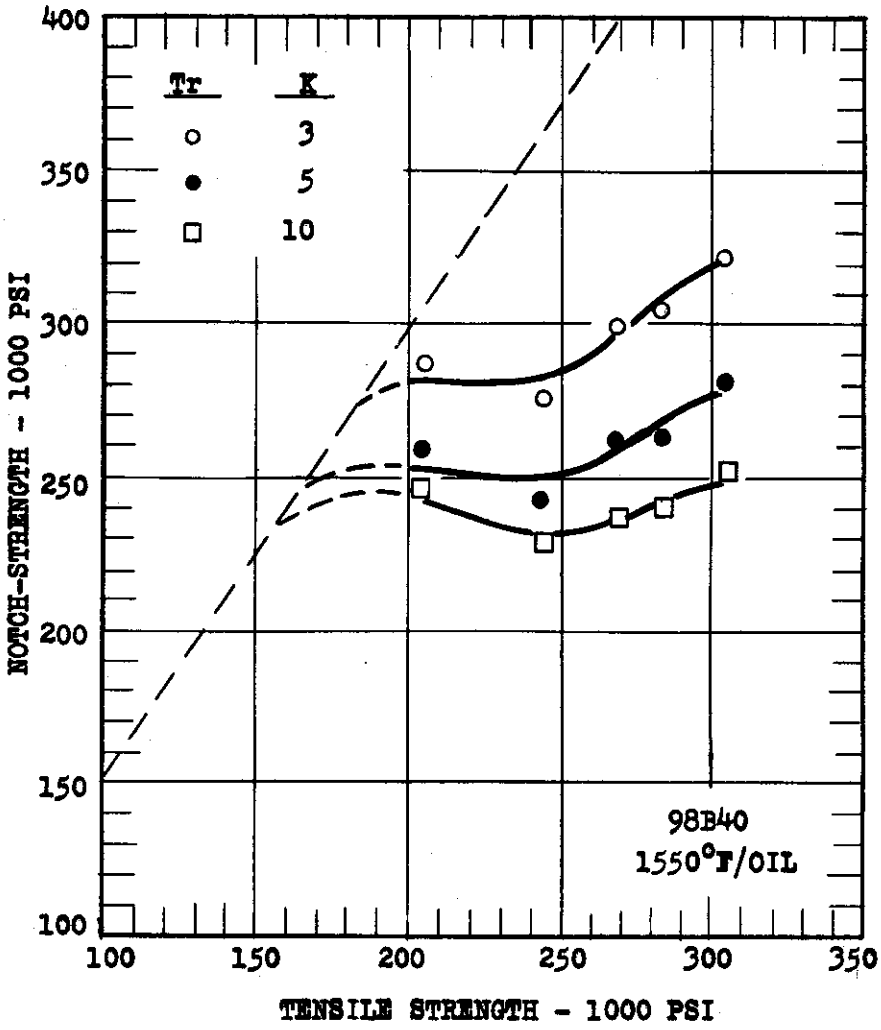


FIG. 108 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

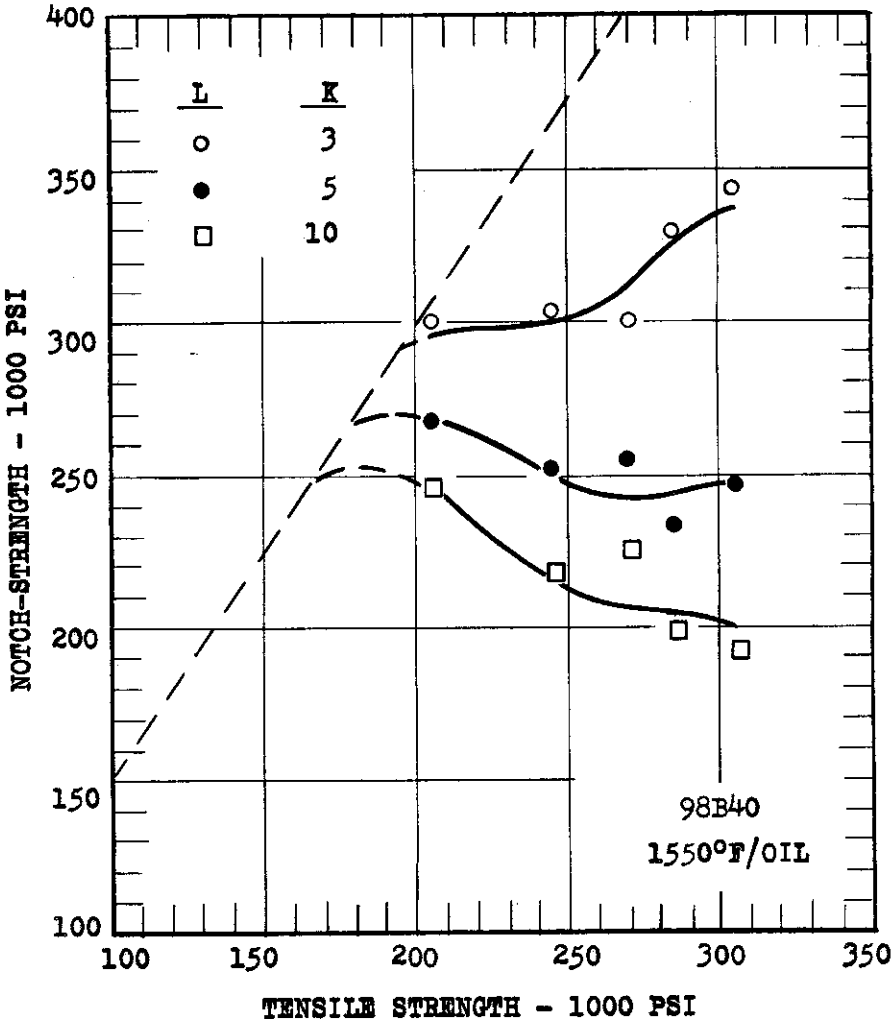


FIG.109 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

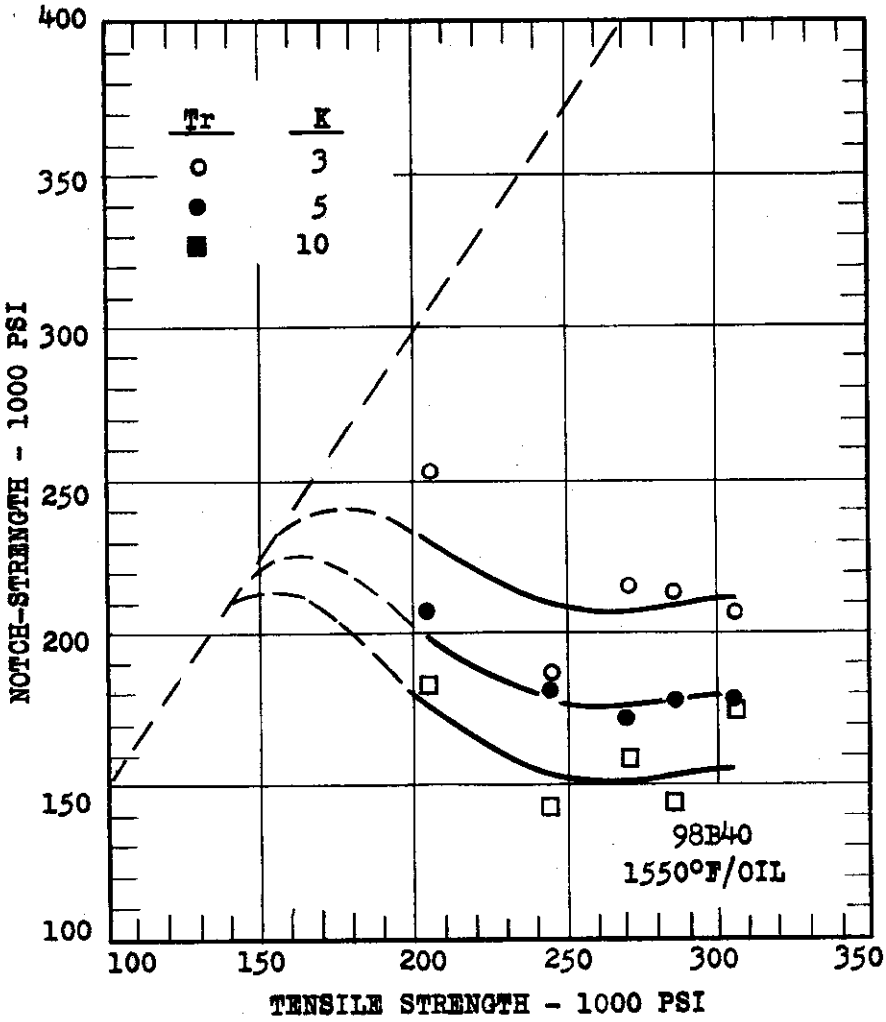


FIG. 110 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP:R.T.

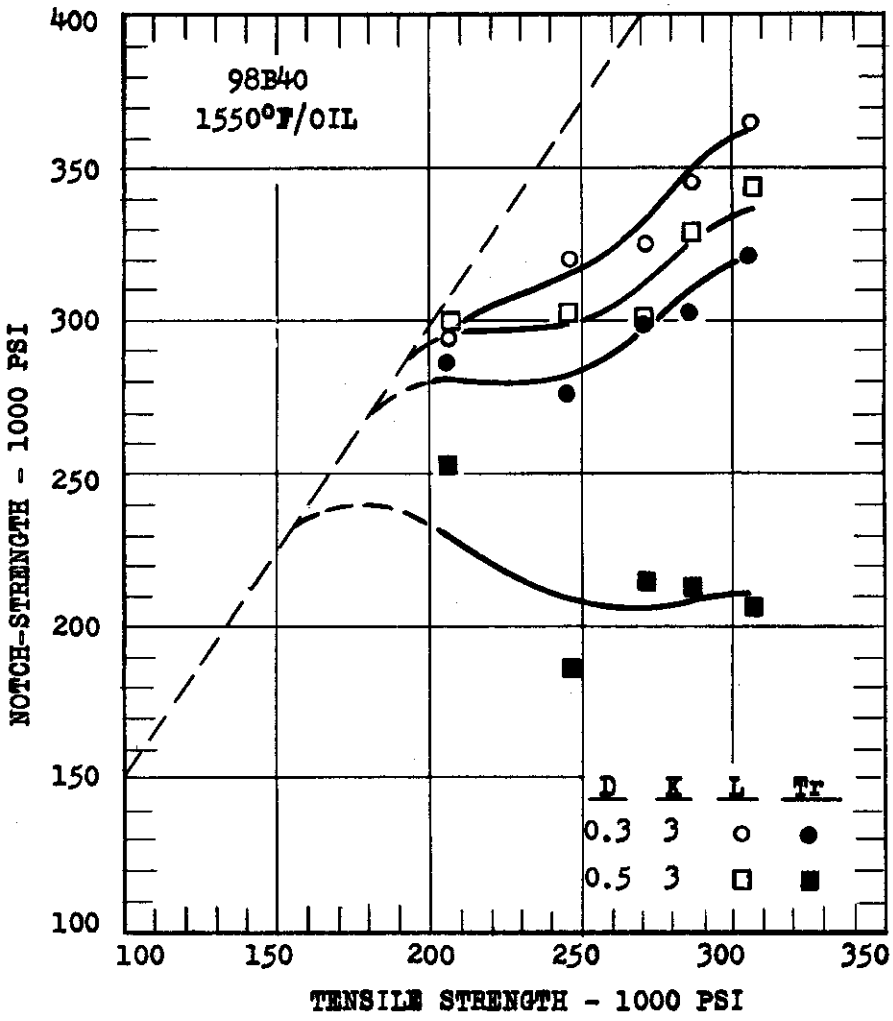


FIG. 111 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN.DIA.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

TEST TEMP: R.T.

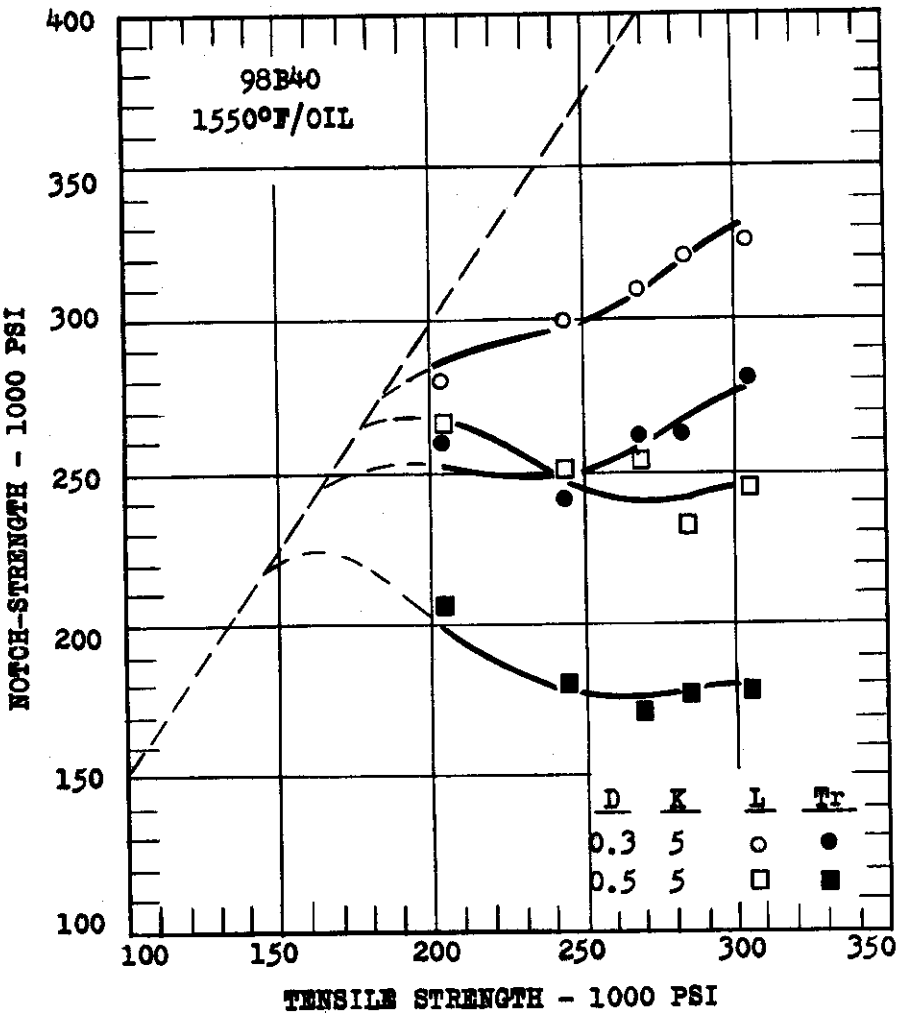


FIG. 112 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: $4\frac{1}{2}$ IN.DIA.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

REST TEMP: R.T.

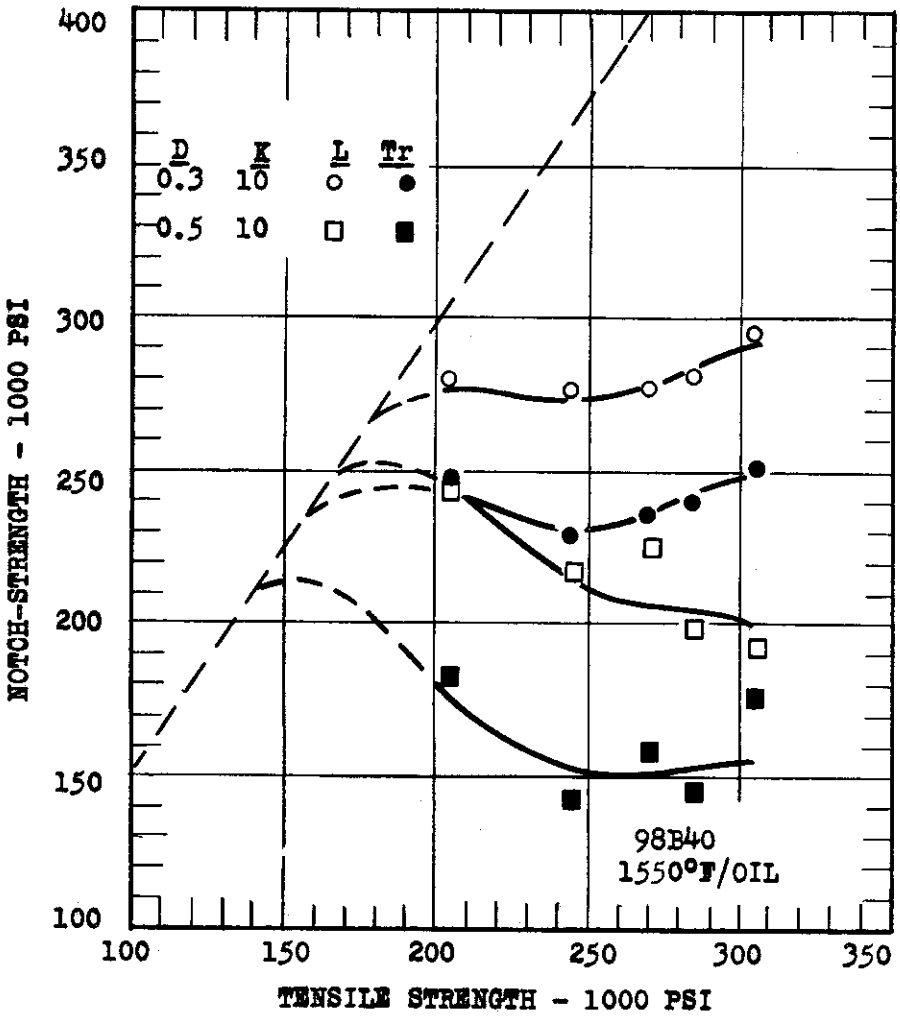


FIG. 113 NOTCH -STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN. DIA.

SPECIMEN: 0.3 and 0.5

TEST TEMP: R.T.

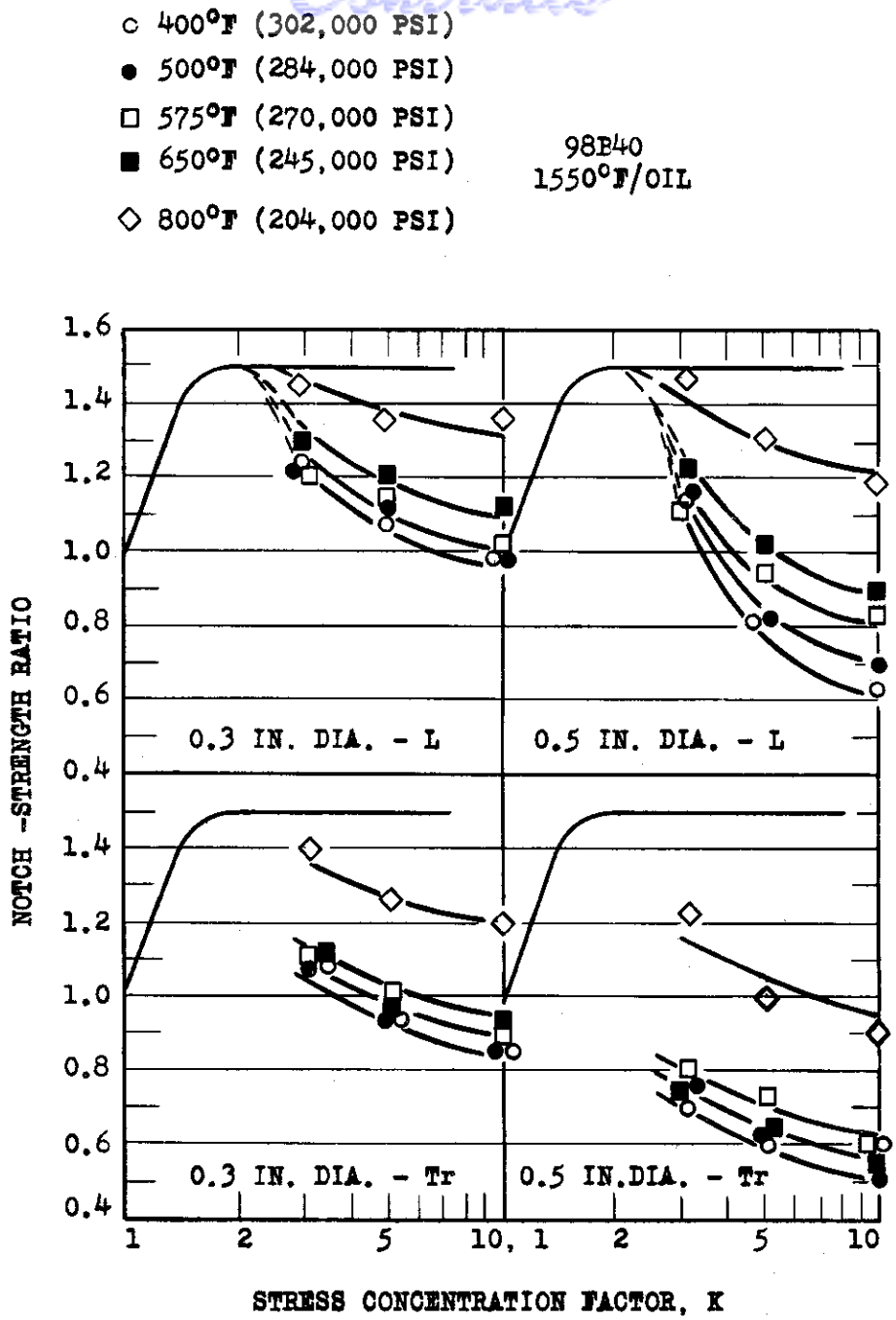


FIG. 114 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 4½ IN. DIA.

TEST TEMP: R.T.

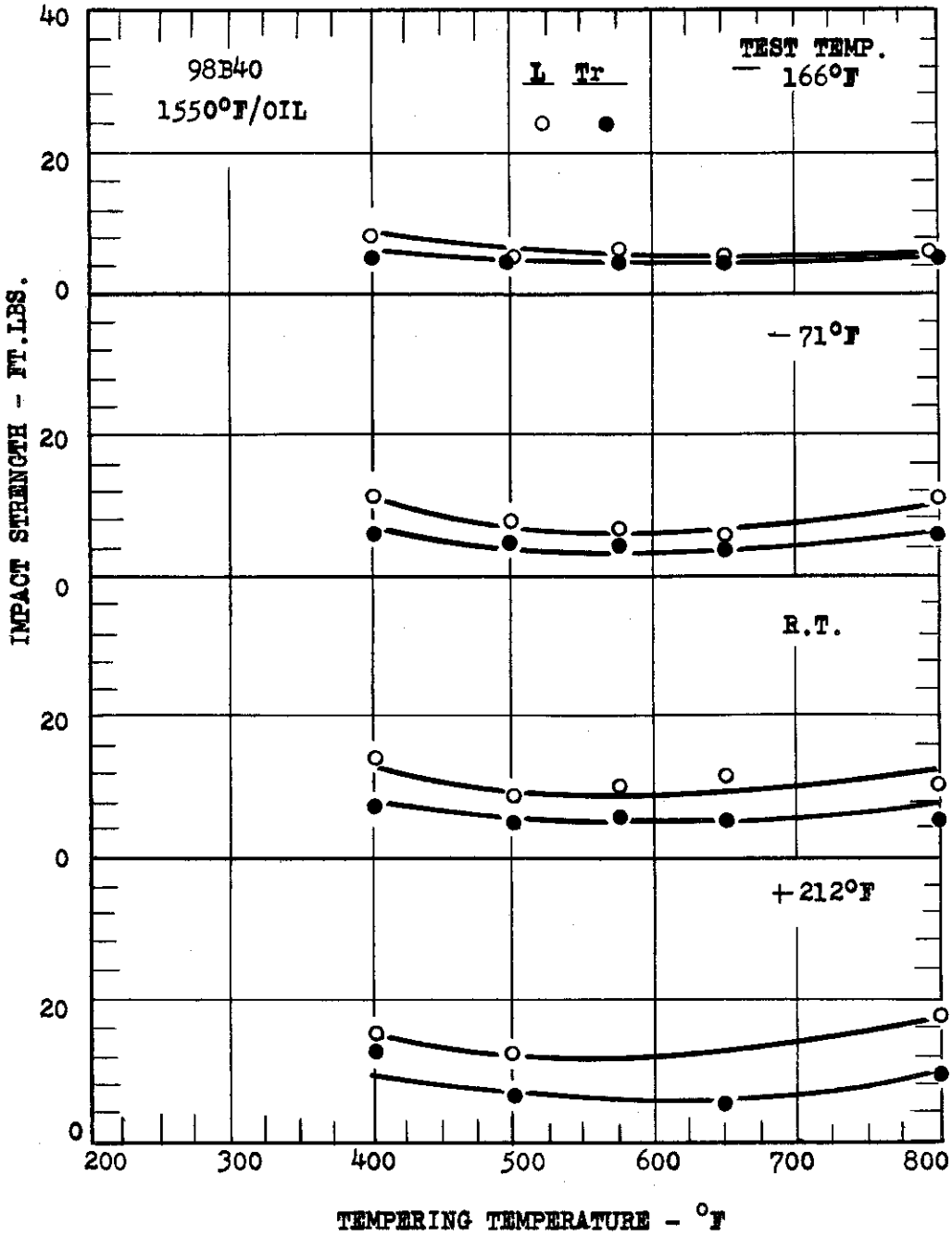


FIG. 115 VARIATION OF IMPACT STRENGTH WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN.DIA.

SPECIMEN: STD. V-NOTCH CHARPY

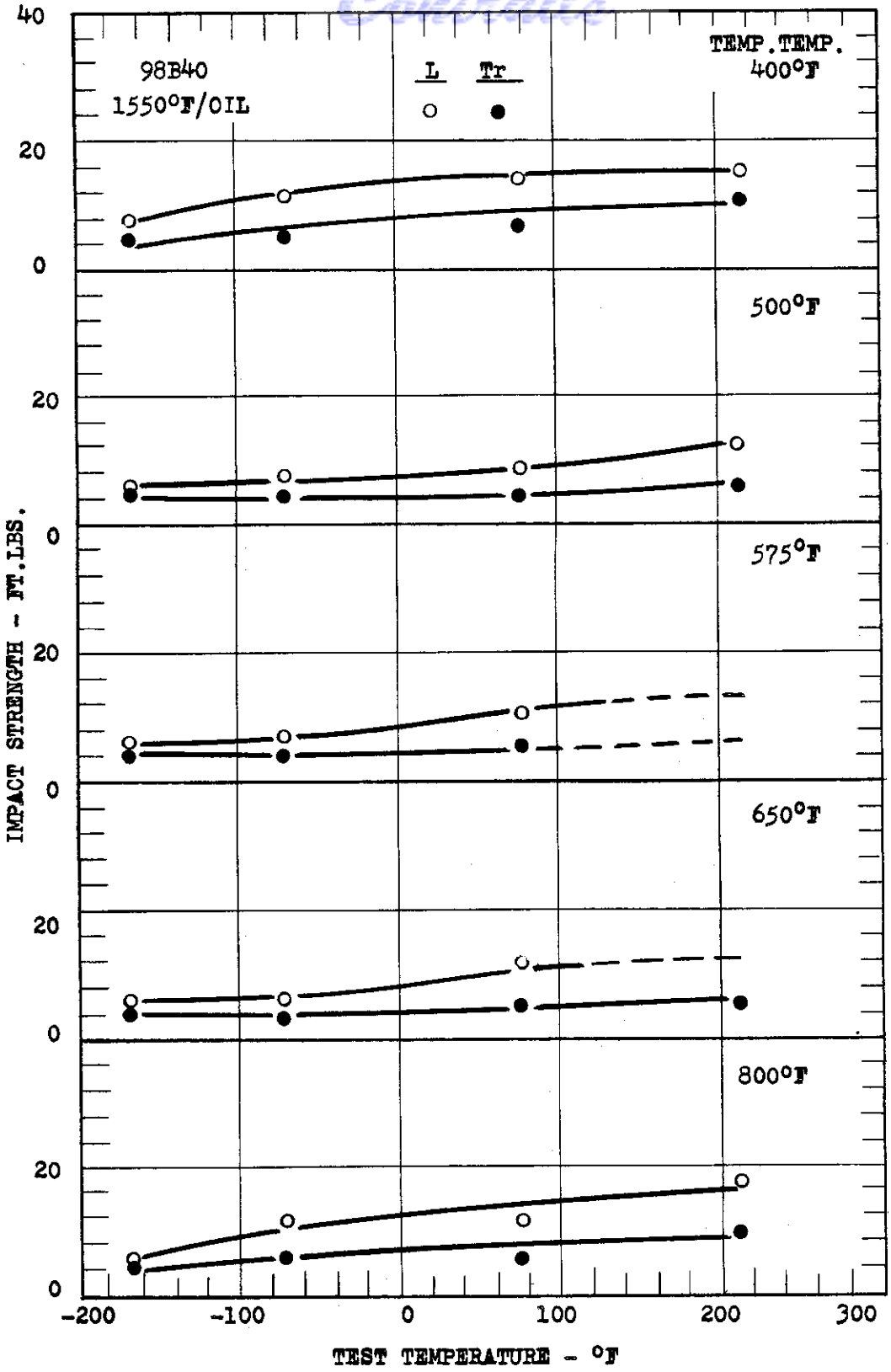


FIG. 116 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE

SECTION: 4½ IN.DIA.

SPECIMEN: STD. V-NOTCH CHARPY

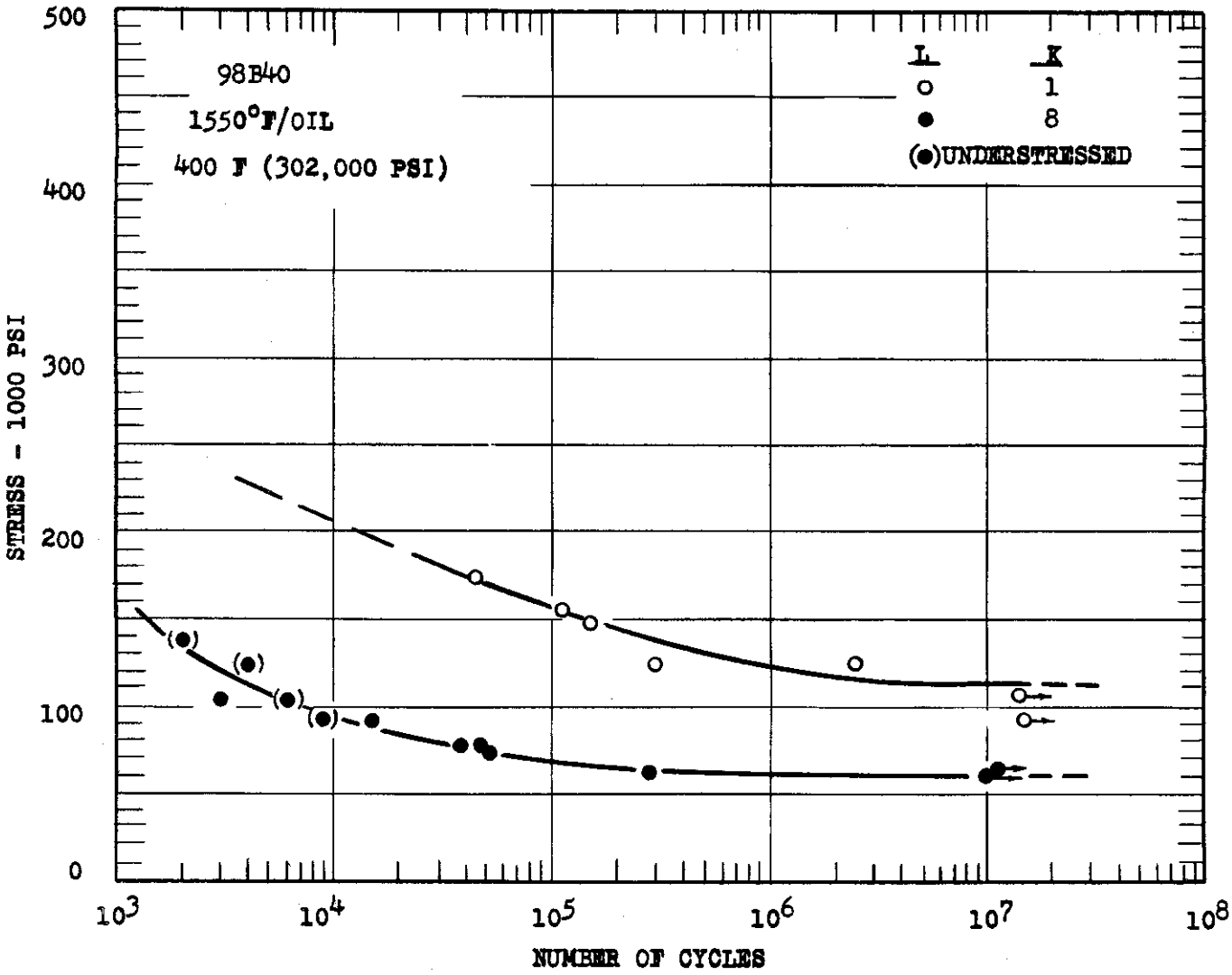


FIG. 117 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4½ IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

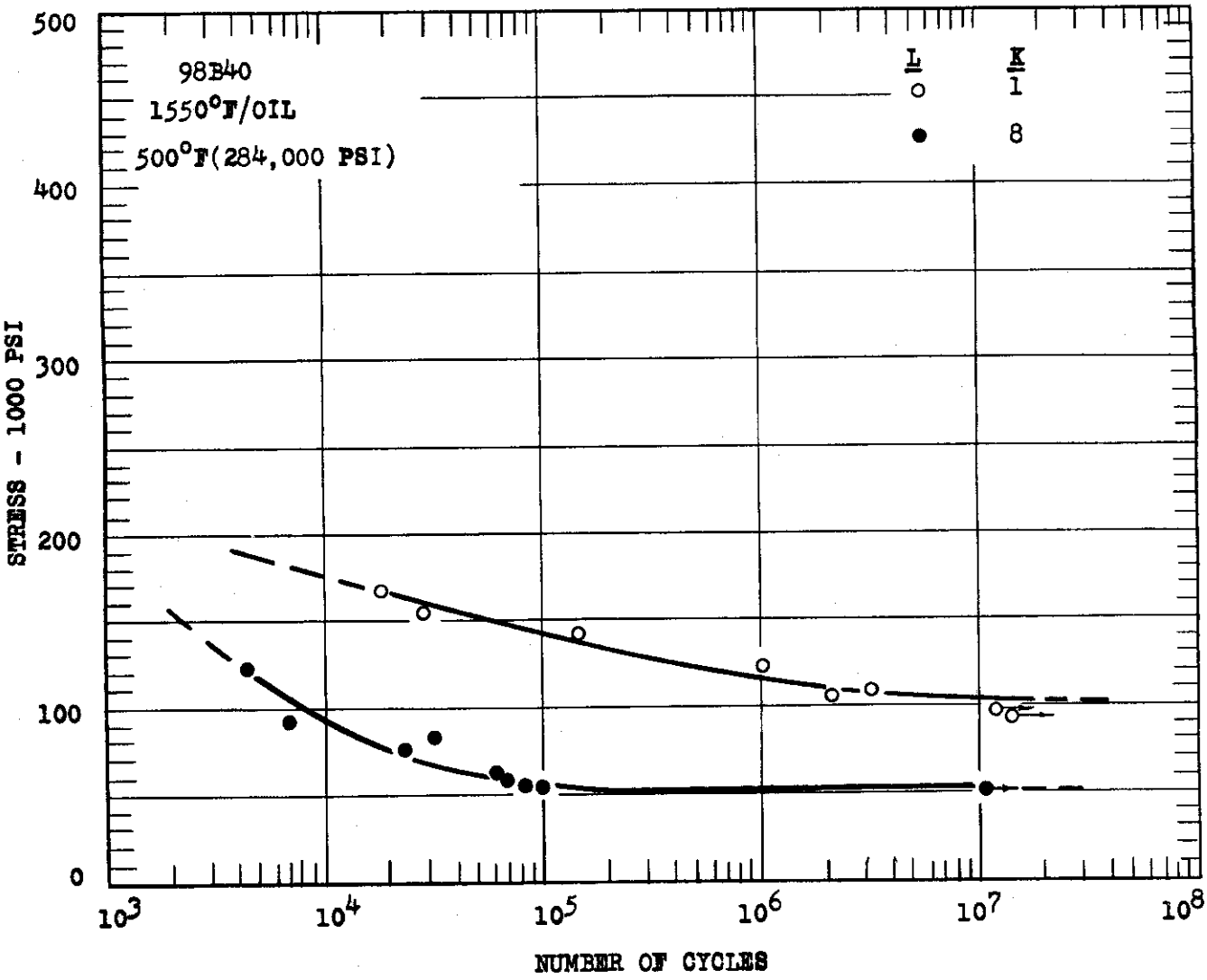


FIG. 118 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4½ IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

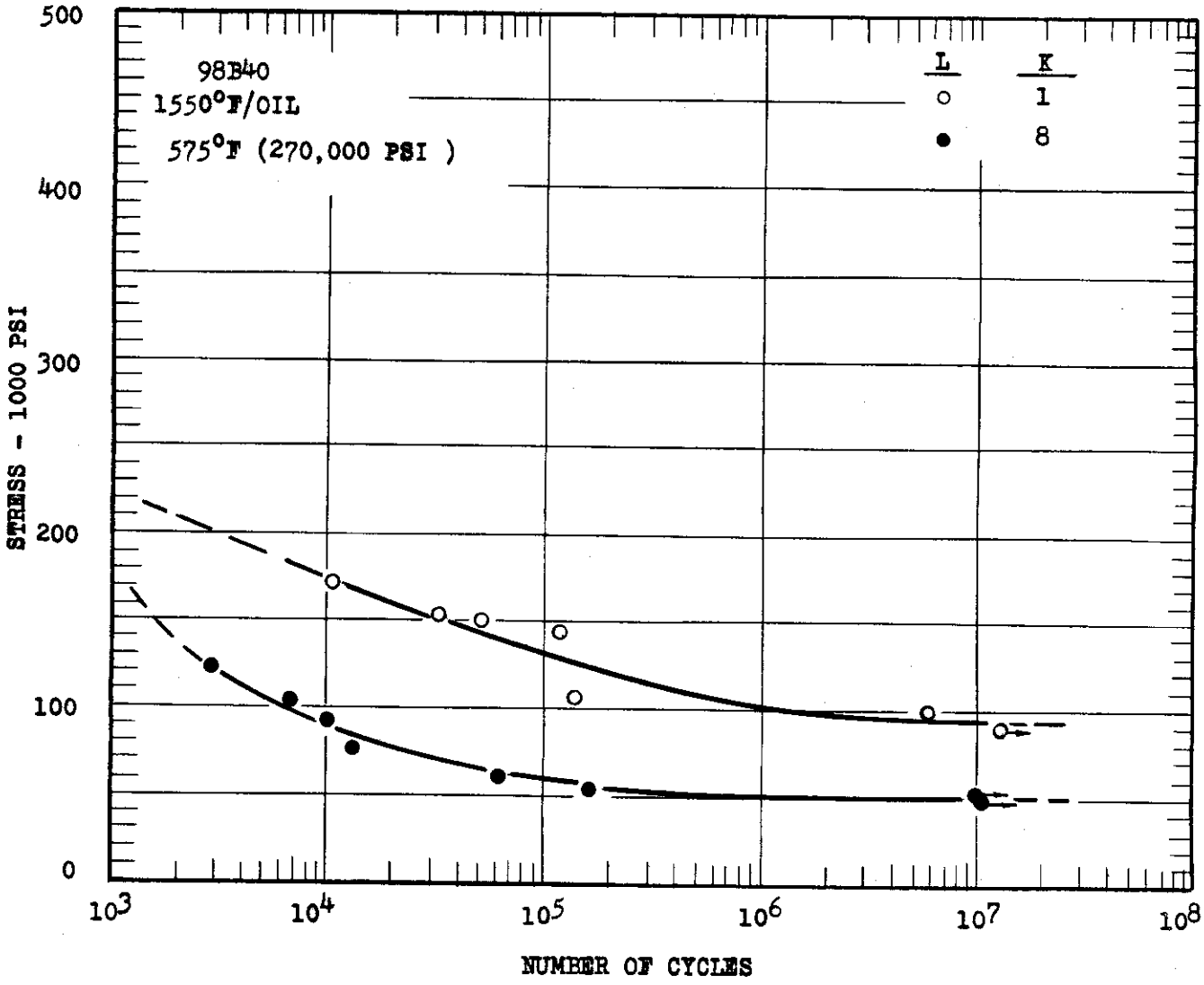


FIG. 119 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: $4\frac{1}{8}$ IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

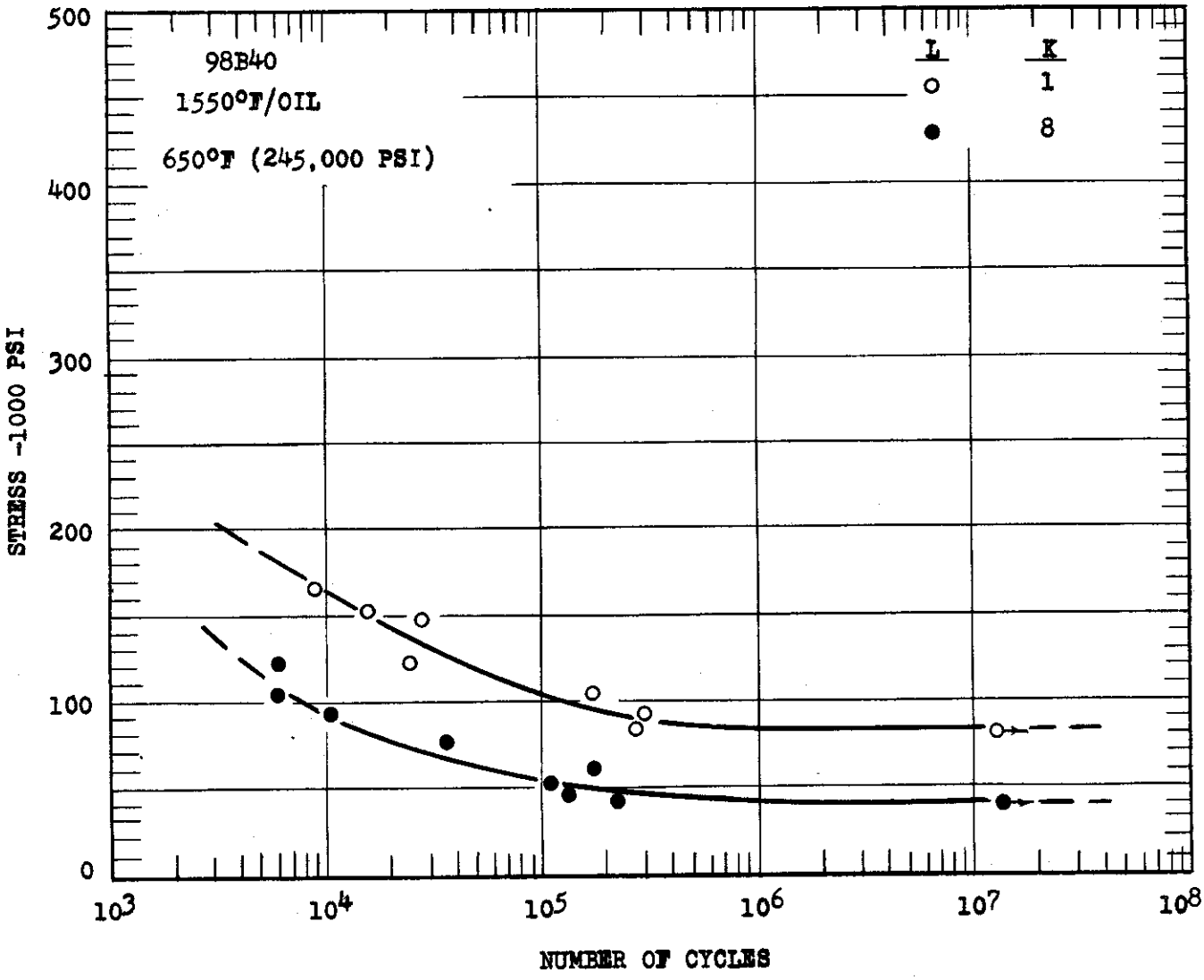


FIG. 120 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4½ IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

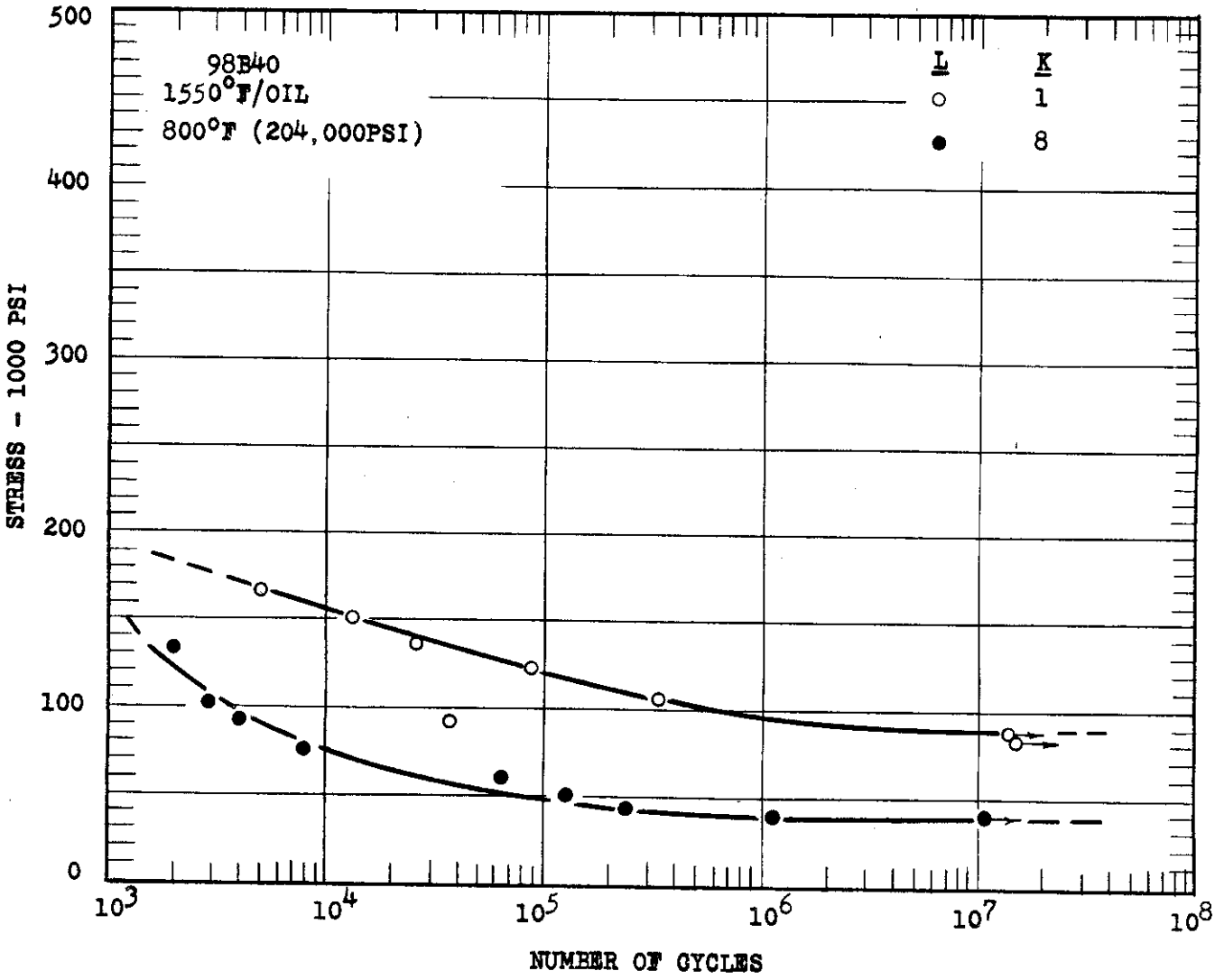


FIG. 121 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SPECIMEN: ROTATING BEAM TYPE

SECTION: 4⅛ IN.DIA.

TEST TEMP: R.T.

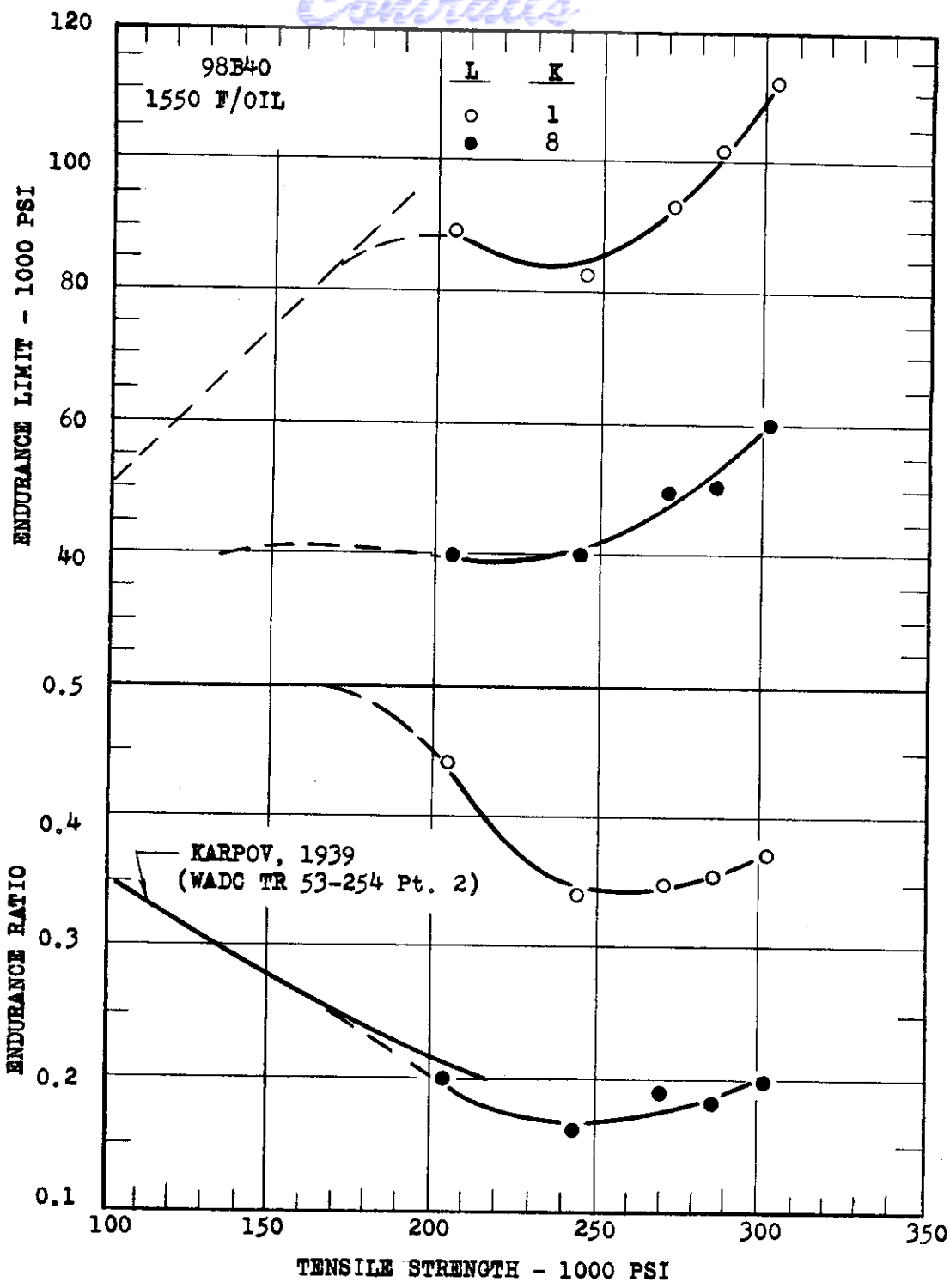


FIG. 122 VARIATION OF ENDURANCE LIMIT AND ENDURANCE RATIO WITH TENSILE STRENGTH.

SECTION: $4\frac{1}{2}$ IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP:R.T.

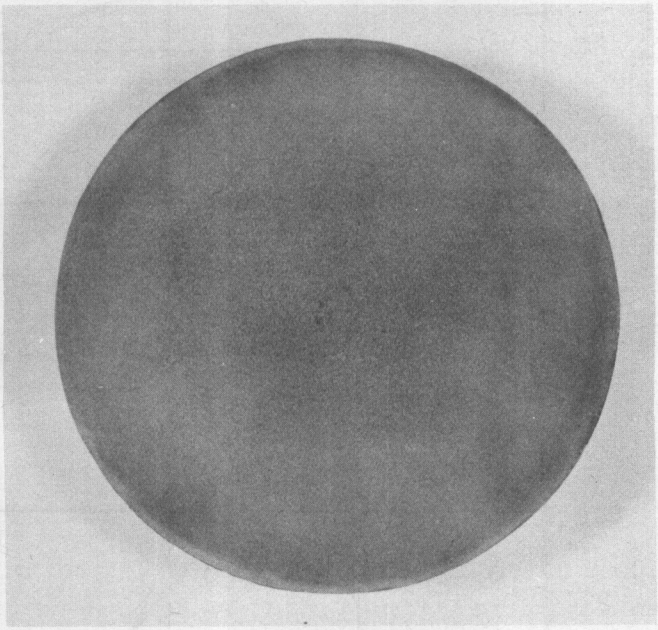
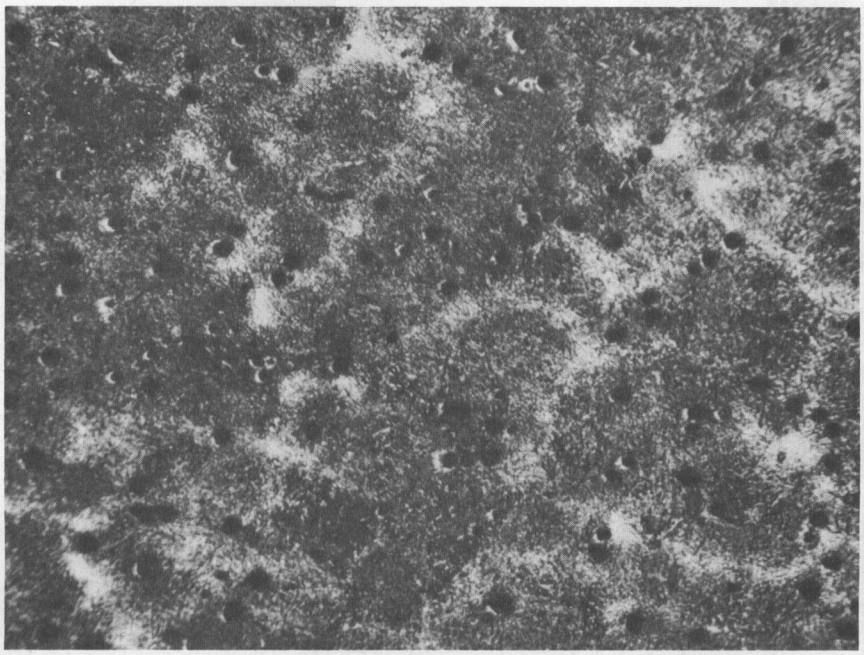
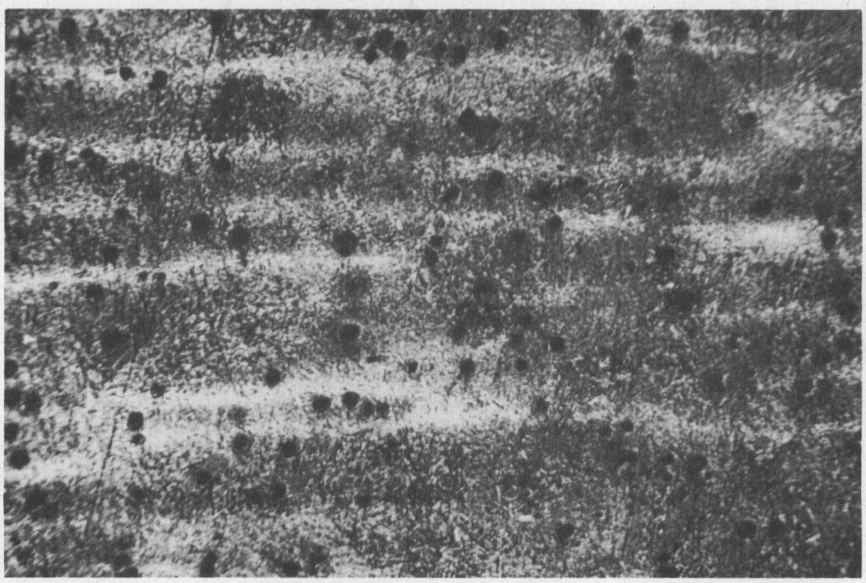


FIG. 123 MICROGRAPH OF SUPER HY-TUF STEEL AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) Transverse Pattern



(b) Longitudinal Pattern

FIG.124 PHOTOMICROGRAPHS OF SUPER HY-TUF STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

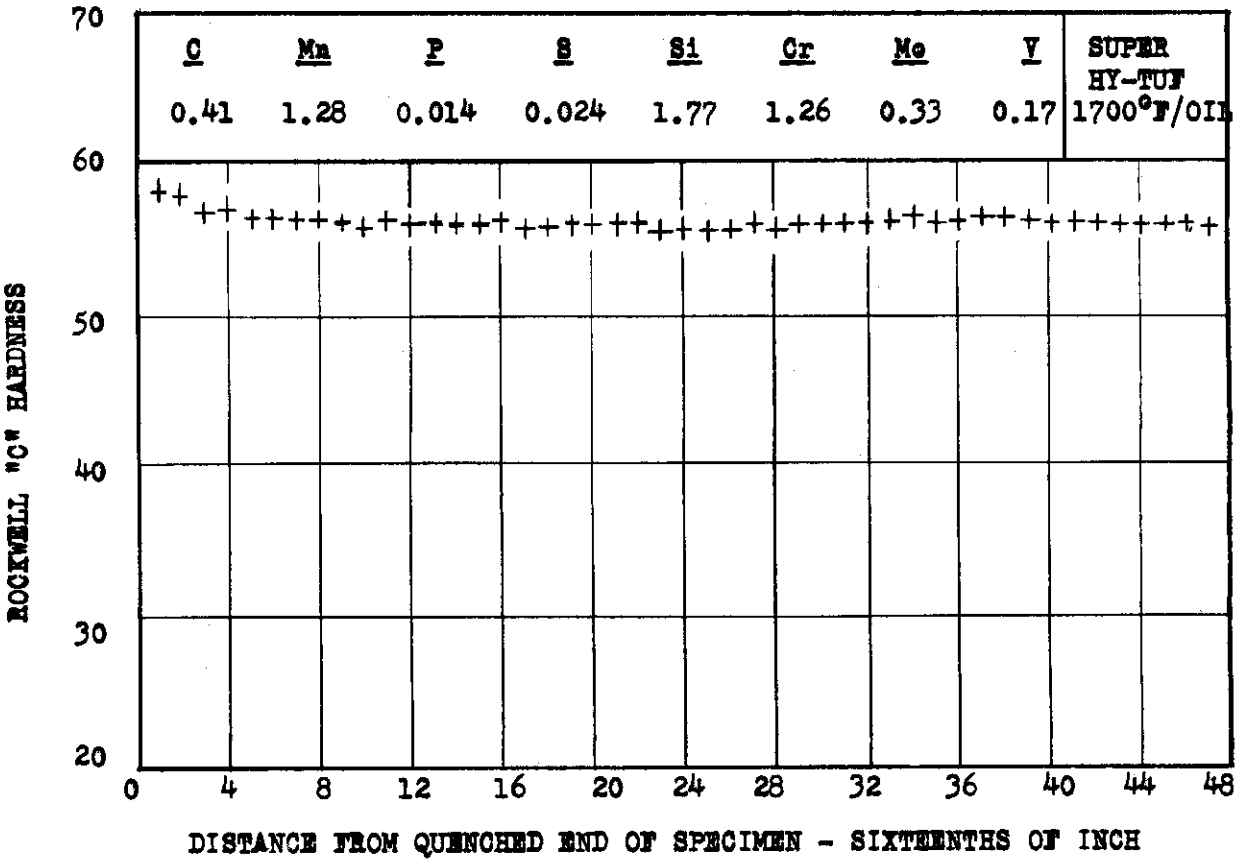


FIG. 125 HARDENABILITY OF JOMINY - QUENCH BAR.

SECTION: 3 IN.DIA.

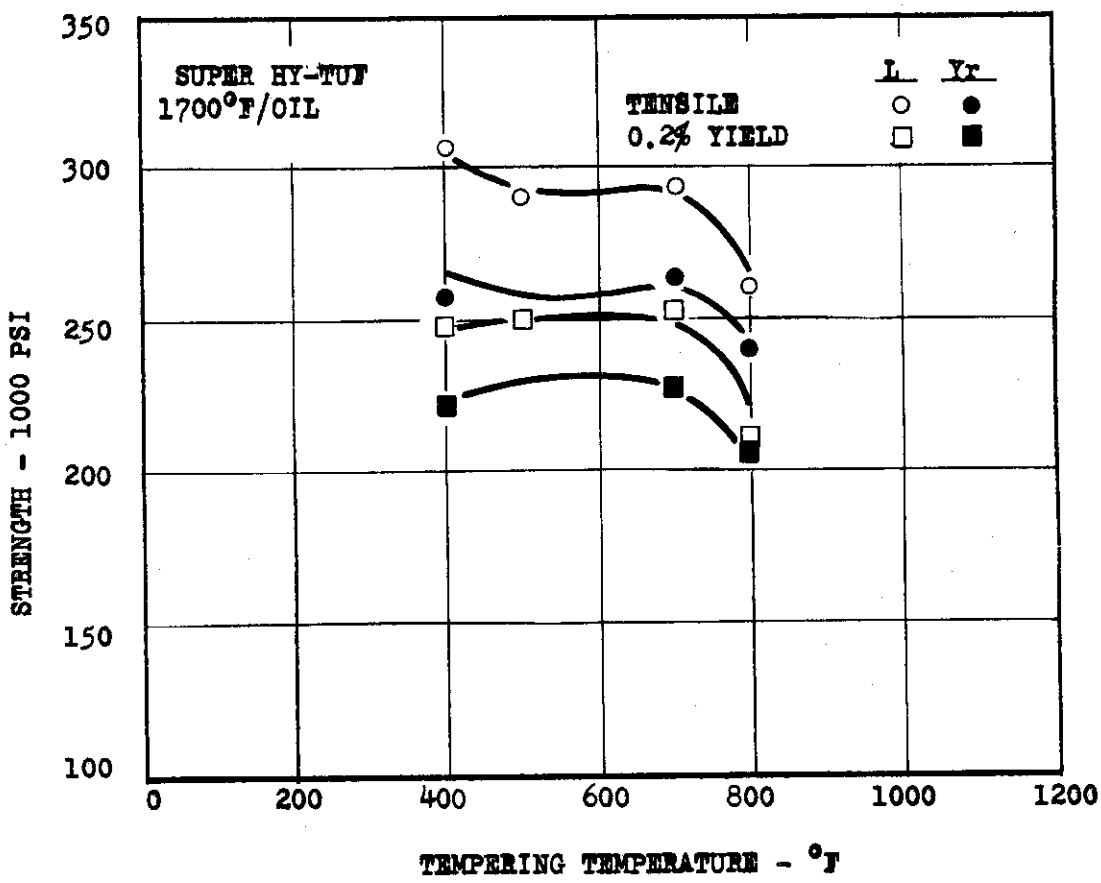


FIG. 126 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

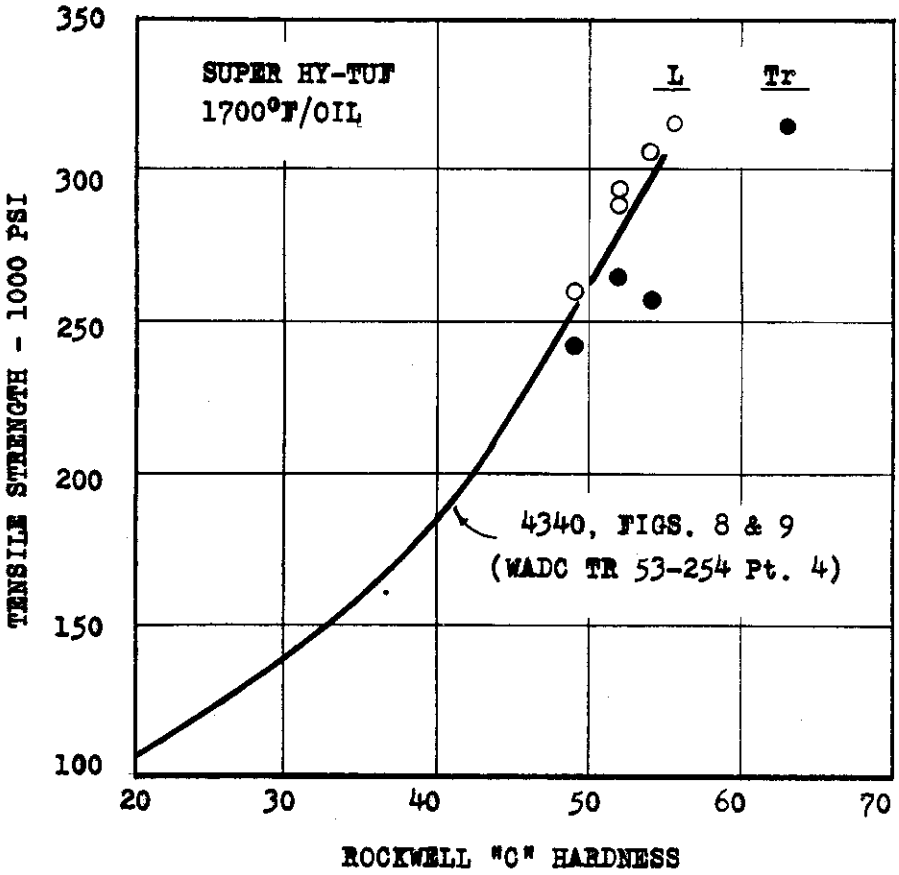


FIG. 127 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

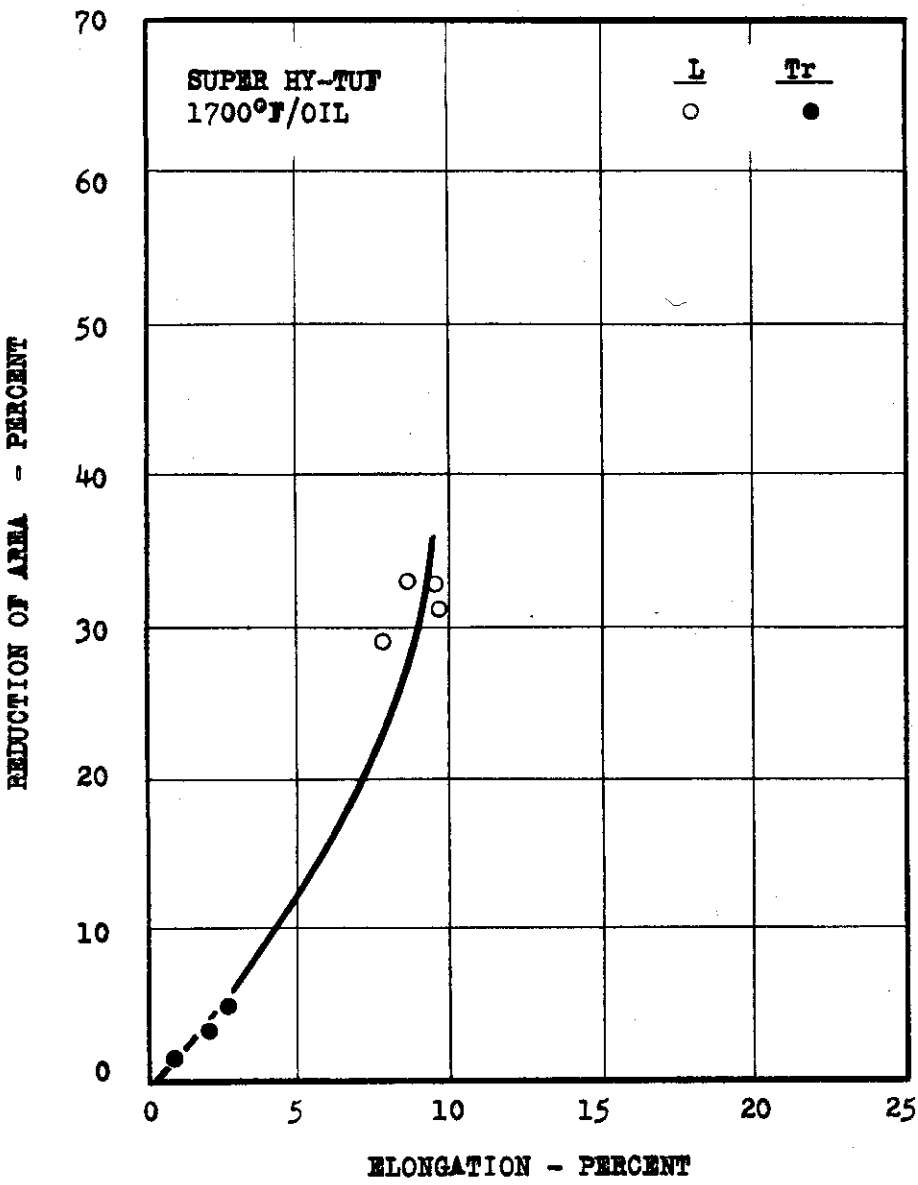


FIG. 128 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

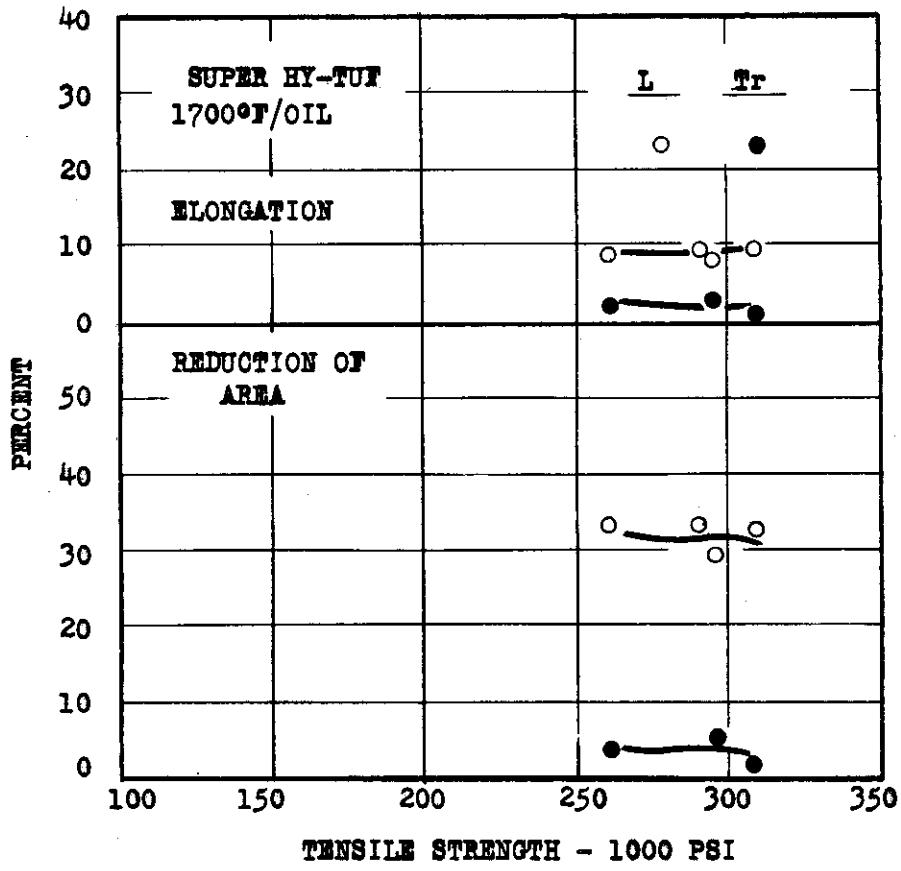


FIG. 129 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

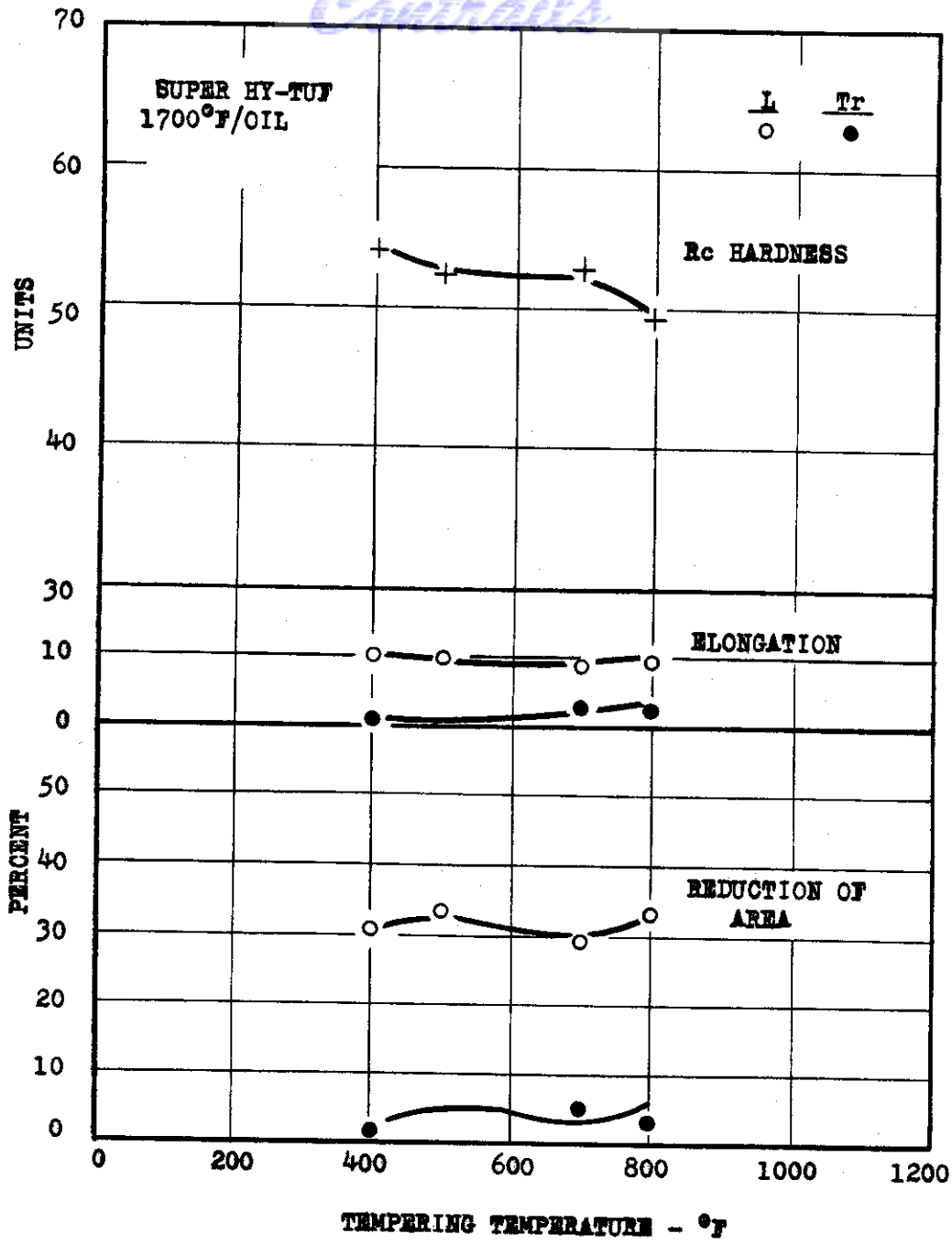


FIG. 130 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

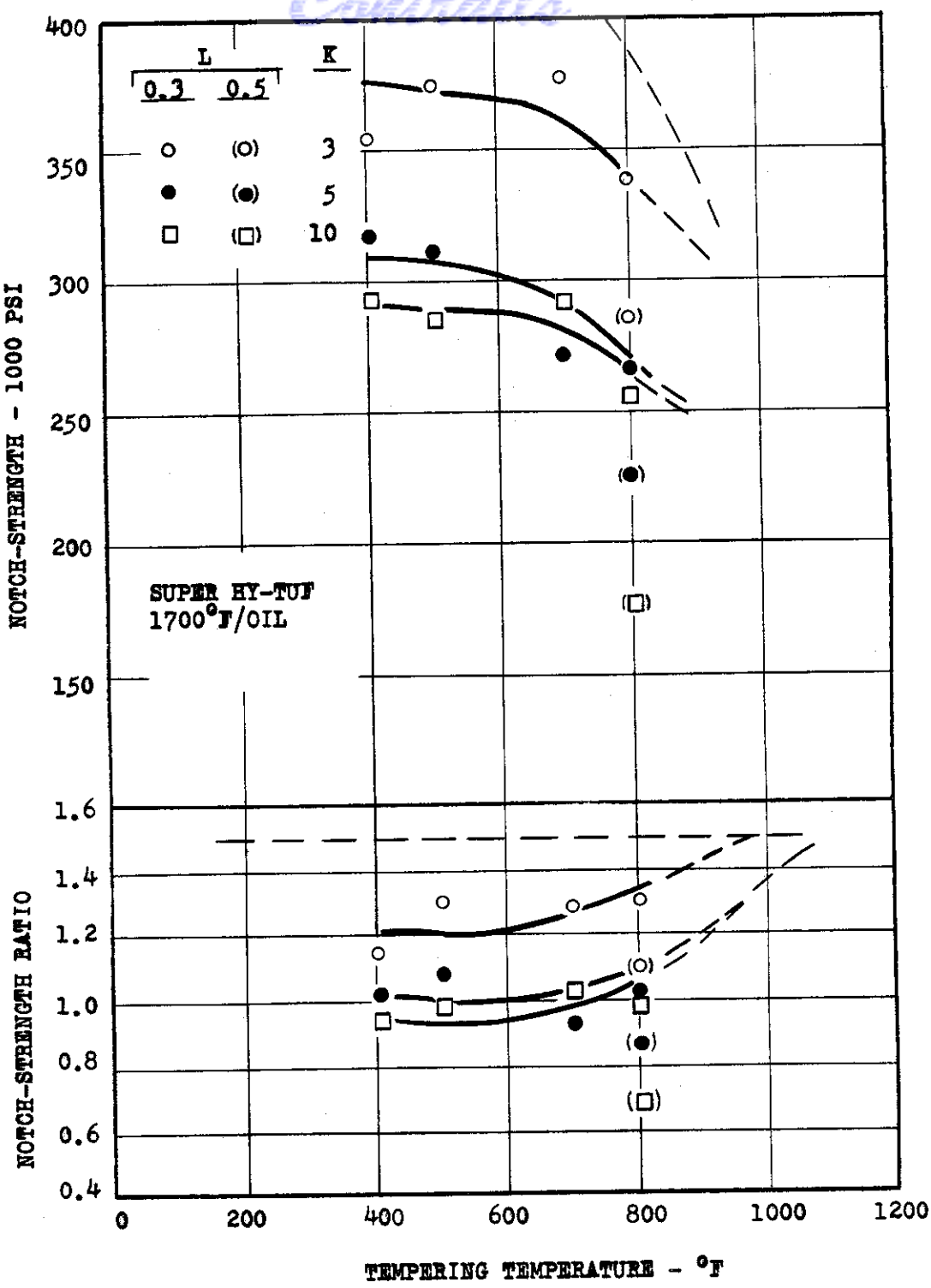


FIG. 131 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

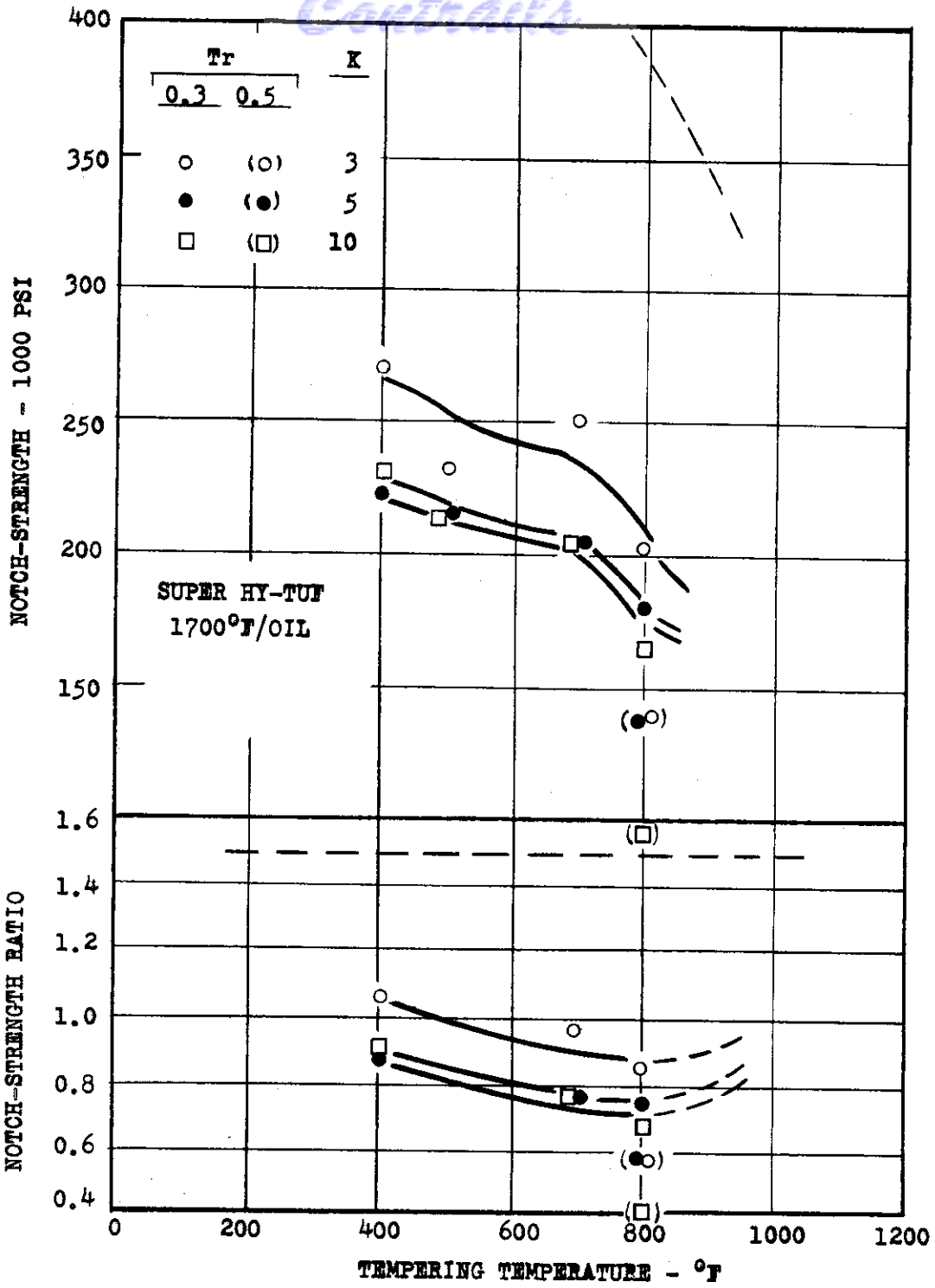


FIG. 132 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

TEST TEMP: R.T.

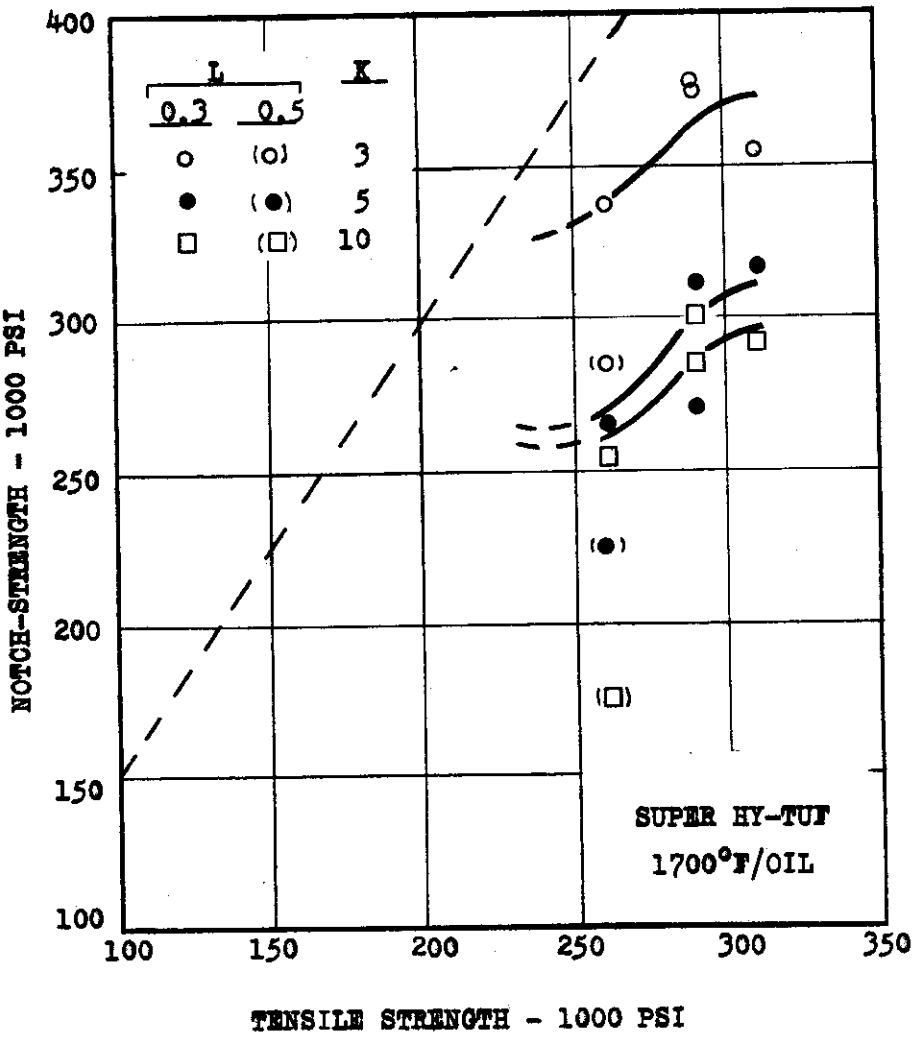


FIG. 133 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

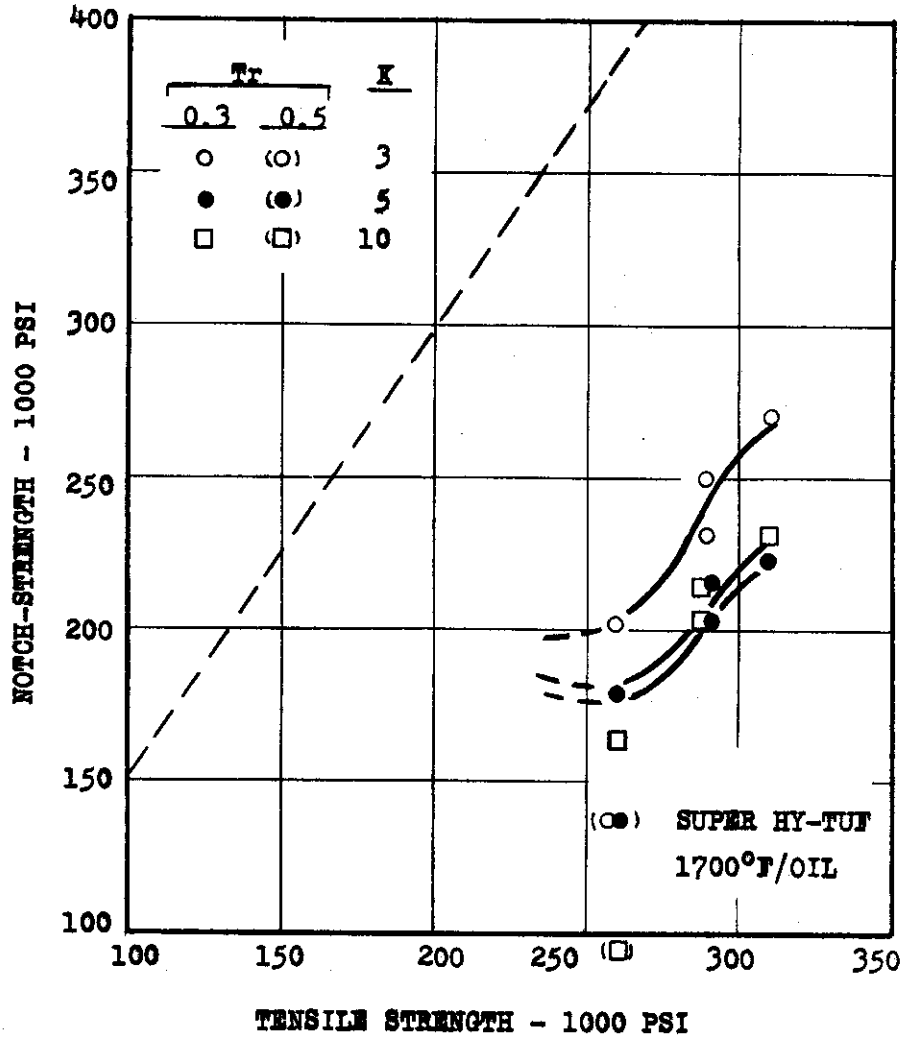


FIG. 134 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

○ 400°F (307,000 PSI)

● 500°F (290,000 PSI) SUPER HY-TUF

□ 700°F (294,000 PSI) 1700°F/OIL

■ 800°F (260,000 PSI)

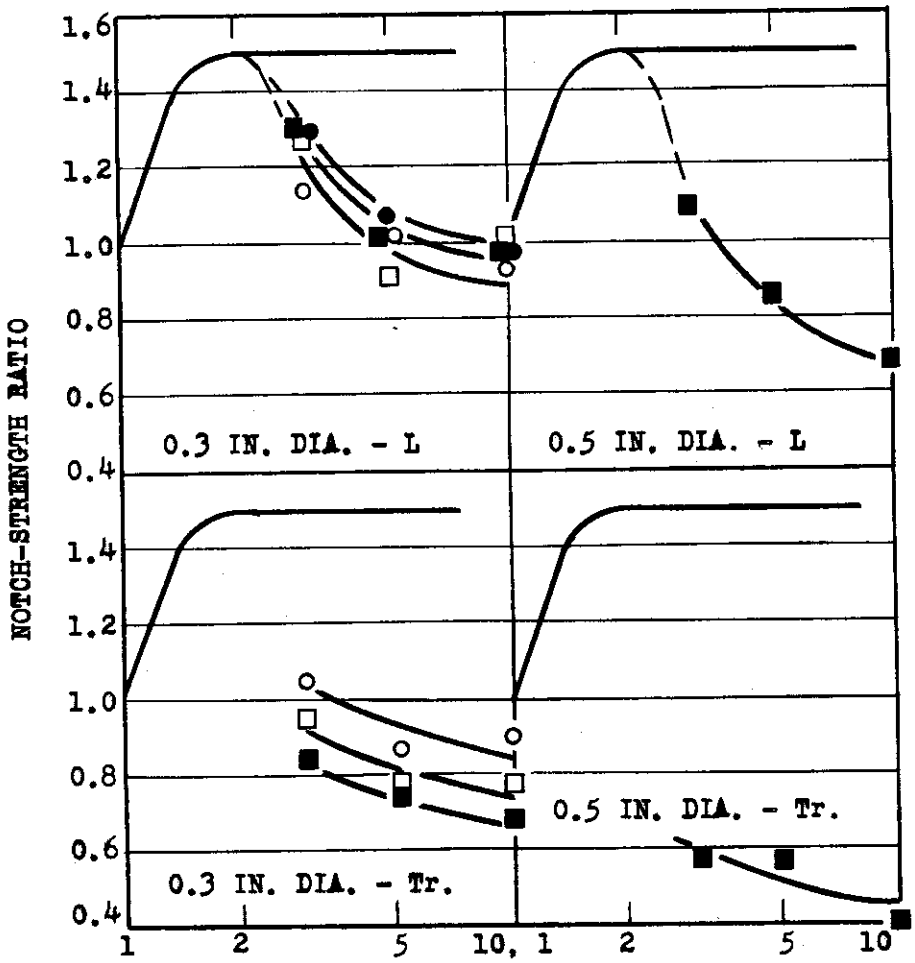


FIG. 135 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 3 IN.DIA.

TEST TEMP: R.T.

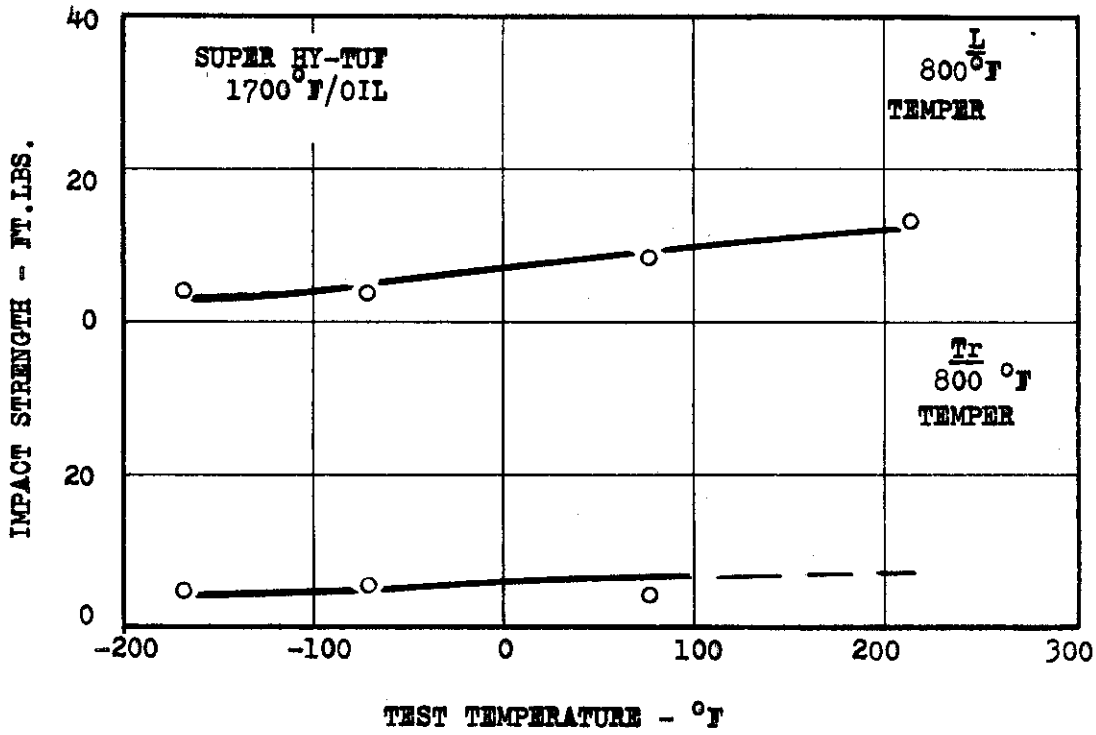


FIG. 136 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: STD. V-NOTCH CHARPY

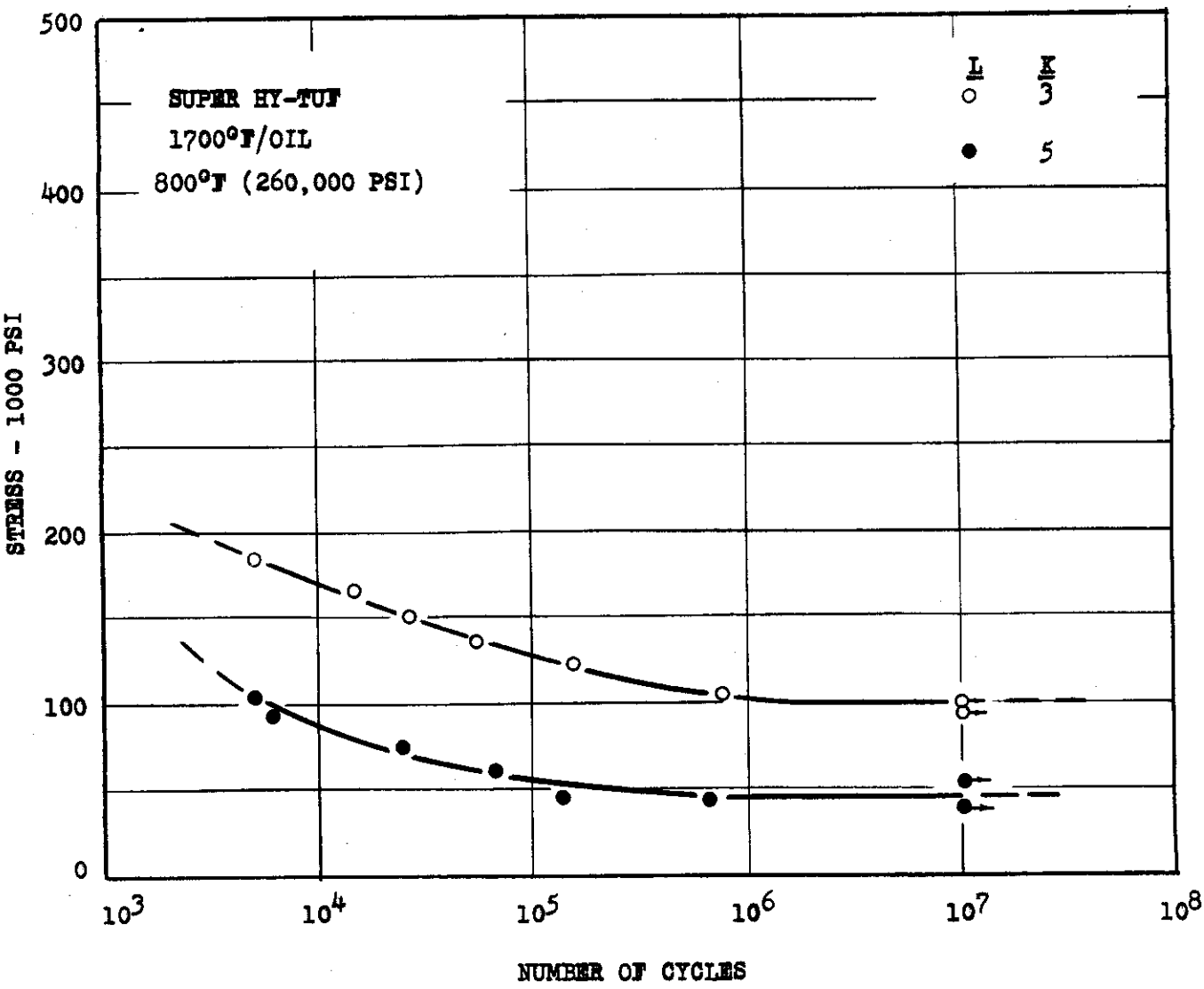


FIG. 137 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 3 IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

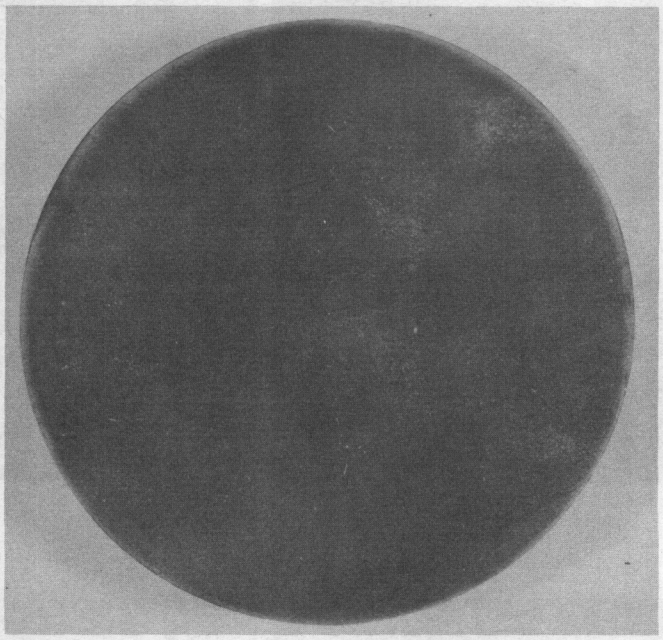
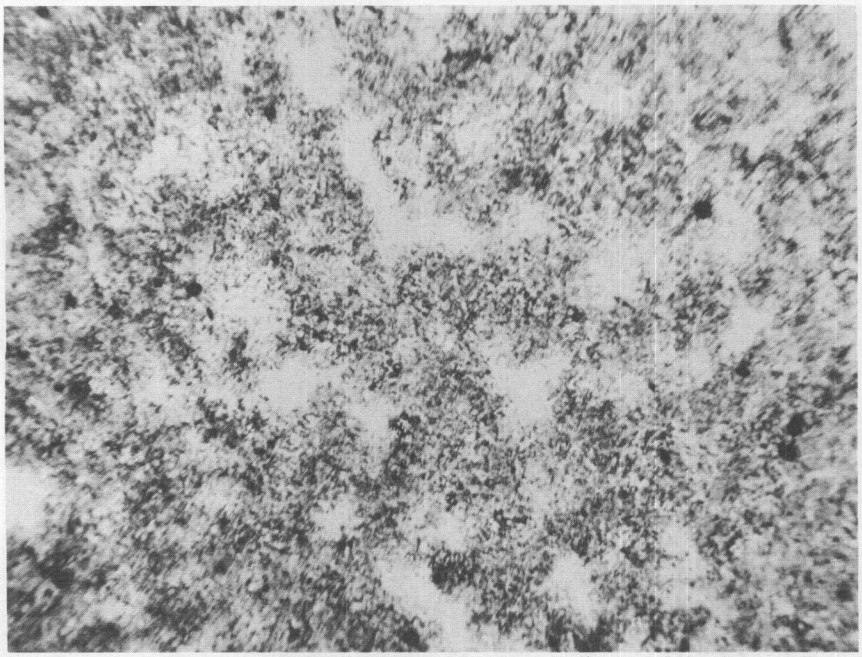
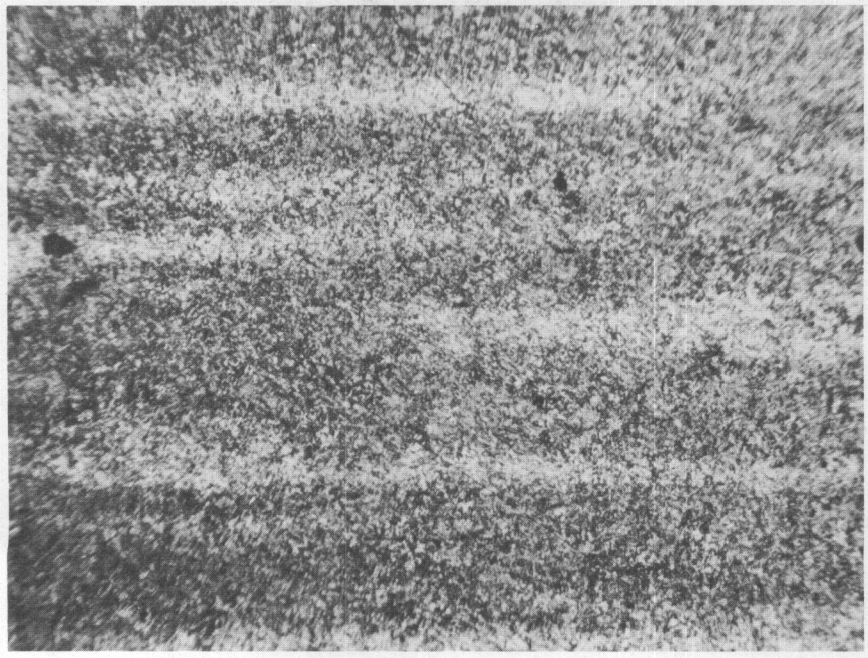


FIG. 138 MACROGRAPH OF SUPER TM-2 STEEL AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) TRANSVERSE PATTERN



(a) LONGITUDINAL PATTERN

FIG. 139 PHOTOMICROGRAPHS OF SUPER TM-2 STEEL, OIL QUENCHED AND TEMPERED AT 5000F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

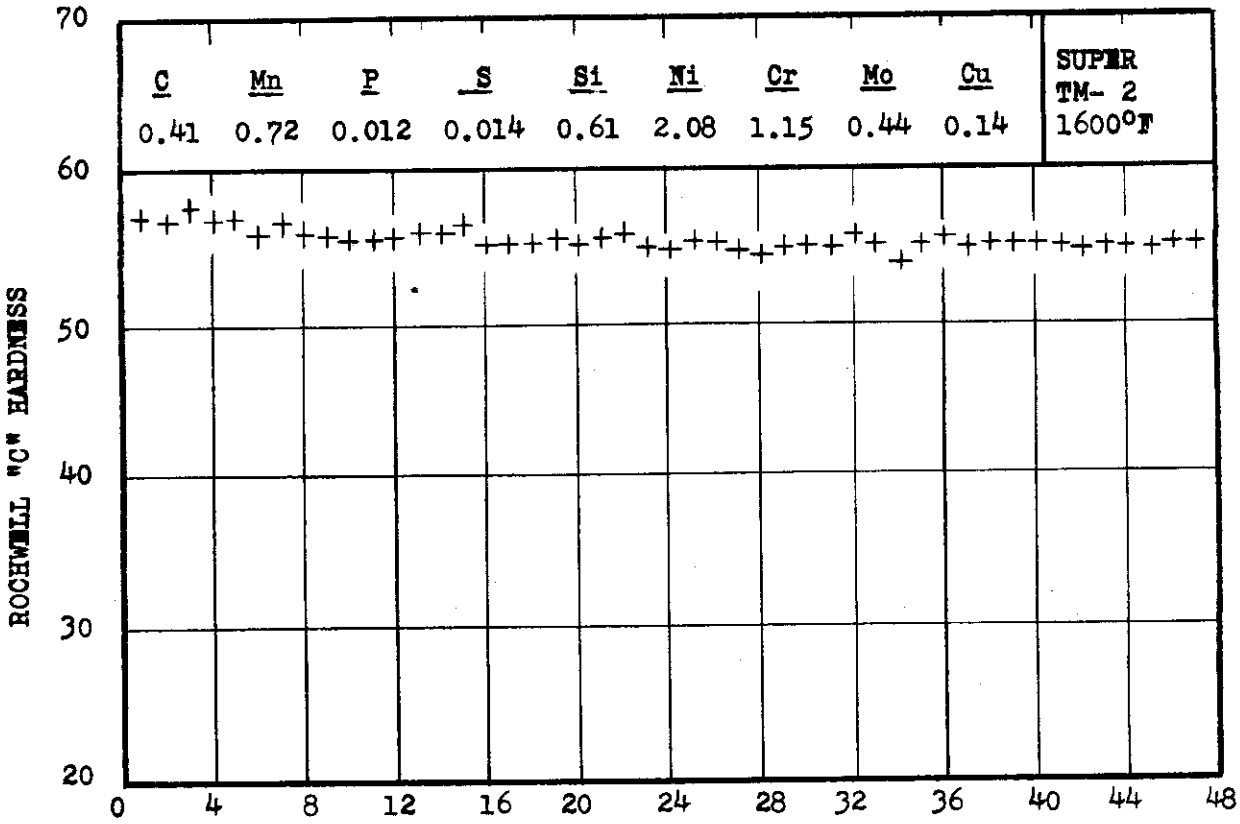


FIG. 140 HARDENABILITY OF JOMINY-QUENCH BAR.

SECTION: 3 IN. DIA.

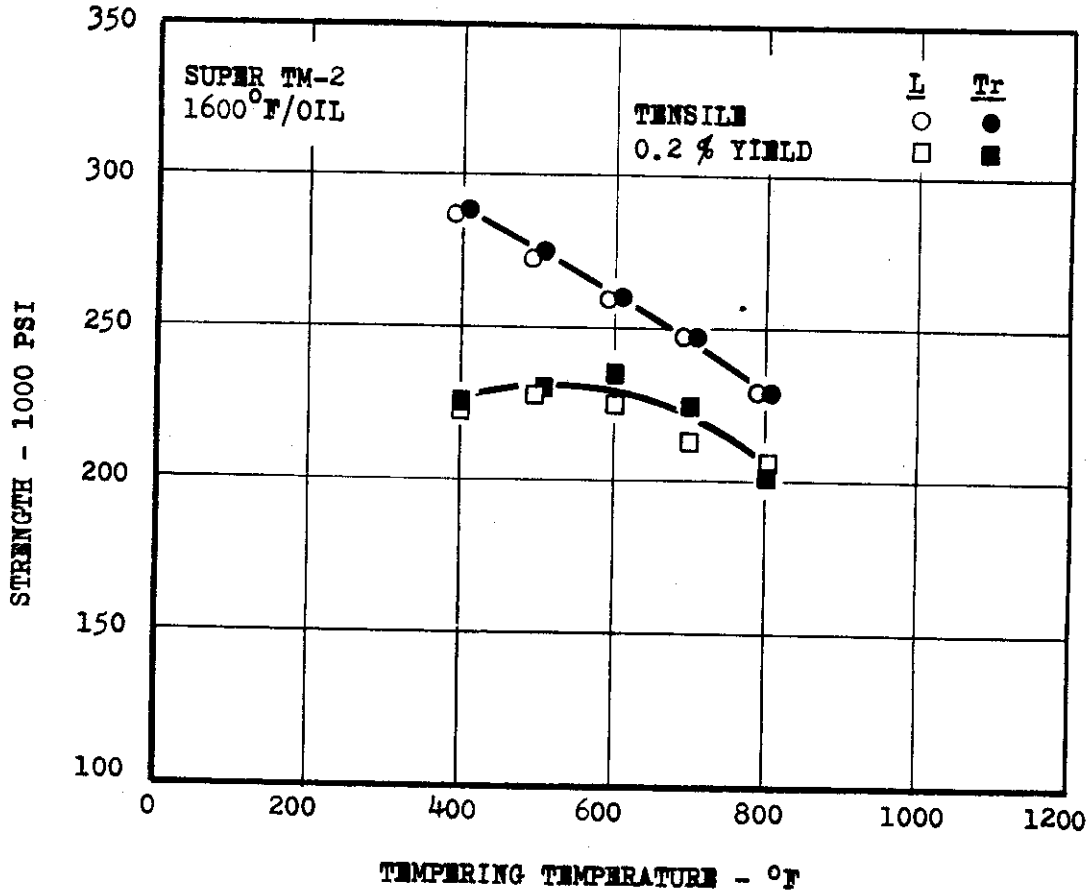


FIG. 141 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

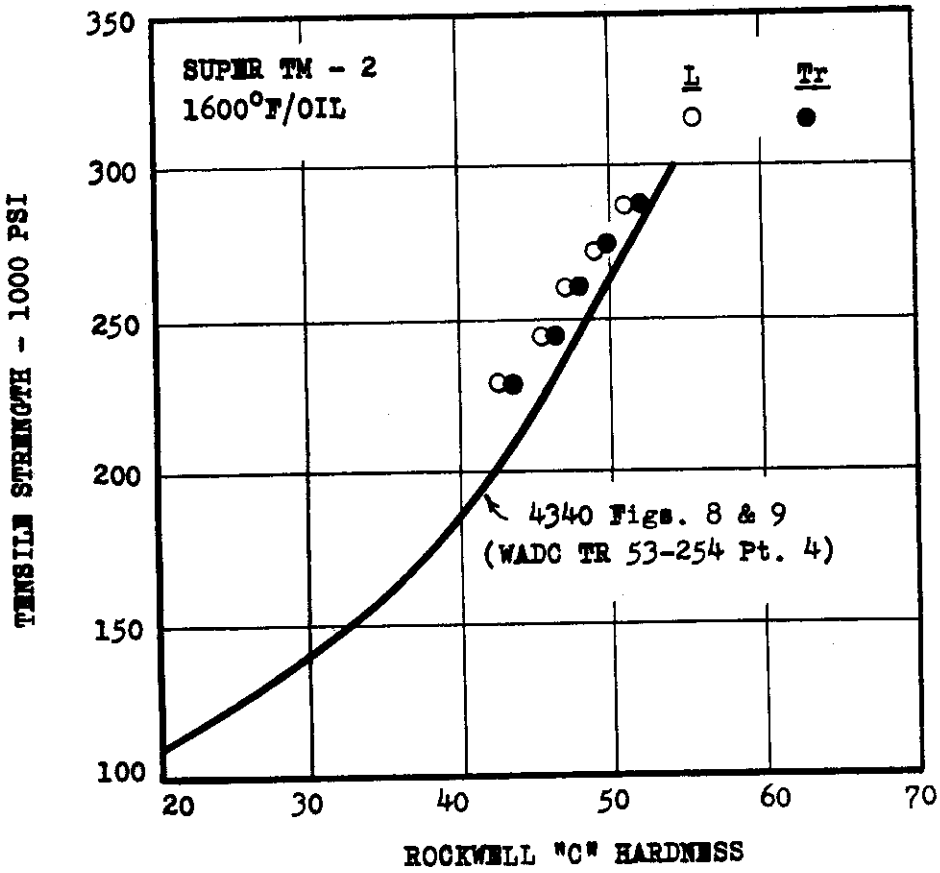


FIG. 142 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 3 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

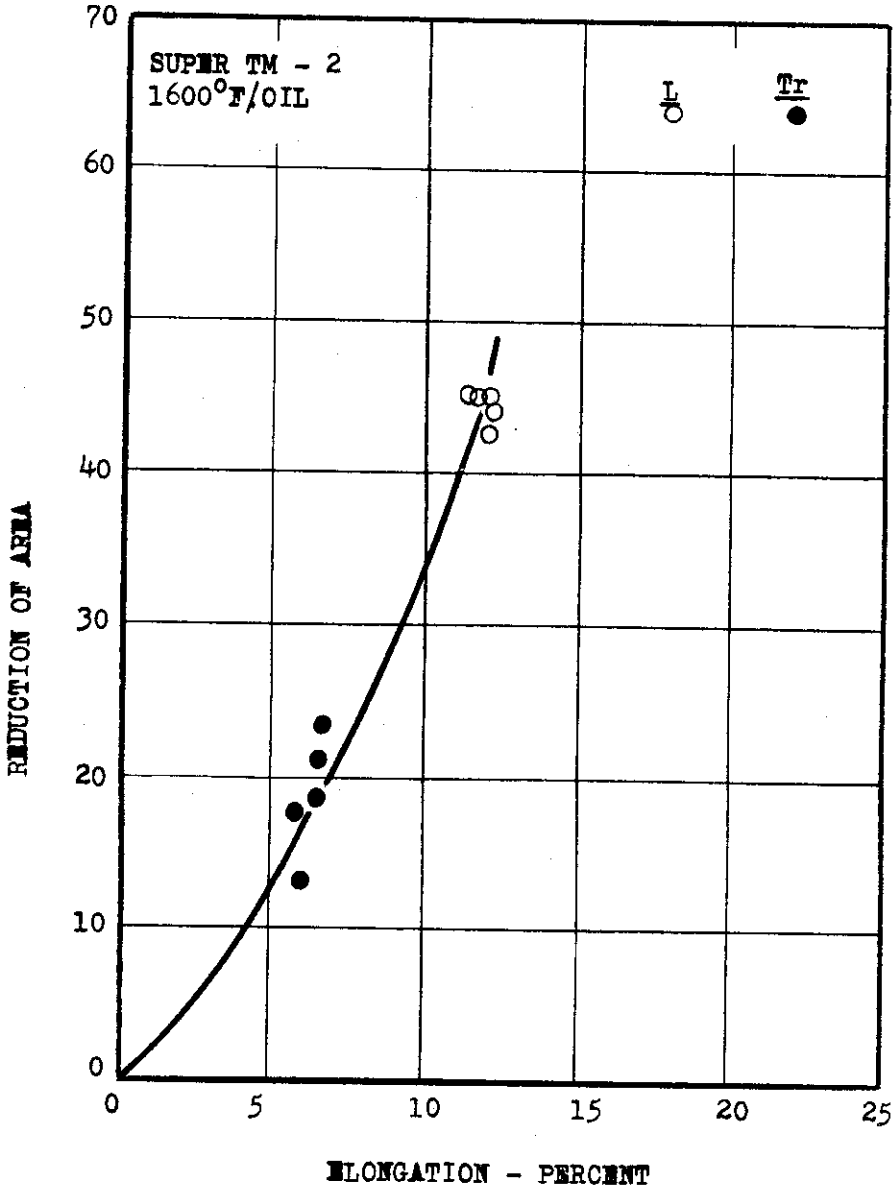


FIG.143 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 3 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

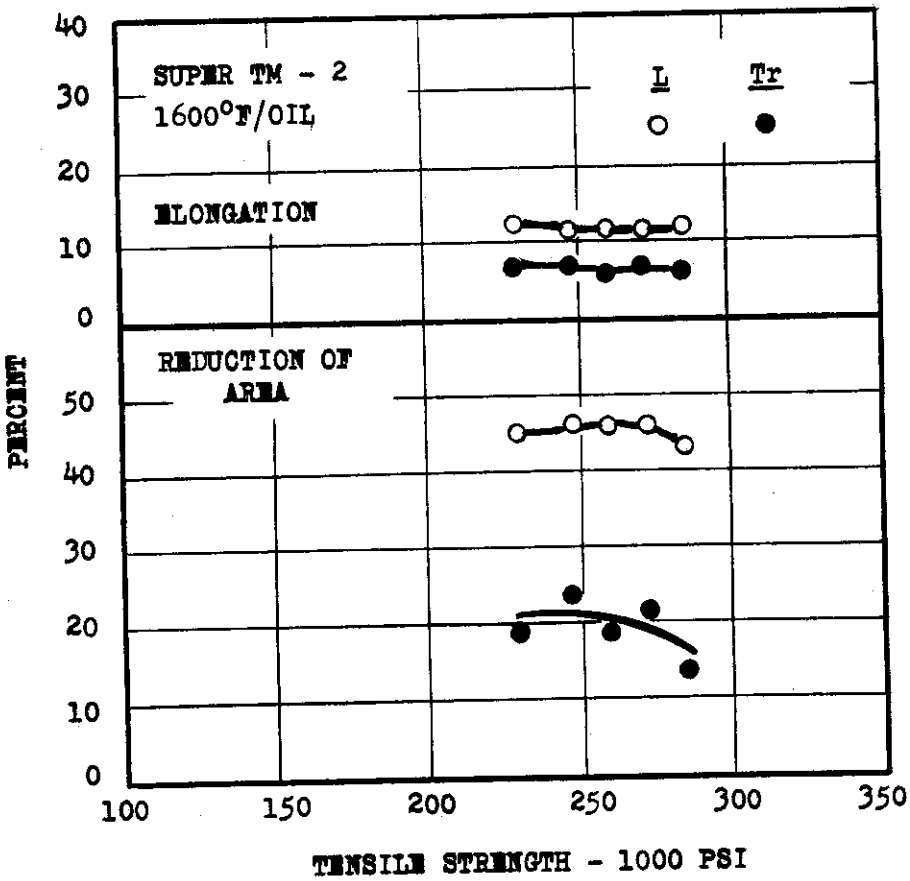


FIG. 144 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 3 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

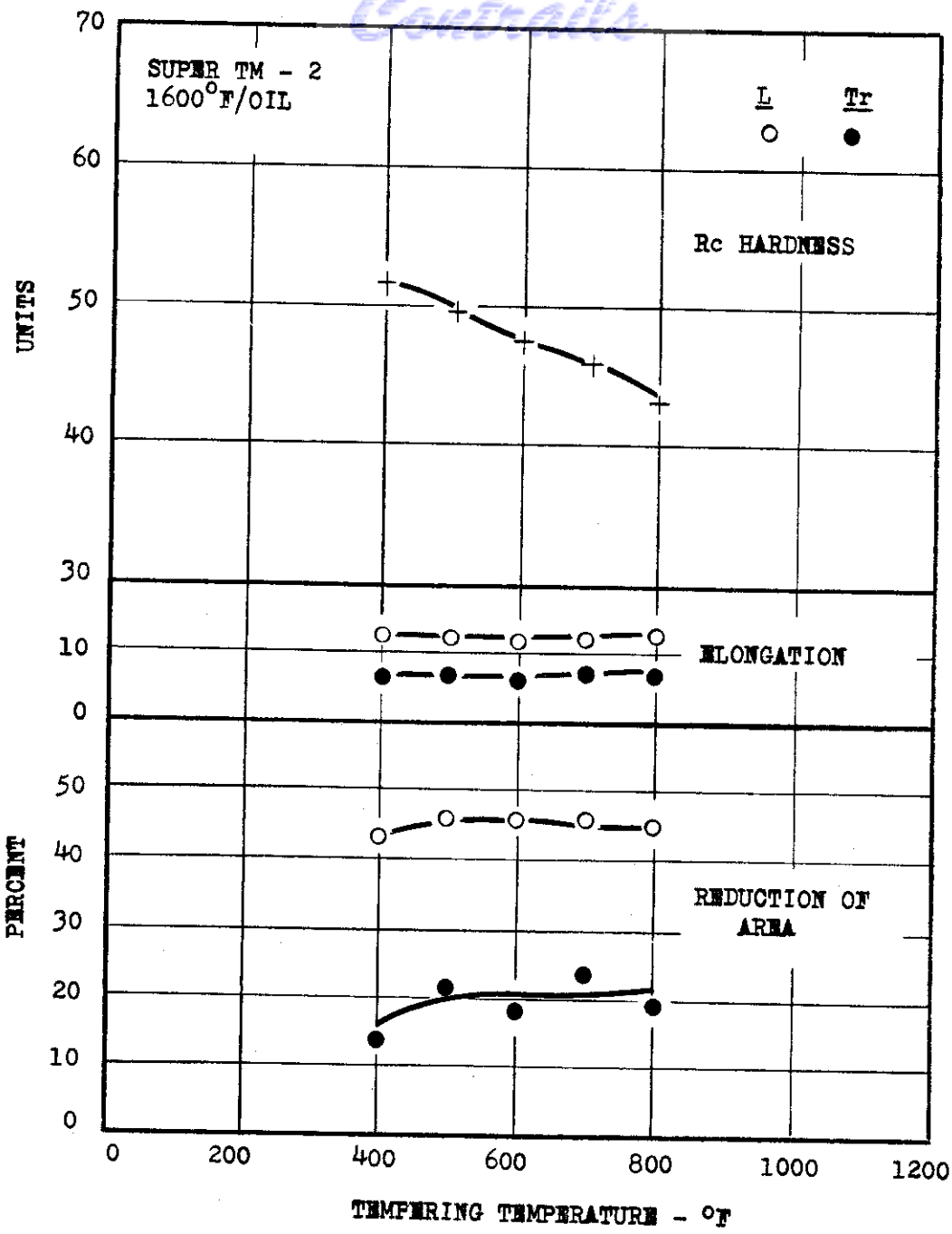


FIG. 145 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 IN. DIA.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

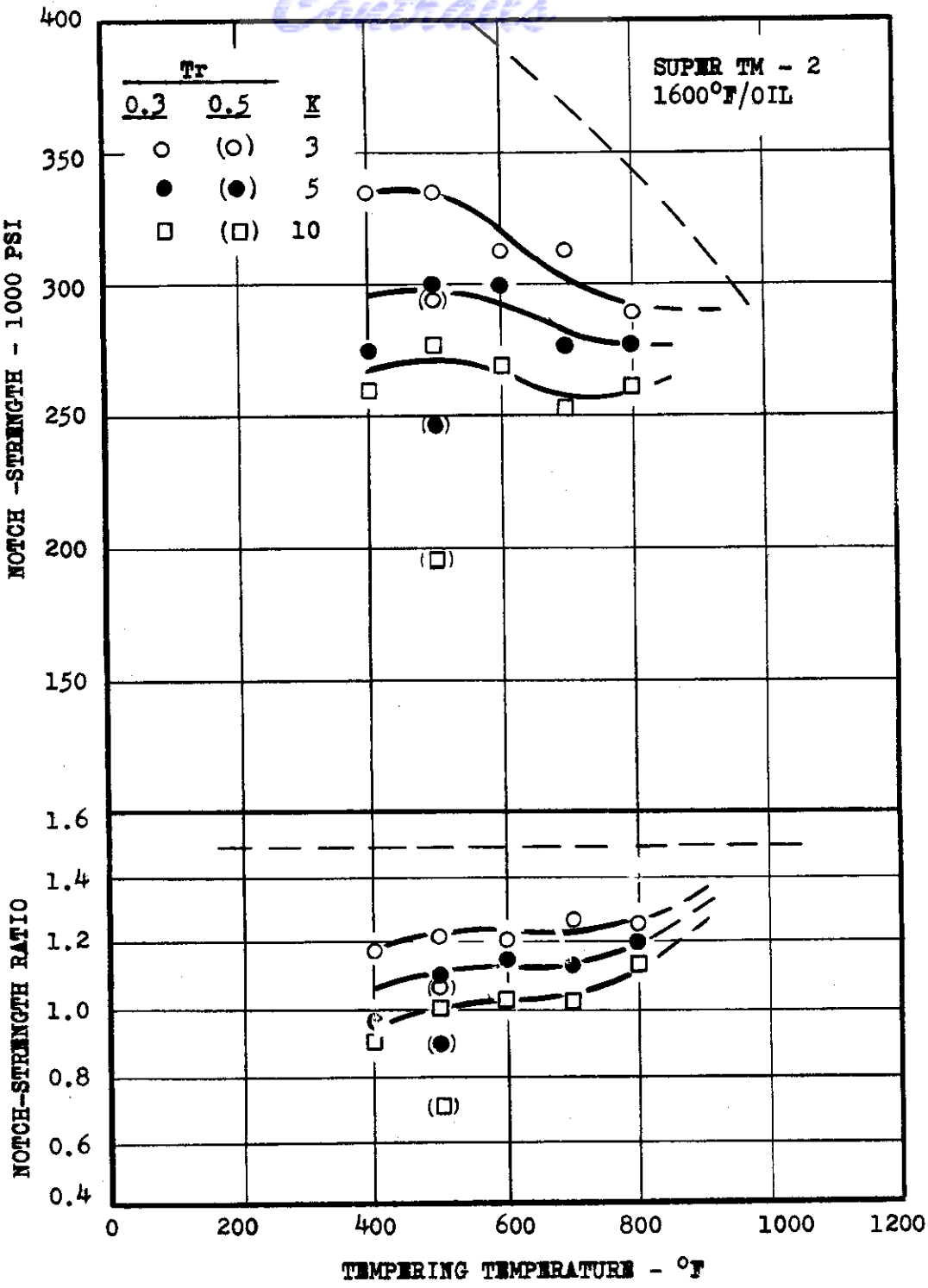


FIG. 146 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 IN. DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

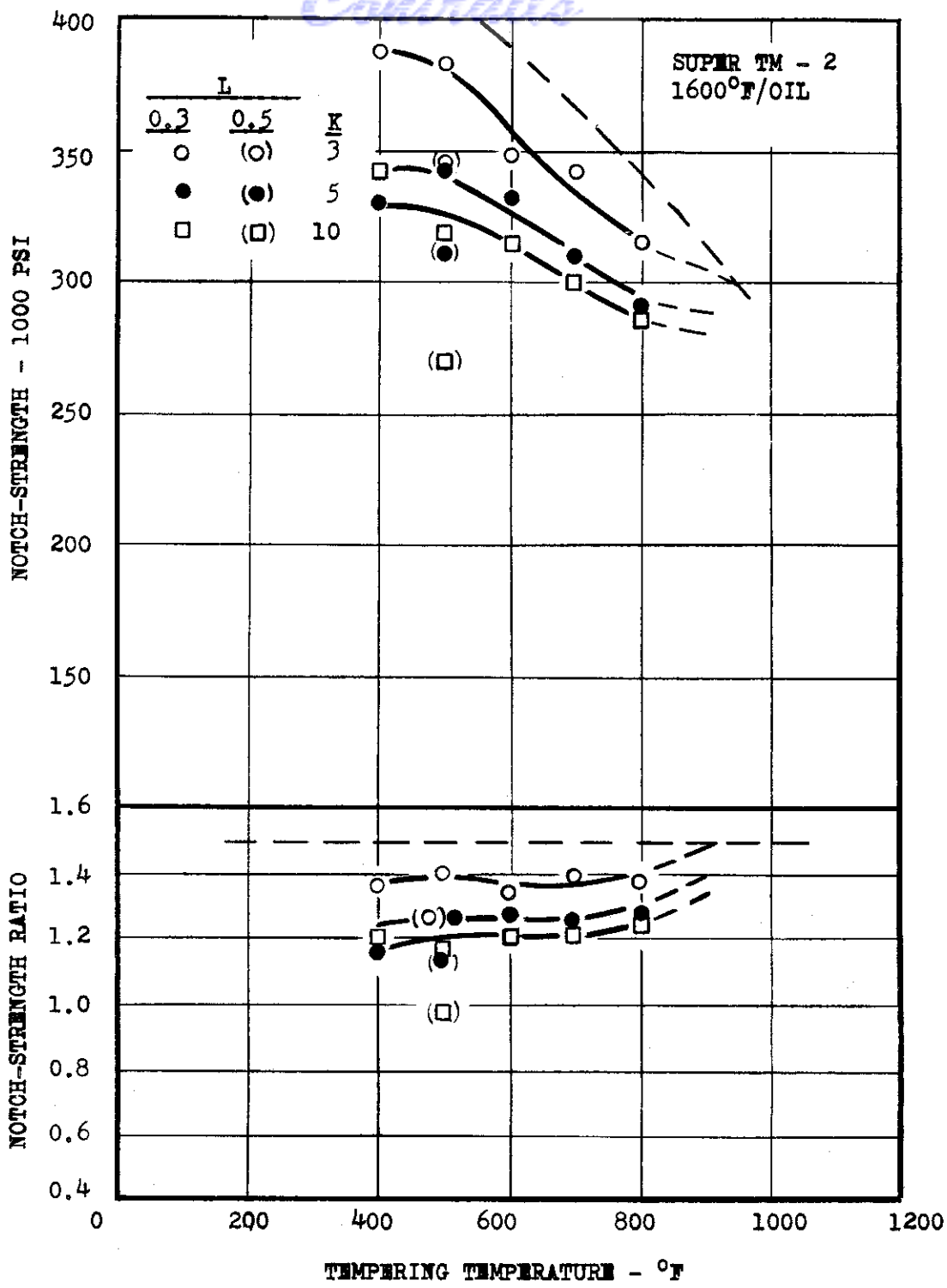


FIG. 147 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 IN. DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

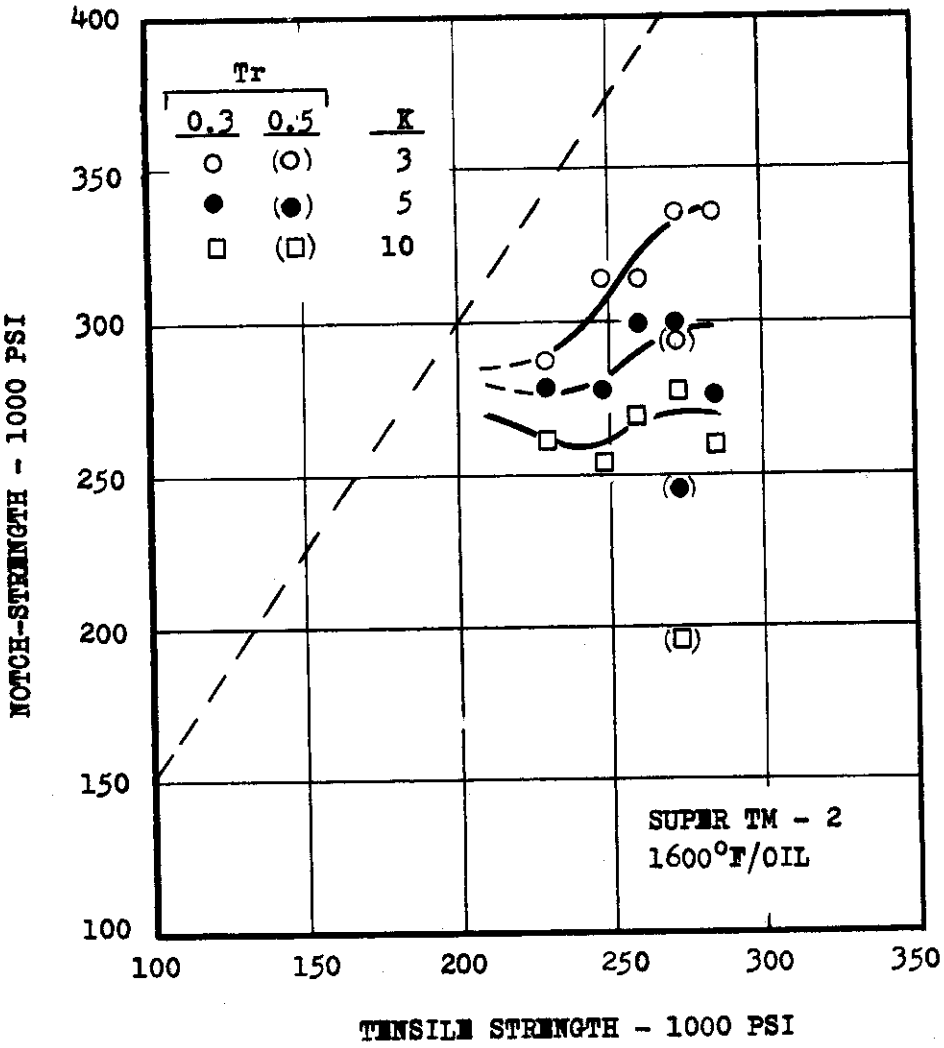


FIG. 148 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 IN. DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

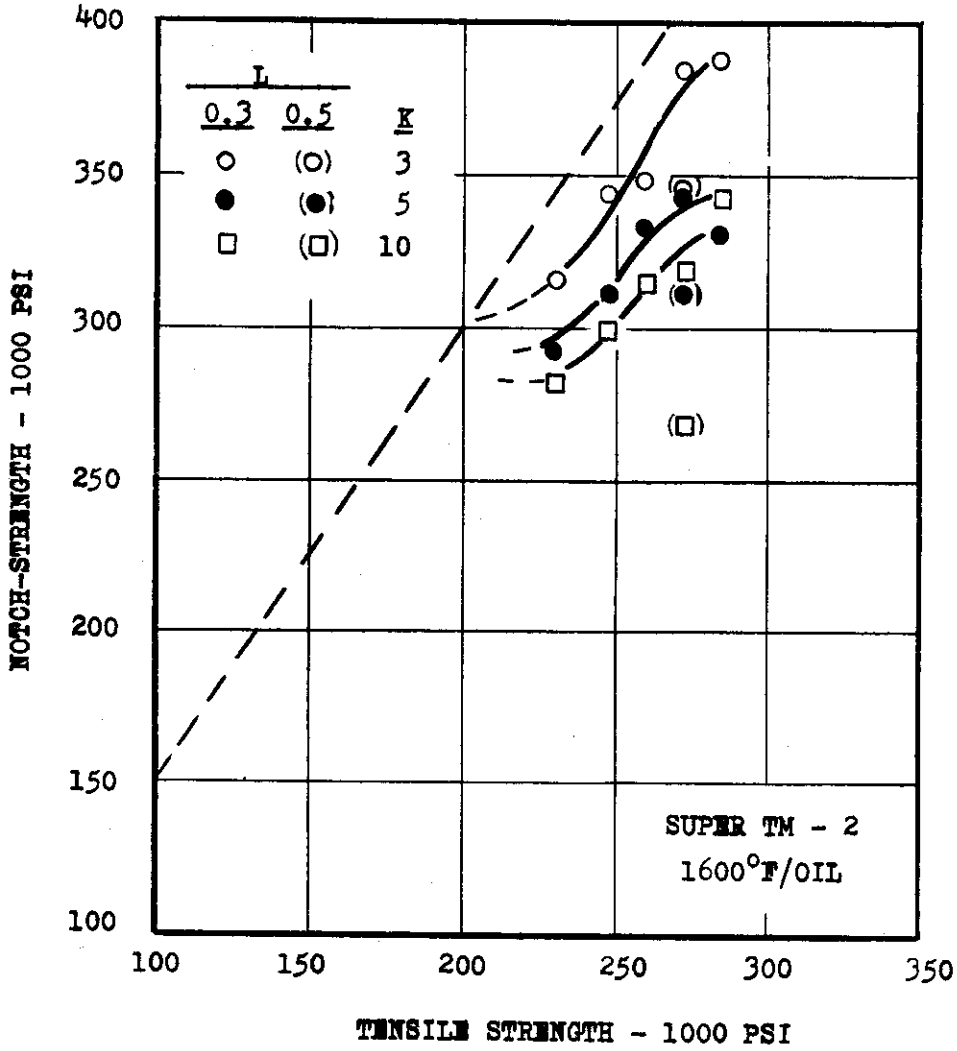


FIG. 149 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

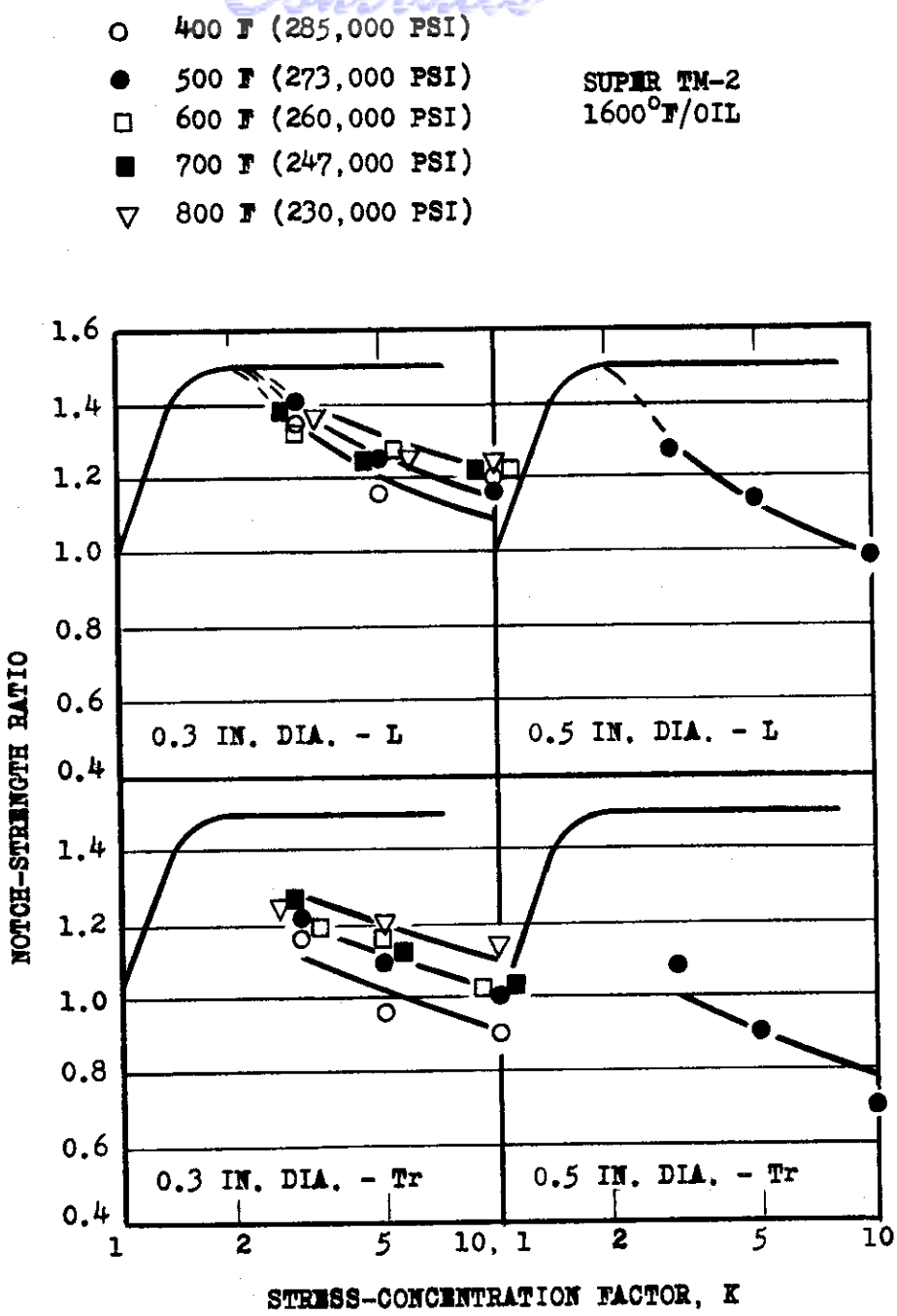


FIG. 150 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 3 IN. DIA.

TEST TEMP: R.T.

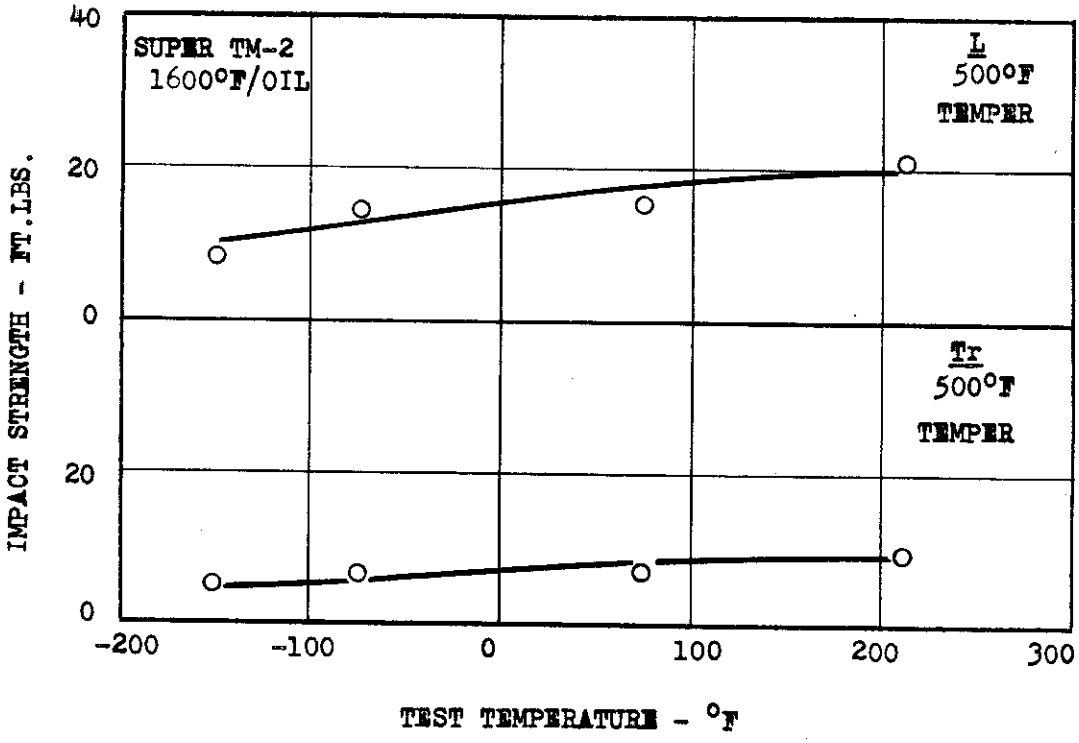


FIG. 151 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: STD. V-NOTCH CHARPY

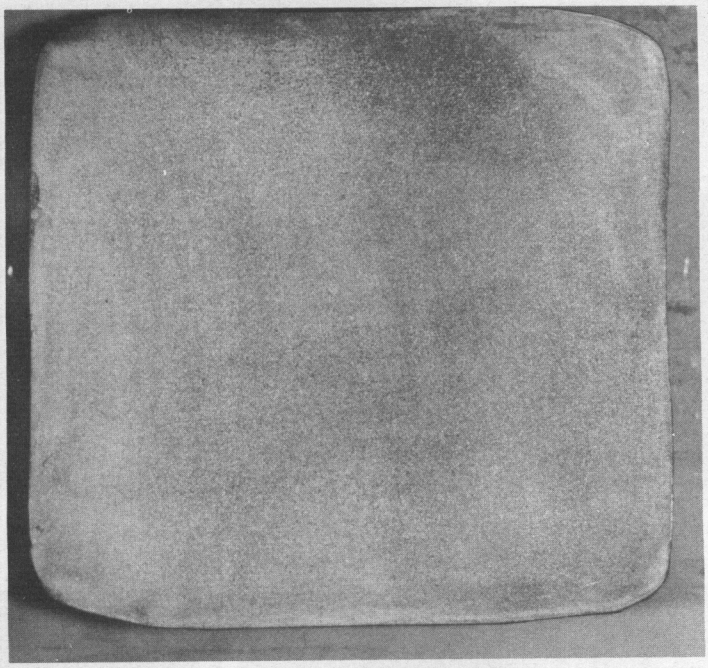
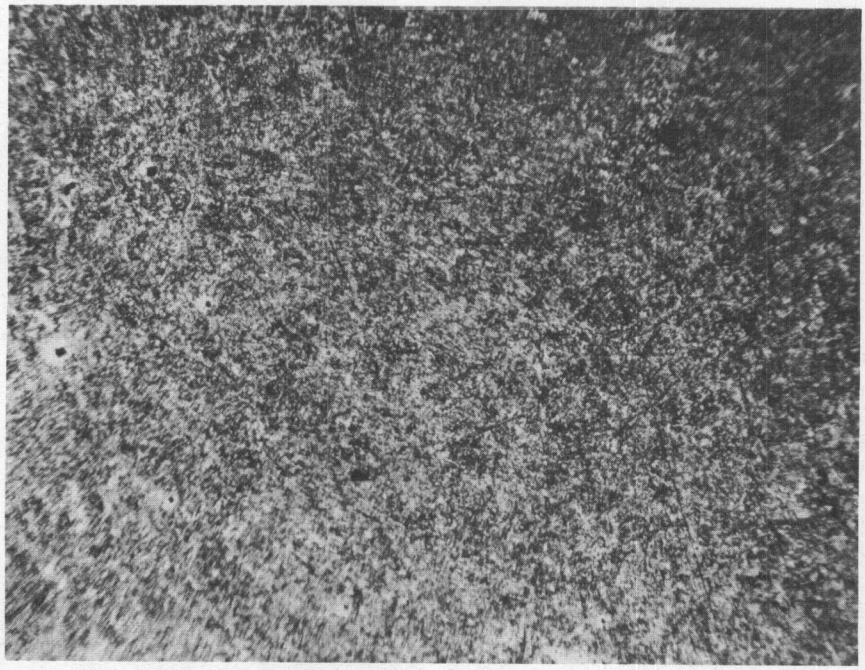
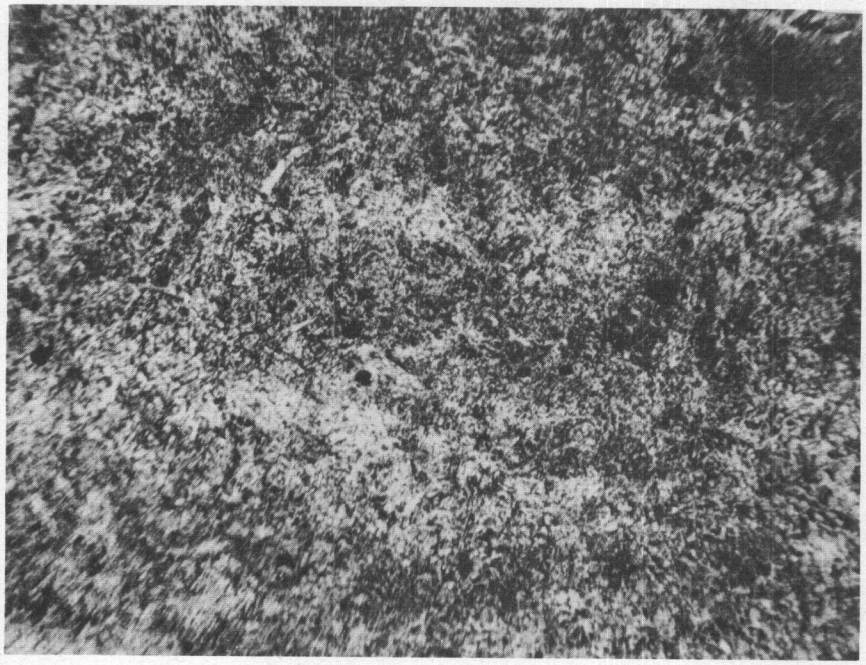


FIG. 152 MACROGRAPH OF INCO STEEL AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) TRANSVERSE PATTERN



(a) LONGITUDINAL PATTERN

FIG.153 PHOTOMICROGRAPHS OF INCO STEEL, OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL. 100 DIAMETER MAGNIFICATION.

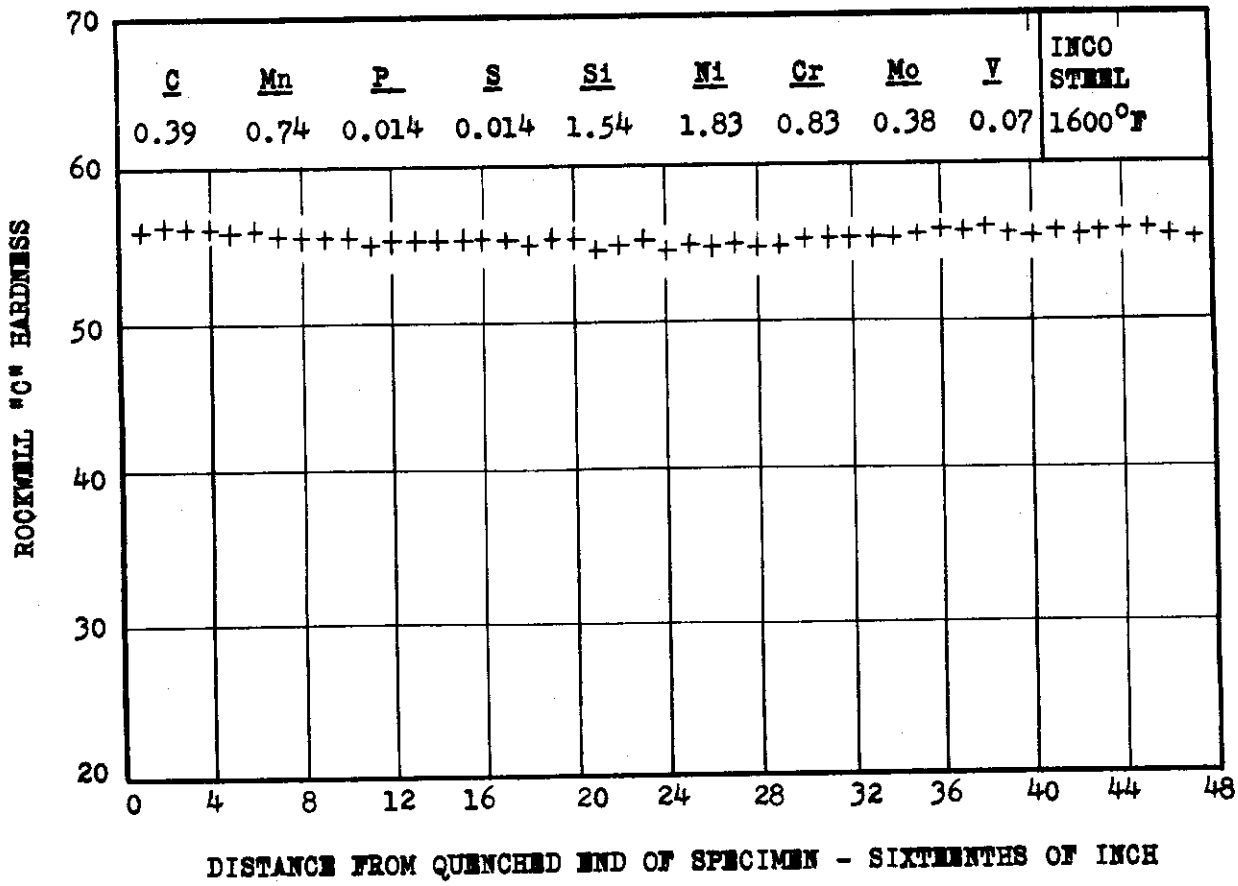


FIG. 154 HARDENABILITY OF JOMINY-QUENCH BAR.

SECTION: 4½ IN. SQ.

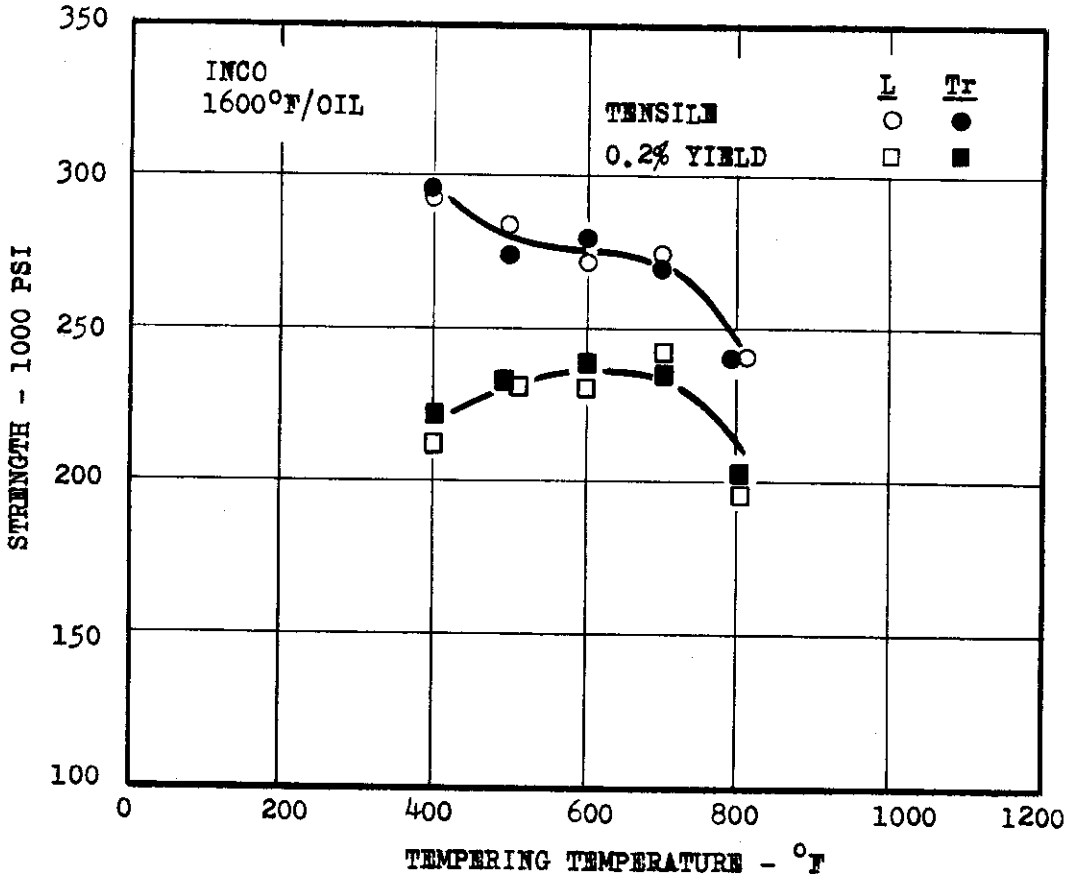


FIG. 155 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4¼ IN. SQ.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

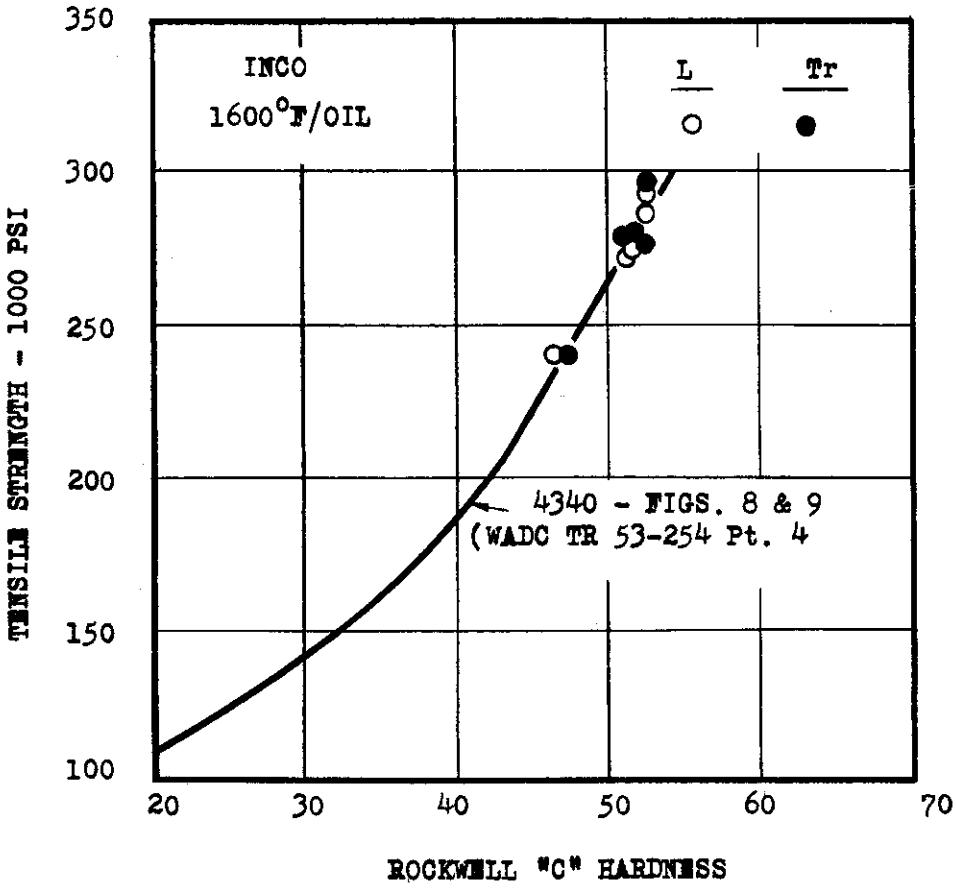


FIG. 156 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 4½ IN. SQ.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

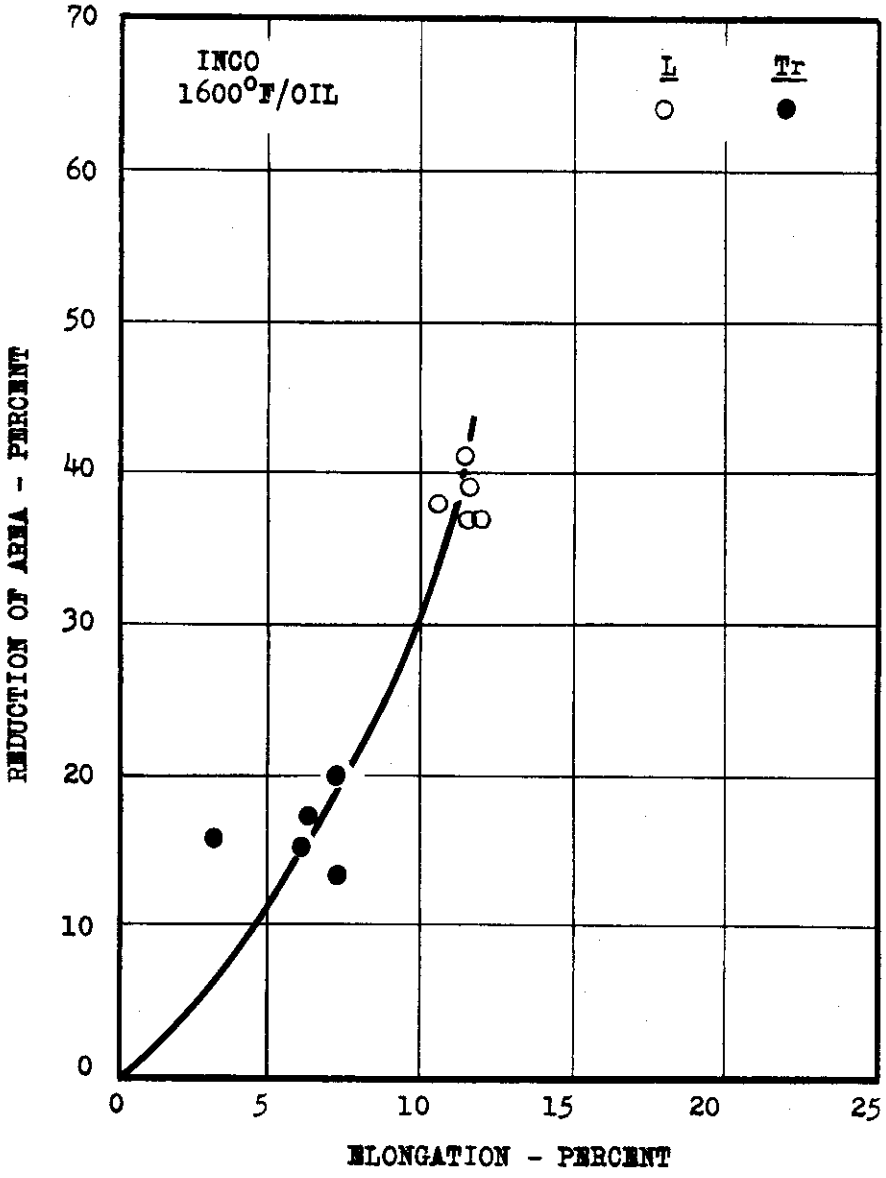


FIG. 157 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 4½ IN. SQ.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

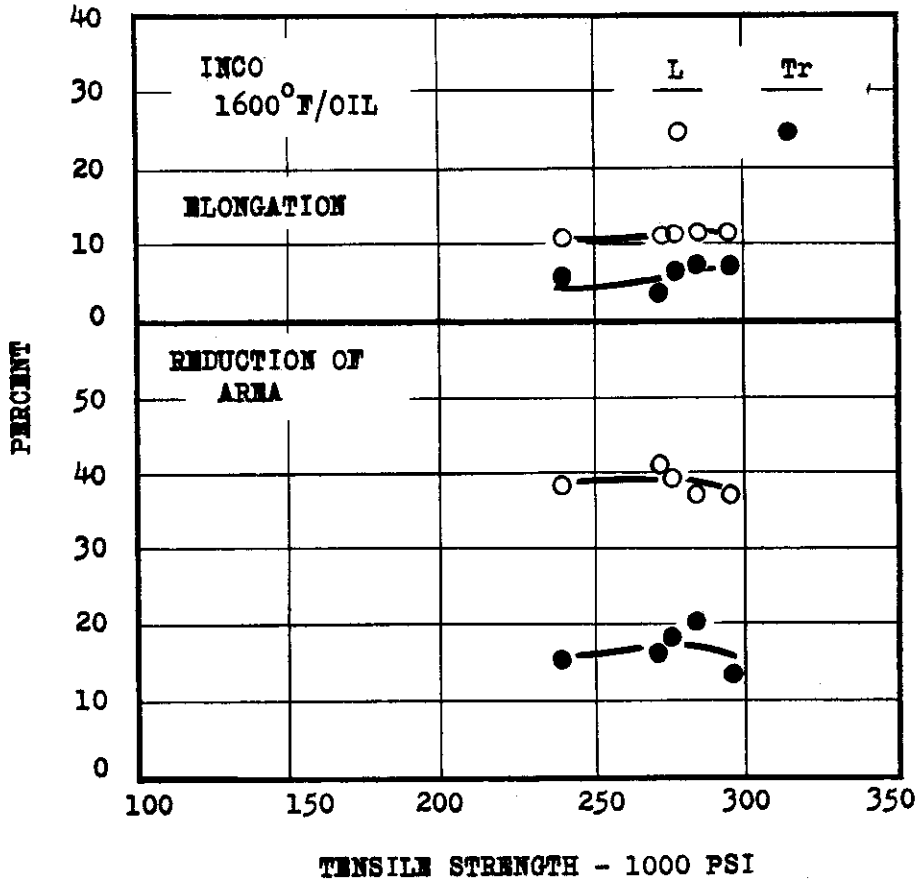


FIG. 158 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 4½ IN. SQ.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

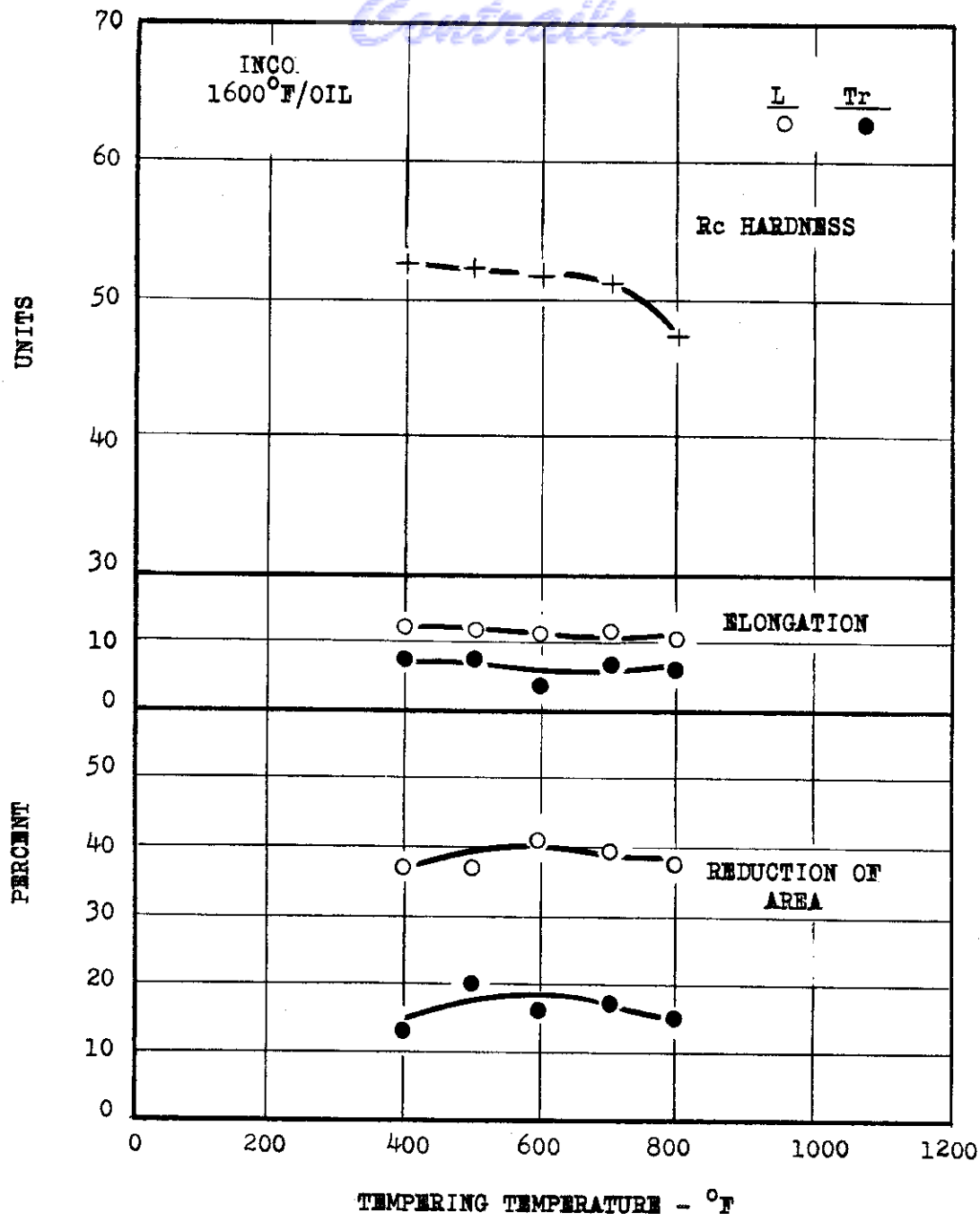


FIG. 159 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4½ IN. SQ.

SPECIMEN: 0.28 IN. DIA.

TEST TEMP: R.T.

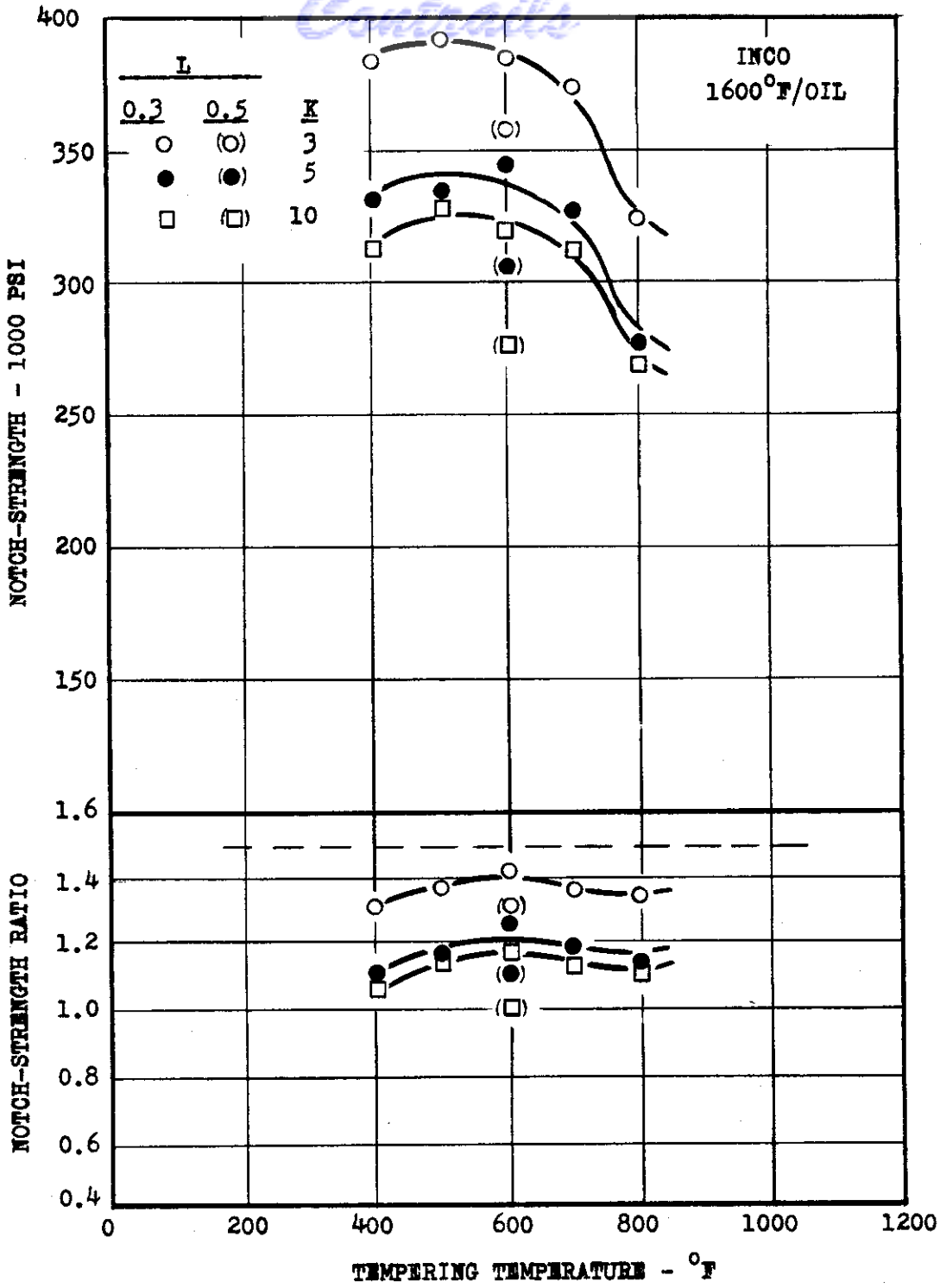


FIG. 160 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4¼ IN. SQ.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

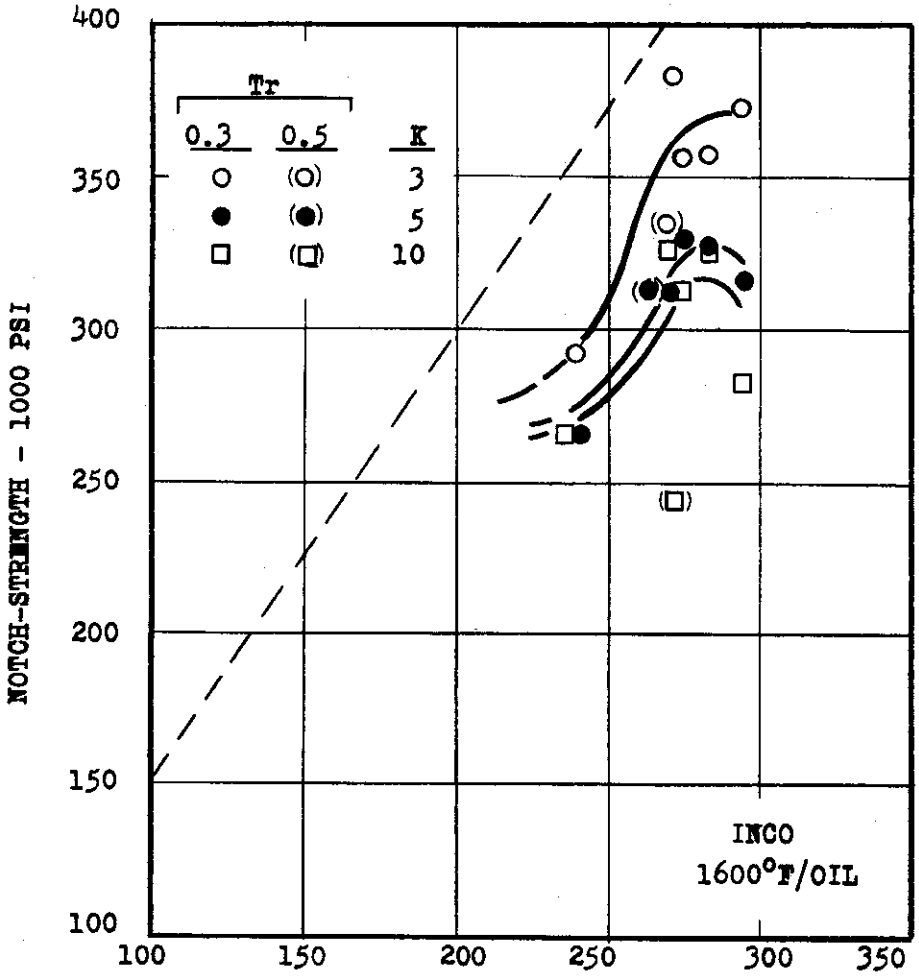


FIG. 161 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN. SQ.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

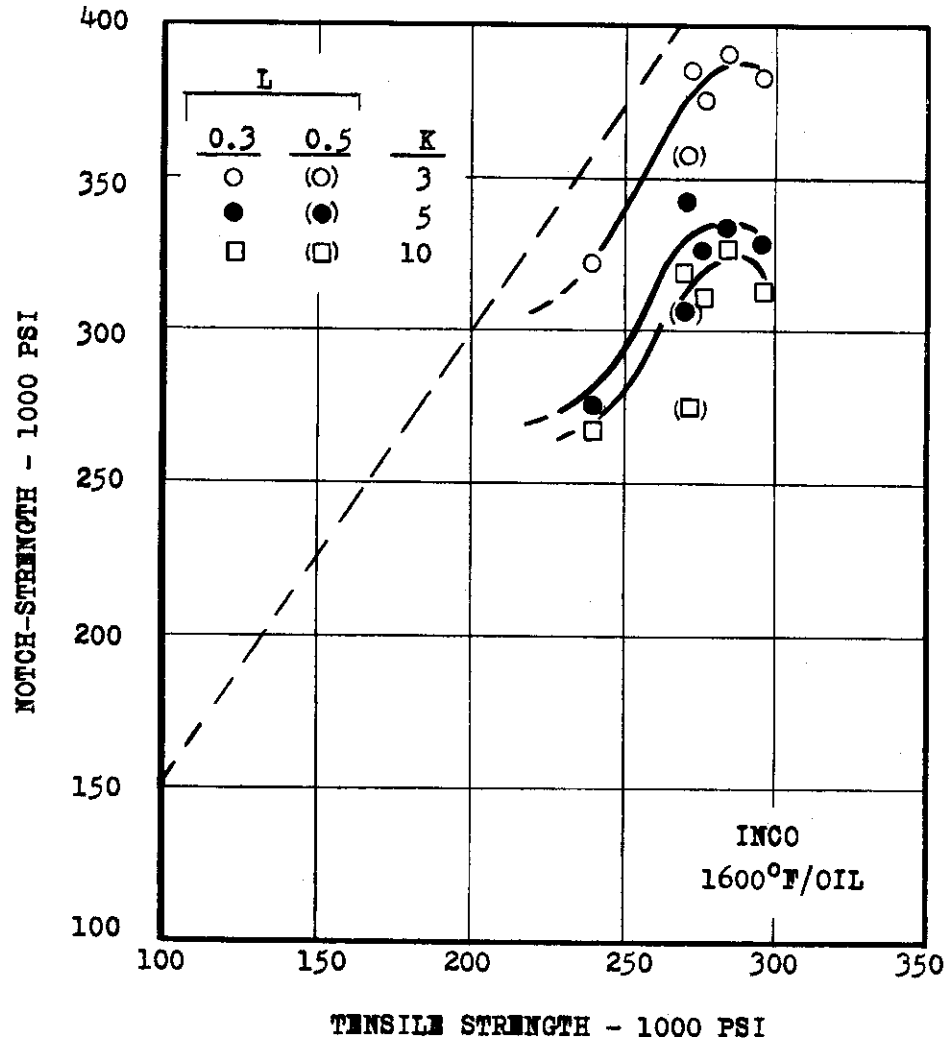


FIG. 162 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4½ IN. SQ.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

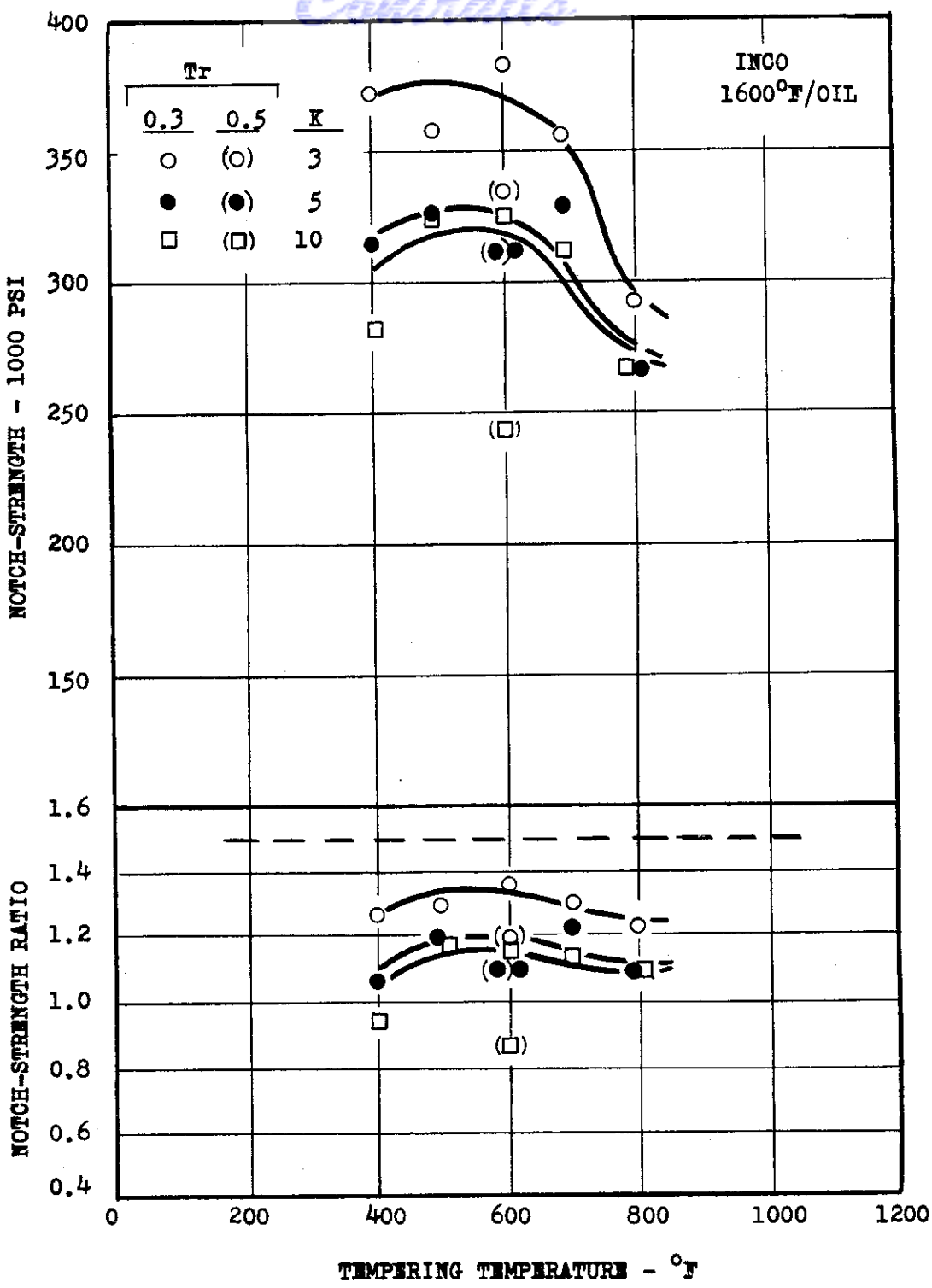


FIG. 163 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4½ IN. SQ.

SPECIMEN: 0.3 and 0.5 IN. DIA.

TEST TEMP: R.T.

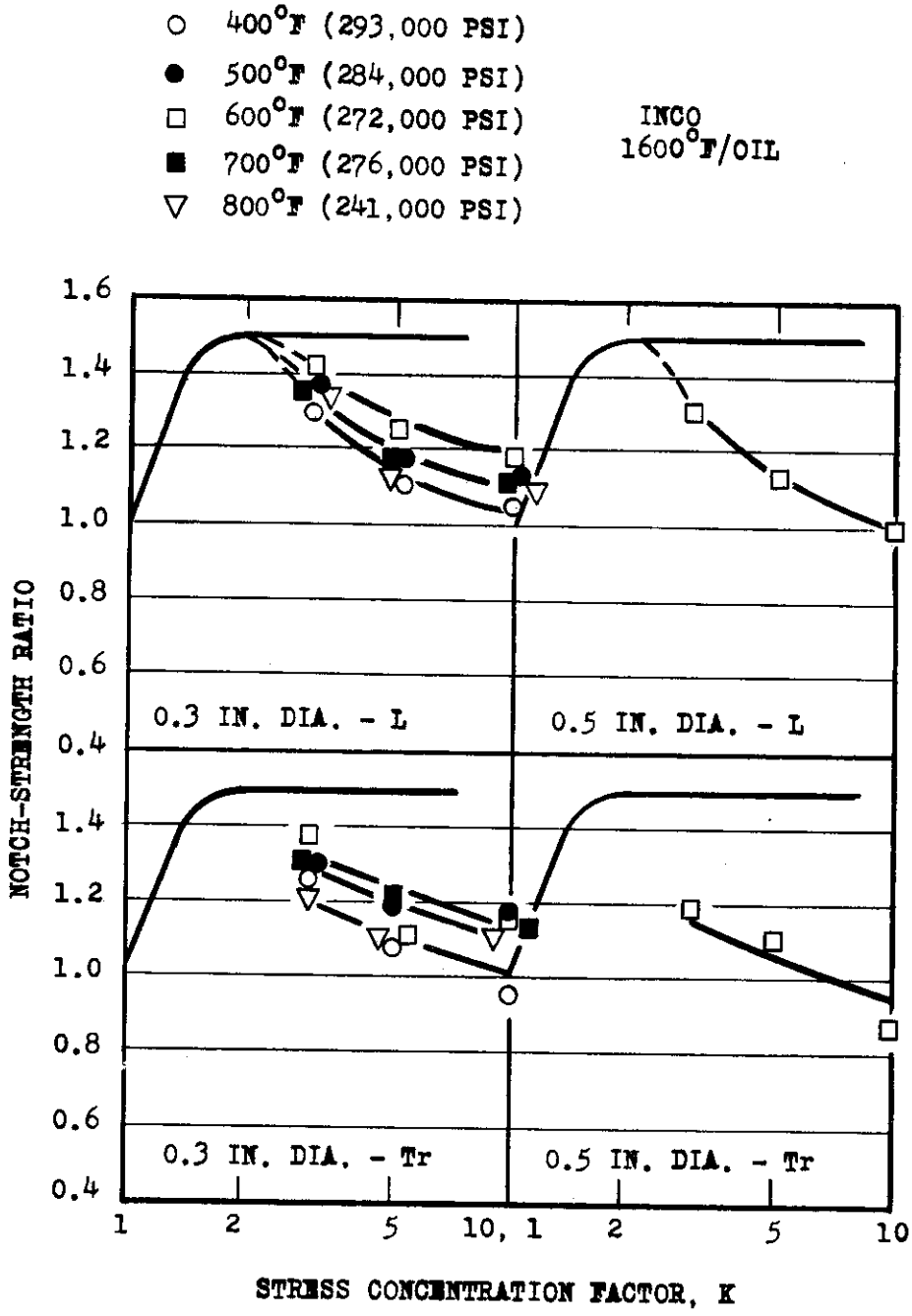


FIG. 164 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 4½ IN. SQ.

TEST TEMP: R.T.

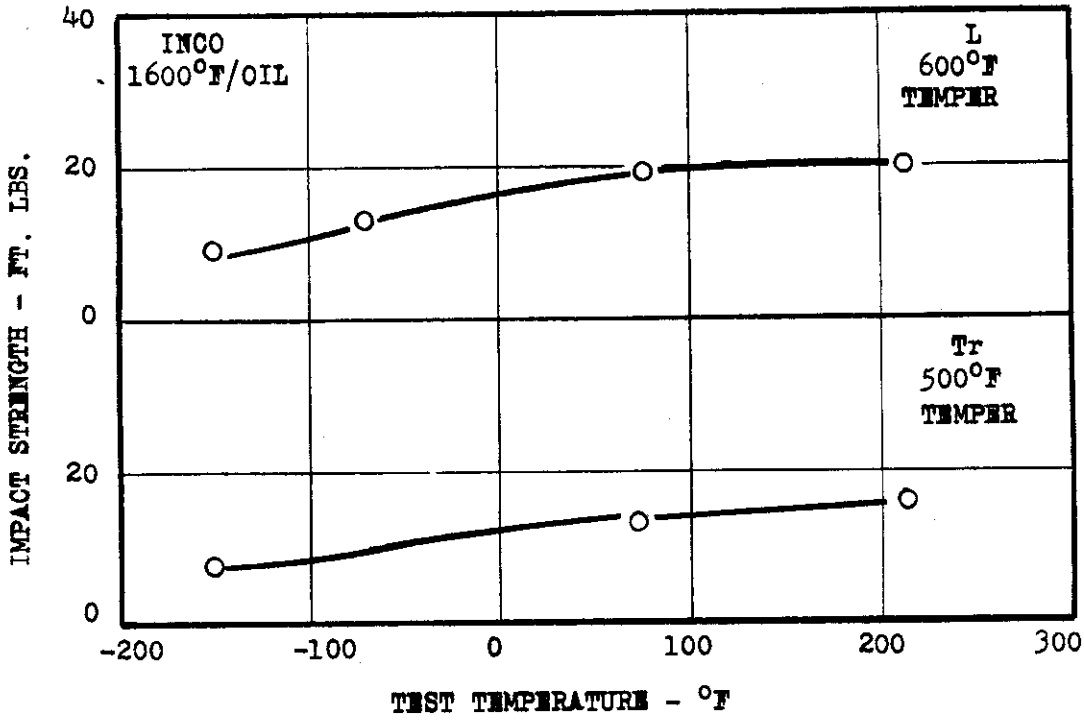


FIG. 165 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 4¼ IN. SQ.

SPECIMEN: STD. V-NOTCH CHARPY

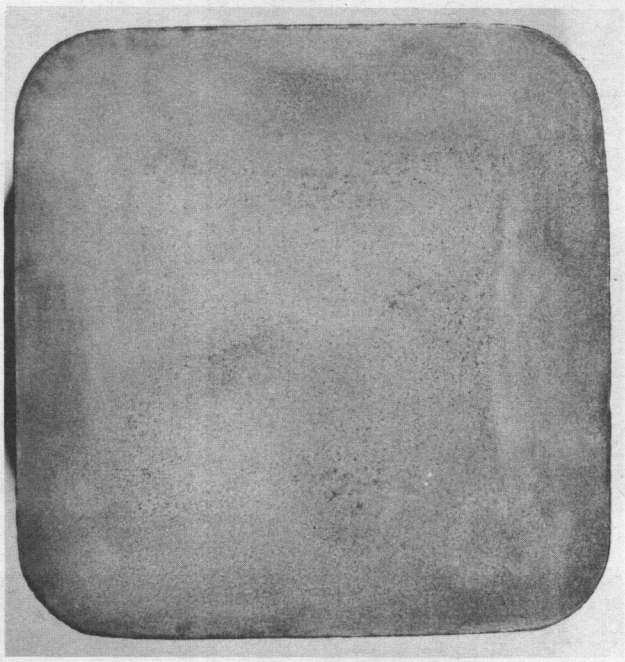
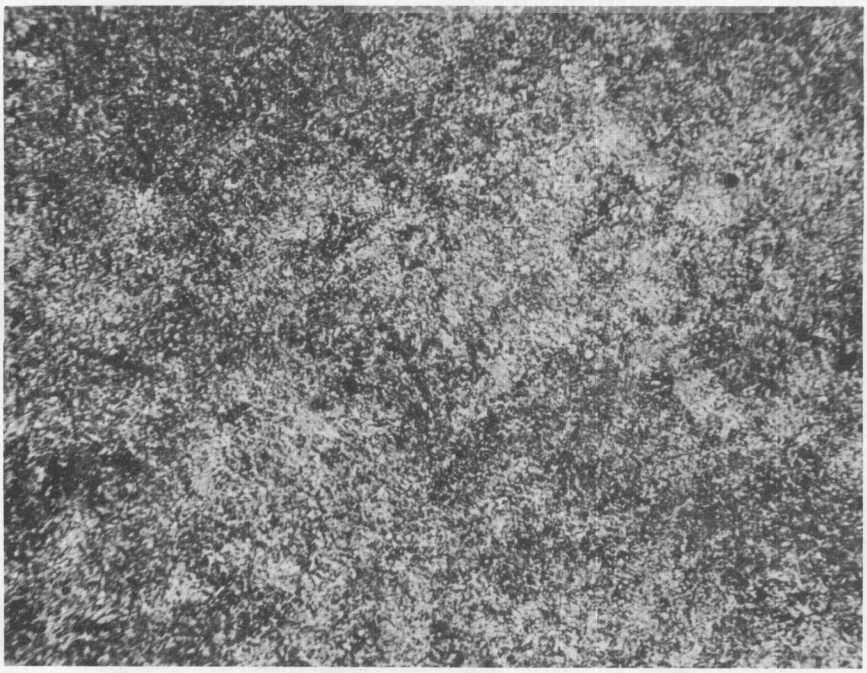
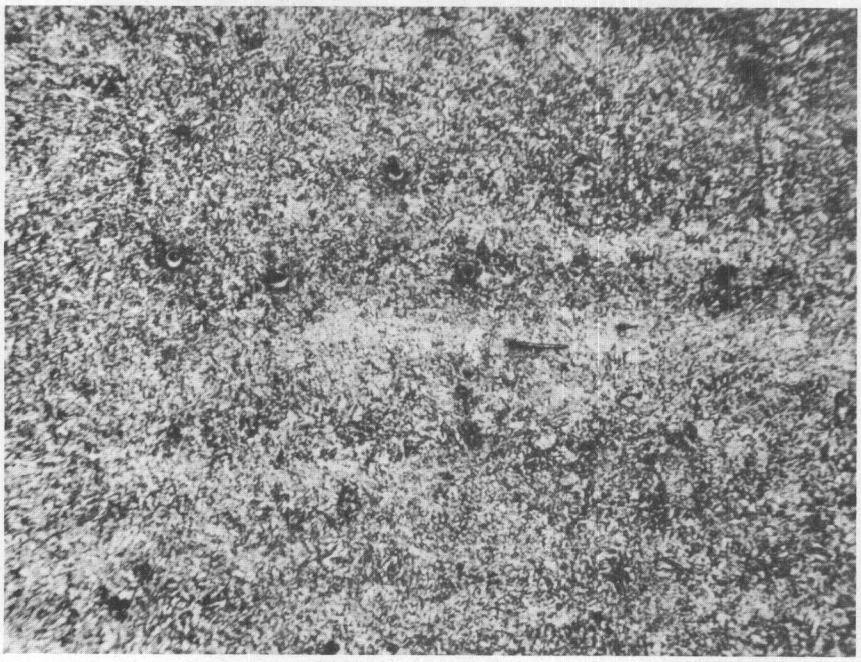


FIG. 166 MACROGRAPH OF V-MOD. 4330 STEEL AS RECEIVED SECTION, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) Transverse Pattern



(b) Longitudinal Pattern

FIG. 167 PHOTOMICROGRAPHS OF V-MOD. 4330 STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

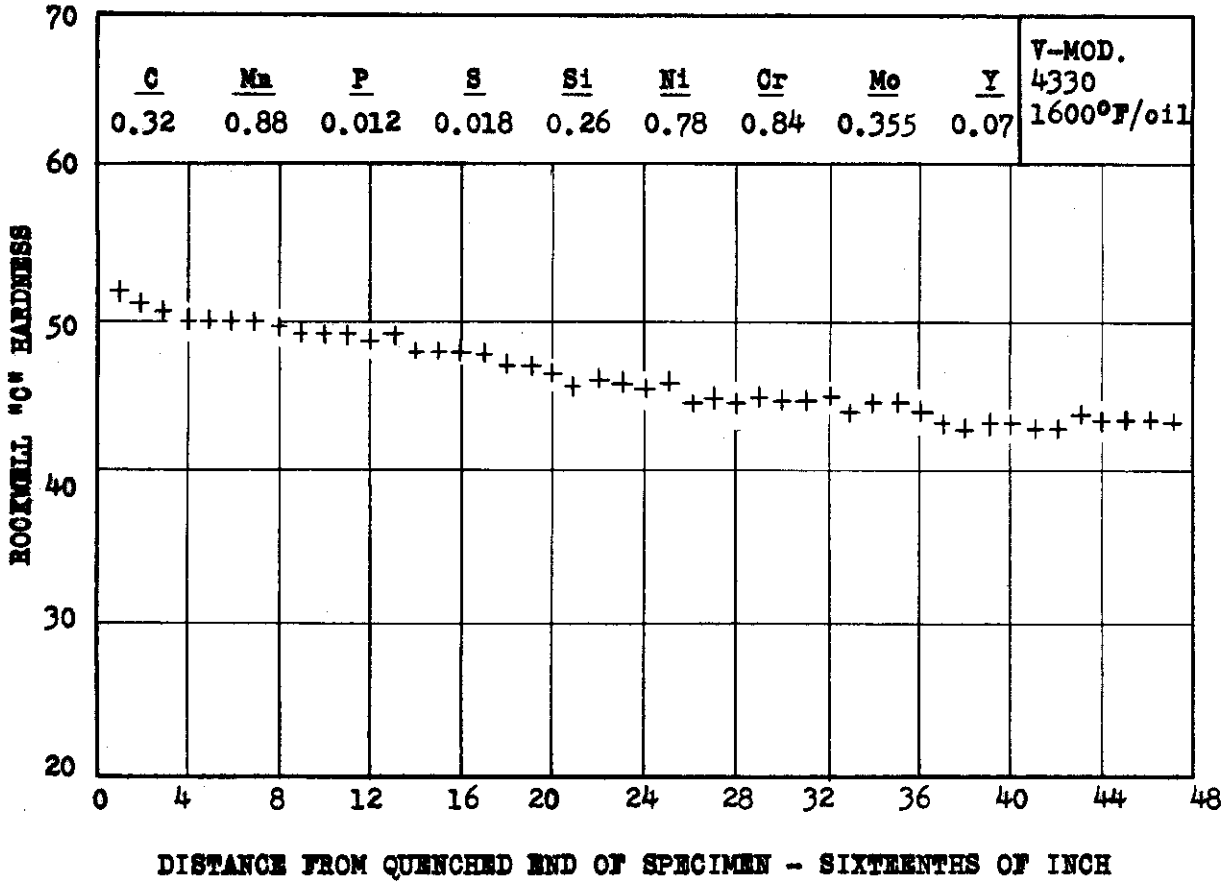


FIG. 168 HARDENABILITY OF JOMINY-QUENCH BAR.

SECTION: 4 IN.SQ.

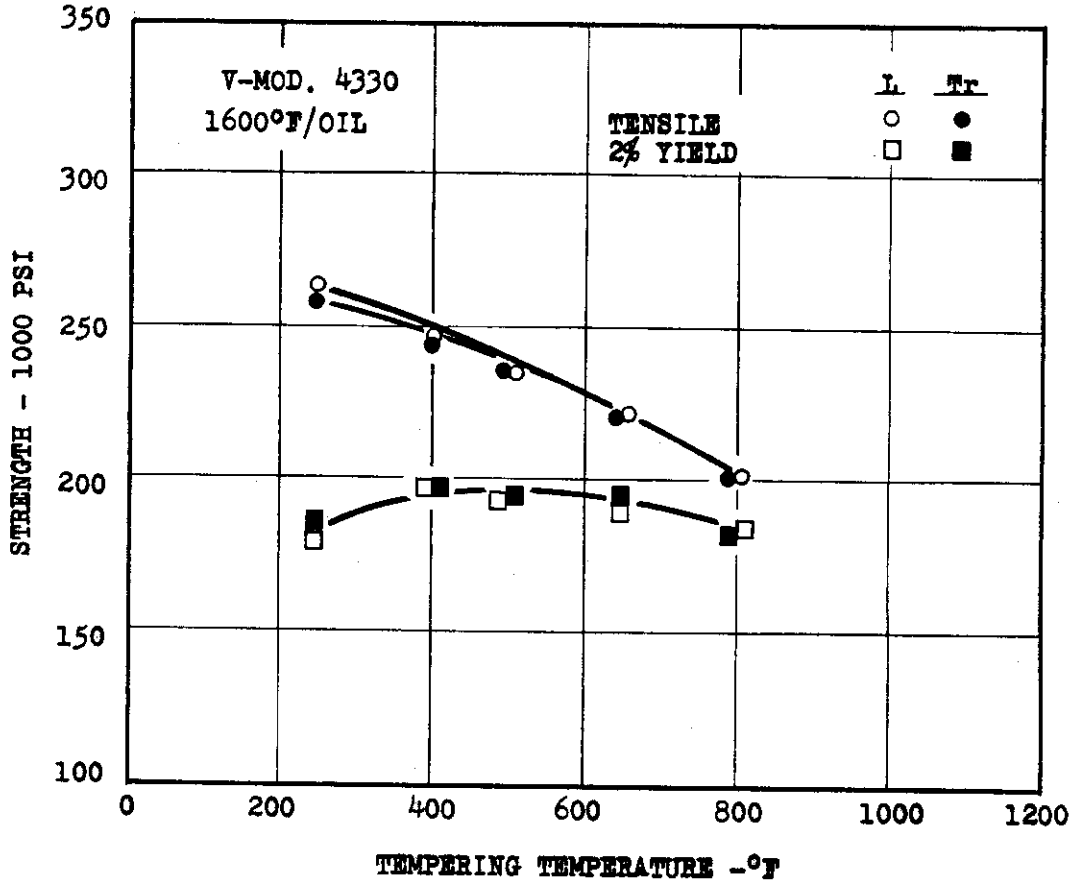


FIG. 169 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

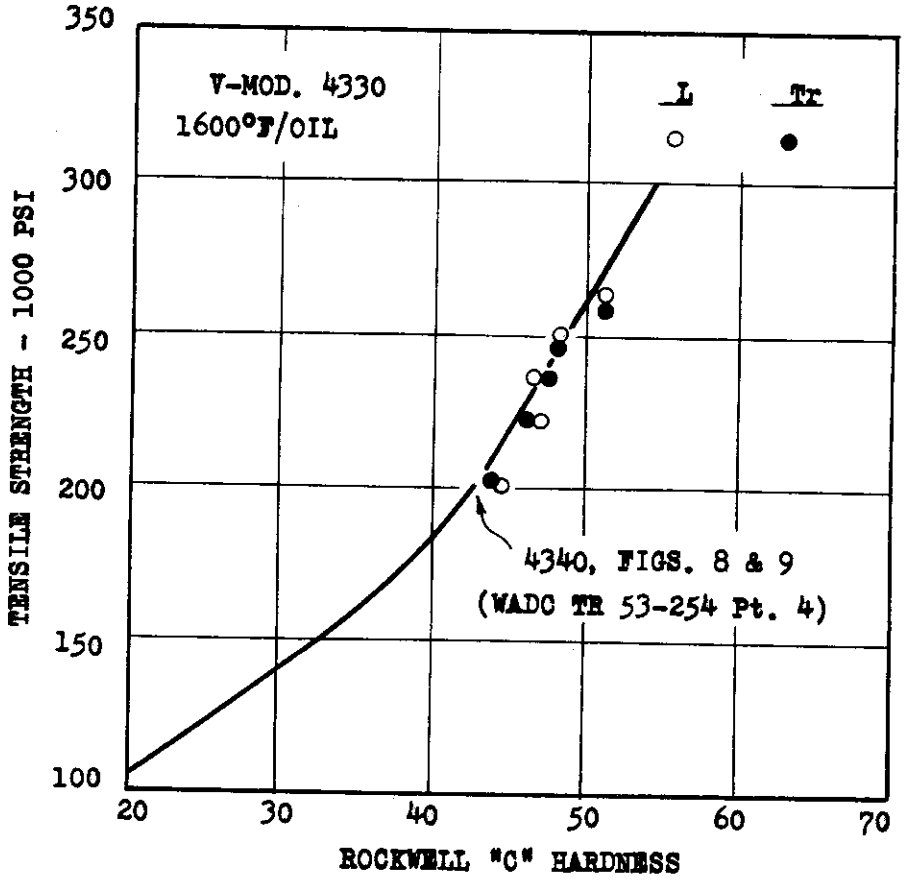


FIG. 170 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 4 IN. SQ.

SPECIMEN: 0.3 IN DIA.

TEST TEMP: R.T.

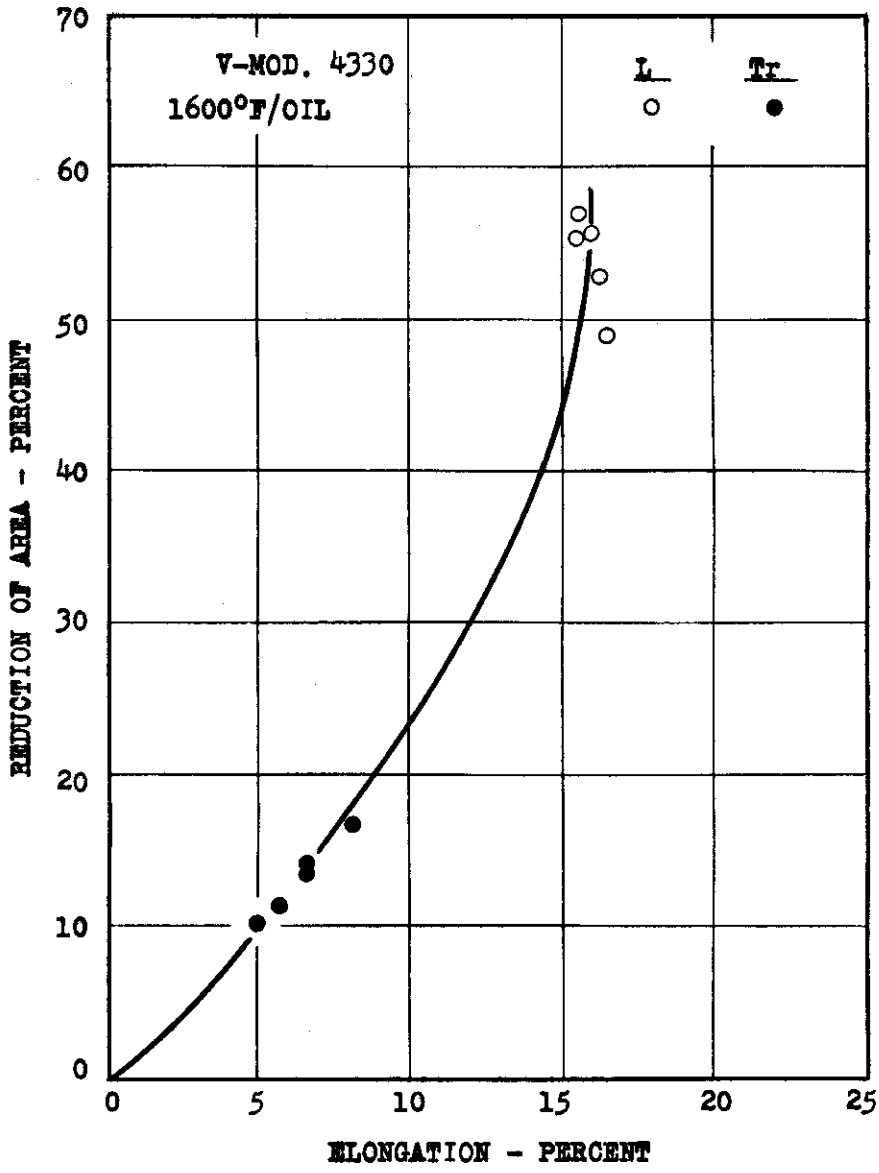


FIG. 171 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 4 IN. SQ.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

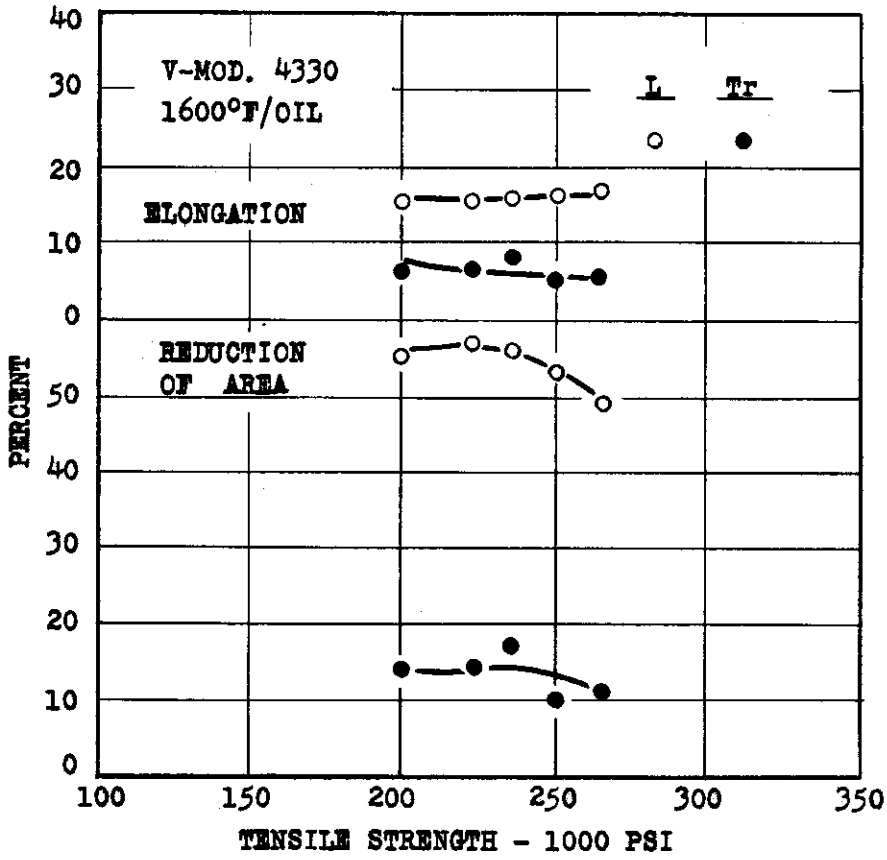


FIG. 172 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

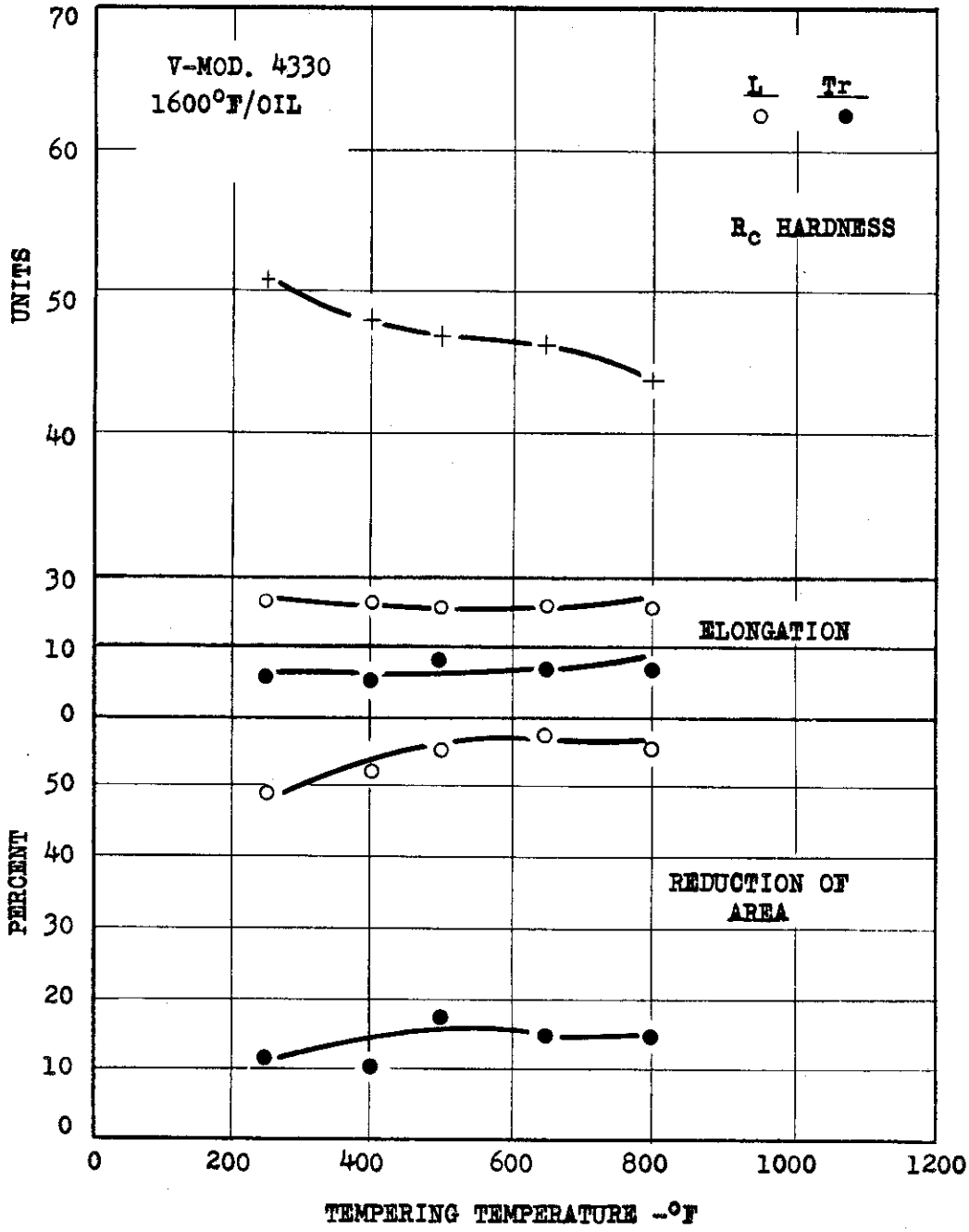


FIG. 173 HARDNESS, ELONGATION AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

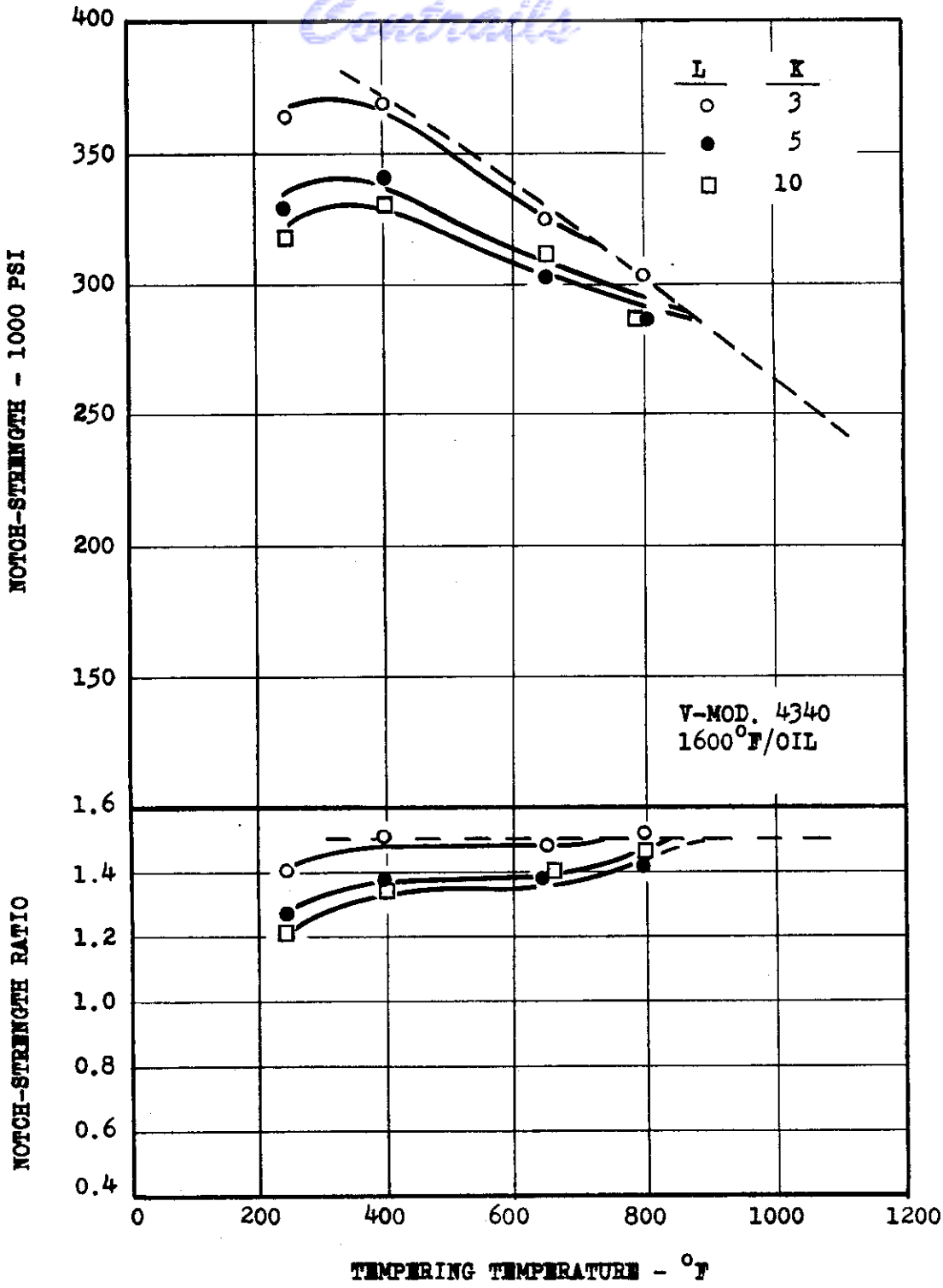


FIG. 174 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN. SQ.

SPECIMEN: 0.3 IN. DIA.

TEST TEMP: R.T.

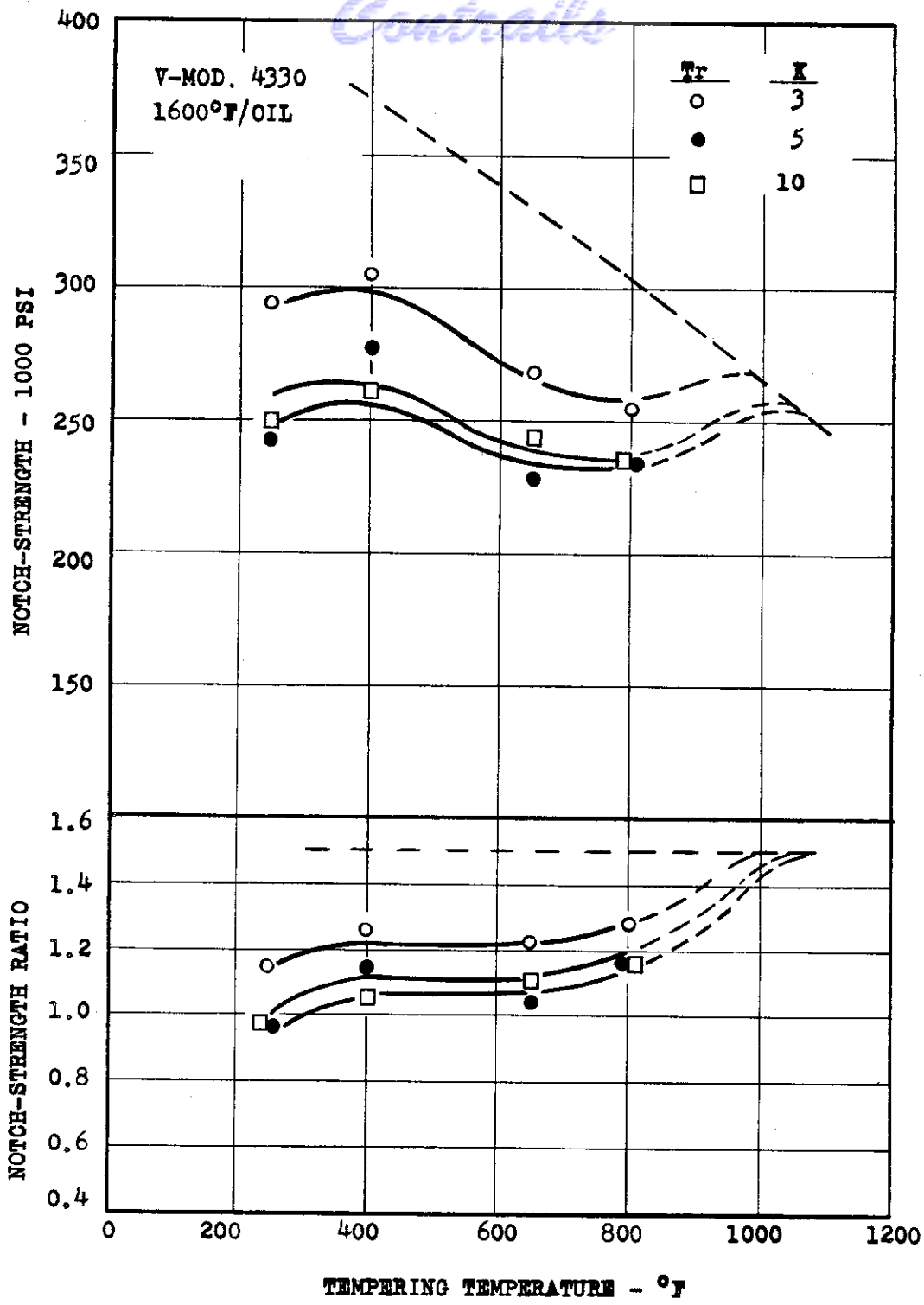


FIG. 175 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

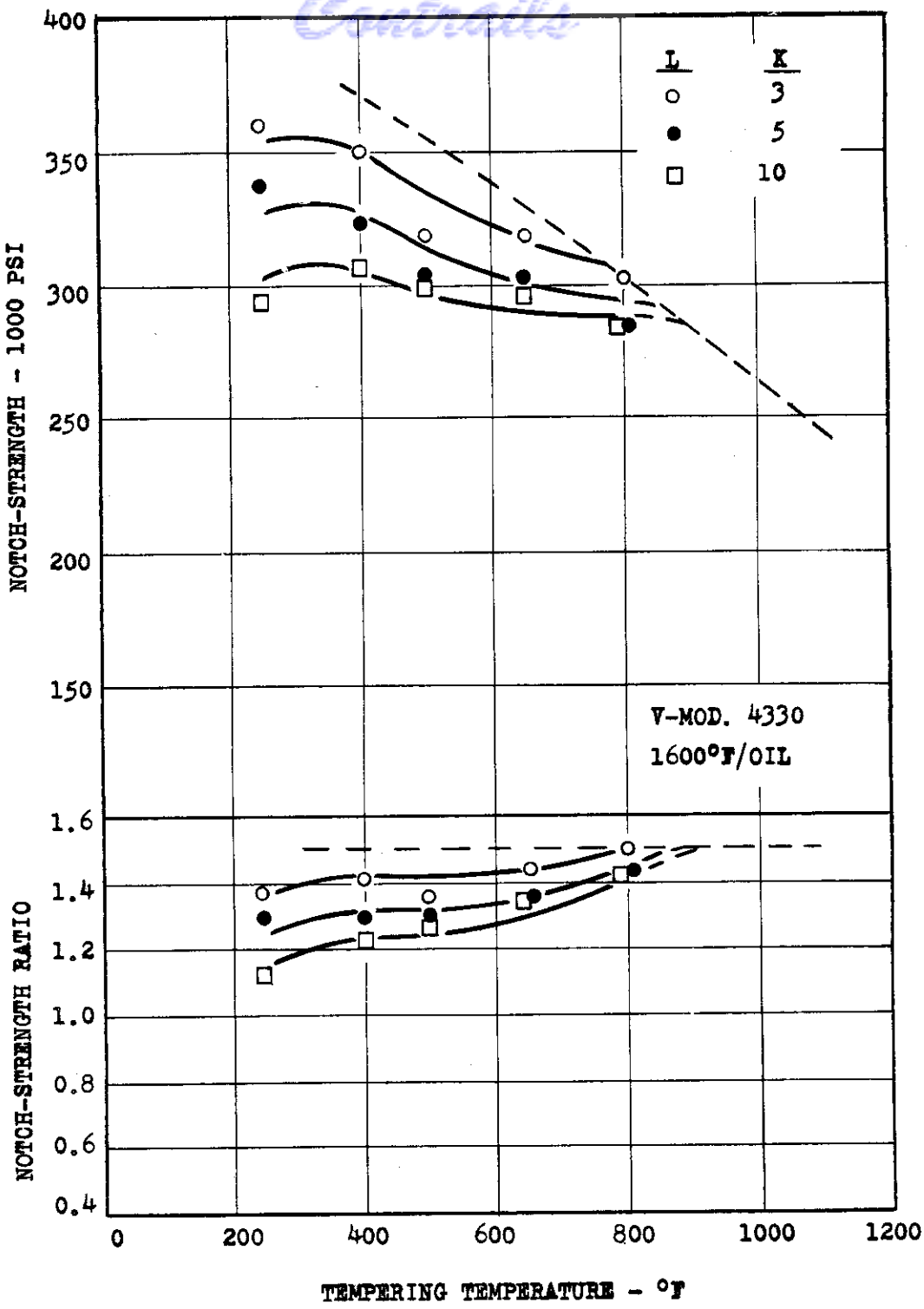


FIG. 176 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

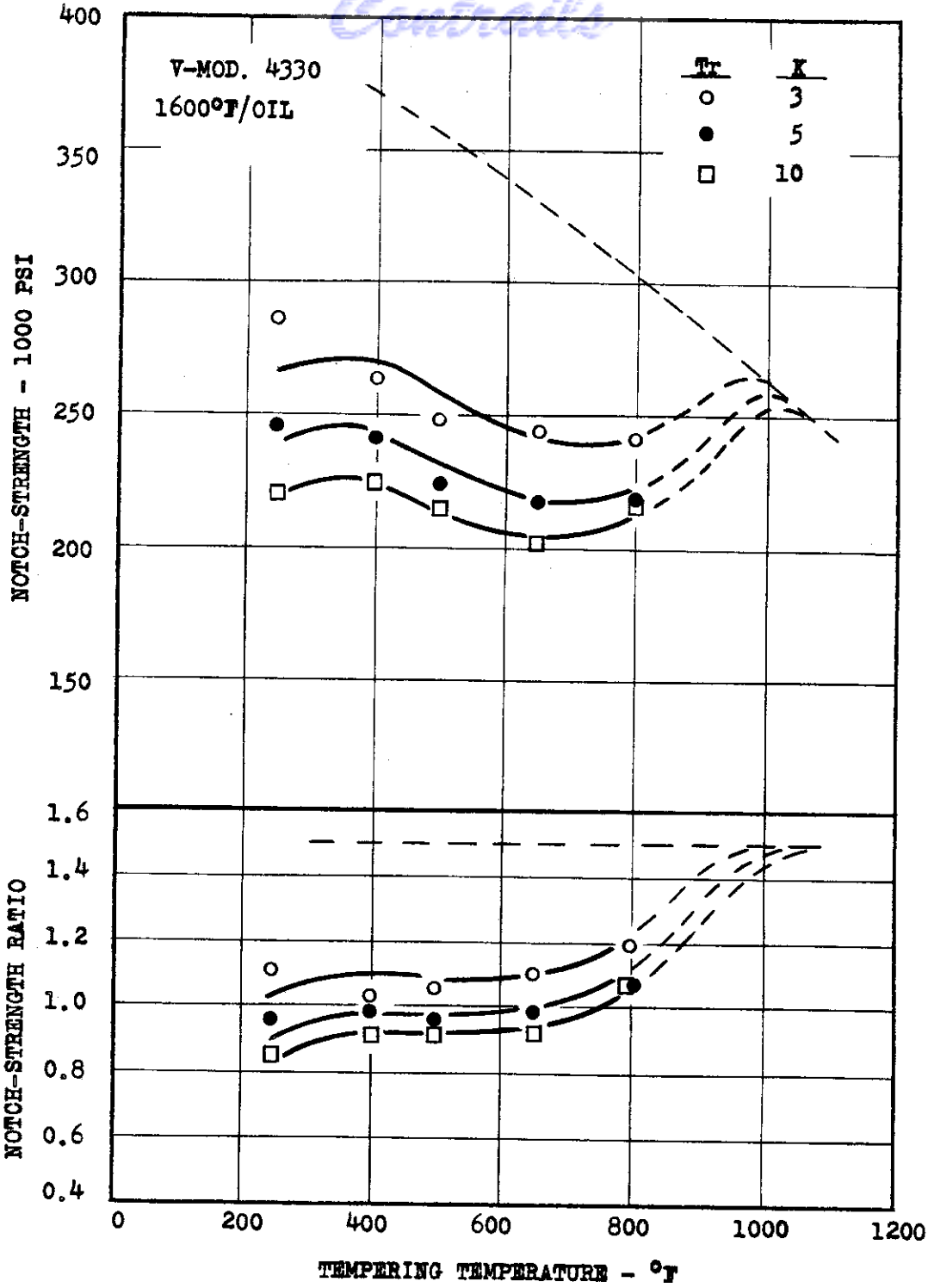


FIG. 177 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

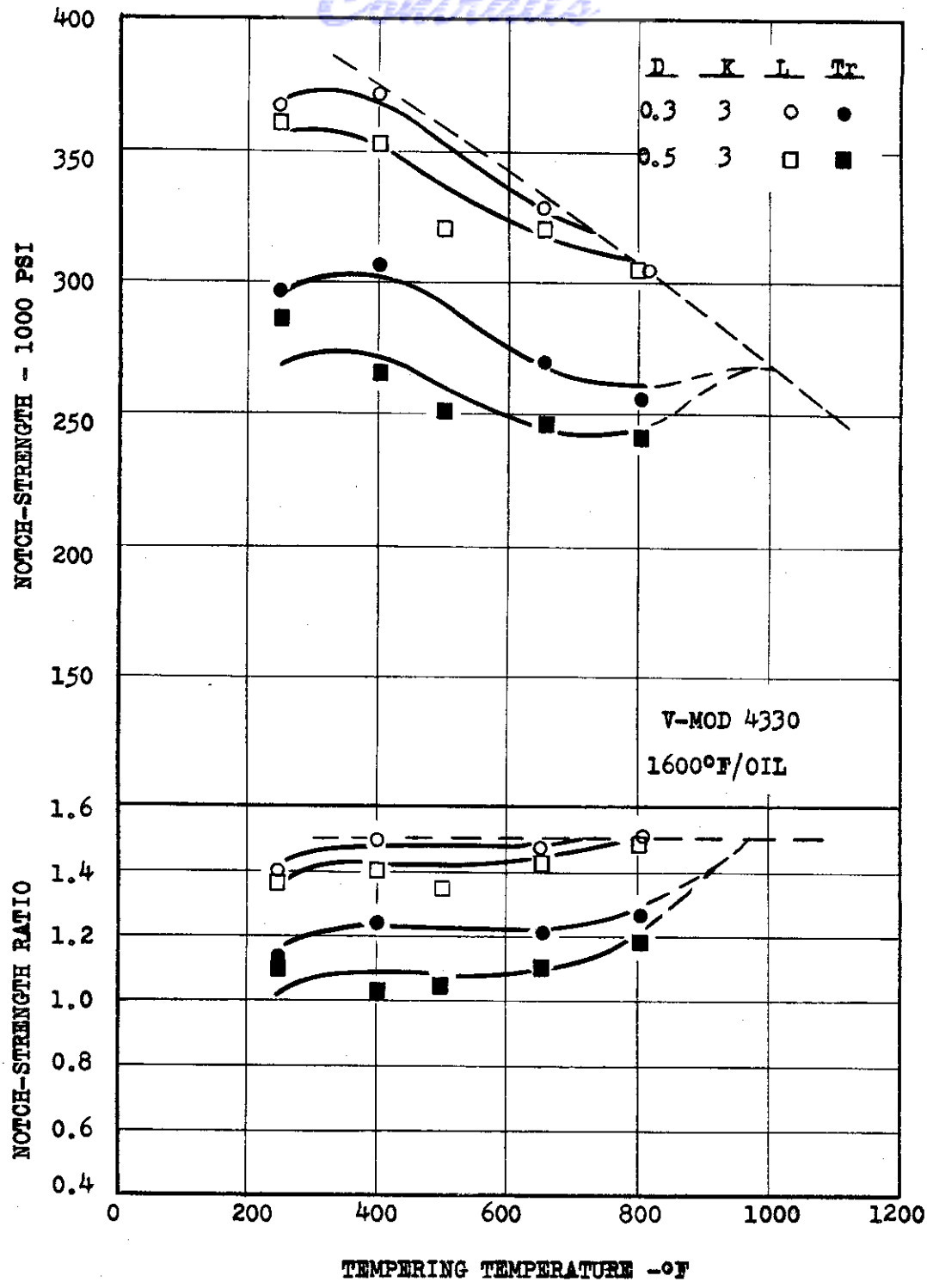


FIG. 178 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

TEST TEMP: R.T.

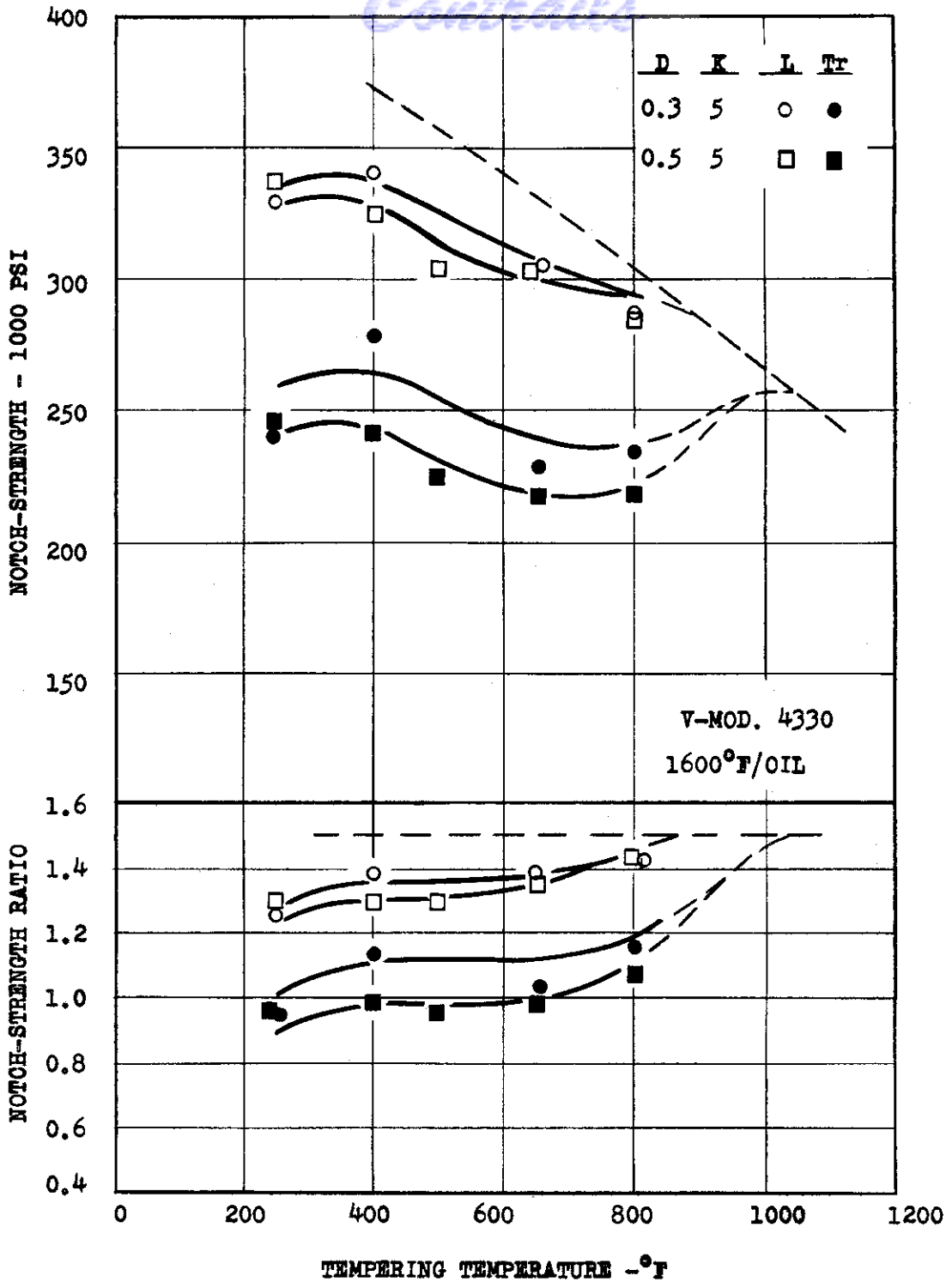


FIG. 179 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

TEST TEMP: R.T.

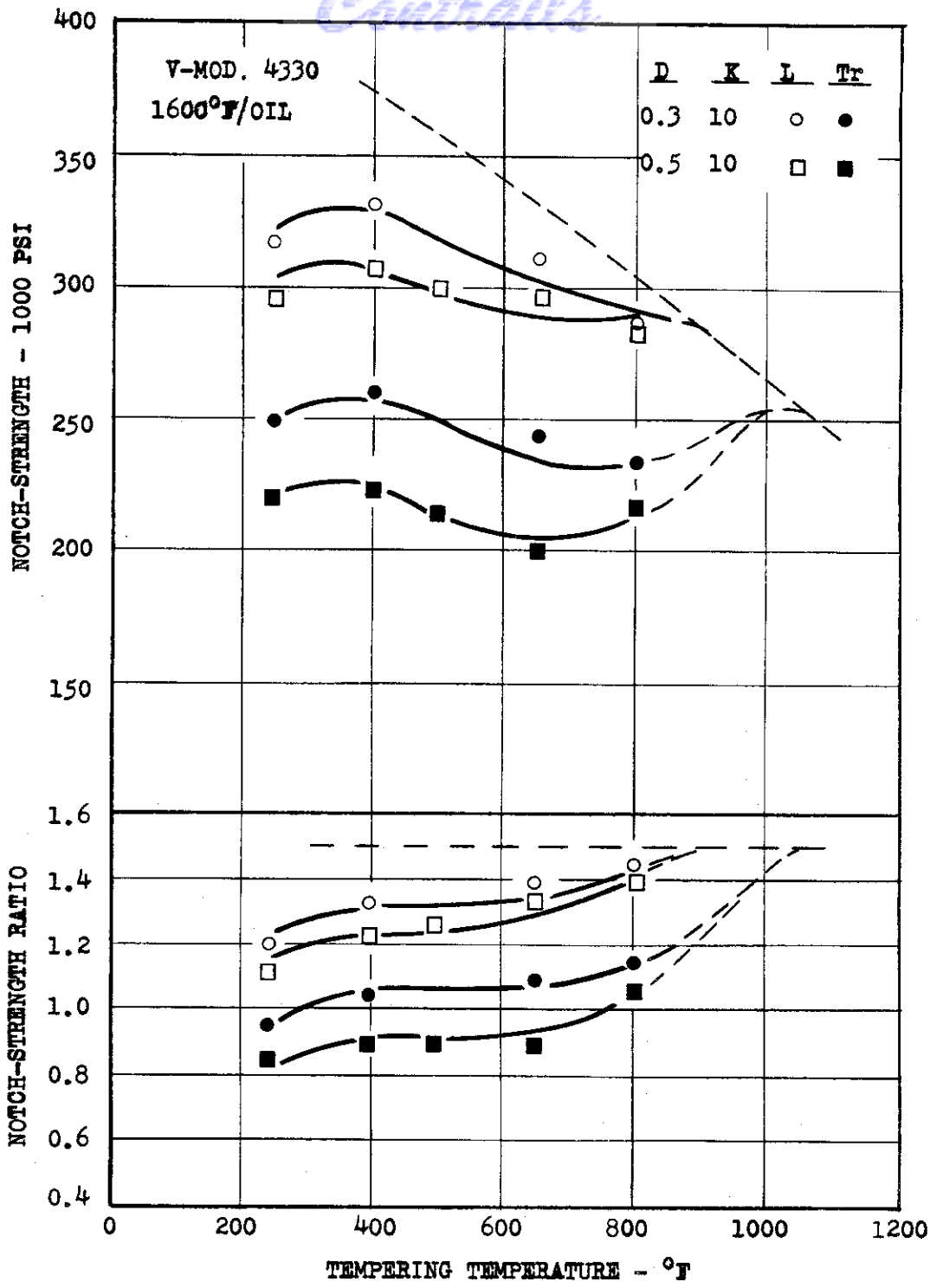


FIG. 180 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 AND 0.5 IN.DIA.

TEST TEMP: R.T.

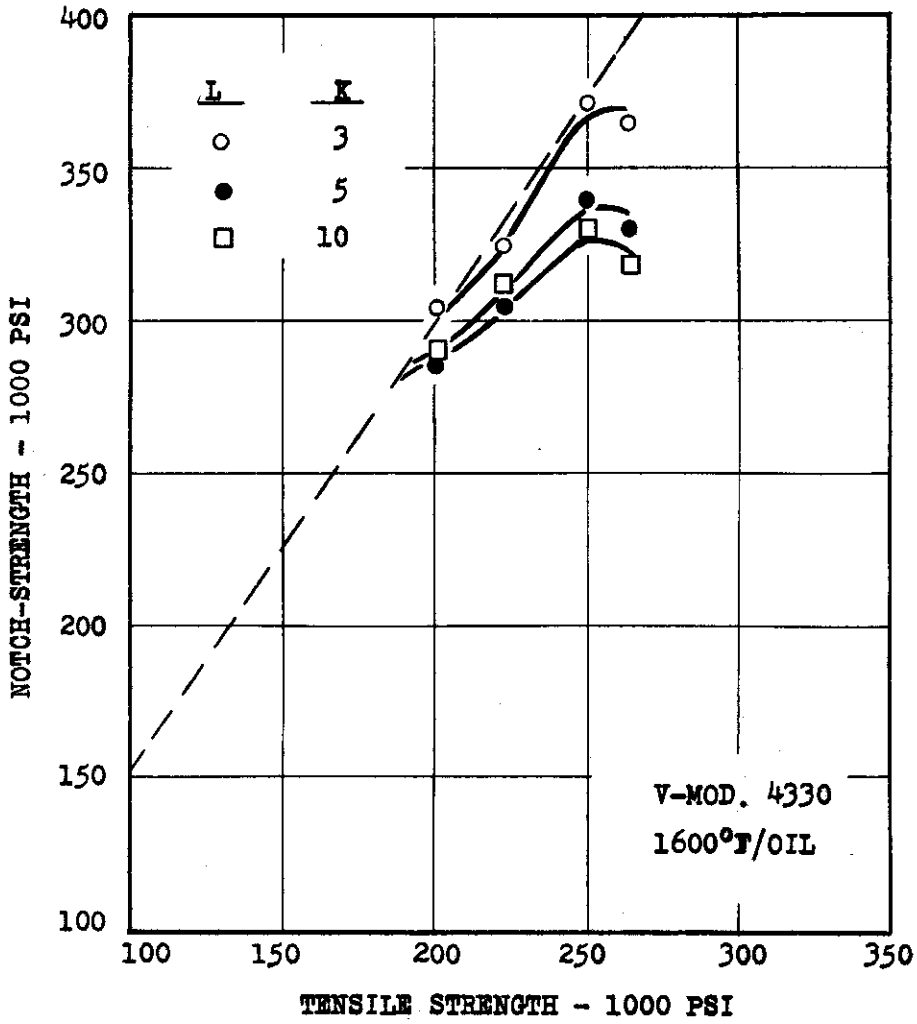


FIG. 181 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4IN.SQ.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

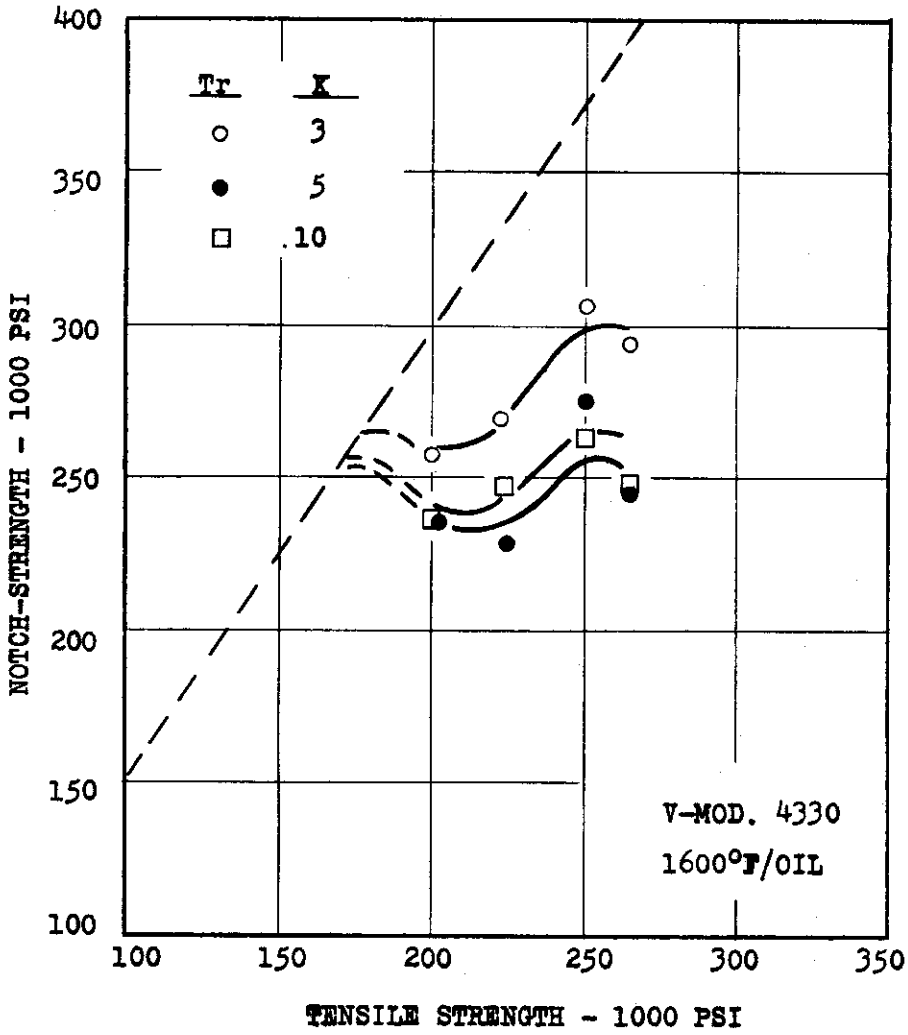


FIG. 182 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 IN.DIA.

TEST TEMP: R.T.

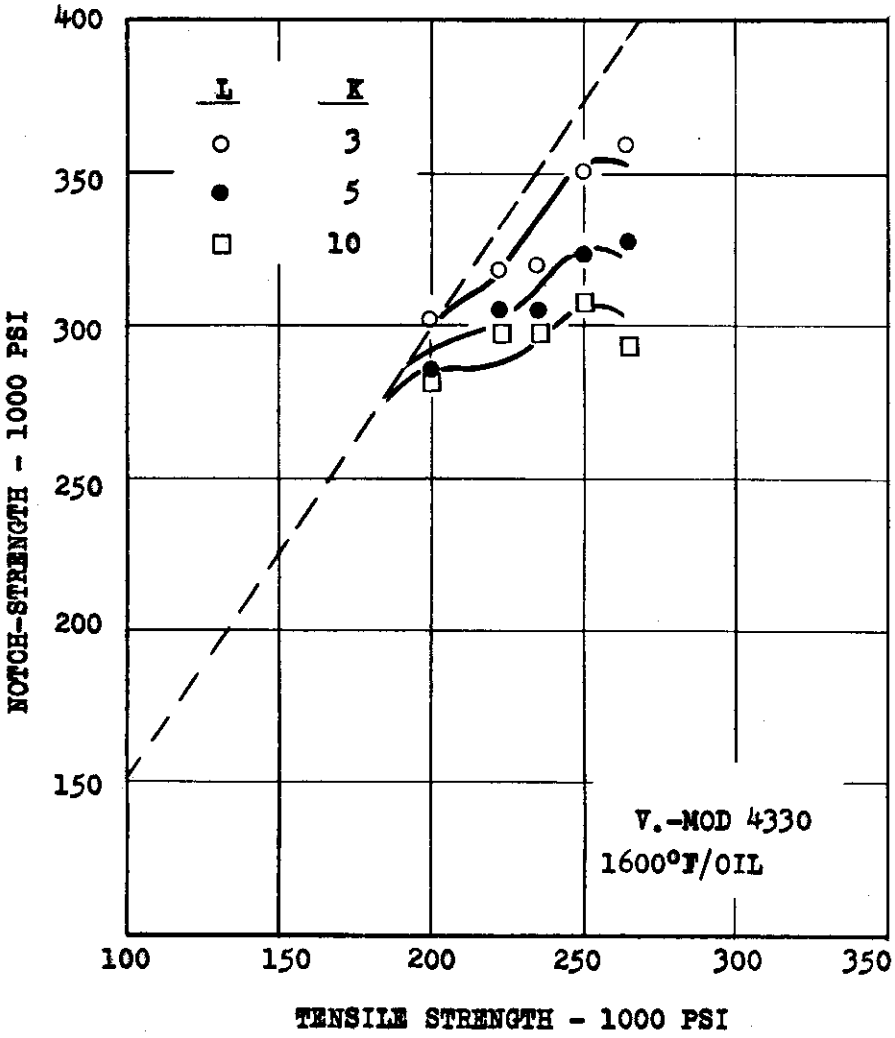


FIG. 183 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

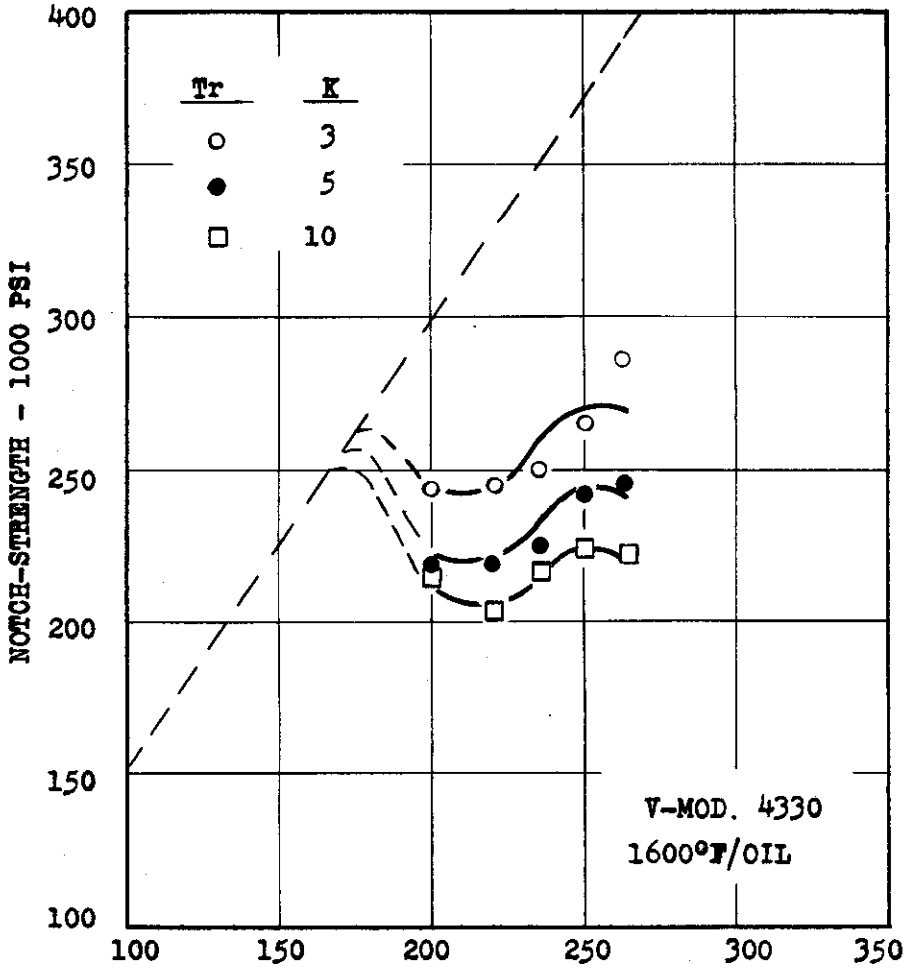


FIG. 184 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: 0.5 IN.DIA.

TEST TEMP: R.T.

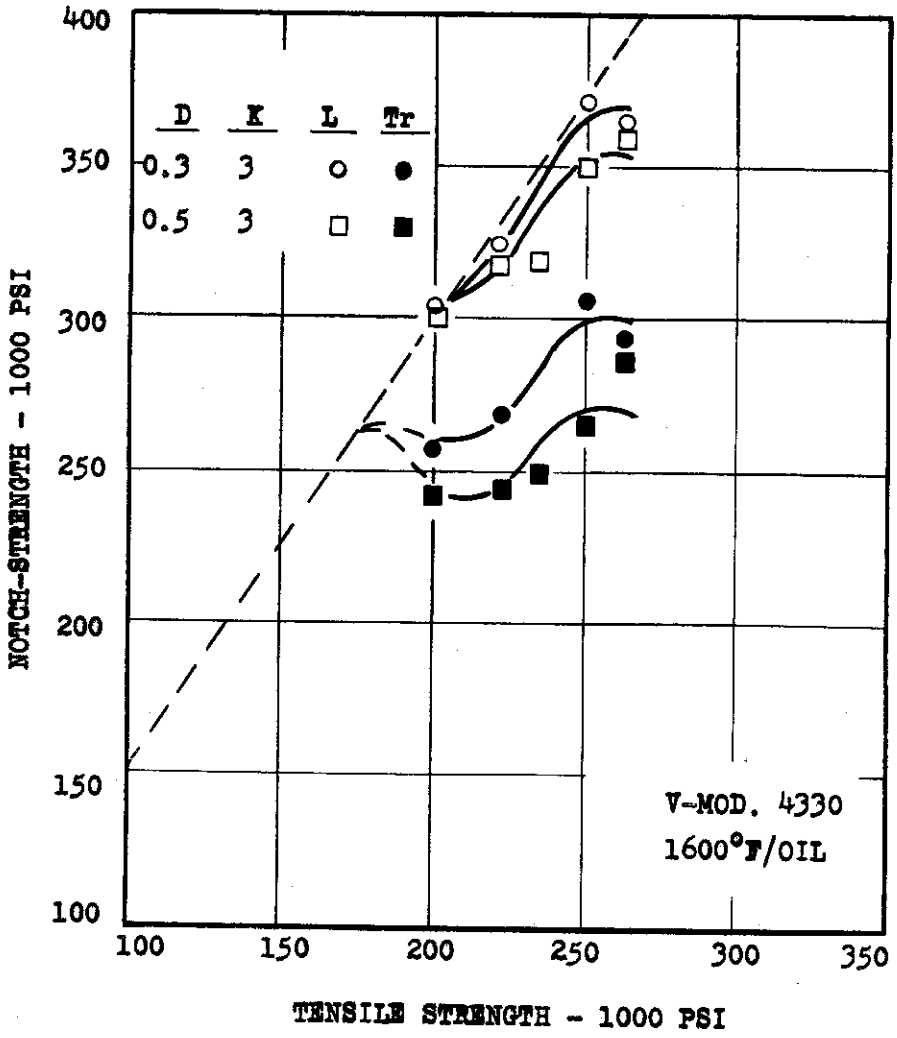


FIG. 185 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

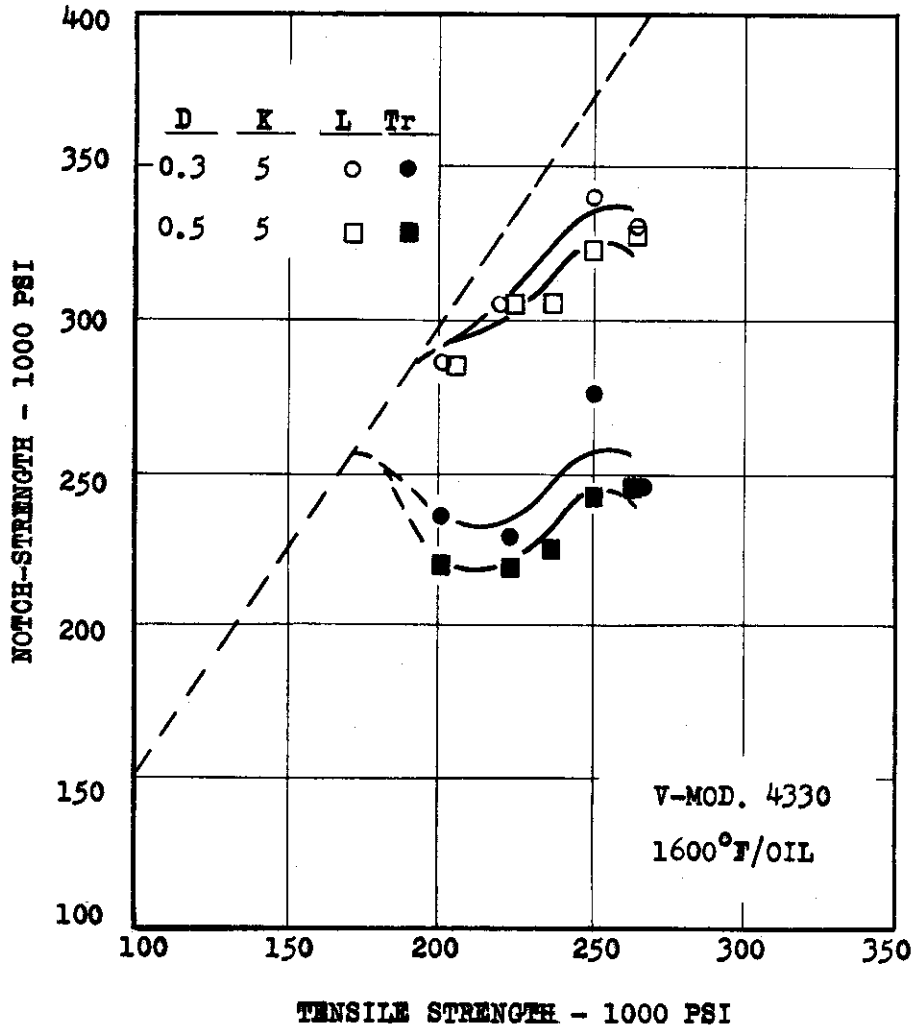


FIG. 186 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

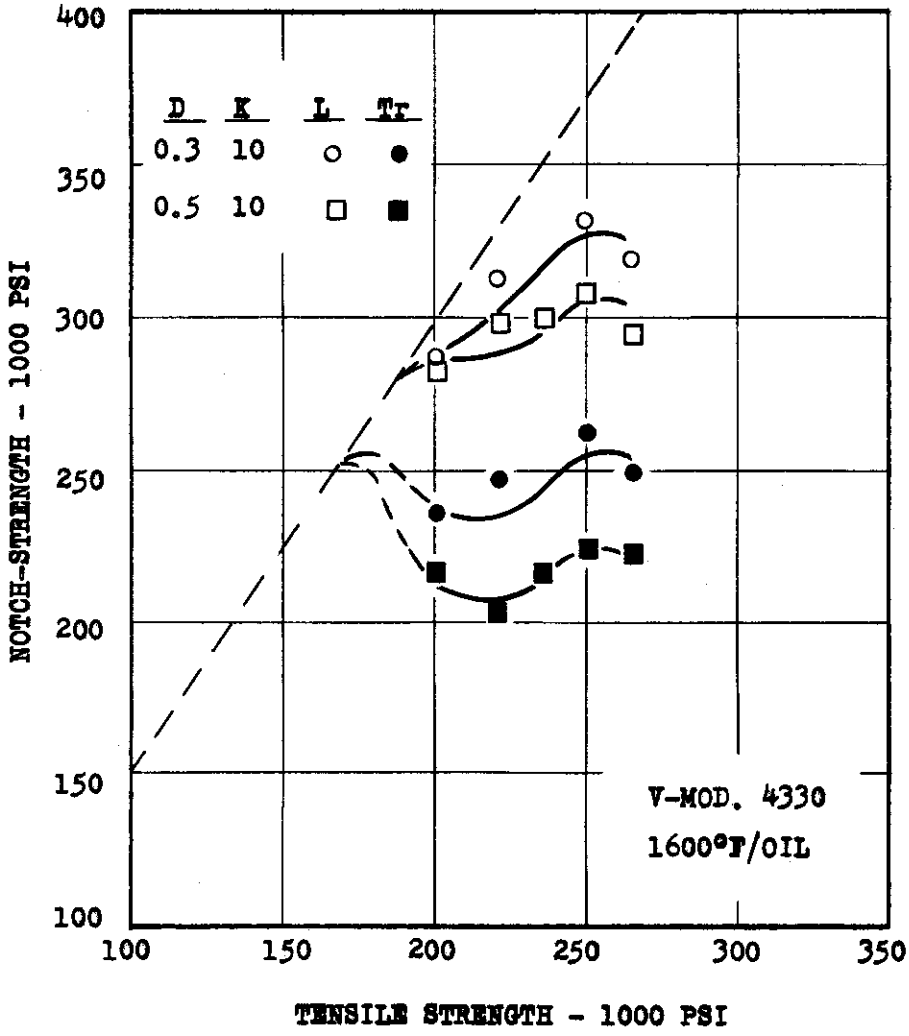


FIG. 187 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

○ 250°F (263,000 PSI)
● 400°F (250,000 PSI)
◇ 500°F (236,000 PSI)
□ 650°F (222,000 PSI)
■ 800°F (201,000 PSI)

V-MOD. 4330
1600°F/OIL

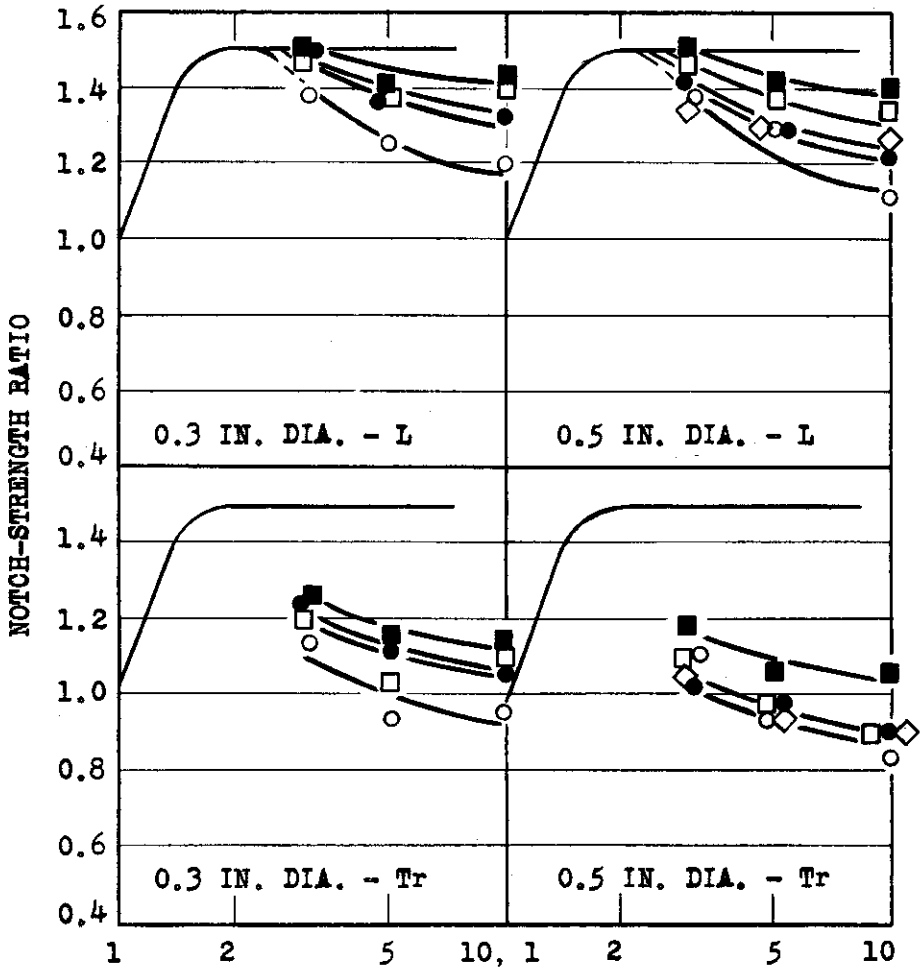


FIG. 188 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 4 IN.SQ.

TEST TEMP: R.T.

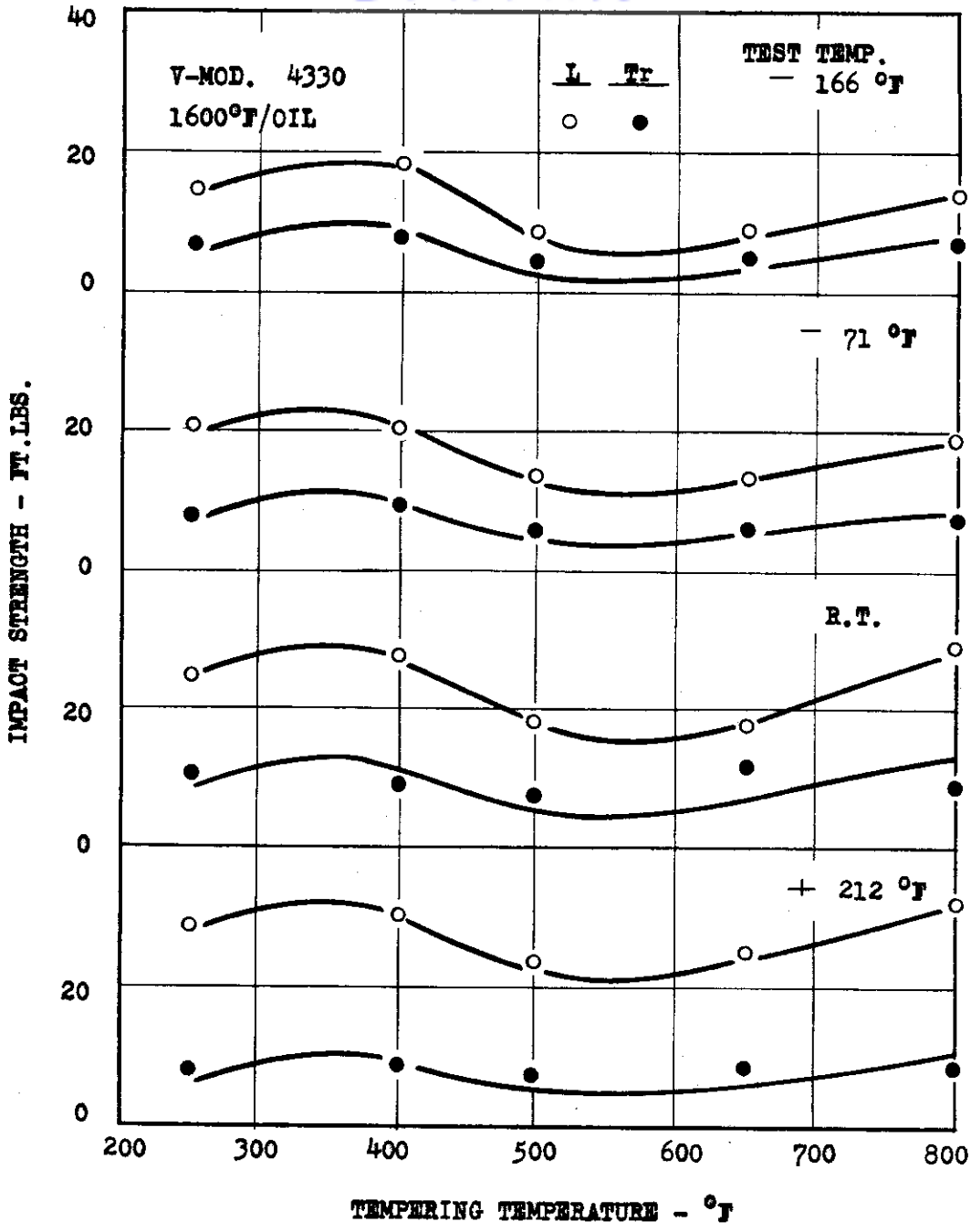


FIG. 189 VARIATION OF IMPACT STRENGTH WITH TEMPERING TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: STD. V-NOTCH CHARPY

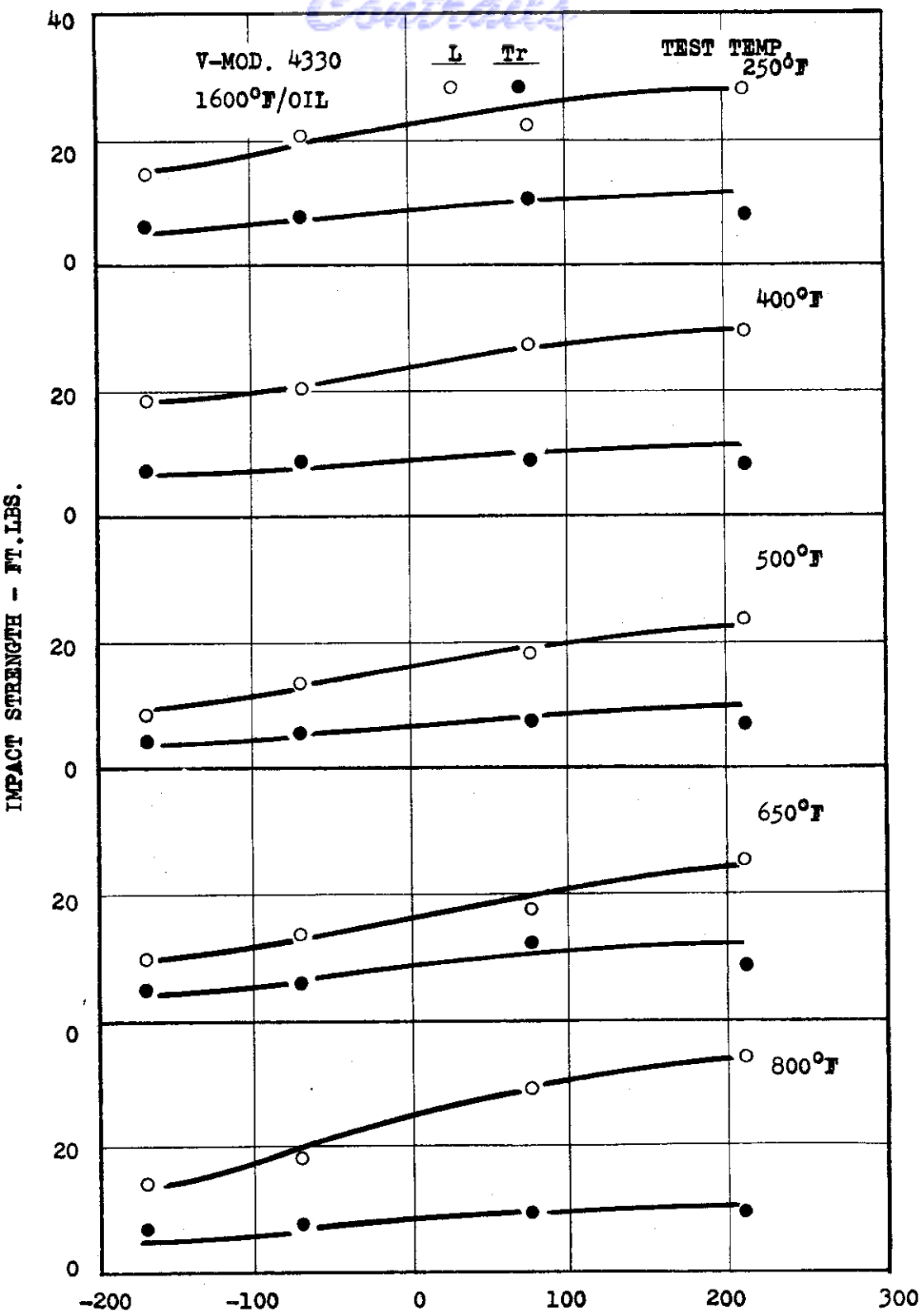


FIG. 190 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 4 IN.SQ.

SPECIMEN: STD. V-NOTCH CHARPY

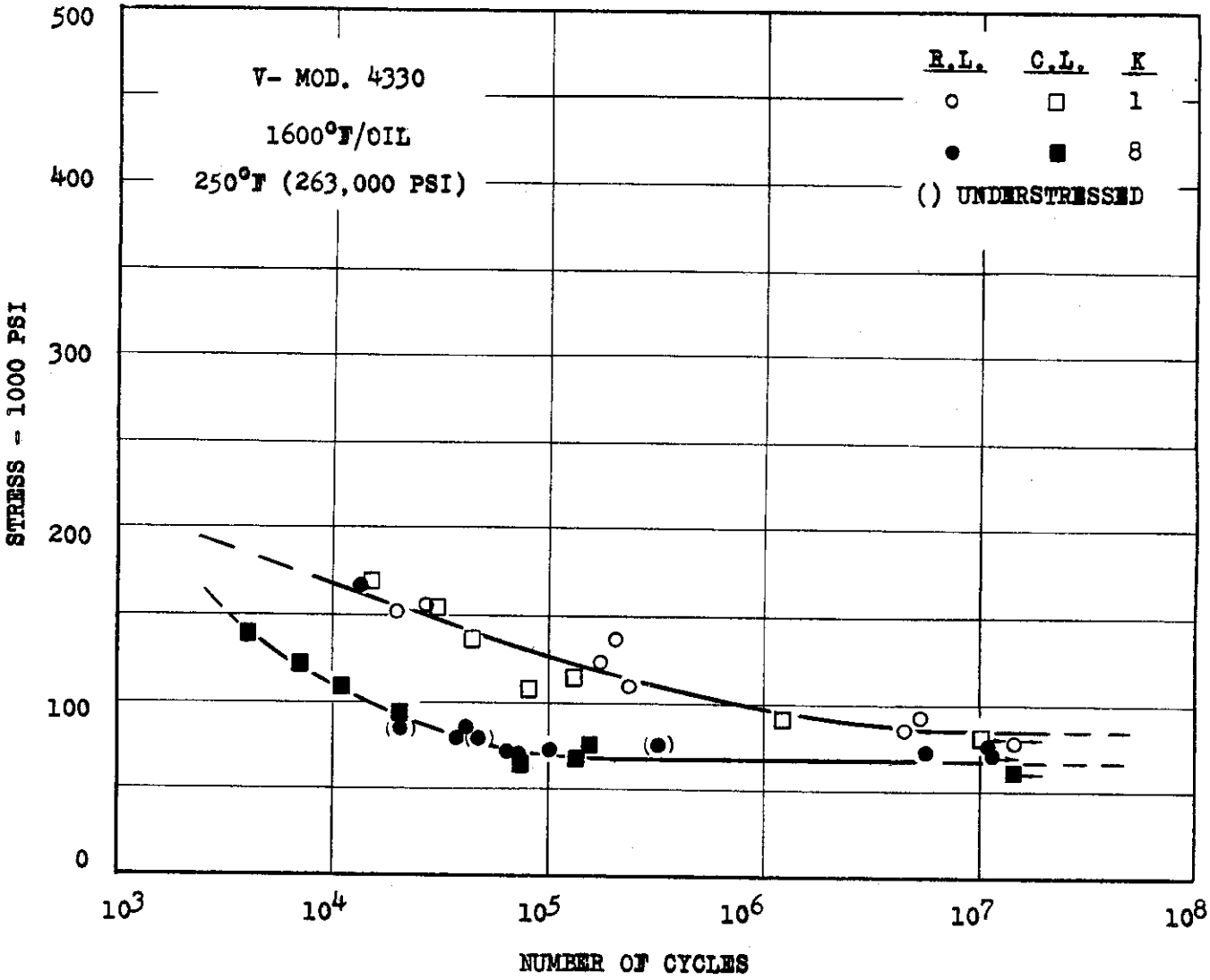


FIG.191 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4 IN.SQ.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

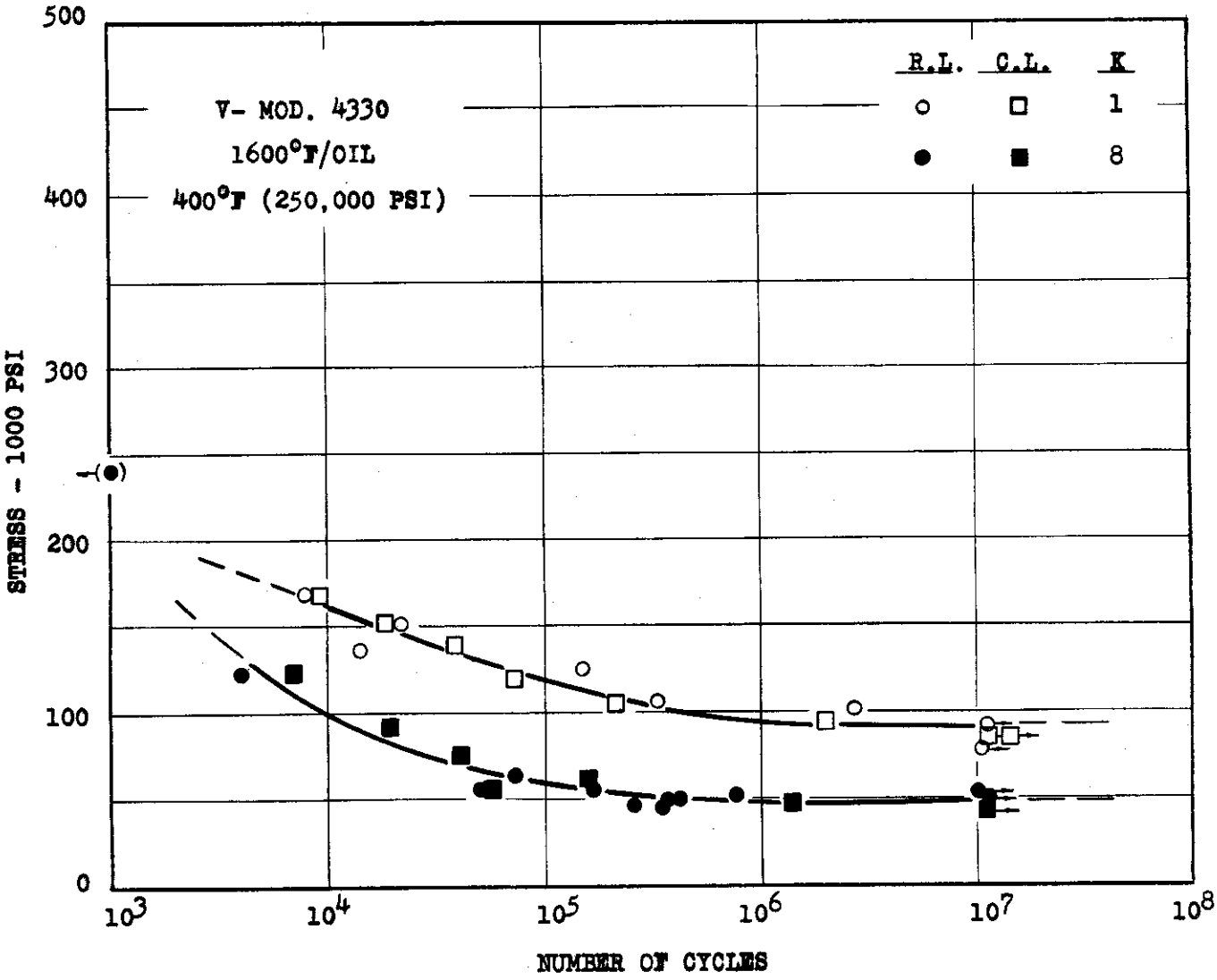


FIG. 192 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS

SECTION : 4 IN.SQ.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

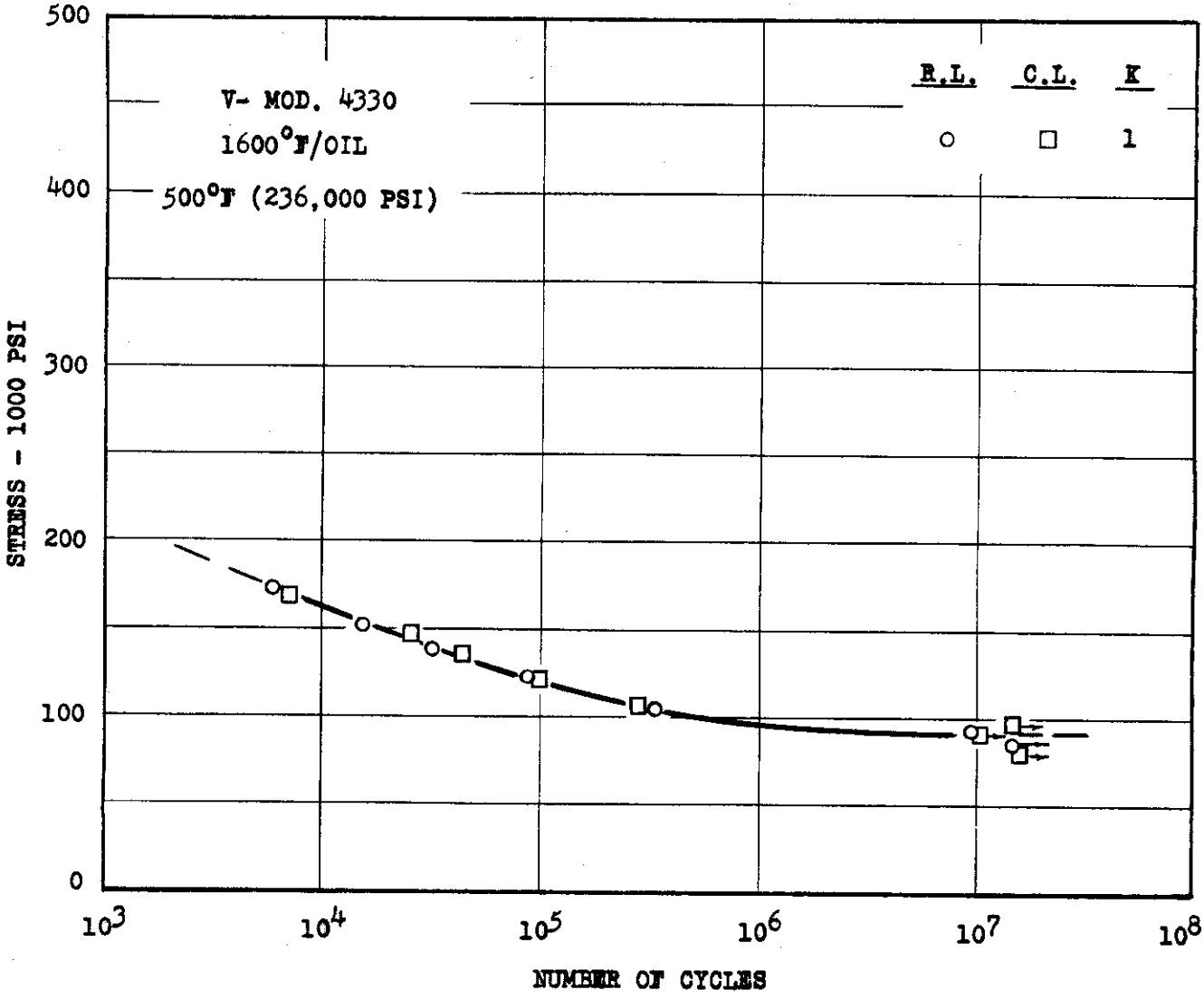


FIG.193 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4 IN.SQ.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

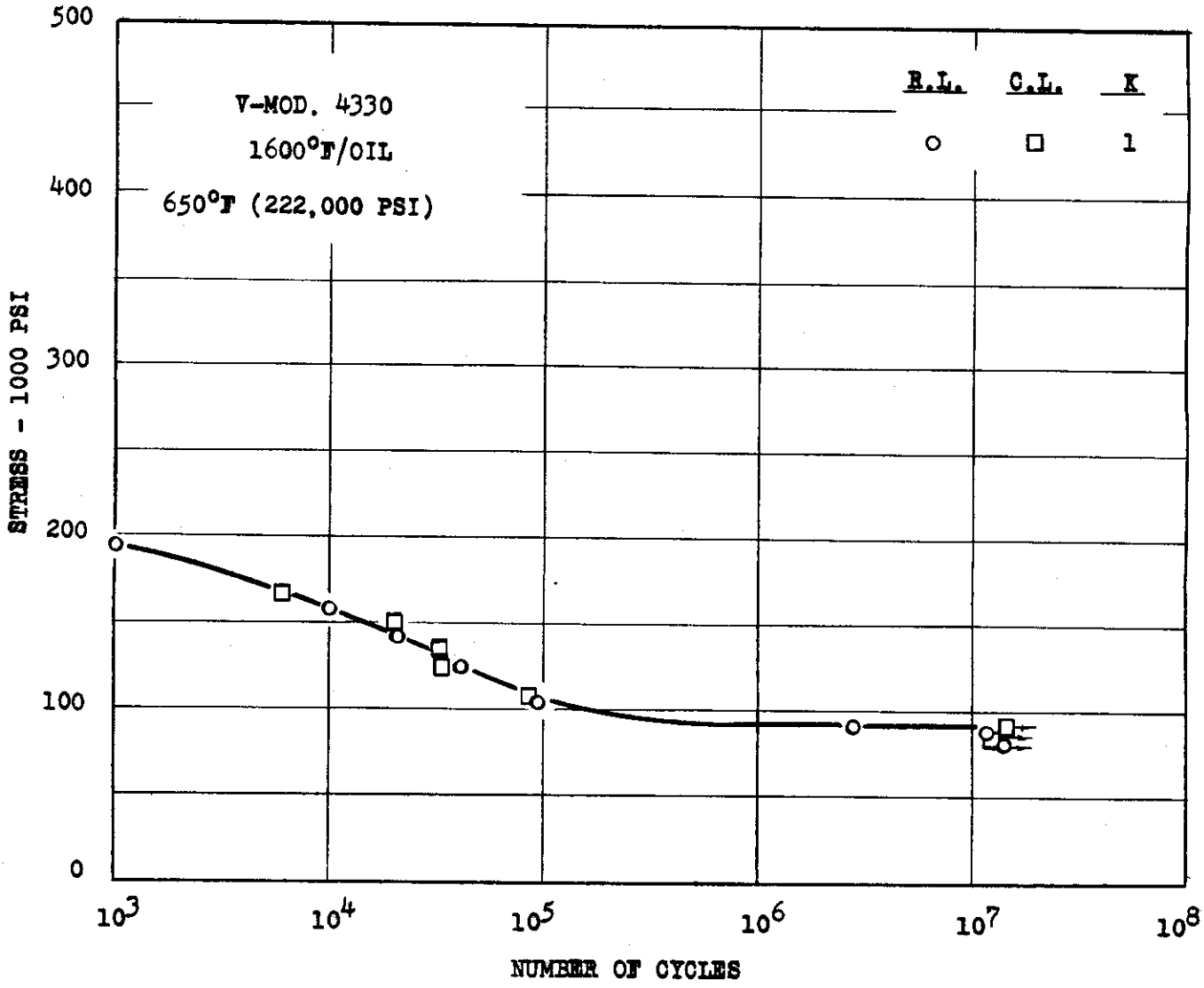


FIG. 194 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 4 IN.SQ.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

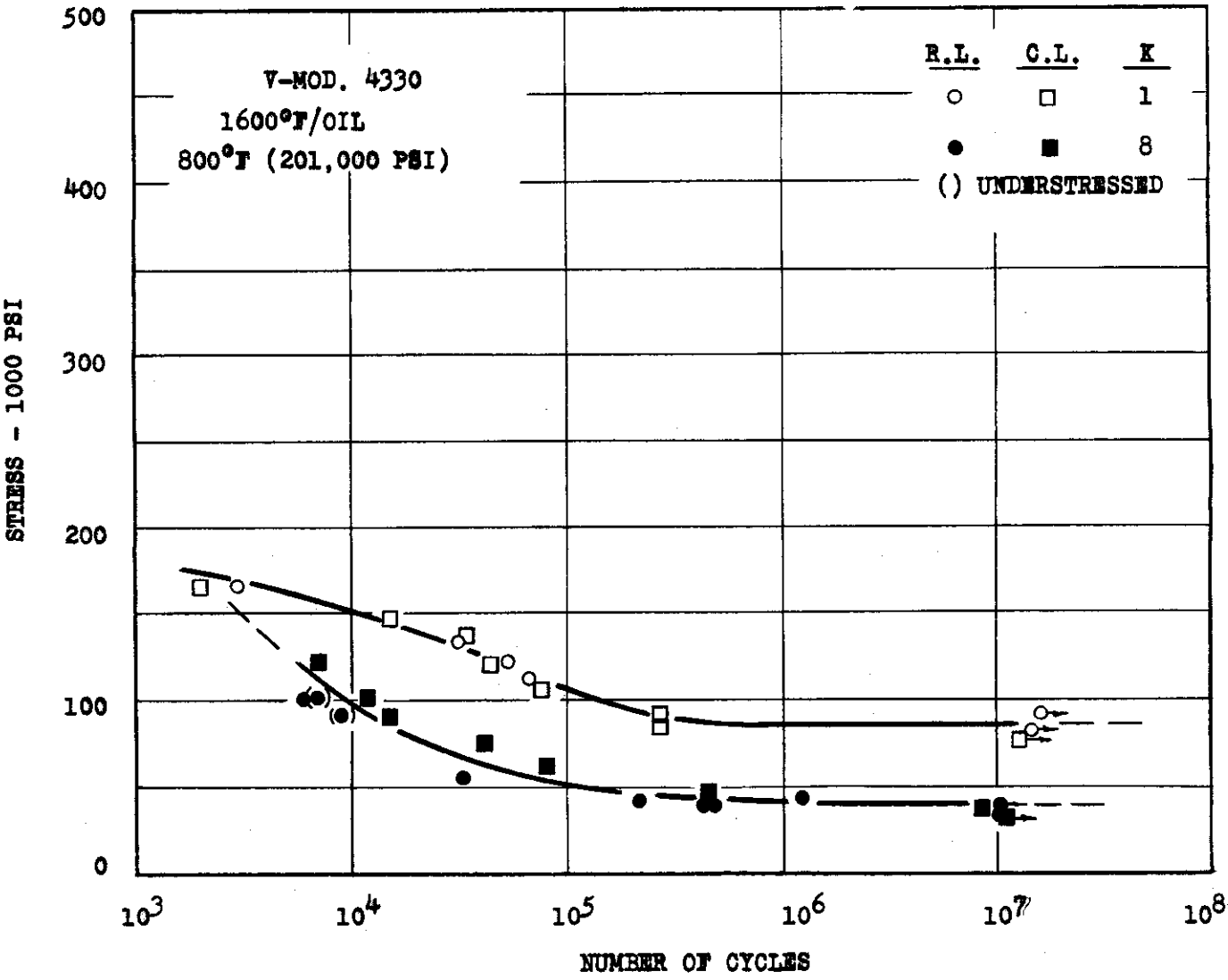


FIG. 195 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS .

SECTION: 4 IN.SQ.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

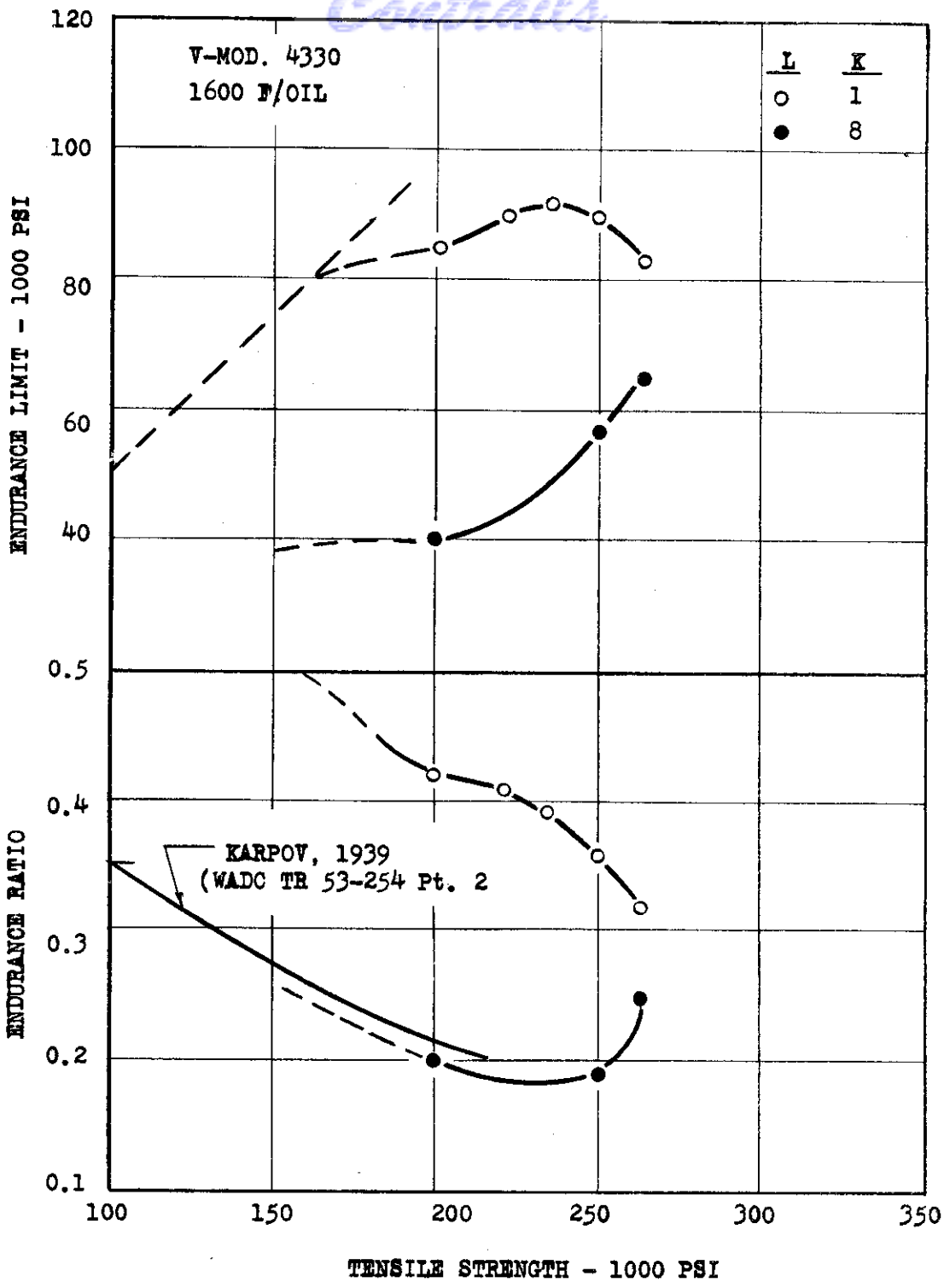


FIG.196 VARIATION OF ENDURANCE LIMIT AND ENDURANCE RATIO WITH TENSILE STRENGTH.

SECTION: 4 IN.SQ.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.

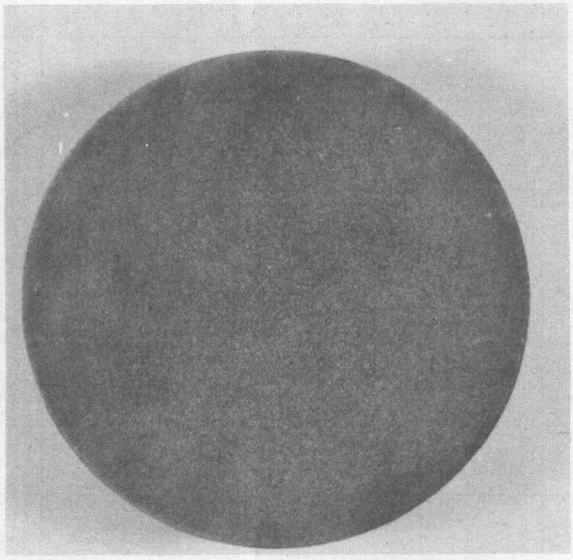
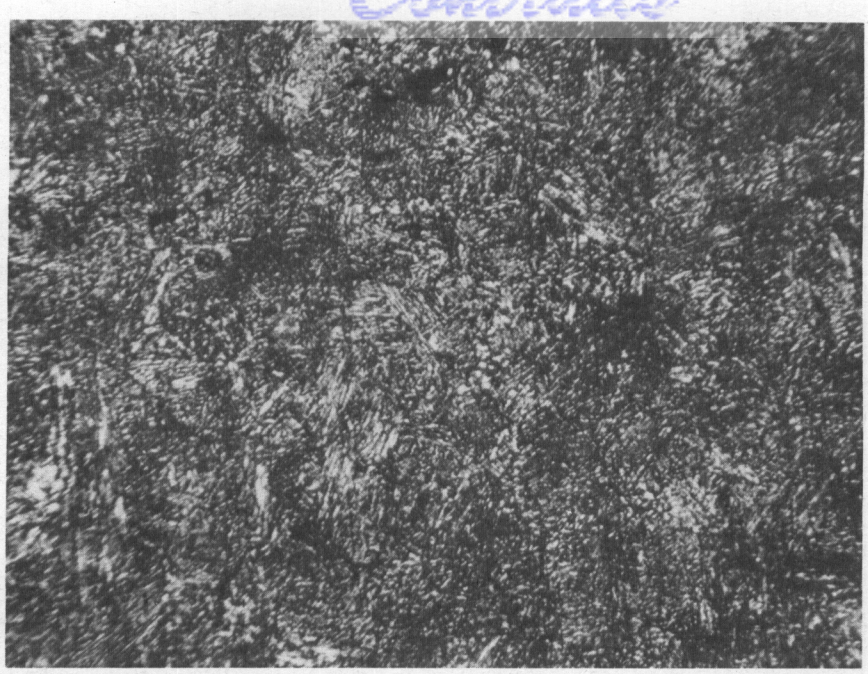
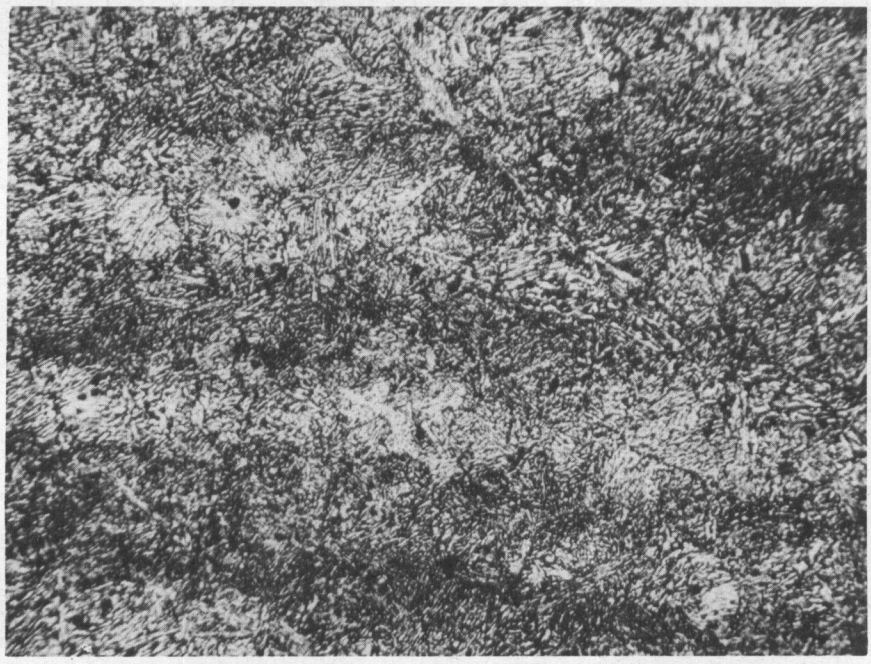


FIG. 197 MACROGRAPHS OF HY-TUF STEEL AS RECEIVED, ETCHED WITH 25% SOLUTION OF NITRIC ACID.



(a) Transverse Pattern



(b) Longitudinal Pattern

FIG. 198 PHOTOMICROGRAPHS OF HY-TUF STEEL OIL QUENCHED AND TEMPERED AT 500°F. 4% NITAL ETCH. 100 DIAMETER MAGNIFICATION.

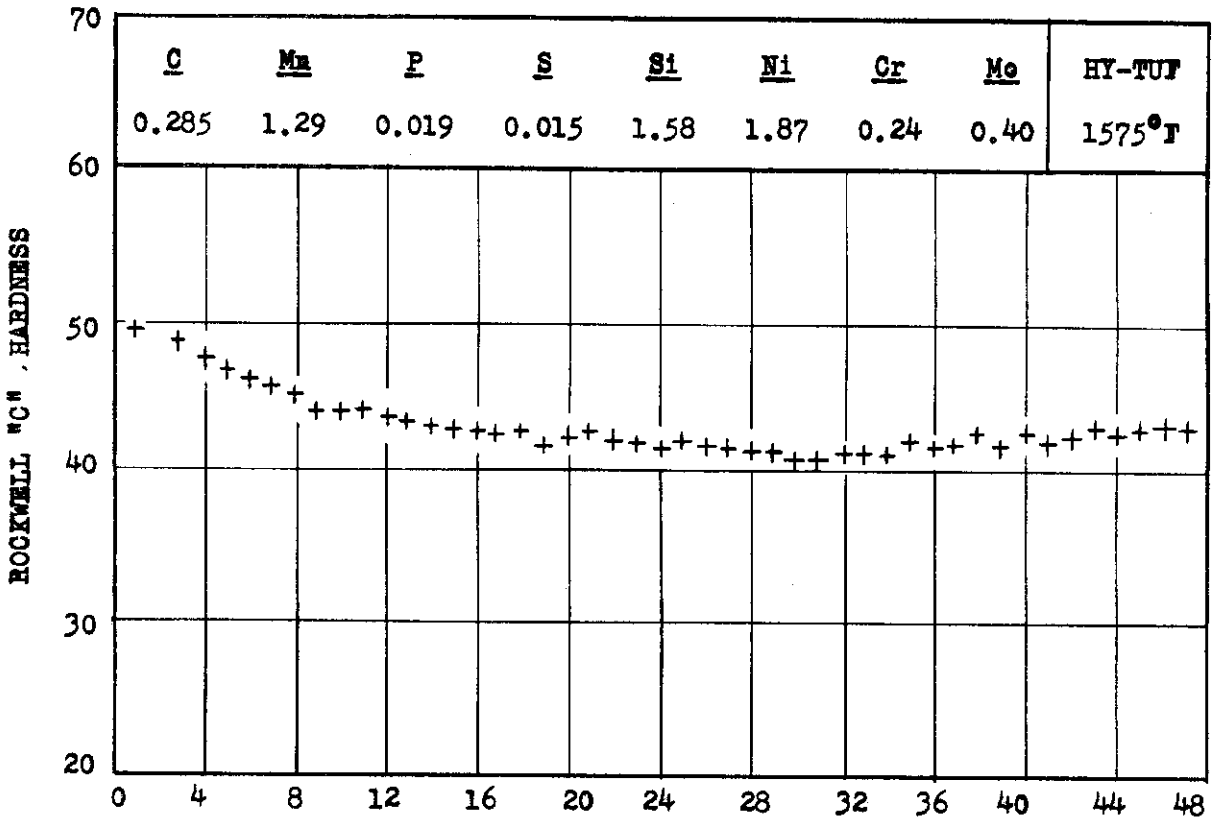


FIG. 199 HARDENABILITY OF JOMINY - QUENCH BAR.

SECTION: 3 IN. DIA.

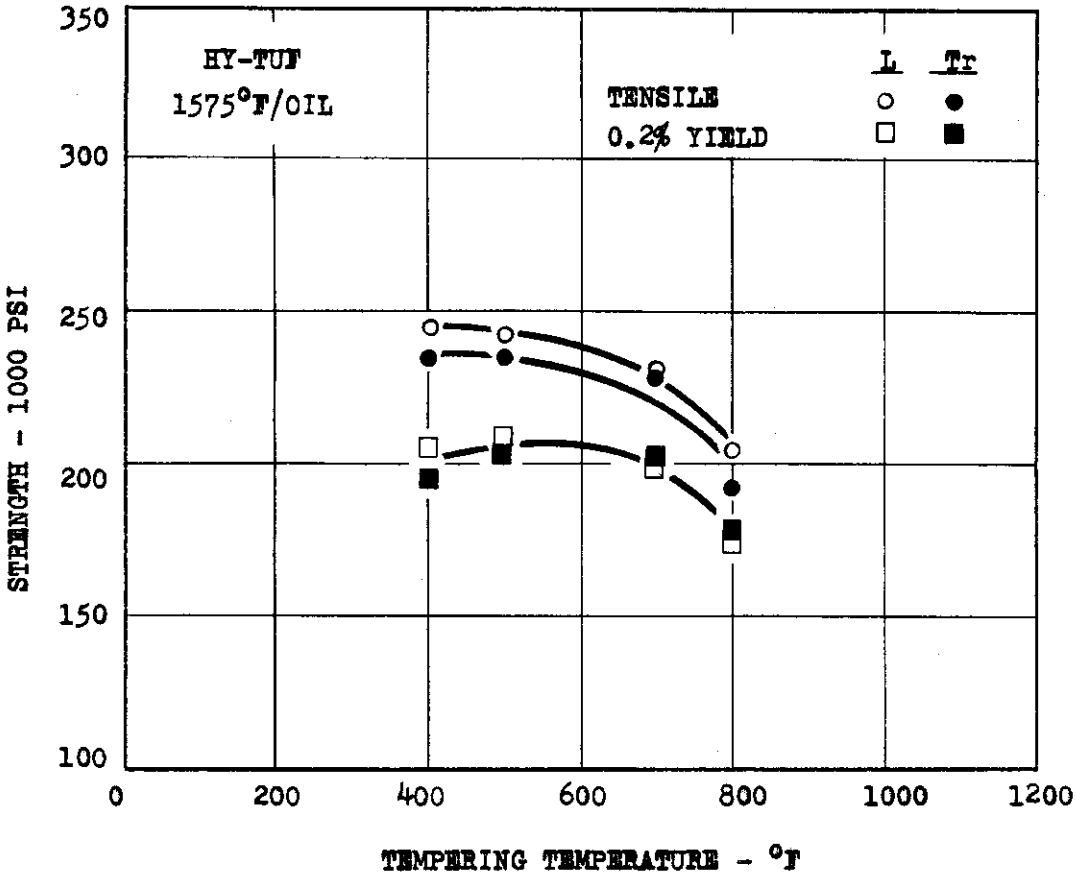


FIG. 200 TENSILE AND YIELD STRENGTH AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

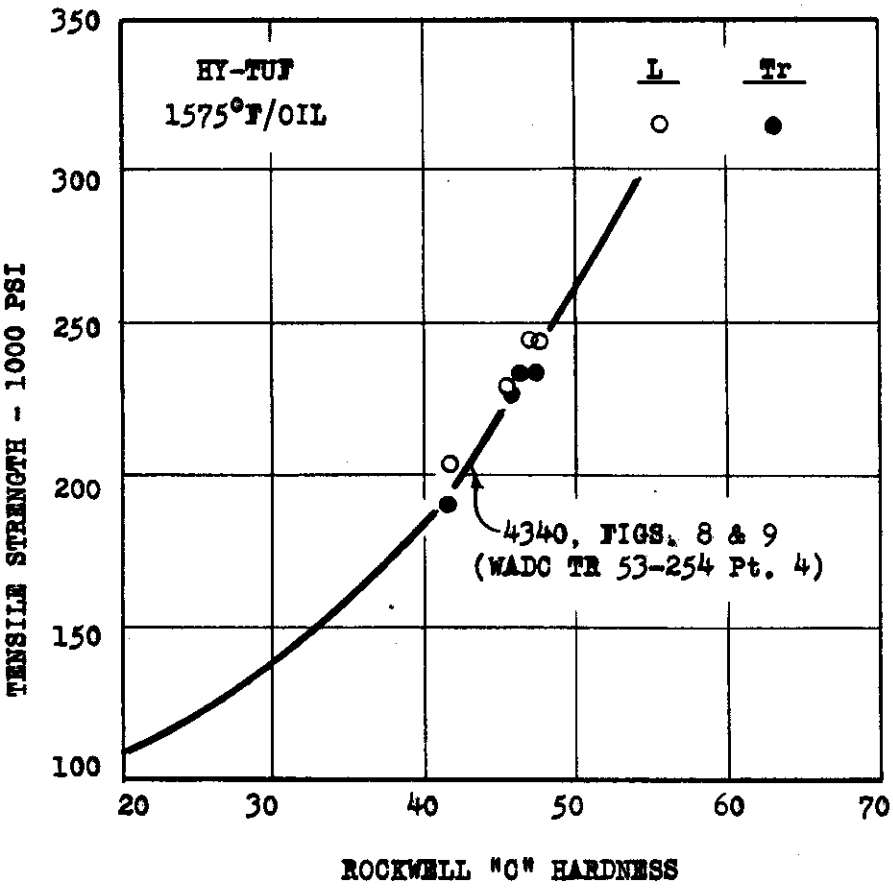


FIG. 201 VARIATION OF TENSILE STRENGTH WITH HARDNESS.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

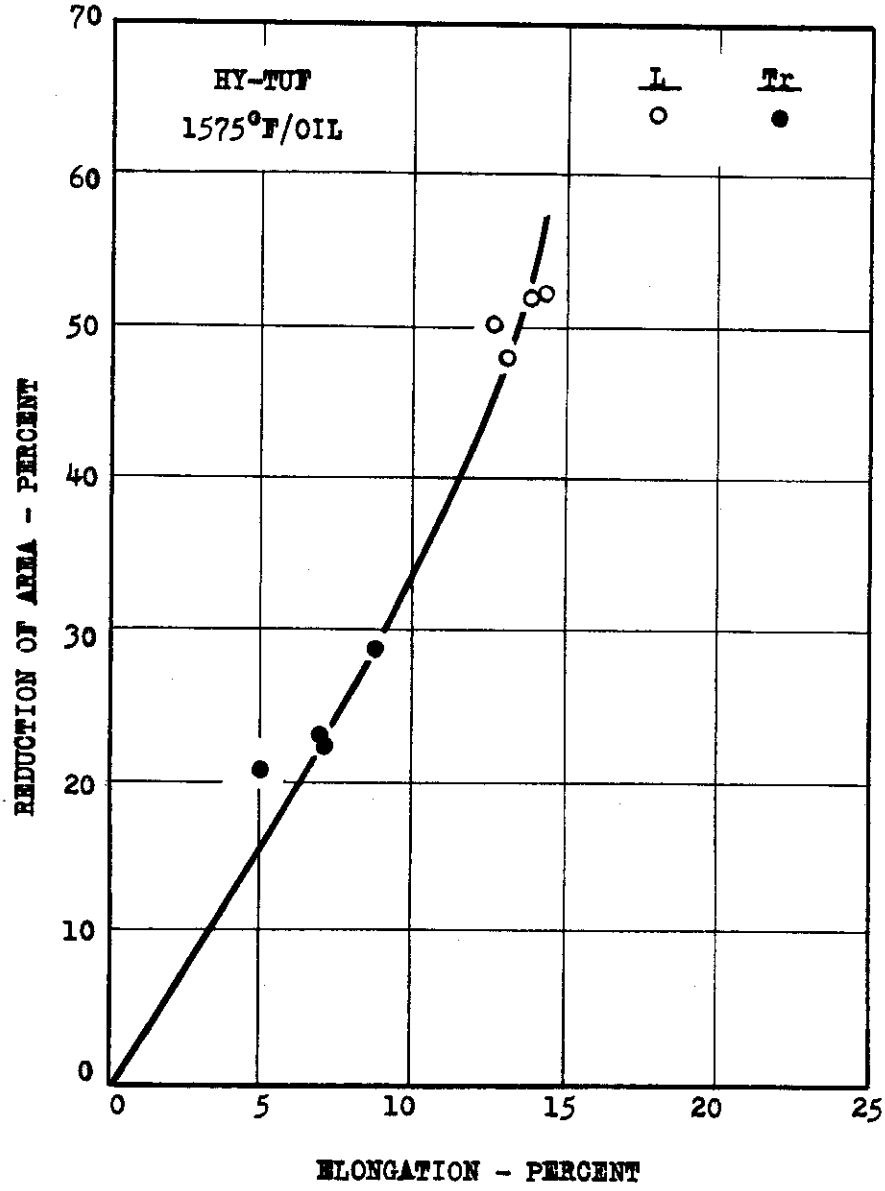


FIG. 202 REDUCTION OF AREA AS A FUNCTION OF ELONGATION.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

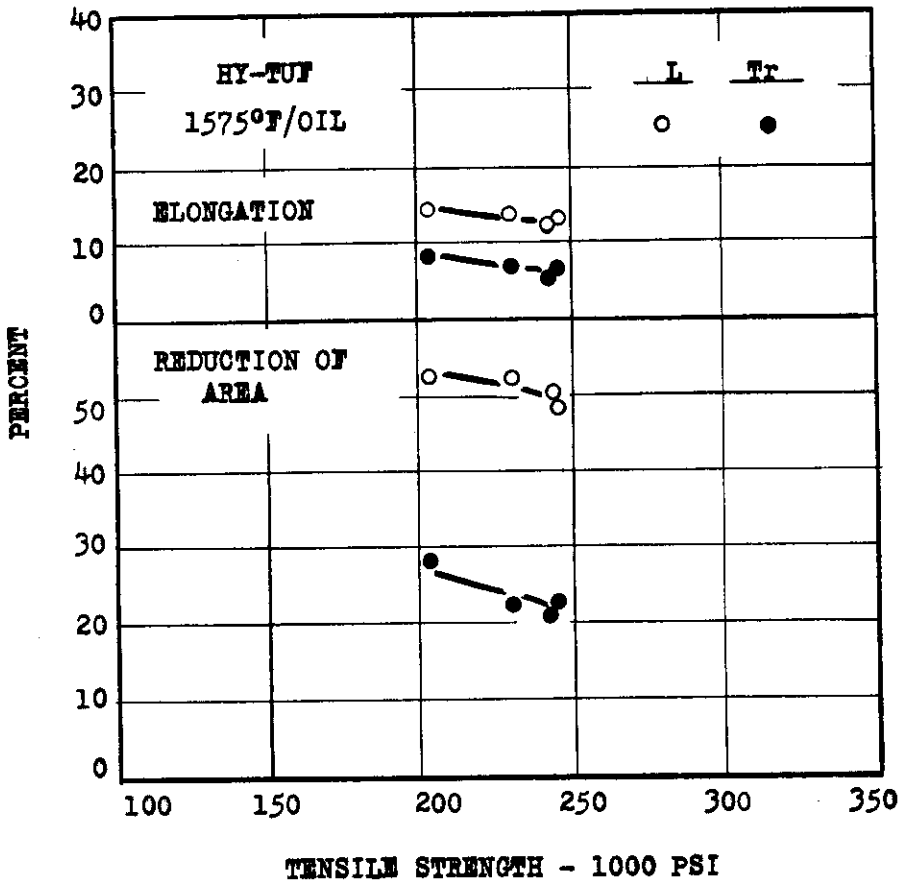


FIG. 203 VARIATION OF ELONGATION AND REDUCTION OF AREA WITH TENSILE STRENGTH.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

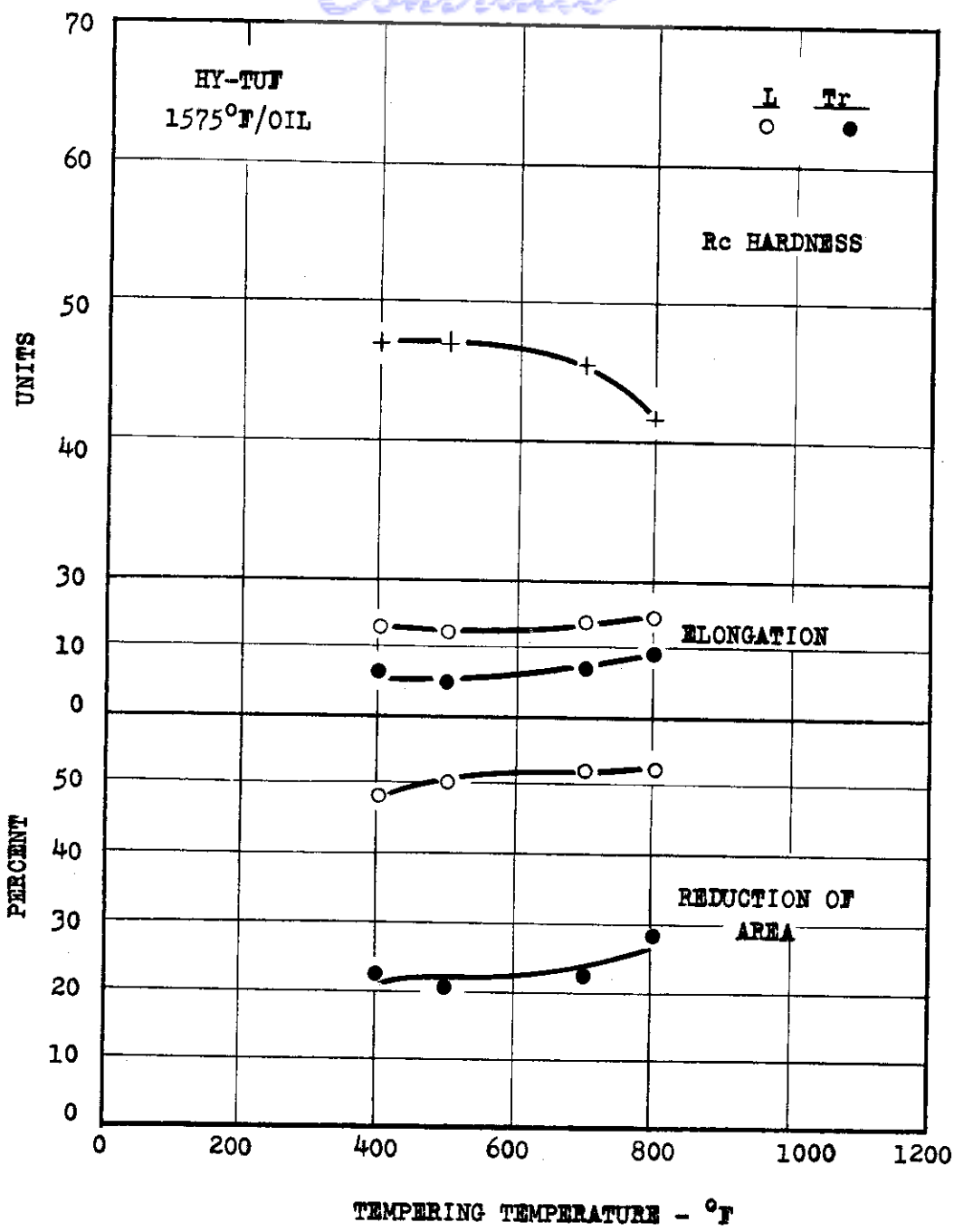


FIG.204 HARDNESS, ELONGATION, AND REDUCTION OF AREA AS A FUNCTION OF TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.28 IN.DIA.

TEST TEMP: R.T.

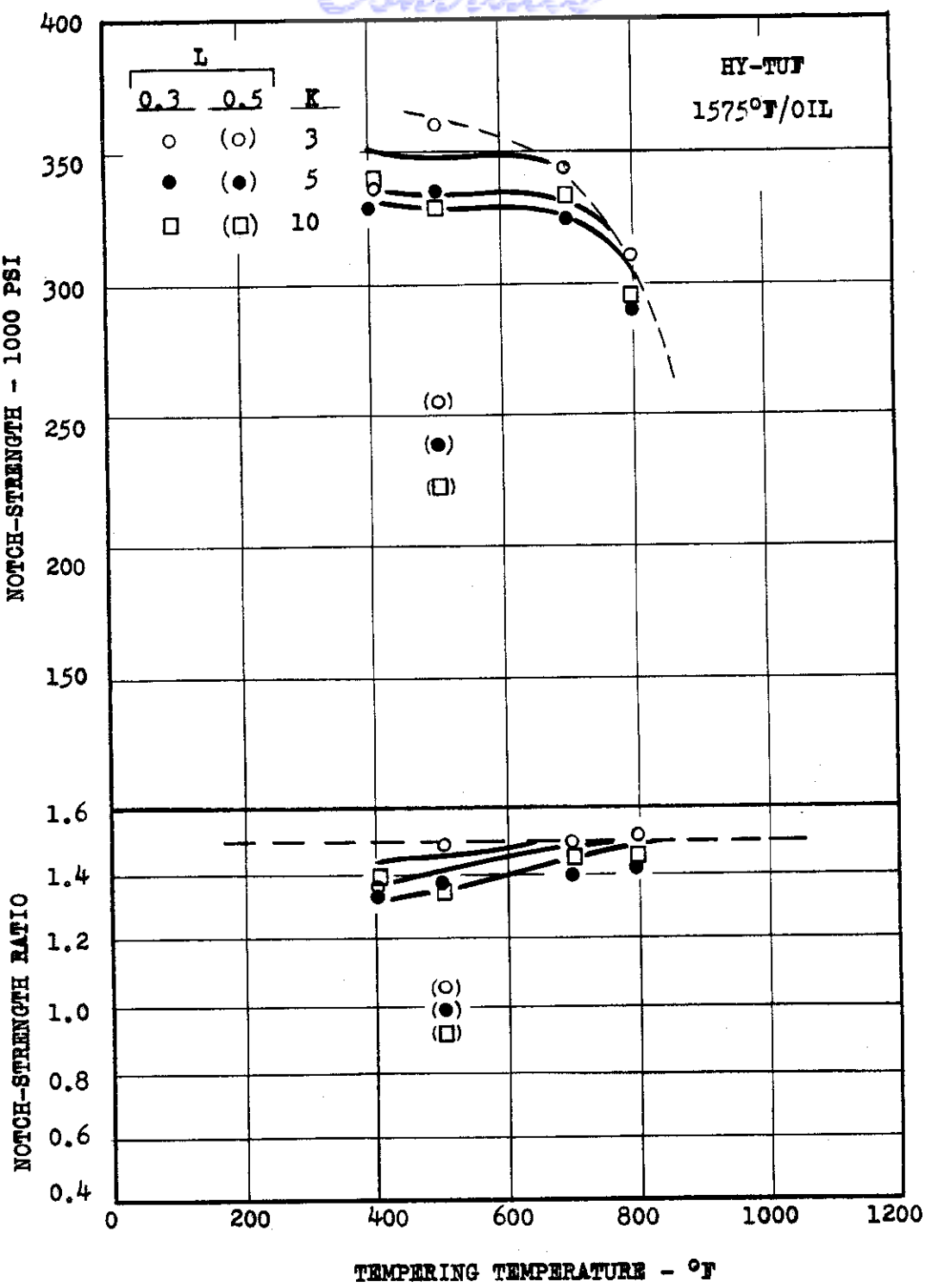


FIG. 205 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

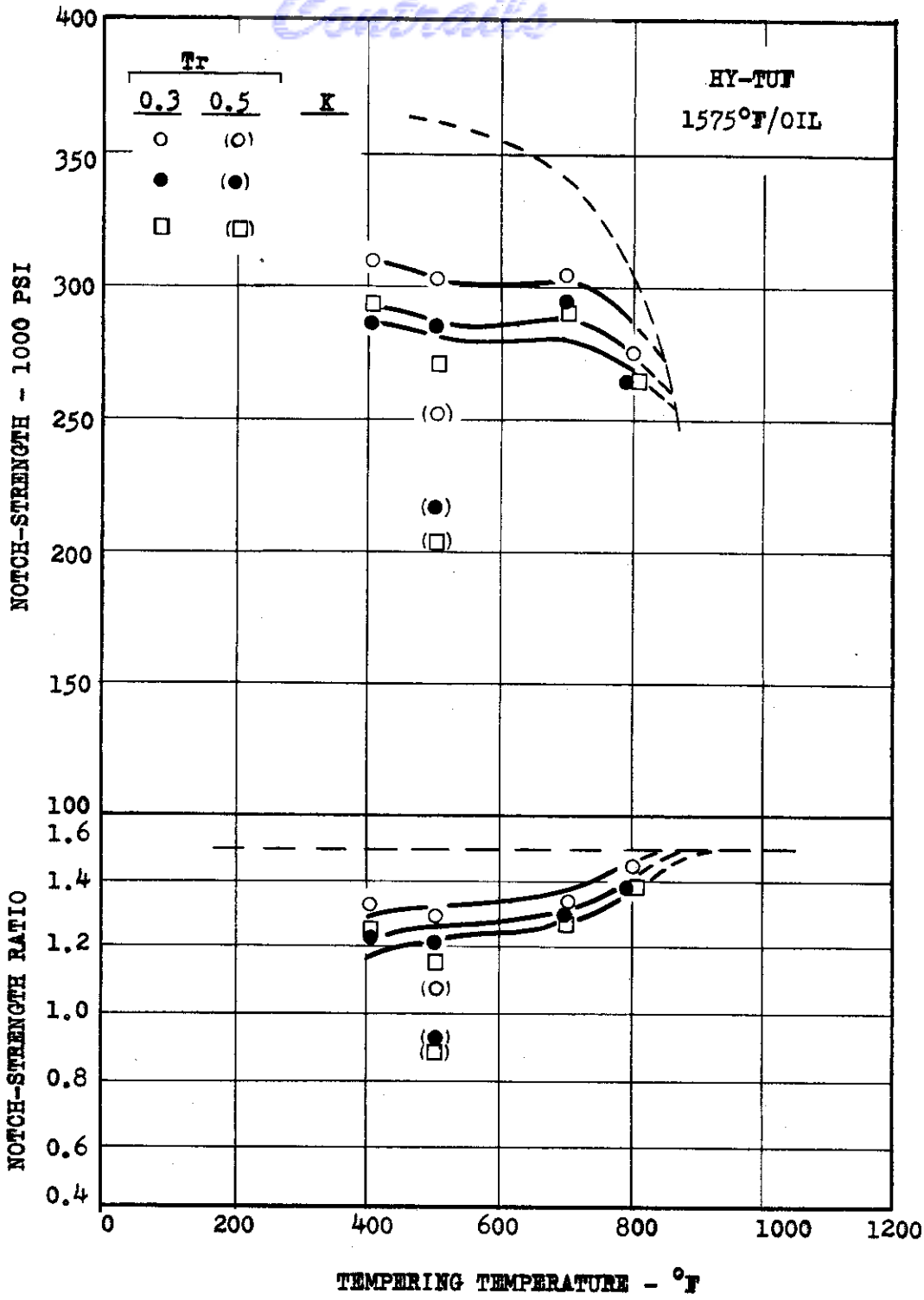


FIG. 206 VARIATION OF NOTCH-STRENGTH AND NOTCH-STRENGTH RATIO WITH TEMPERING TEMPERATURE.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

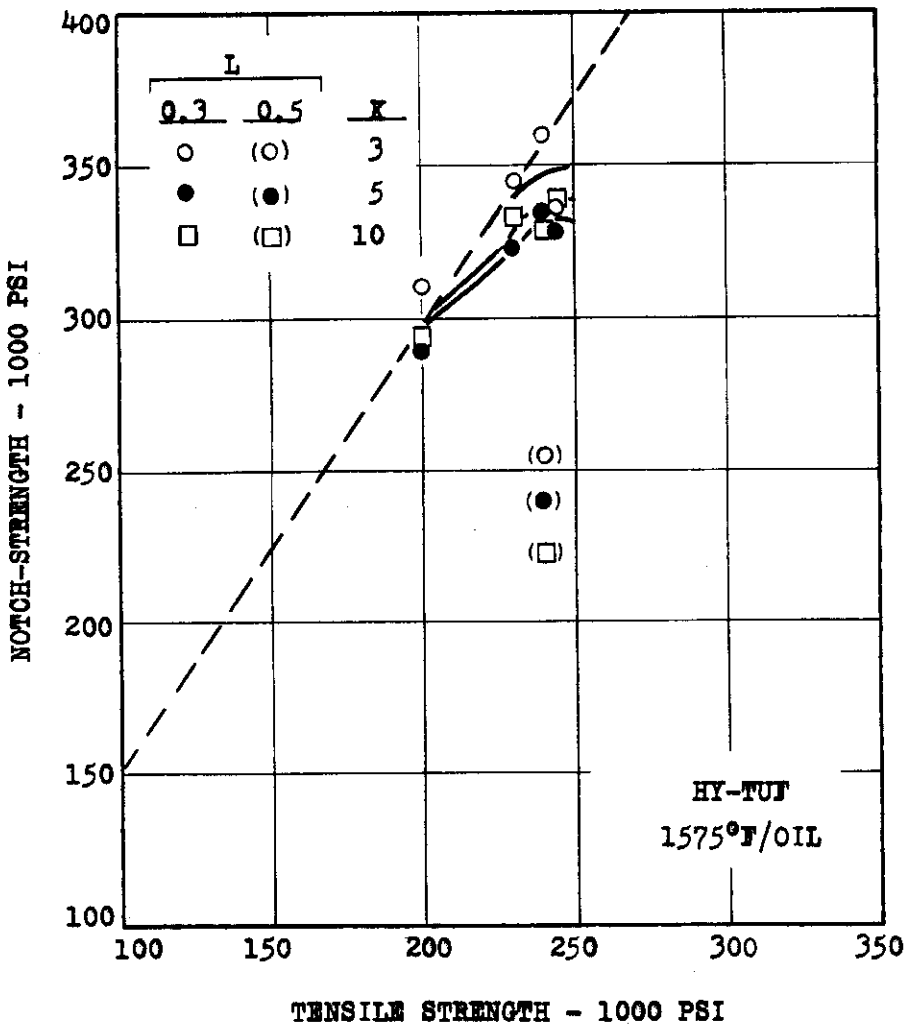


FIG.207 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

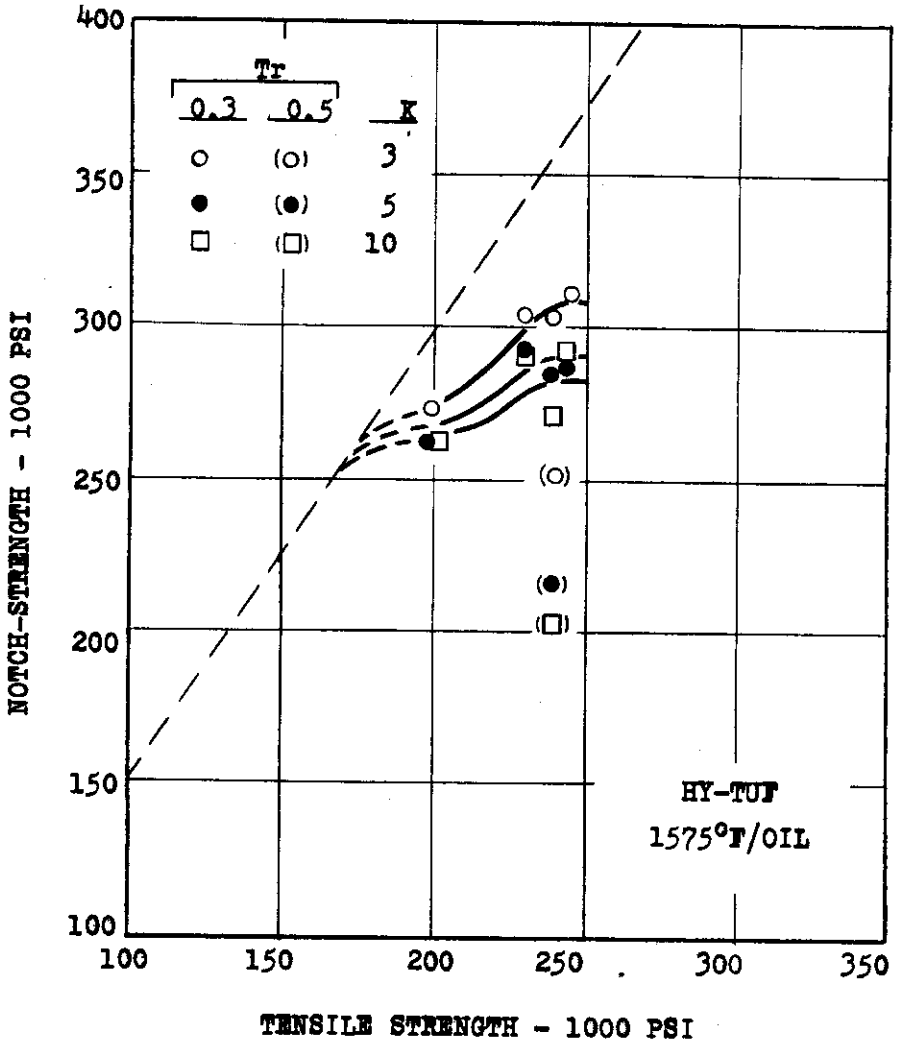


FIG. 208 NOTCH-STRENGTH AS A FUNCTION OF TENSILE STRENGTH.

SECTION: 3 IN.DIA.

SPECIMEN: 0.3 and 0.5 IN.DIA.

TEST TEMP: R.T.

○ 400 F (245,000 PSI)

● 500 F (243,000 PSI) HY-TUF

□ 700 F (231,000 PSI) 1575°F/OIL

■ 800 F (203,000 PSI)

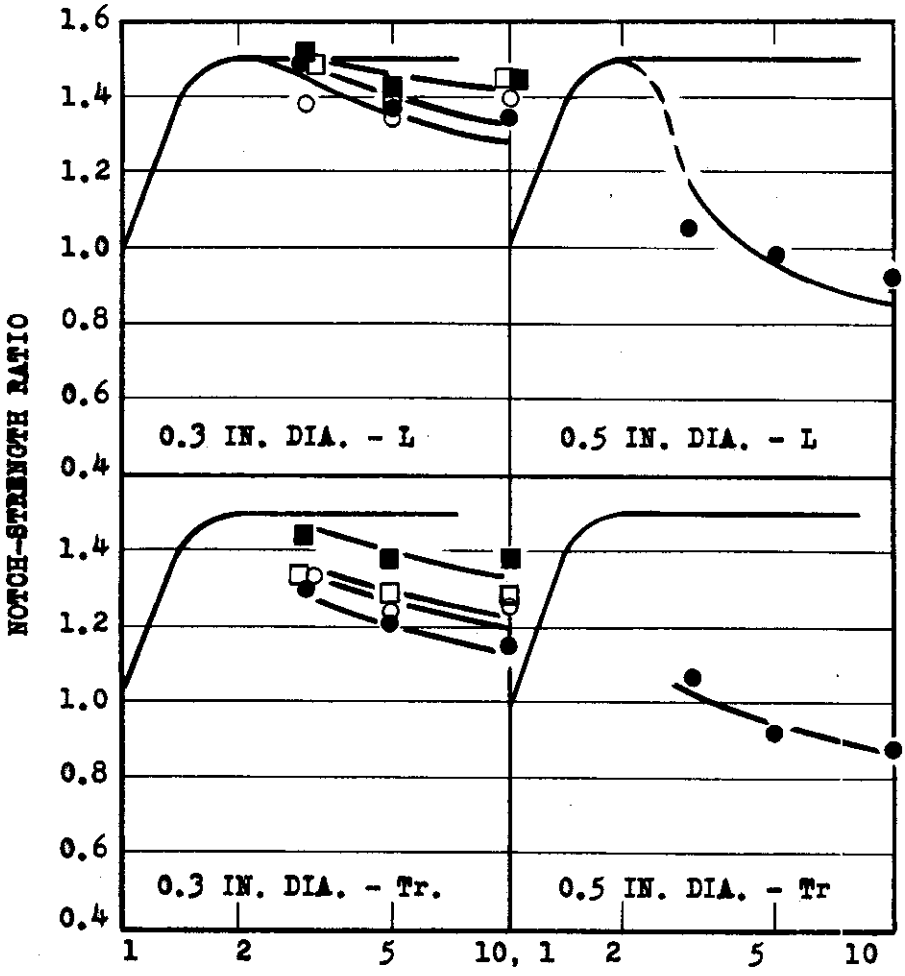


FIG. 209 VARIATION OF NOTCH-STRENGTH RATIO WITH K.

SECTION: 3 IN.DIA.

TEST TEMP: R.T.

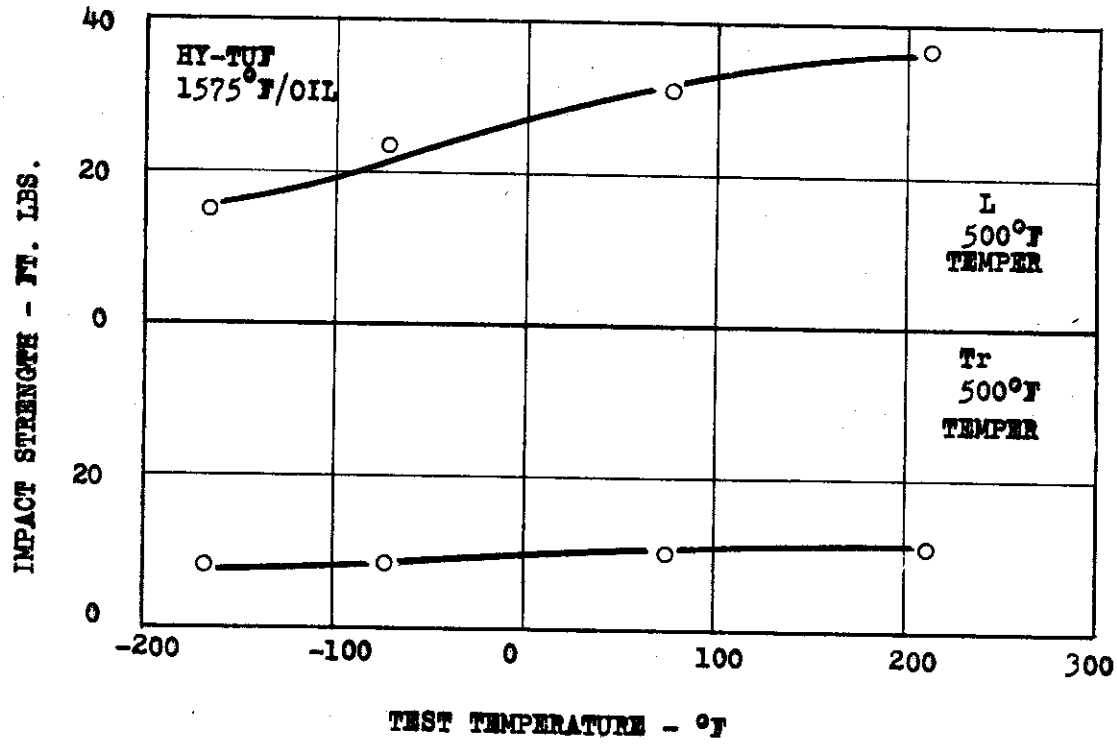


FIG. 210 VARIATION OF IMPACT STRENGTH WITH TEST TEMPERATURE.

SECTION: 3 IN. DIA.

SPECIMEN: STD. V-NOTCH CHARPY

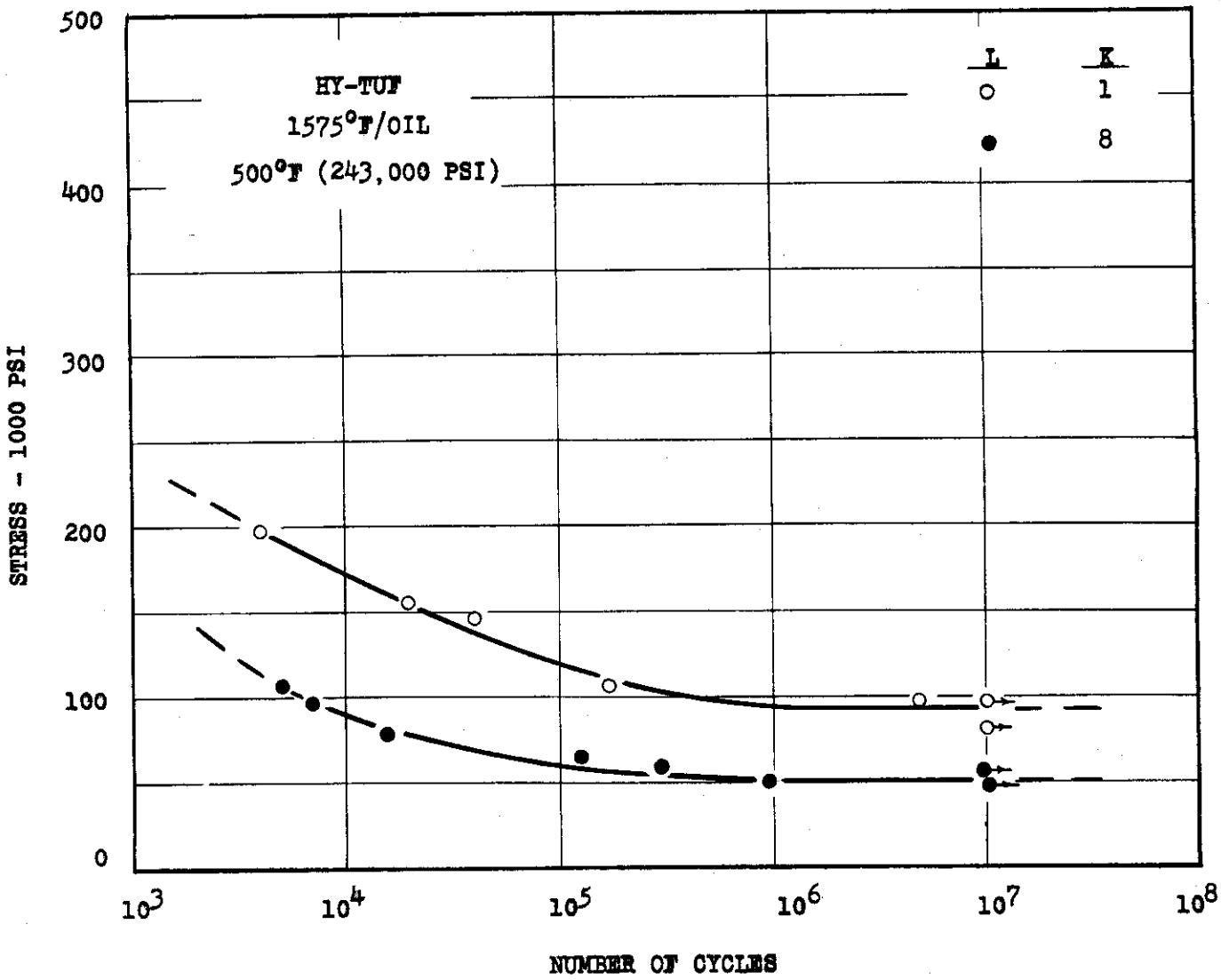


FIG. 211 S-N CURVES FOR SMOOTH AND NOTCHED SPECIMENS.

SECTION: 3 IN.DIA.

SPECIMEN: ROTATING BEAM TYPE

TEST TEMP: R.T.