

Lehigh University Lehigh Preserve

Fritz Laboratory Reports

Civil and Environmental Engineering

1948

Comparison of three notch sensitivity tests.

C. J. Osborn

R. D. Stout

A. Scotchbrook

B. G. Johnston

Follow this and additional works at: <http://preserve.lehigh.edu/engr-civil-environmental-fritz-lab-reports>

Recommended Citation

Osborn, C. J.; Stout, R. D.; Scotchbrook, A.; and Johnston, B. G., "Comparison of three notch sensitivity tests." (1948). *Fritz Laboratory Reports*. Paper 1443.

<http://preserve.lehigh.edu/engr-civil-environmental-fritz-lab-reports/1443>

This Technical Report is brought to you for free and open access by the Civil and Environmental Engineering at Lehigh Preserve. It has been accepted for inclusion in Fritz Laboratory Reports by an authorized administrator of Lehigh Preserve. For more information, please contact preserve@lehigh.edu.

*Comparison of Three Notch
Sensitivity Tests, by
C.J. Osborn, R.D. Stout,
A. Scotchbrook, and B.G. Johnston.*

Fritz Laboratory
Lehigh University
Bethlehem, Pa
February 13, 1948

Pressure Vessel Research Committee
Fabrication Division

Gentlemen:

Enclosed is a copy of a brief report which has been prepared to familiarize you with the work being done at Lehigh for the Fabrication Division. Attached to the report are blue print copies of the results obtained and it is hoped that you will have time to study these before the Division meeting on February 18. Would you please bring these reports with you to the meeting.

Very truly yours,

Bruce G. Johnston

BGJ/CJO/ps
c.c. All members.

LEHIGH UNIVERSITY
FRITZ LABORATORY

P. V. R. C. Fabrication Division Project

Interim Report on:

12 February, 1948

"Comparison of Three Notch Sensitivity Tests"

1. Introduction:

This report is written to acquaint members of the Fabrication Division of the P.V.R.C. with the results of the comparison of three specified notch sensitivity tests performed at Lehigh University at the request of the Fabrication Division Meeting of September 10, 1947. The three tests investigated were:

- (a) Lehigh slow notched bend test.
- (b) Ship Structures Committee slow notched bend test.
- (c) Kahn tear test.

To assist the Division in appraising these tests, observations concerning their convenience, cost, significance and general suitability will be included in this report in addition to the test results.

II. Scope of Investigation:

The three tests under consideration were used to follow the brittle temperature transition in the following materials:-

- A-70 steel, 5/8" plate: (a) as rolled
(b) after 10% tensile strain
(c) after 10% tensile strain

followed by aging at 200 for 2 hours.

A-70 steel, 1 1/4" plate, in these same three conditions, a, b, and c.

A-201 steel, 5/8" plate, conditions a, b, and c.

A-201 steel, 1 1/4" plate, conditions a, b, and c.

For each of these 12 materials, 24 specimens were tested over a range of temperatures, four at each temperature.

In order that the three tests could be compared directly, all criteria of ductility commonly measured in any of the tests were measured in all three. This necessitated four or five different measurements for each test; viz. (1) The percentage of the fracture area which exhibited a brittle, cleavage type of failure. (2) The energy absorbed by the specimen after passing the maximum load until the load had fallen to half the maximum. (3) The percentage contraction in the width of the specimen at a point 1/32" below the notch. (4) The percentage contraction in width at the midpoint of the specimen.

(5) The bend angle or bend deflection at maximum load were measured in the bend tests; the % elongation on a 2" gauge length 1/4" below the notch was measured in the tear tests.

III. Experimental Procedure:

The tests were carried out in the usual manner, an autographic load-deflection diagram being obtained for each specimen. The only modification of normal procedure was made in the Kahn tear test, when 1" pins were used on the heavier 1 1/4" specimens in place of the usual 3/4" pins.

A uniform procedure was adopted for plotting all results. The arithmetic means of the four values at each temperature were joined by straight lines, except for some cases where such a method would produce a temporary and meaningless change in sign of the slope within the transition scatter zone. In these cases the points at each end of the inconsistent section were by-passed and the straight lines drawn to the midpoint of this section. For an example, see Fig. 5, as rolled.

IV. Results:

All the results obtained are given in the figures attached to this report and they have been summarized in the three tables of transition temperature. For these tables, the transition temperature was taken as the temperature at which the curve had fallen, with decreasing temperature to half its maximum value. There were two exceptions to this practice. In the energy vs. temperature plots of the Lehigh bend results some of the curves lacked points at temperatures sufficiently high to ensure that a maximum energy value had been reached; in this case the transition temperature was taken as that giving a prescribed energy level (312.5 ft. lbs). In the S.S.C. bend test and the Kahn tests with plots of bend deflection, % elongation and % contraction below the notch, many curves did not fall to values of the order of half their maximum even at temperatures down to -90°F. However, many of the curves (see for example Figs. 17 and 19) exhibited a sudden drop in these criteria within the range of testing temperatures and the transition temperatures quoted are the temperatures at a mean between the upper and lower levels of this sudden drop.

V. Comparison of Tests:

In the early stages of this investigation the factors to be considered in a choice of tests were listed and the following notes are observations concerning these factors.

A. Convenience and Cost of the Test.

1. Machining. There is little to choose between the three tests in the matter of machining time but the Lehigh and Kahn tests probably have an advantage over the S.S.C. test.

2. Testing rig. The Lehigh test set-up is the simplest of the three, but both the bend tests are much simpler than the Kahn test. The latter is the only one in which regular replacements of any parts-in this case the pins-are necessary.

3. Ease and Speed of Testing. Here again the bend tests show a definite superiority over the Kahn test, with the Lehigh test somewhat quicker and more convenient than the S.S.C. test.

4. Size of Specimen. The S.S.C. test is considerably more economical of material than the Kahn and Lehigh tests, the latter using slightly more than Kahn.

B. Criterion Chosen.

The various criteria of ductility which were used in this investigation fall into two classes; those which can be regarded as a measure of the energy required to initiate failure and those which are measures of the energy required to propagate failure. In the first class are bend angle or bend deflection, and % contraction below the notch; in the second class are % brittle in the fracture, % contraction at points removed from the notch, and energy absorbed after maximum load. A study of the transition temperatures in Tables 1, 2 and 3 will emphasize this distinction.

Without discussing at this stage the relative importance of these two types of criteria, it seems desirable to have measurements of at least one quantity from each class. This is not difficult because the % contraction below the notch and the % brittle in the fracture are readily measured on any of the three tests investigated.

At this stage it might be mentioned that autographic load deflection curves on these tests can only be obtained by using the movement of the heads of the testing machine as a measure of the deformation in the specimen. Particularly in the S.S.C. and Kahn tests, (using high loads and small deflections) this produces inaccuracies due to elastic deflection in the head of the machine, which render the autographic load deflection curves very difficult to interpret.

C. Results.

1. Transition Temperature. As can be seen from the curves included in this report there is little to choose between the tests with respect to the temperature ranges in which the transitions occur.

2. Scatter of Results. The curves and transition temperatures show firstly that the S.S.C. test and also the Kahn test have a narrower transition range of temperatures than the Lehigh test, at least in the case of the % brittle curves.

Also it should be emphasized that for some reason not yet apparent, the S.S.C. results conflict with the other tests in that the 1 1/4" A-201 and 5/8" A-70 materials show a lower transition temperature after straining - and sometimes even after strain-aging - than in the as-rolled condition.

D. Validity of Sample.

The criticism has been leveled at the Lehigh specimen that

it does not test the full thickness of plate.

On the other hand, the other two tests can be criticized because the specimen size is not standard and results vary considerably with different plate thicknesses due to the change in geometry of the specimen.

E. Present Extent of Use.

It is clearly undesirable to introduce a new test to this field of testing unless such a test has marked advantages over others at present in use. Actually none of the three tests investigated is more generally accepted than the others.

TABLE 1.

Transition Temperatures in °F - Lehigh Slow Notched Bend Test

	% Brittle	Energy	Bend Angle	% Contraction below notch
<u>A-201, 5/8"</u>				
as rolled	41	33	-88	-68
strained	45	43	-72	-44
strain-aged	101	95	-13	30
<u>A-201, 1 1/4"</u>				
as rolled	95	77	-78	-58
strained	123	95	-17	0
strain-aged	156	105	-21	32
<u>A-70, 5/8"</u>				
as rolled	100	85	-74	-76
strained	123	143	5	37
strain-aged	177	197	-22	15
<u>A-70, 1 1/4"</u>				
as rolled	162	103	-46	-42
strained	190	152	12	45
strain-aged	183	138	30	60

TABLE 2.

Transition Temperatures in °F - S.S.C. Slow Notched Bend Test

	<u>% Brittle</u>	<u>Energy</u>	<u>Bend Deflection</u>	<u>% Contraction at drill-hole</u>	<u>% Contraction at notch</u>
<u>A-201, 5/8"</u>					
as rolled	-23	-15	-32	-11	-9
strained	-19	-26	-30	-13	-22
strain-aged	- 8	-13	- 7 (?)	- 5	-13
<u>A-201, 1 1/4"</u>					
as rolled	43	43	41	43	39
strained	22	21	18	26	14
strain-aged	43	40	27	47	27
<u>A-70, 5/8"</u>					
as rolled	38	41	34	42	40
strained	16	17	7	16	7
strain-aged	53	55	53	58	60
<u>A-70, 1 1/4"</u>					
as rolled	97	98	89	92	53
strained	98	101	100	99	94
strain-aged	106	108	?	105	103

TABLE 3.

Transition Temperatures in °F - Kahn Tear Test

	% Brittle	Energy	% Contraction below notch	% Contraction at Midpoint	Elongation
<u>A-201, 5/8"</u>					
as rolled	28	14	?	20	?
strained	60	32	?	55	?
strain-aged	73	? 25°	-60	65	25
<u>A-201, 1 1/4"</u>					
as rolled	87	57	50	87	60
strained	102	93	86	100	90
strain-aged	140	140	141	138	140
<u>A-70, 5/8"</u>					
as rolled	60	60	57	58	64
strained	88	85	85	85	85
strain-aged	103	83	105	95	110
<u>A-70, 1 1/4"</u>					
as rolled	145	156	134	125	142
strained	192	196	175	182	175
strain-aged	200	205	168	188	170

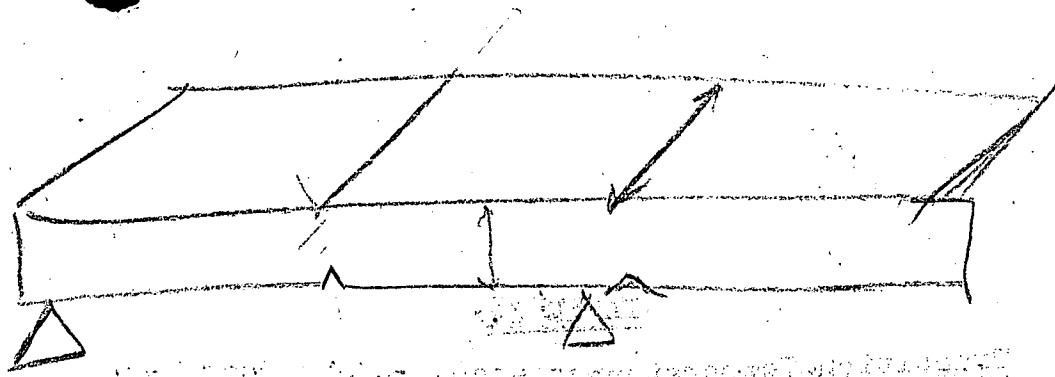


Diagram illustrating the forces acting on a beam.

Point	Force	Distance	Moment	Reaction
A	0	0	0	0
B	100	10	1000	0
C	0	20	0	0
D	200	30	6000	0
E	0	40	0	0
F	0	50	0	0
G	0	60	0	0
H	0	70	0	0
I	0	80	0	0
J	0	90	0	0
K	0	100	0	0
L	0	110	0	0
M	0	120	0	0
N	0	130	0	0
O	0	140	0	0
P	0	150	0	0
Q	0	160	0	0
R	0	170	0	0
S	0	180	0	0
T	0	190	0	0
U	0	200	0	0

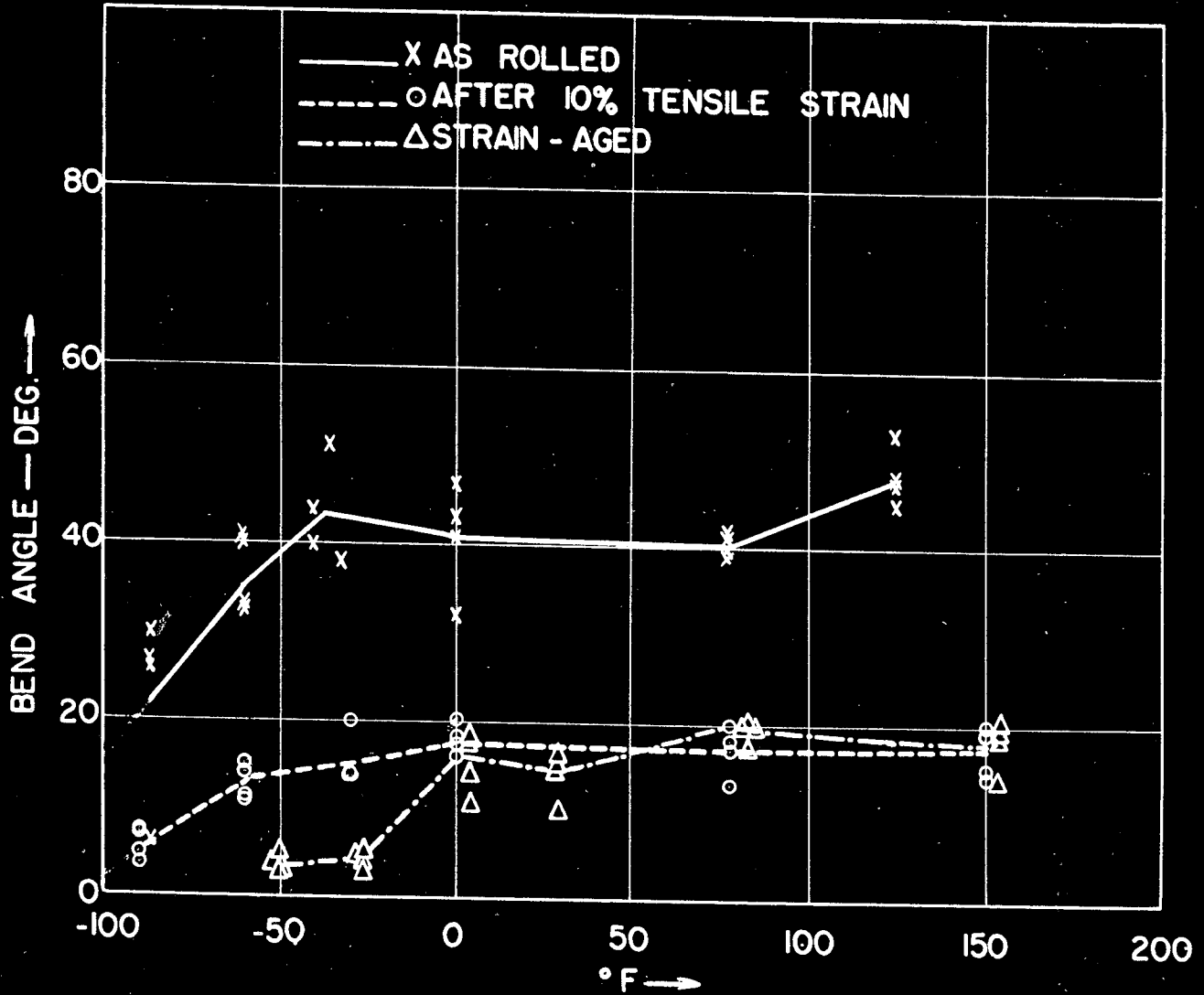


FIG. 1. TRANSITION CURVES FOR A-201 5/8" MATERIAL

LEHIGH BEND TEST

CRITERION: BEND ANGLE

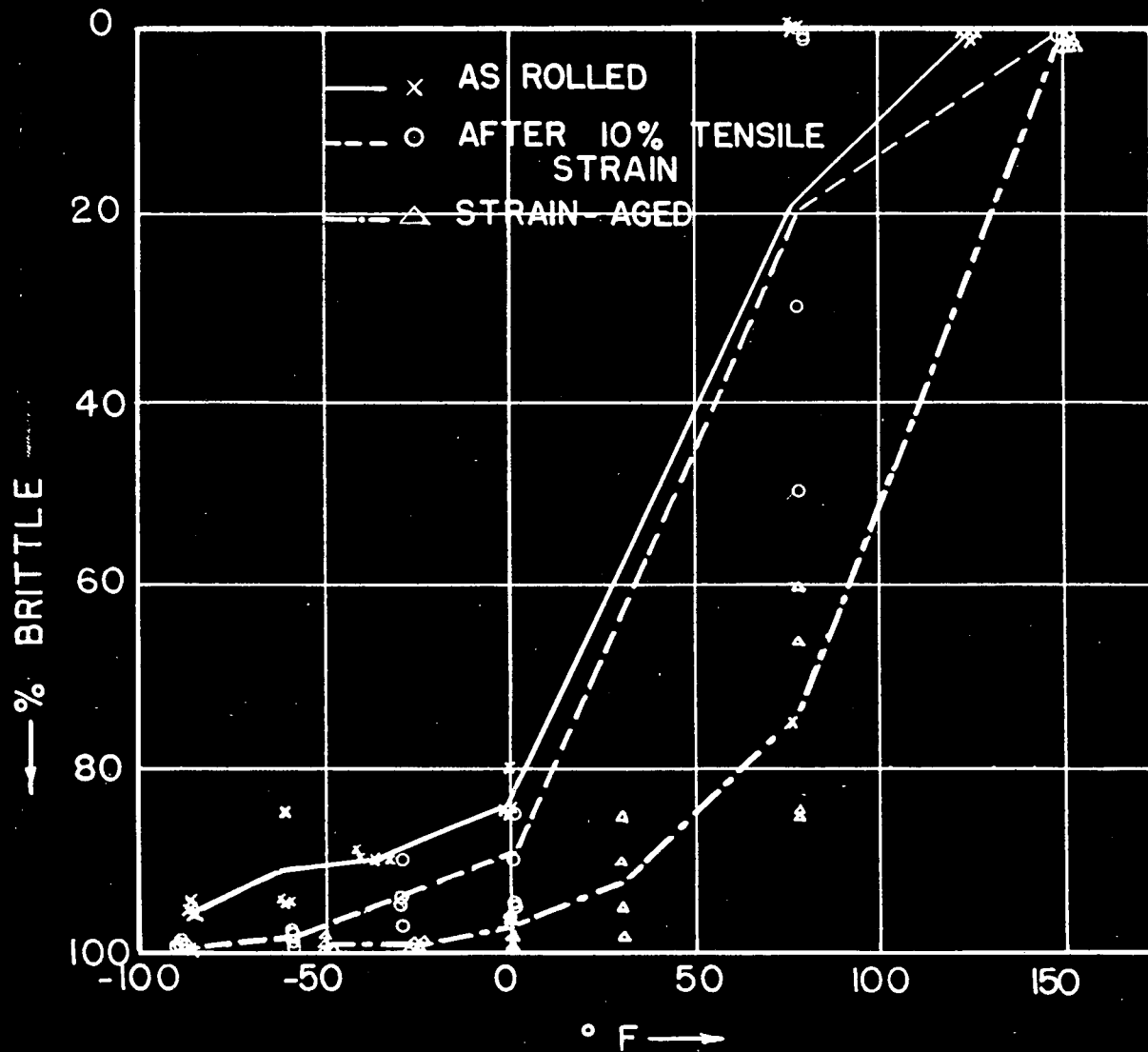


FIG. 2. TRANSITION CURVES FOR A-201, 5/8" MATERIAL
 LEHIGH BEND TEST
 CRITERION: % BRITTLE

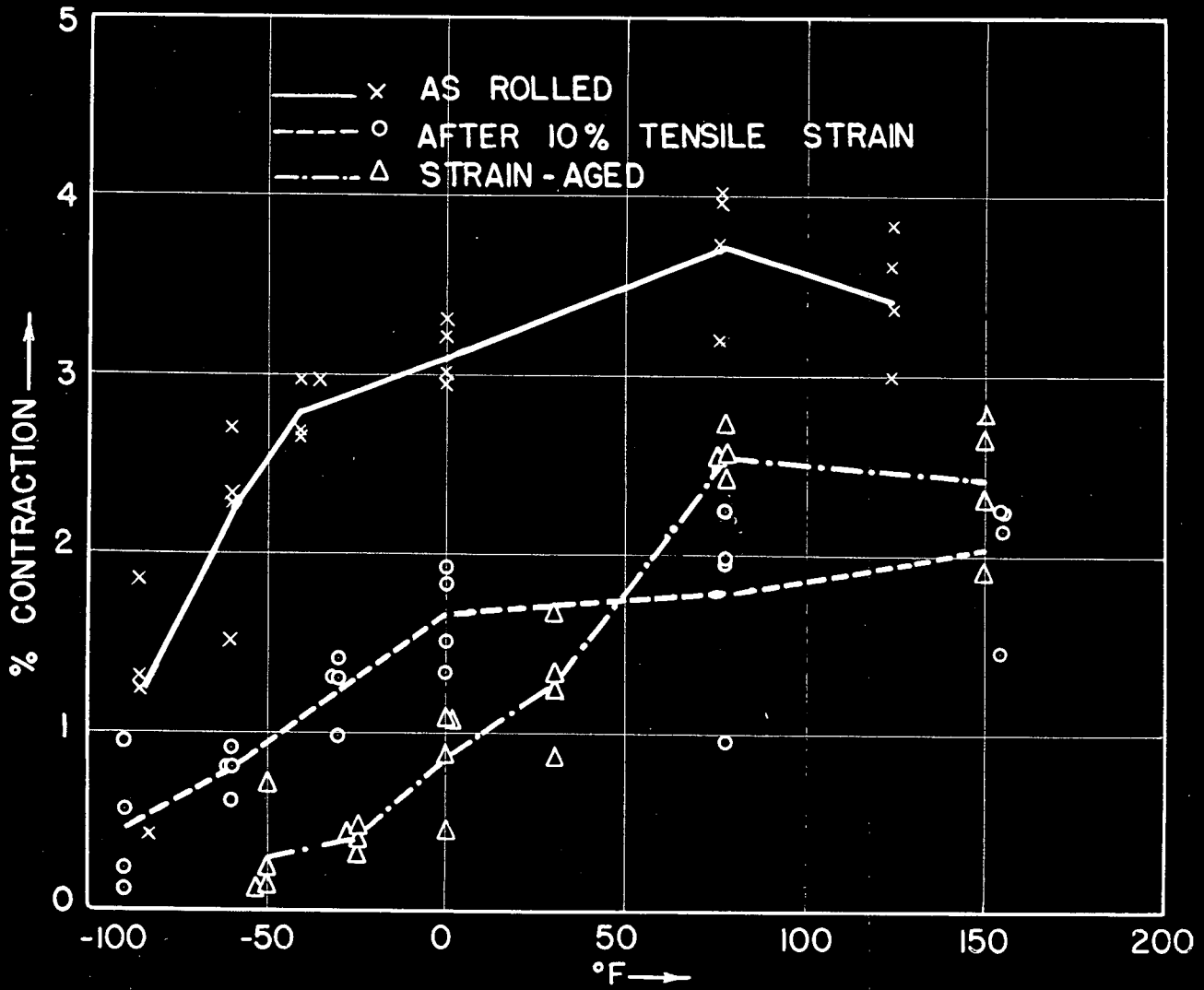


FIG. 3. TRANSITION CURVES FOR A-201, 5/8" MATERIAL
 LEHIGH BEND TEST
 CRITERION: % CONTRACTION BELOW NOTCH

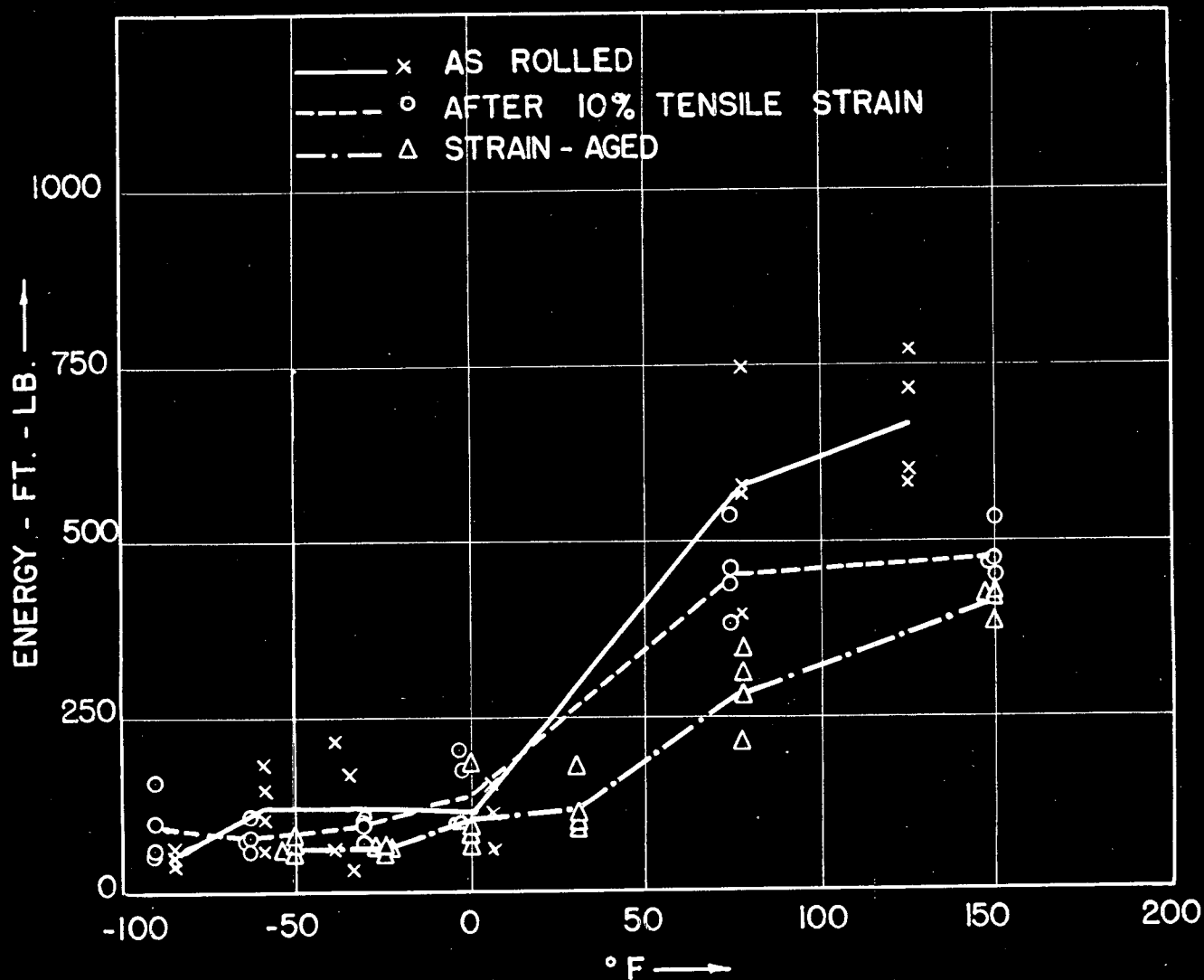


FIG. 4. TRANSITION CURVES FOR A-201, 5/8" MATERIAL
 LEHIGH BEND TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

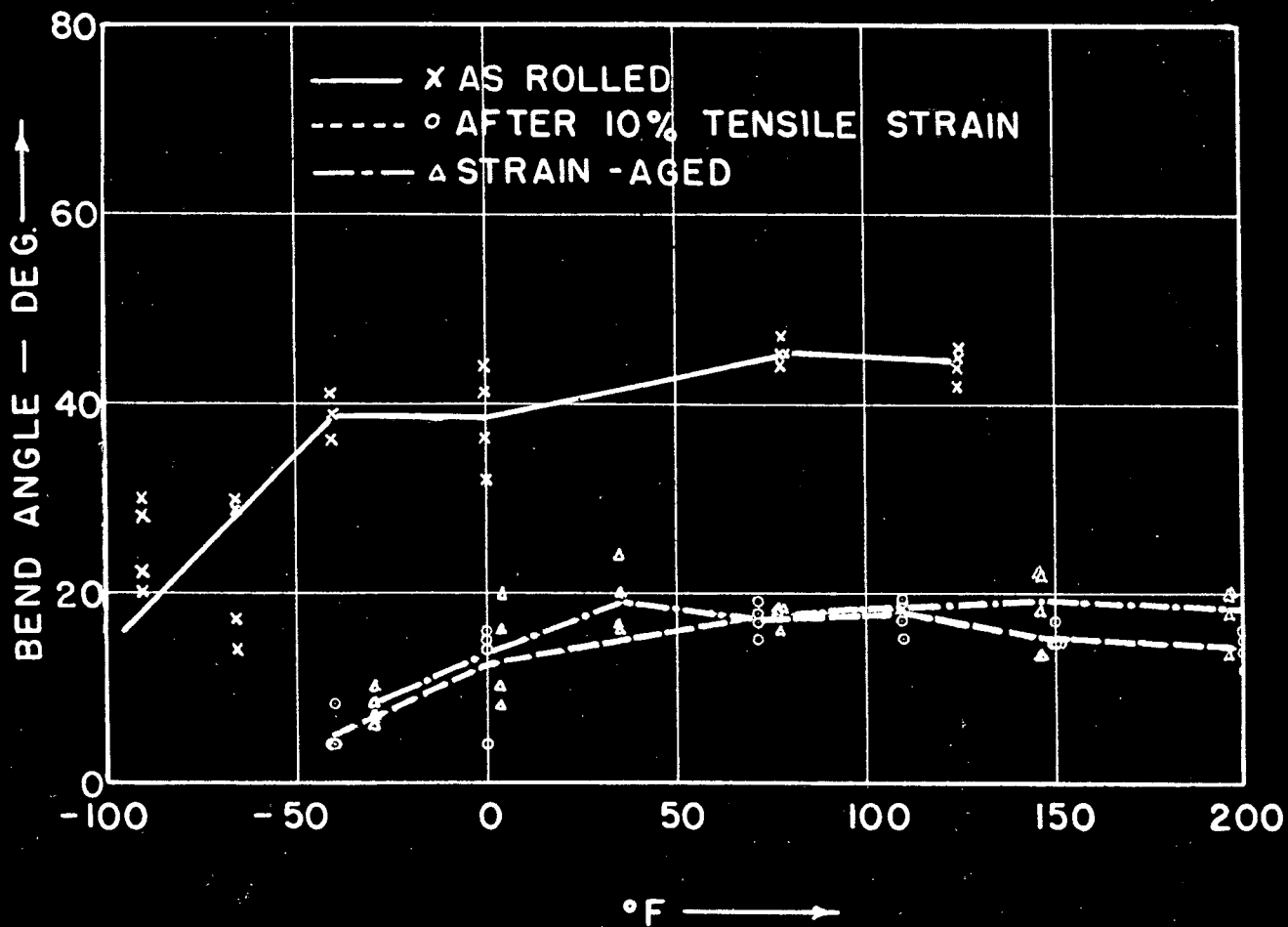


FIG. 5. TRANSITION CURVES FOR A-201, 1/4" MATERIAL
 LEHIGH BEND TEST
 CRITERION: BEND ANGLE

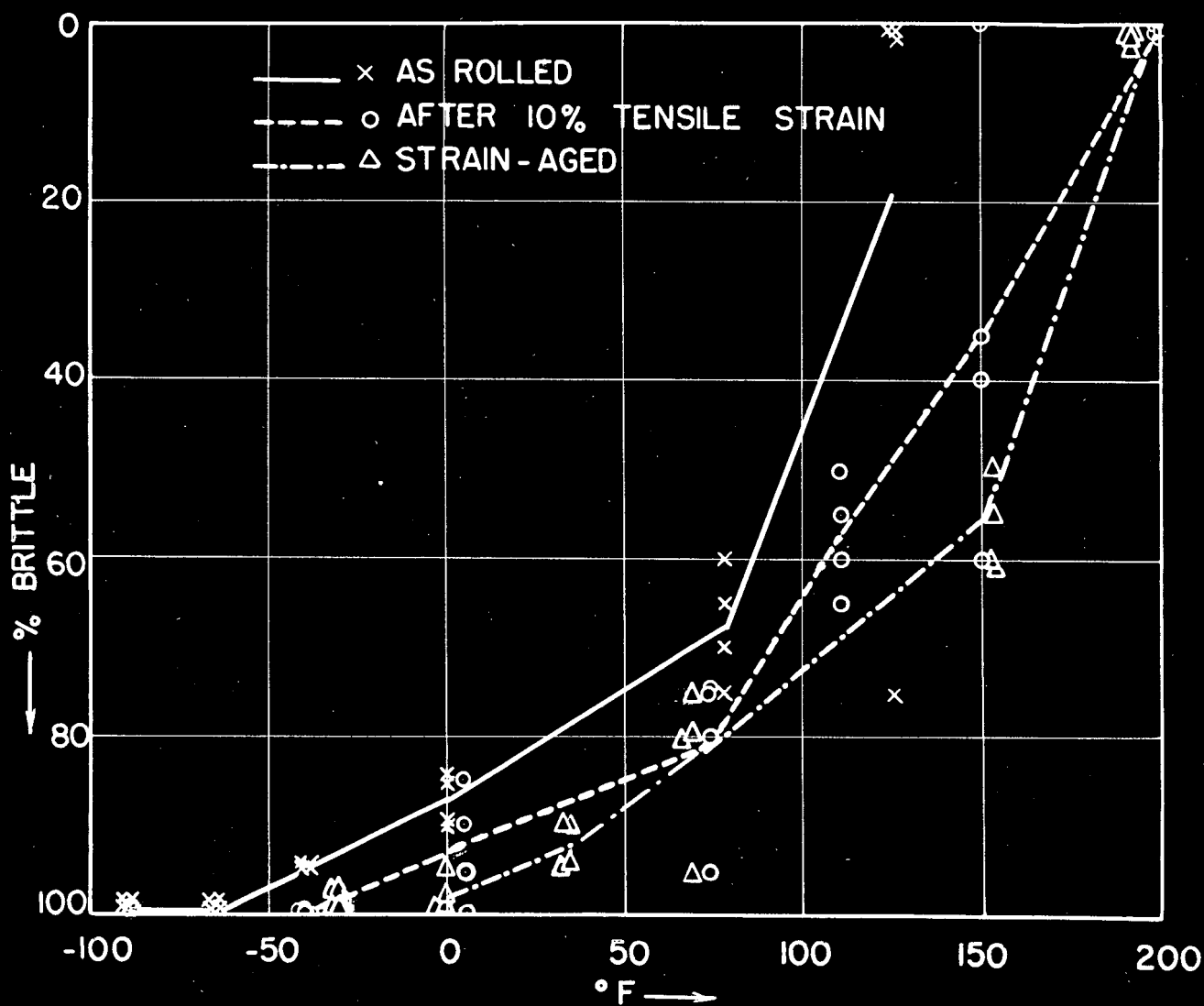


FIG. 6. TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL

LEHIGH BEND TEST

CRITERION: % BRITTLE

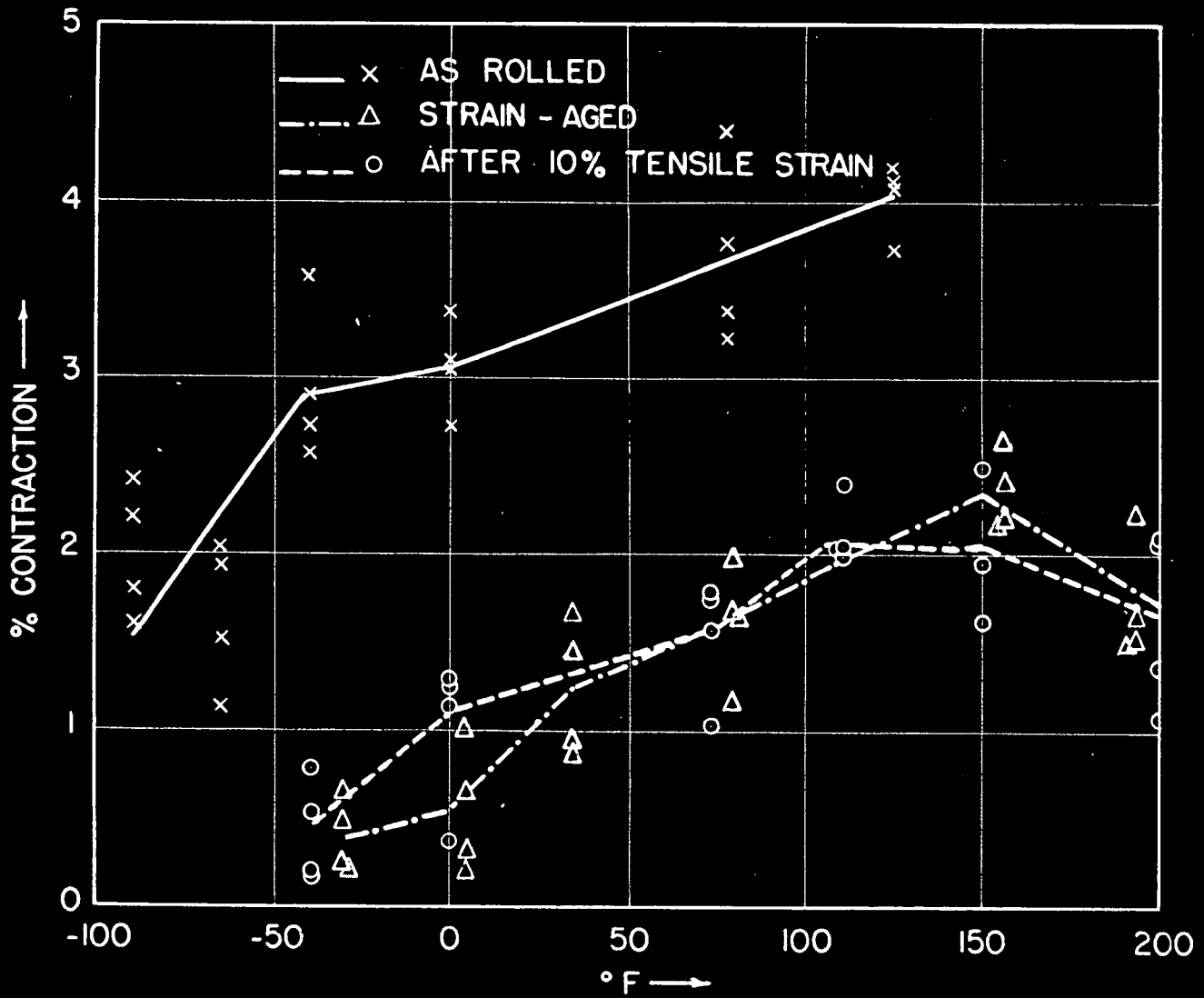


FIG. 7. TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL

LEHIGH BEND TEST

CRITERION: % CONTRACTION BELOW NOTCH

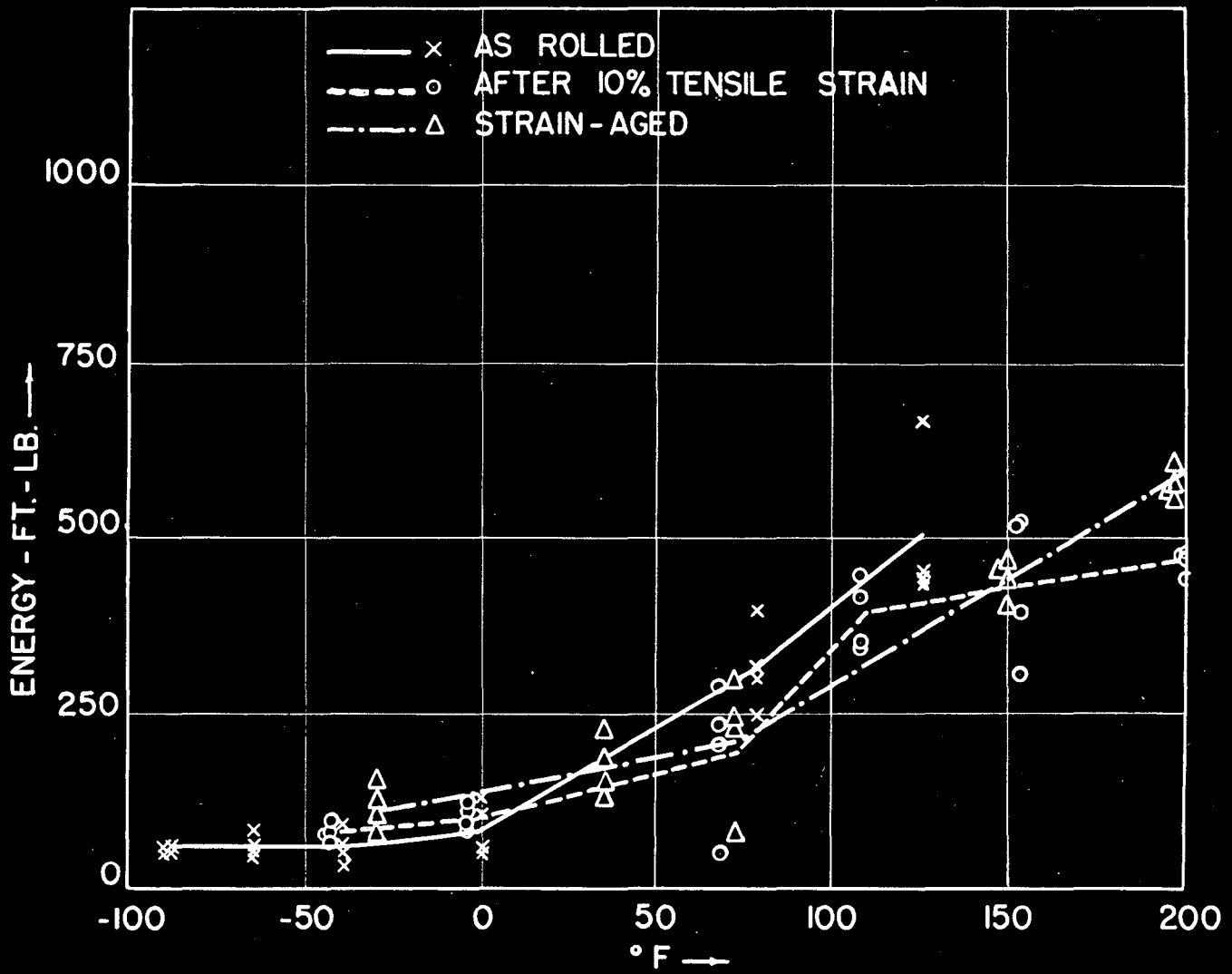


FIG. 8. TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL
 LEHIGH BEND TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

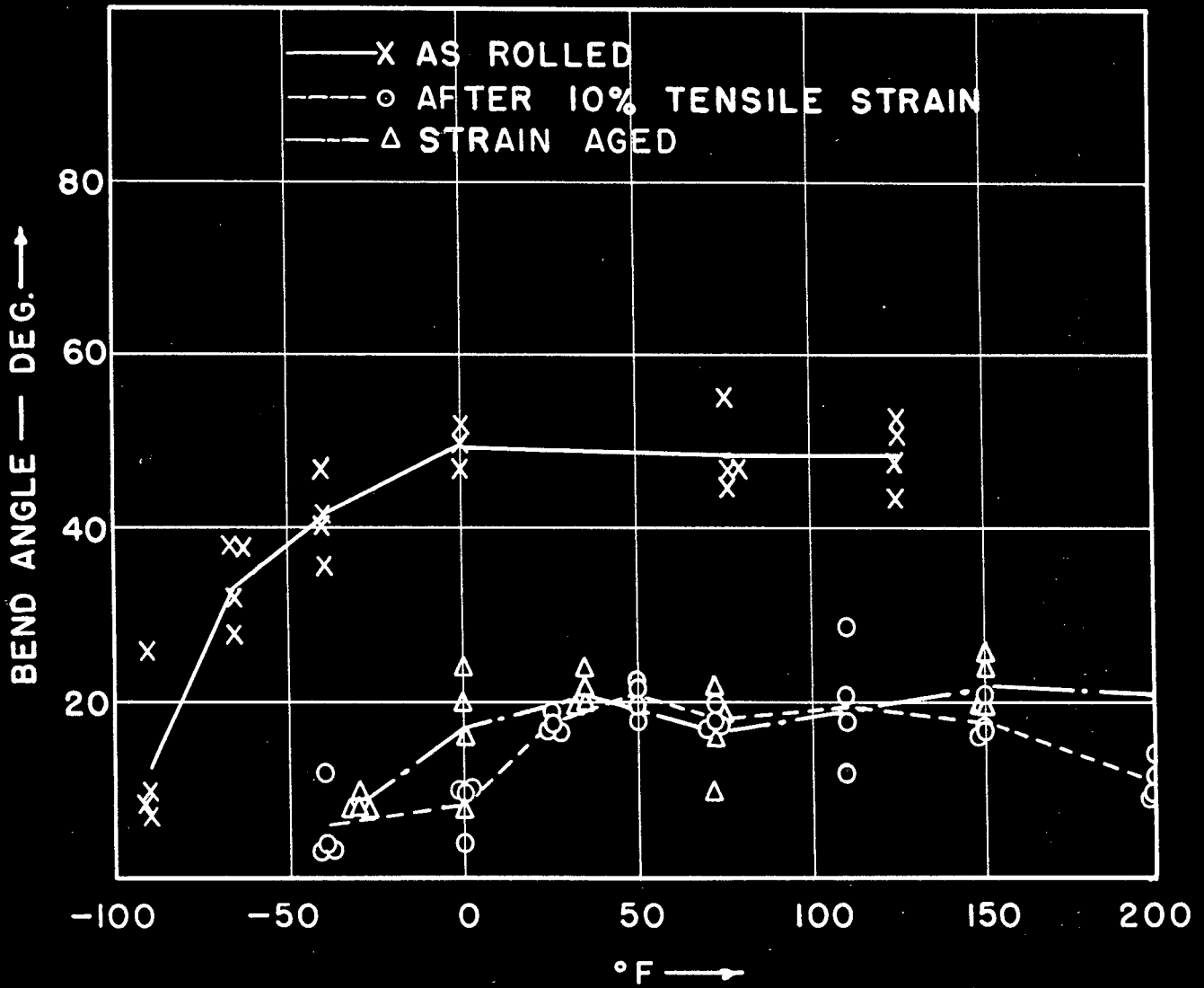


FIG. 9. TRANSITION CURVES FOR A-70 5/8" MATERIAL
 LEHIGH BEND TEST
 CRITERION: BEND ANGLE

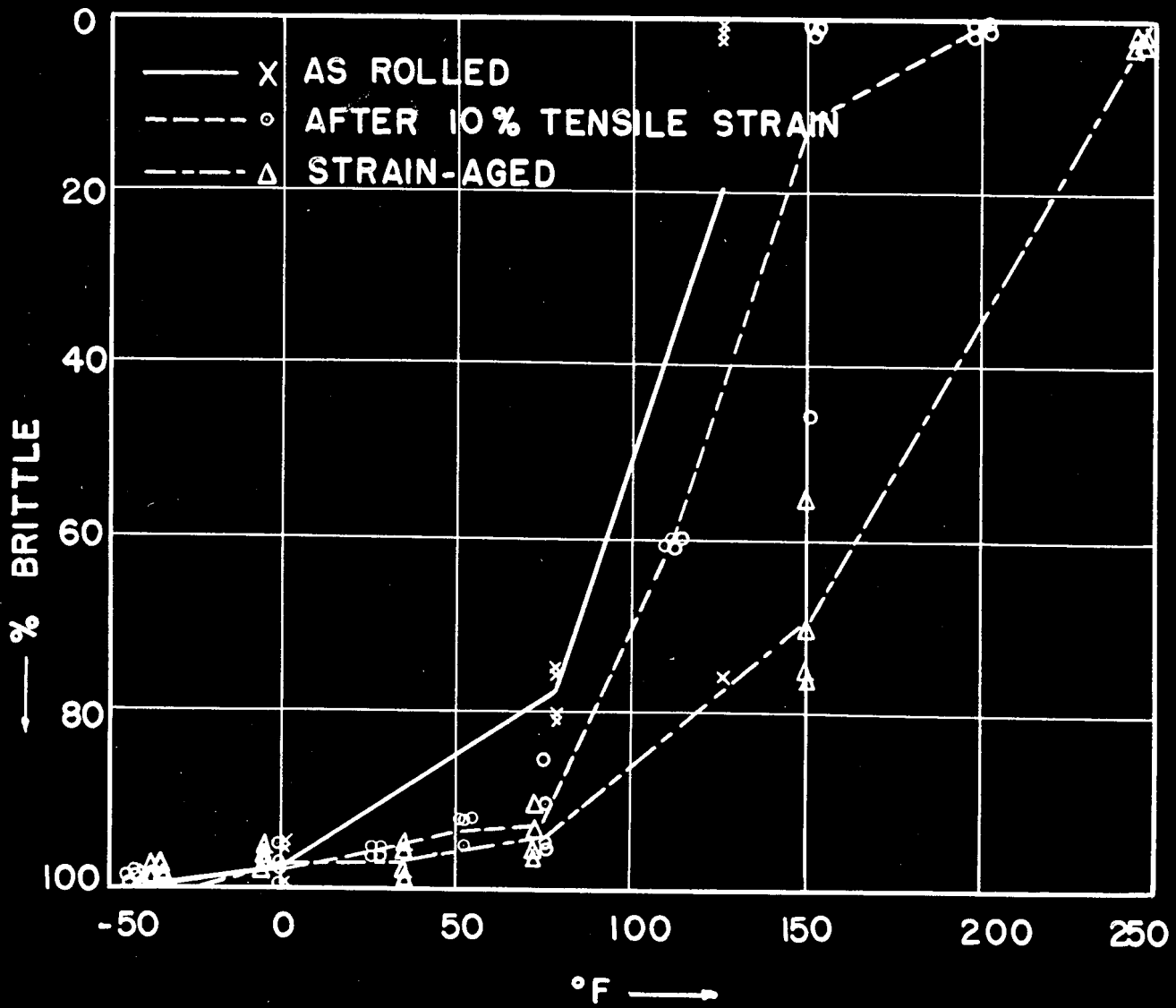


FIG. 10 TRANSITION CURVES FOR A-70, 5/8" MATERIAL
 LEHIGH BEND TEST
 CRITERION: % BRITTLE

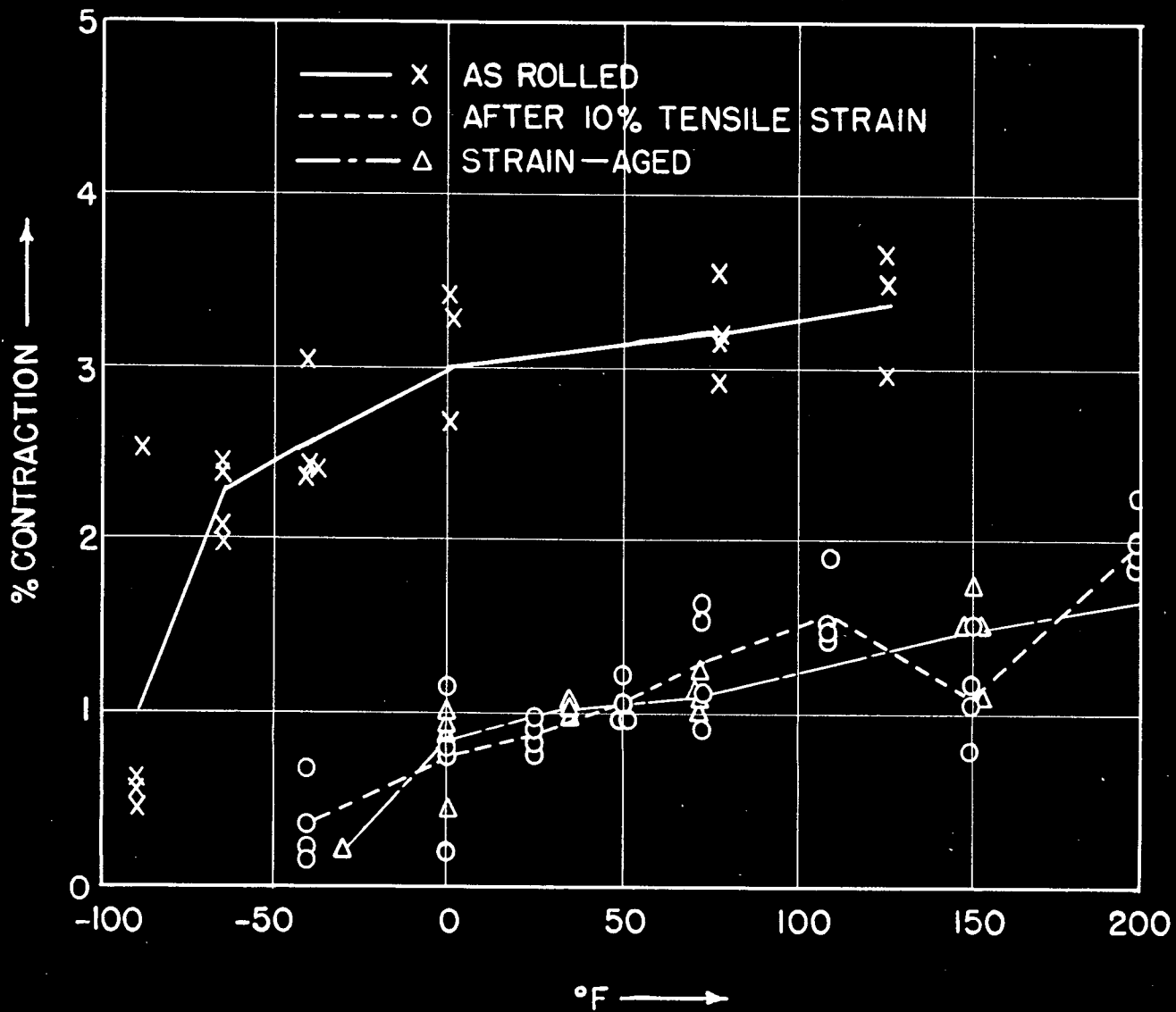


FIG. II TRANSITION CURVES FOR A-70 5/8" MATERIAL
 LEHIGH BEND TEST
 CRITERION: % CONTRACTION BELOW NOTCH

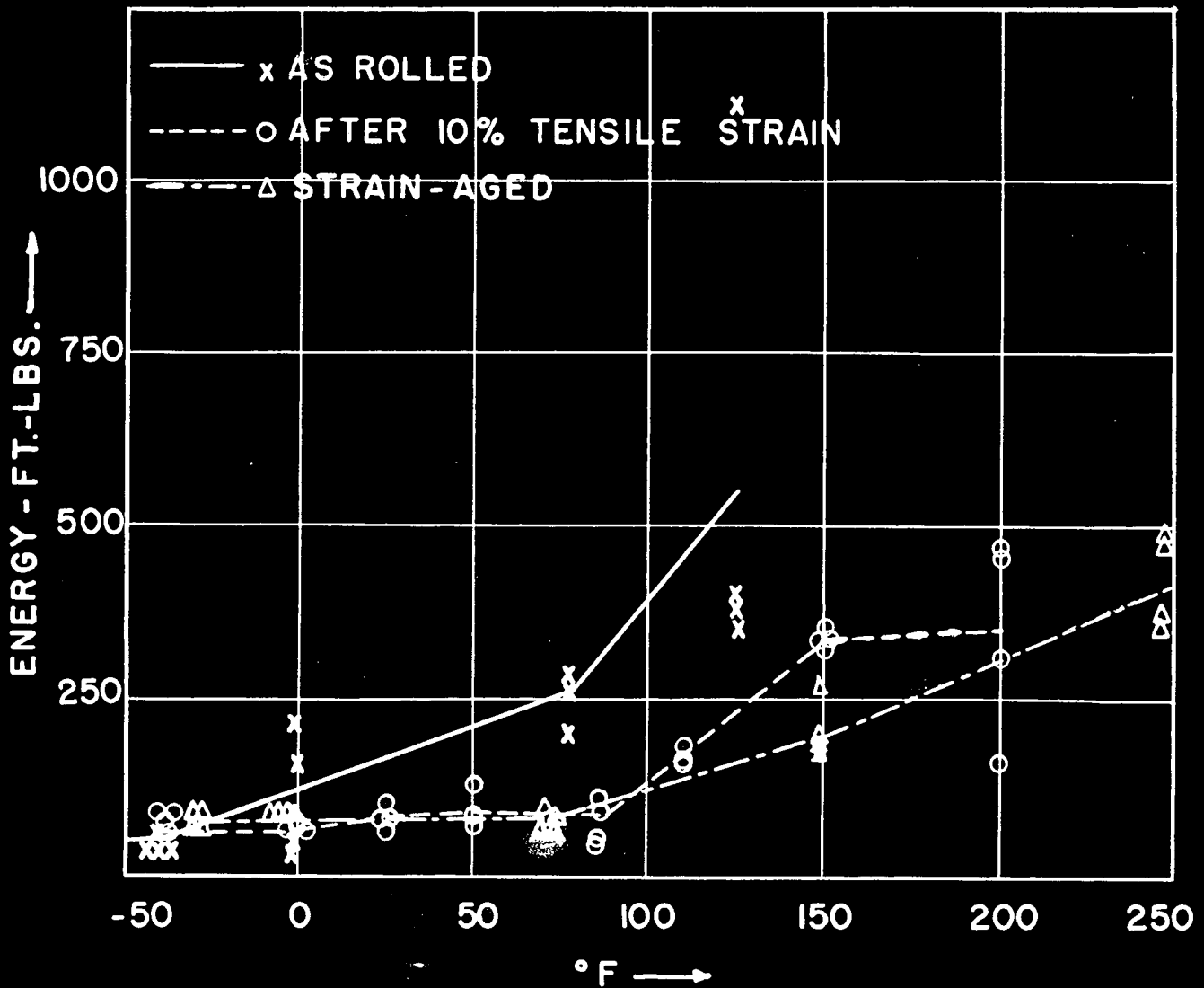


FIG. 12 TRANSITION CURVES FOR A-70, 5/8" MATERIAL
 LEHIGH BEND TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

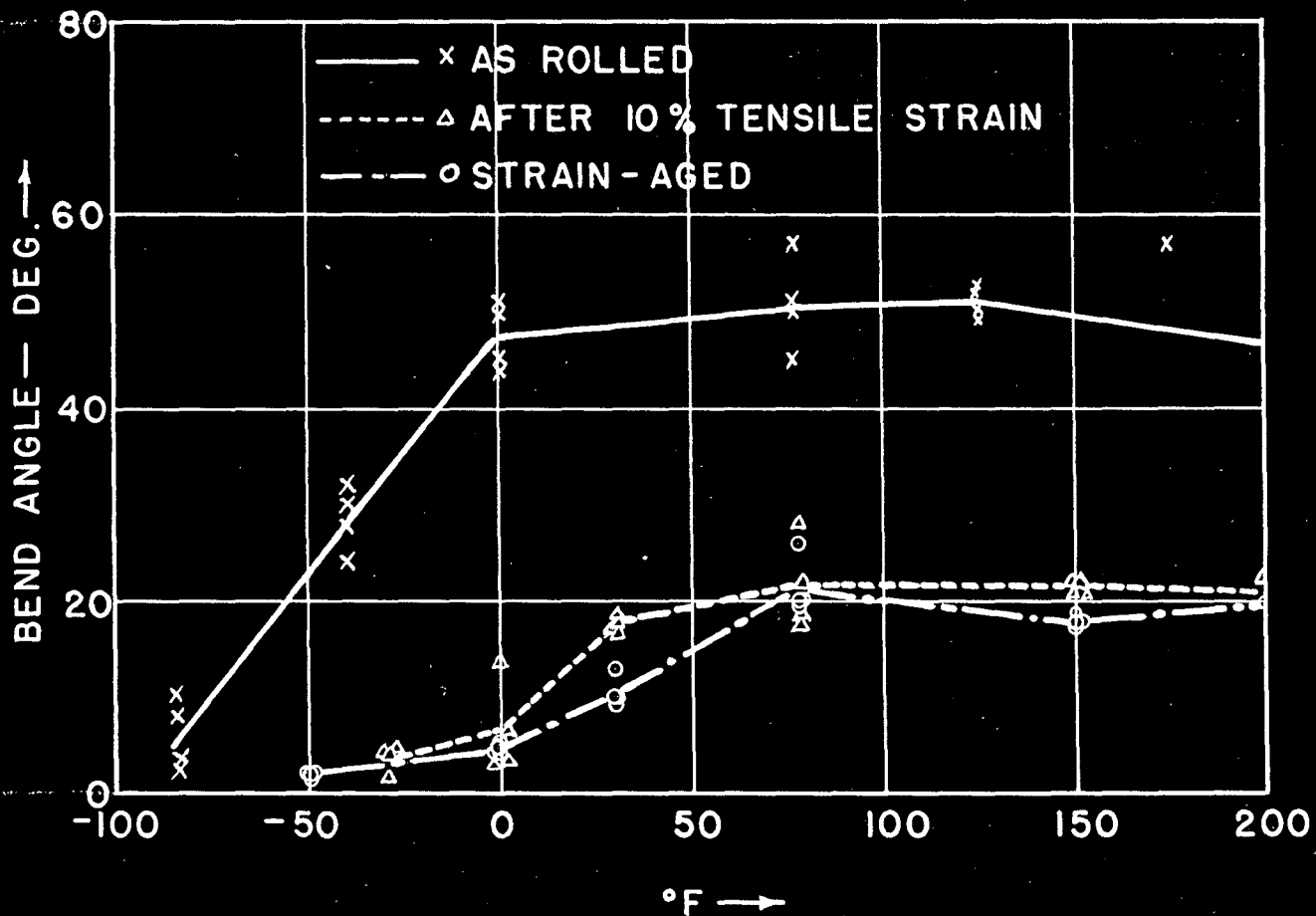


FIG.13. TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL
 LEHIGH BEND TEST
 CRITERION : BEND ANGLE

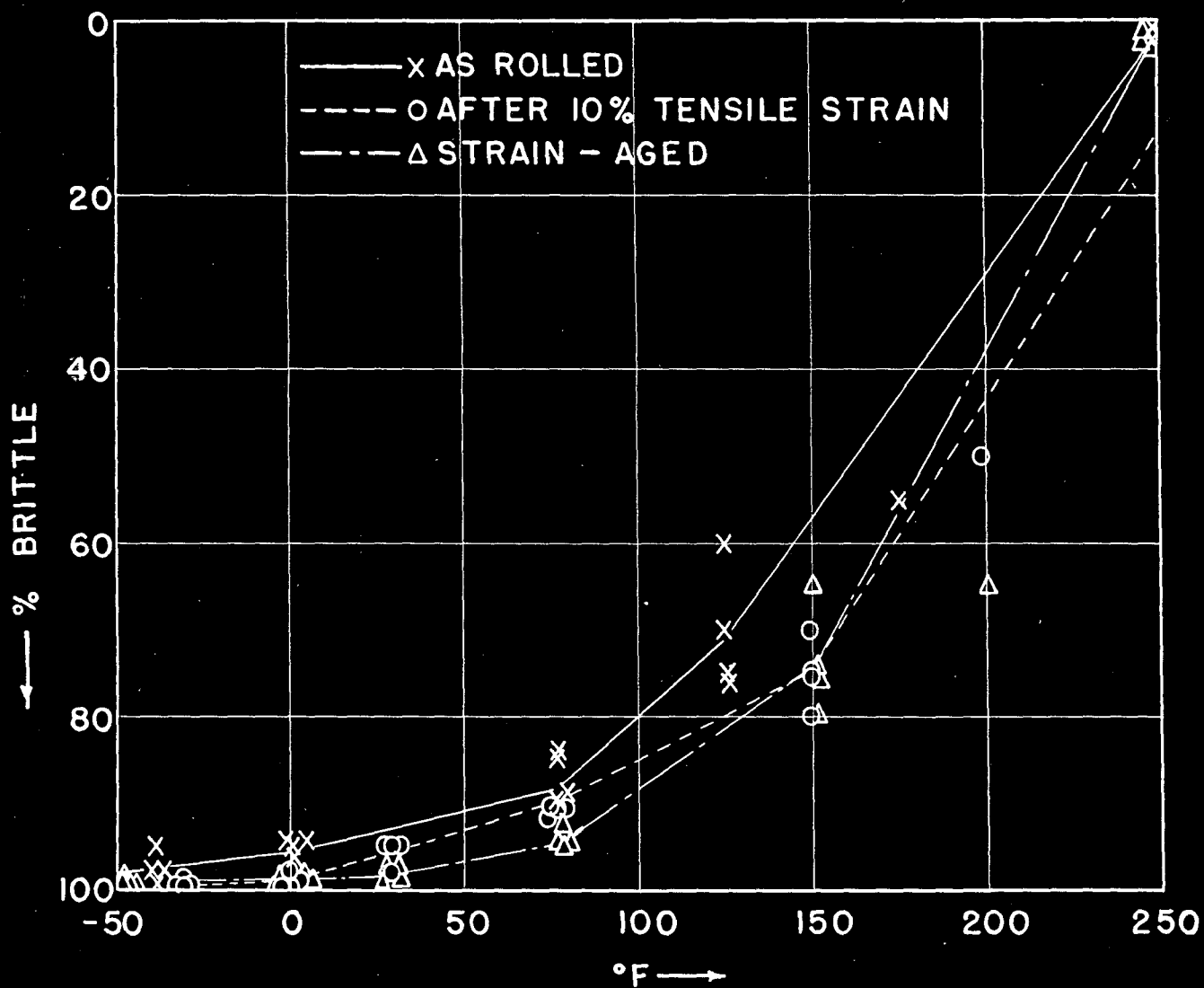


FIG.14. TRANSITION CURVES FOR A-70 1 1/4" MATERIAL

LEHIGH BEND TEST

CRITERION : % BRITTLE

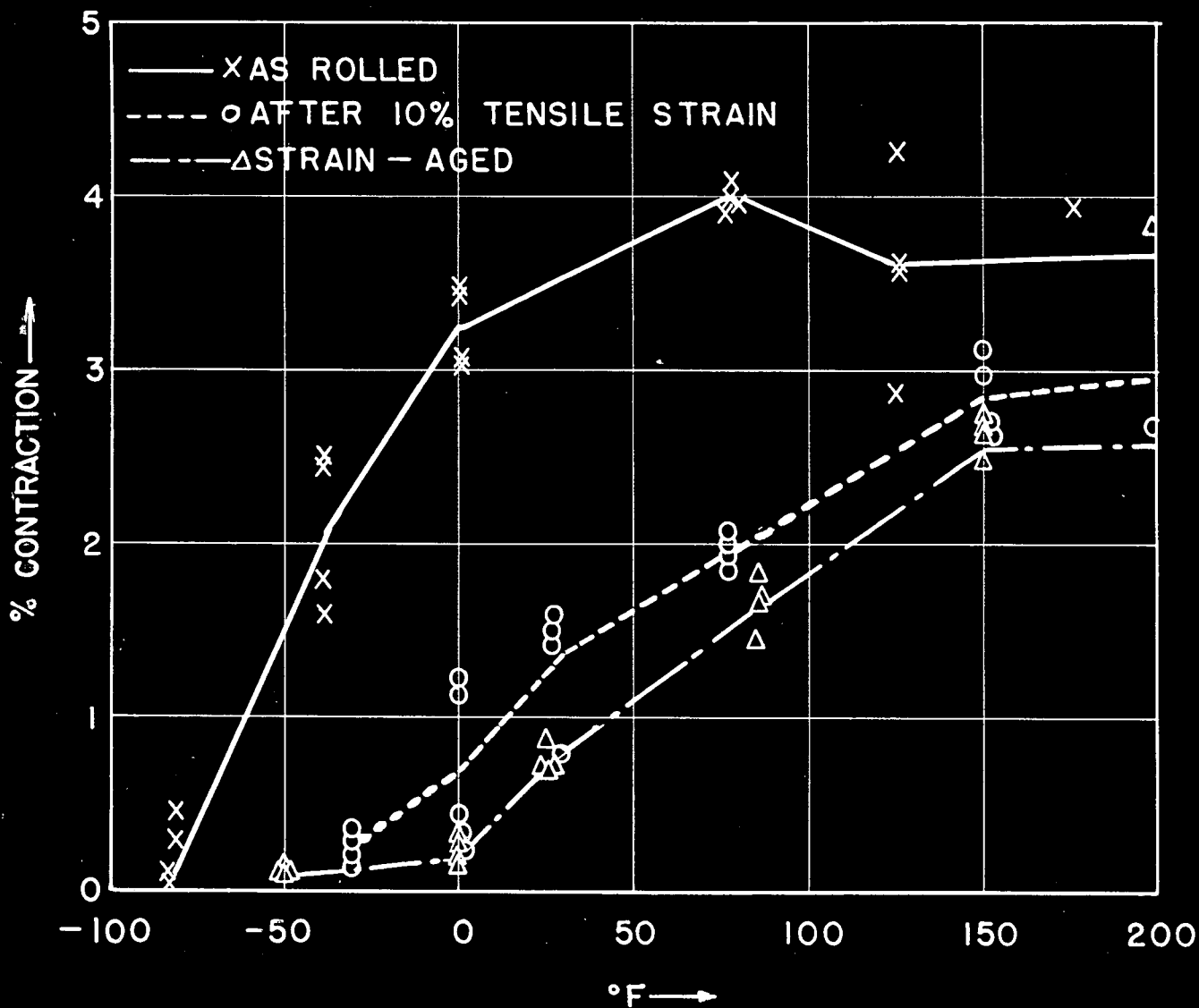


FIG. 15. TRANSITION CURVES FOR A-70 1 1/4" MATERIAL

LEHIGH BEND TEST

CRITERION: % CONTRACTION BELOW NOTCH

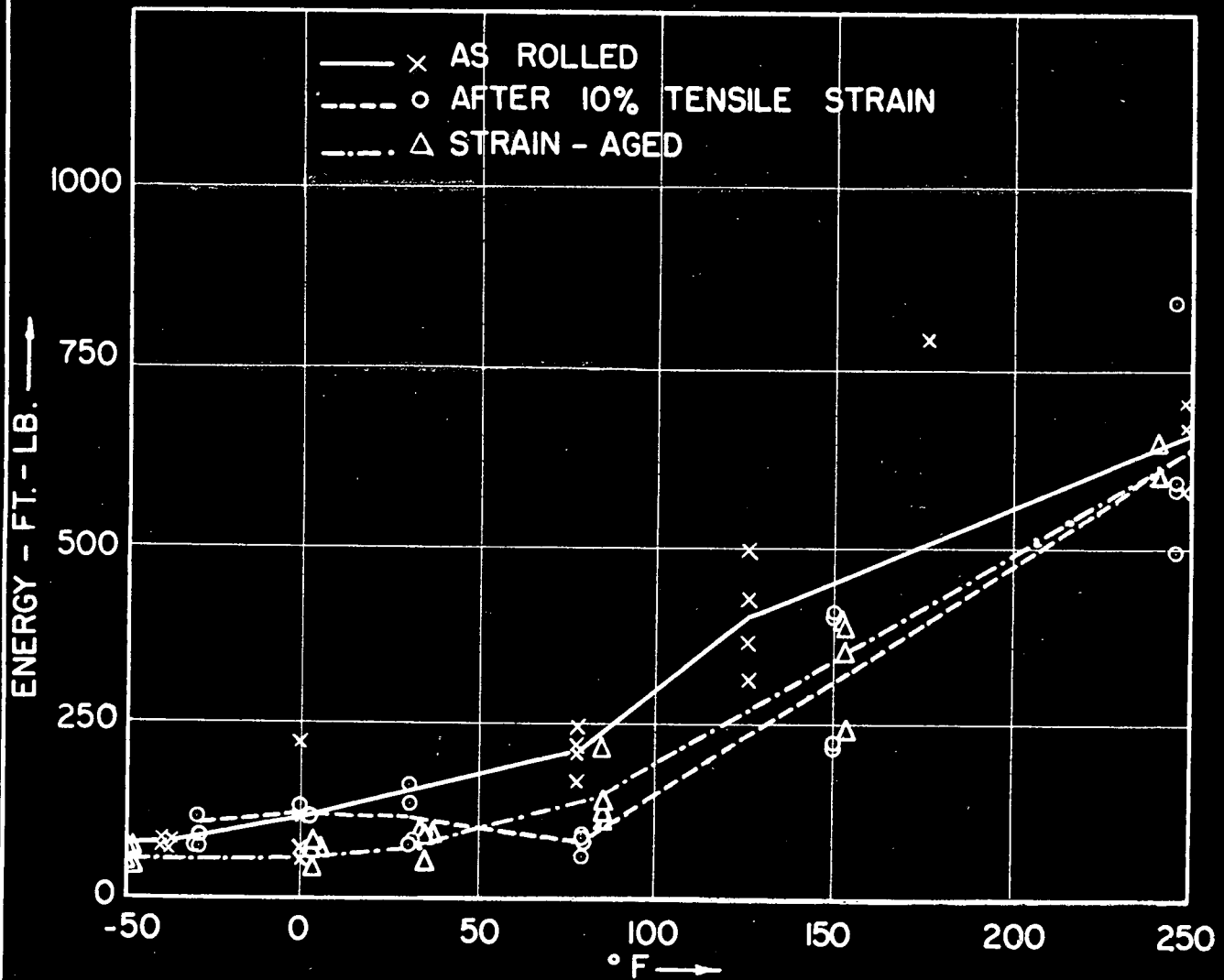


FIG. 16. TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL
 LEHIGH BEND TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

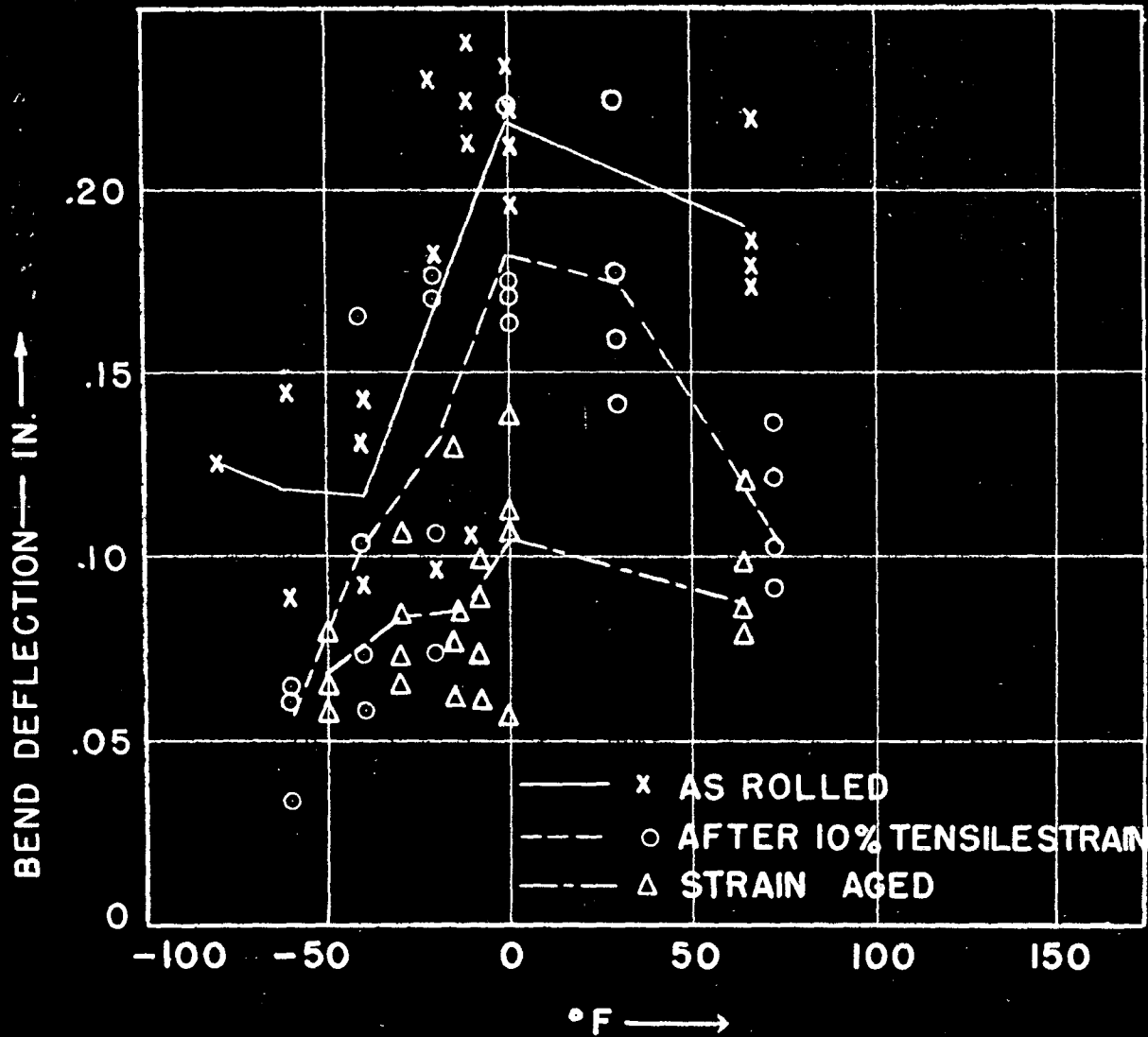


FIG. 17 TRANSITION CURVES FOR A 201, 5/8" MATERIAL
 S.S.C. BEND TEST
 CRITERION: BEND DEFLECTION

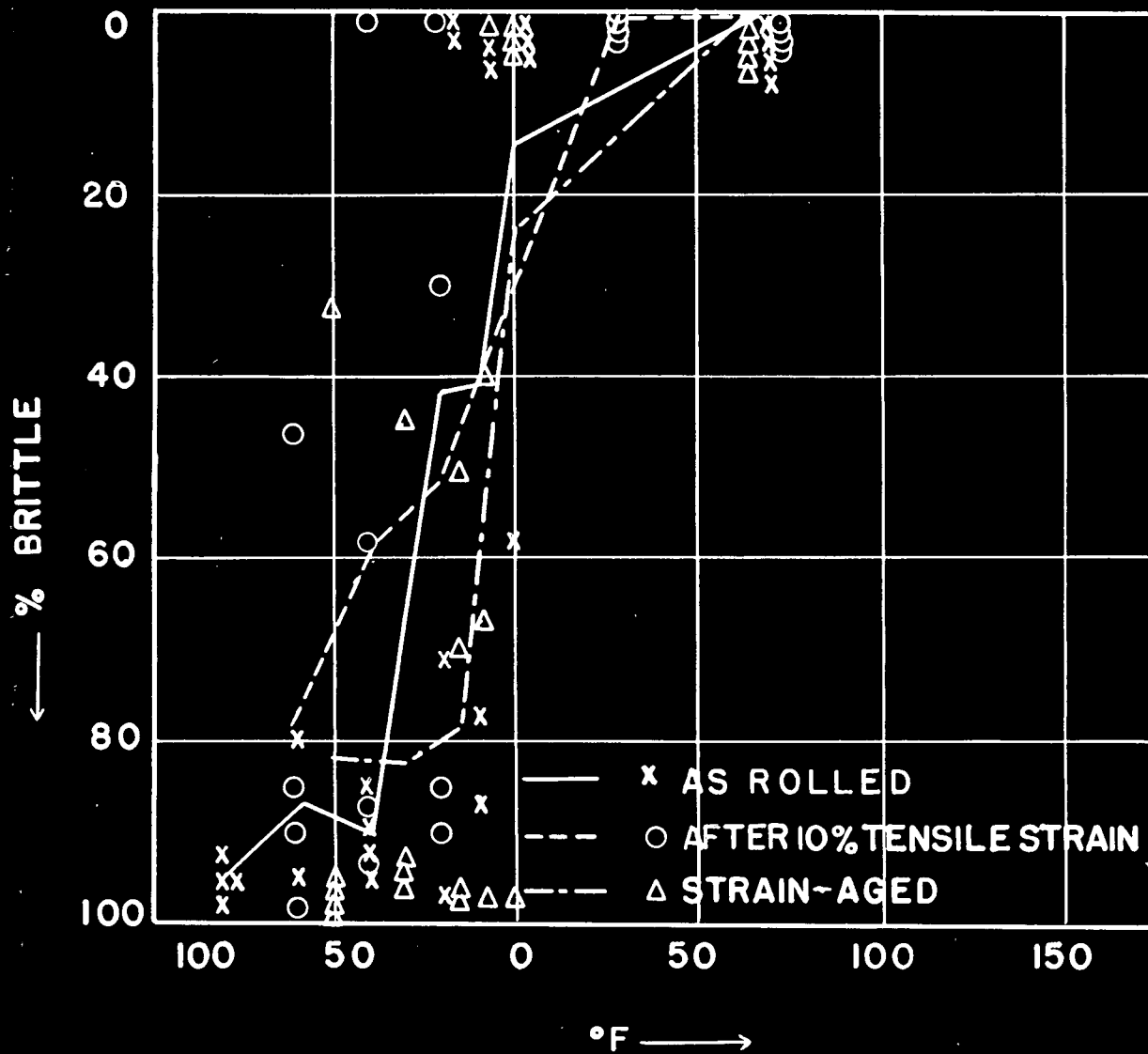


FIG. 18 TRANSITION CURVES FOR A-201, 5/8" MATERIAL

S S C BEND TEST

CRITERION: % BRITTLE

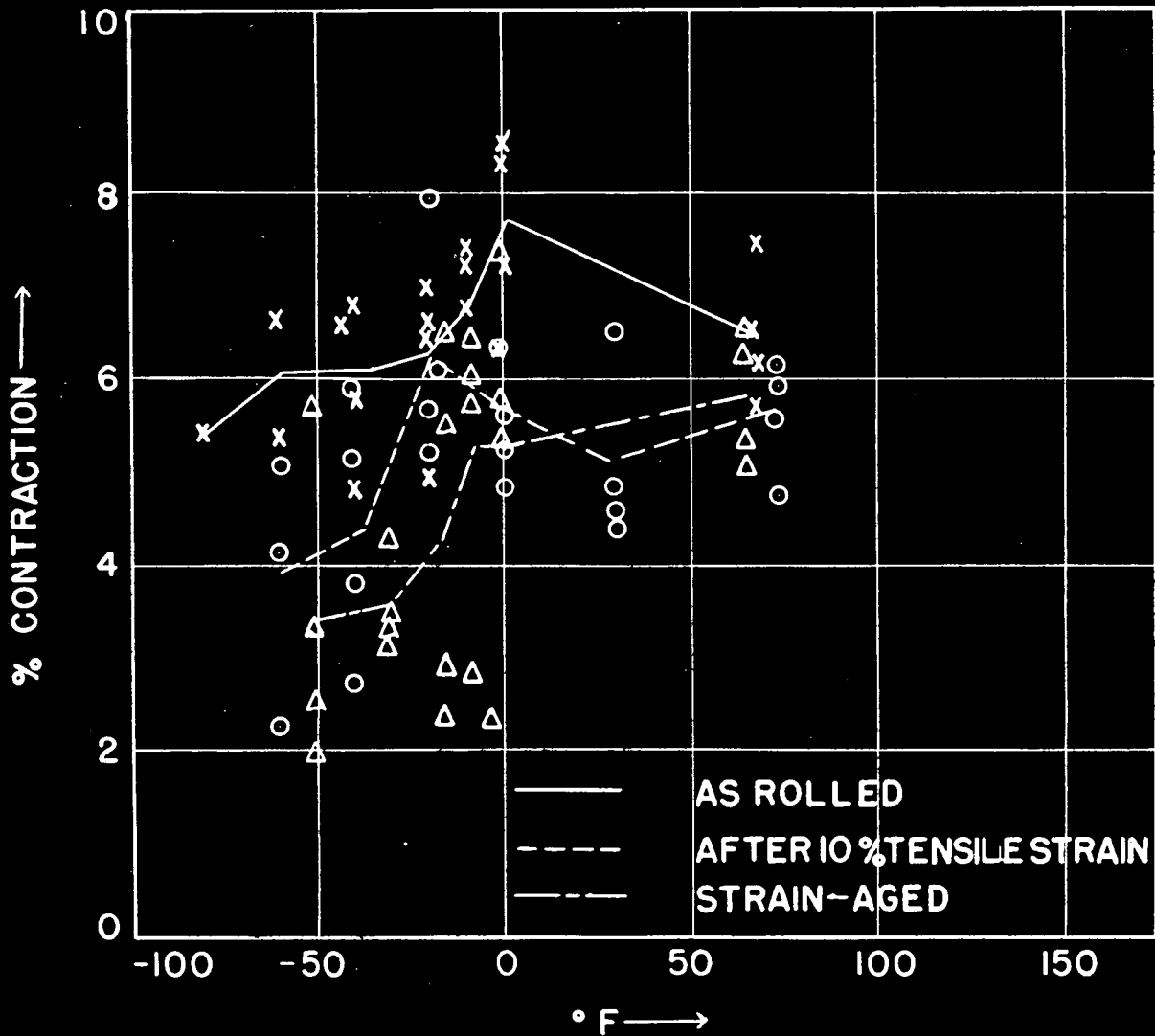


FIG. 19 TRANSITION CURVES FOR A-201, 5/8" MATERIAL

S. S. C. BEND TEST

CRITERION: % CONTRACTION BELOW NOTCH

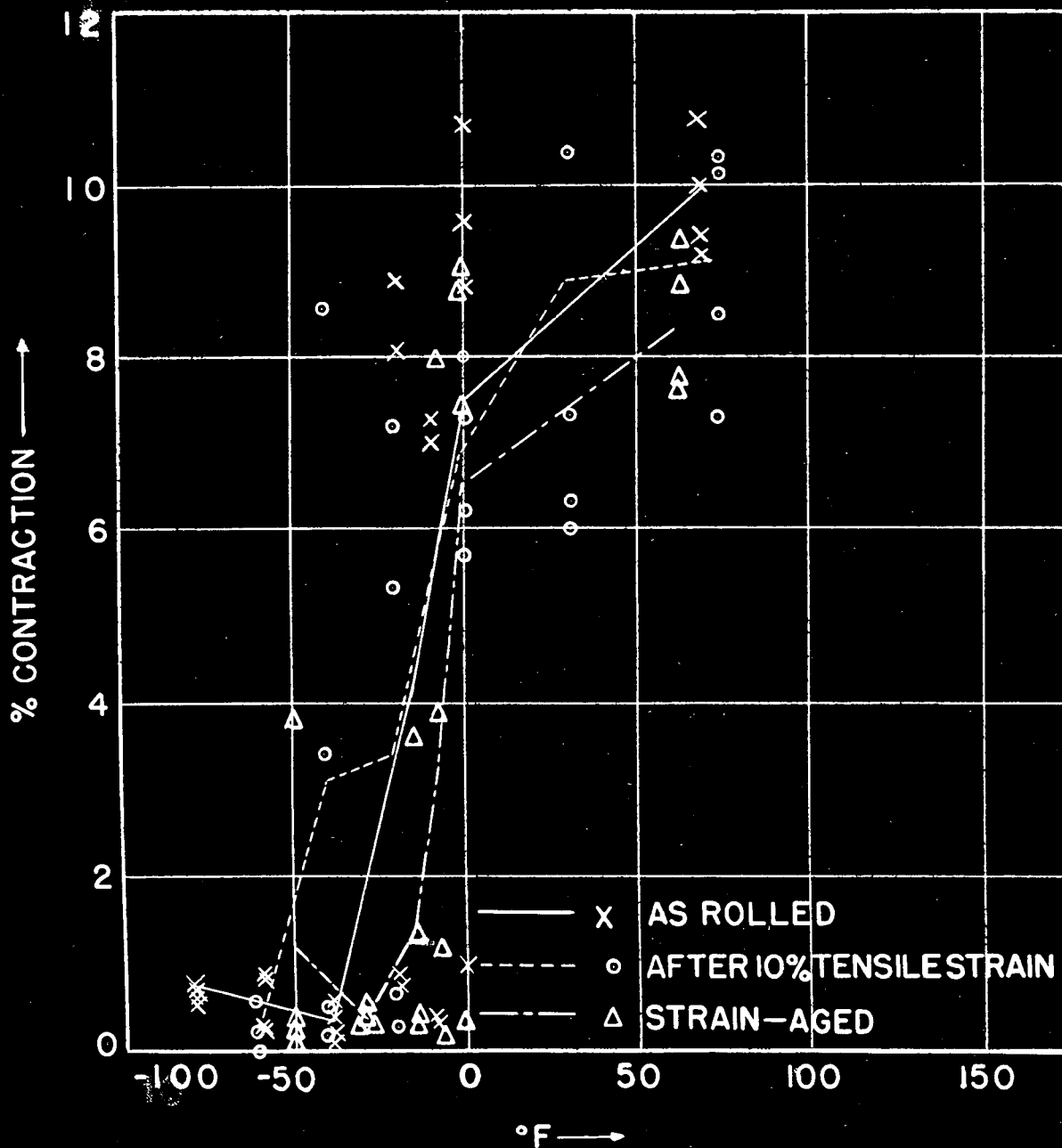


FIG. 20 TRANSITION CURVES FOR A-201, 5/8" MATERIAL
 S.S.C. BEND TEST
 CRITERION % CONTRACTION BELOW DRILL HOLE

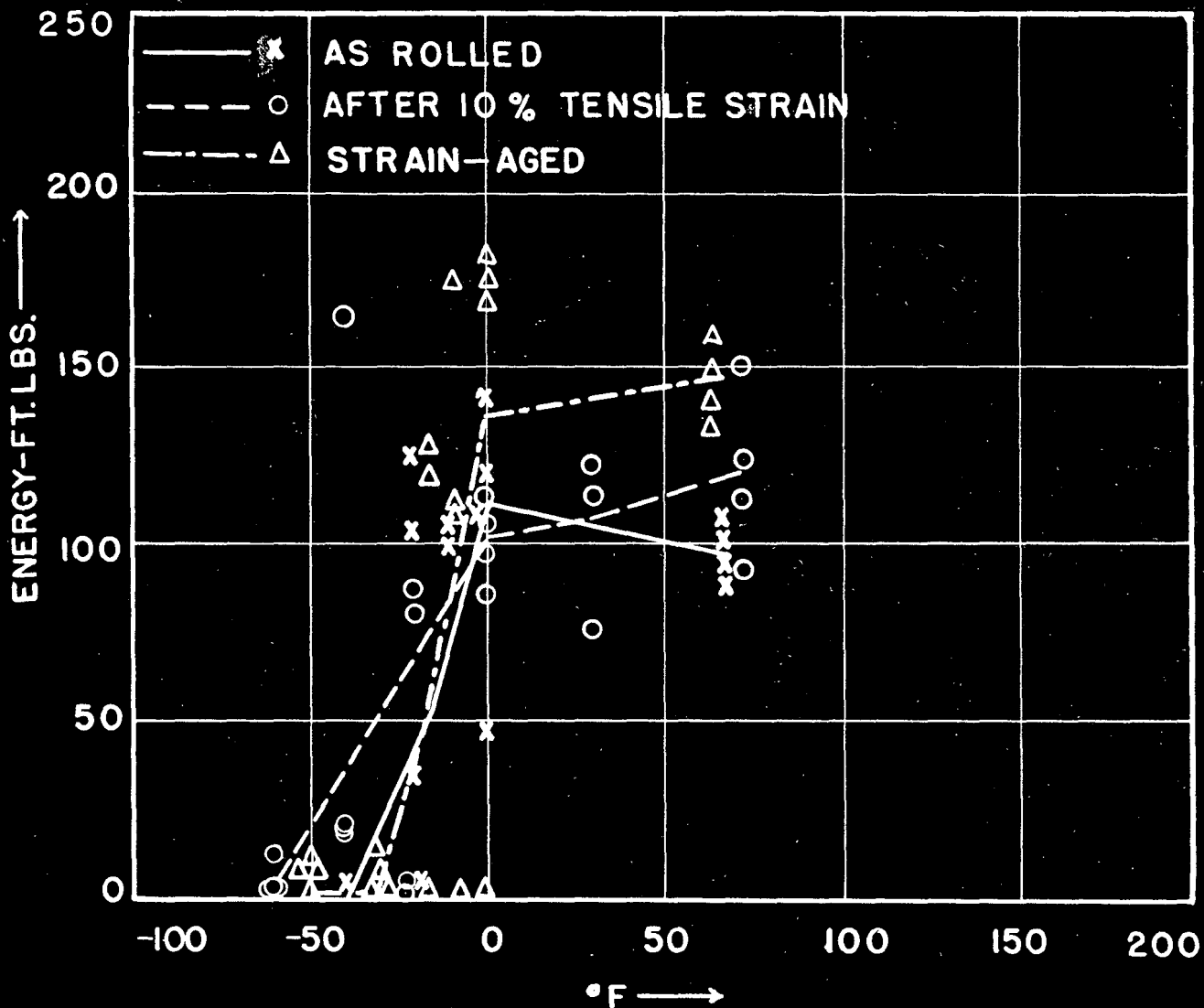


FIG. 21 TRANSITION CURVES FOR A-201, 5/8" MATERIAL
 S. S. C. BEND TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

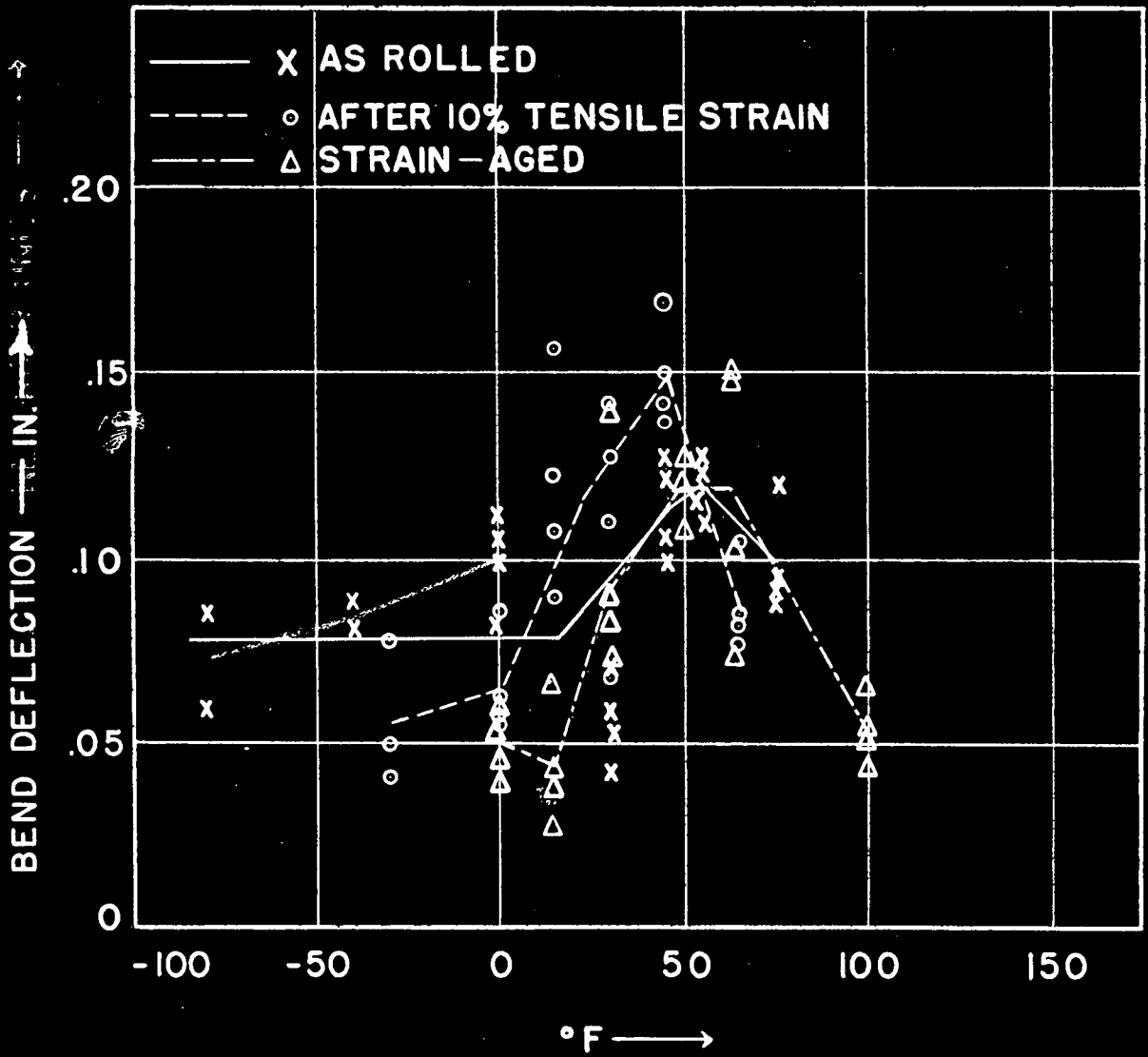


FIG. 22 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL
 S. S. C. BEND TEST
 CRITERION: BEND DEFLECTION

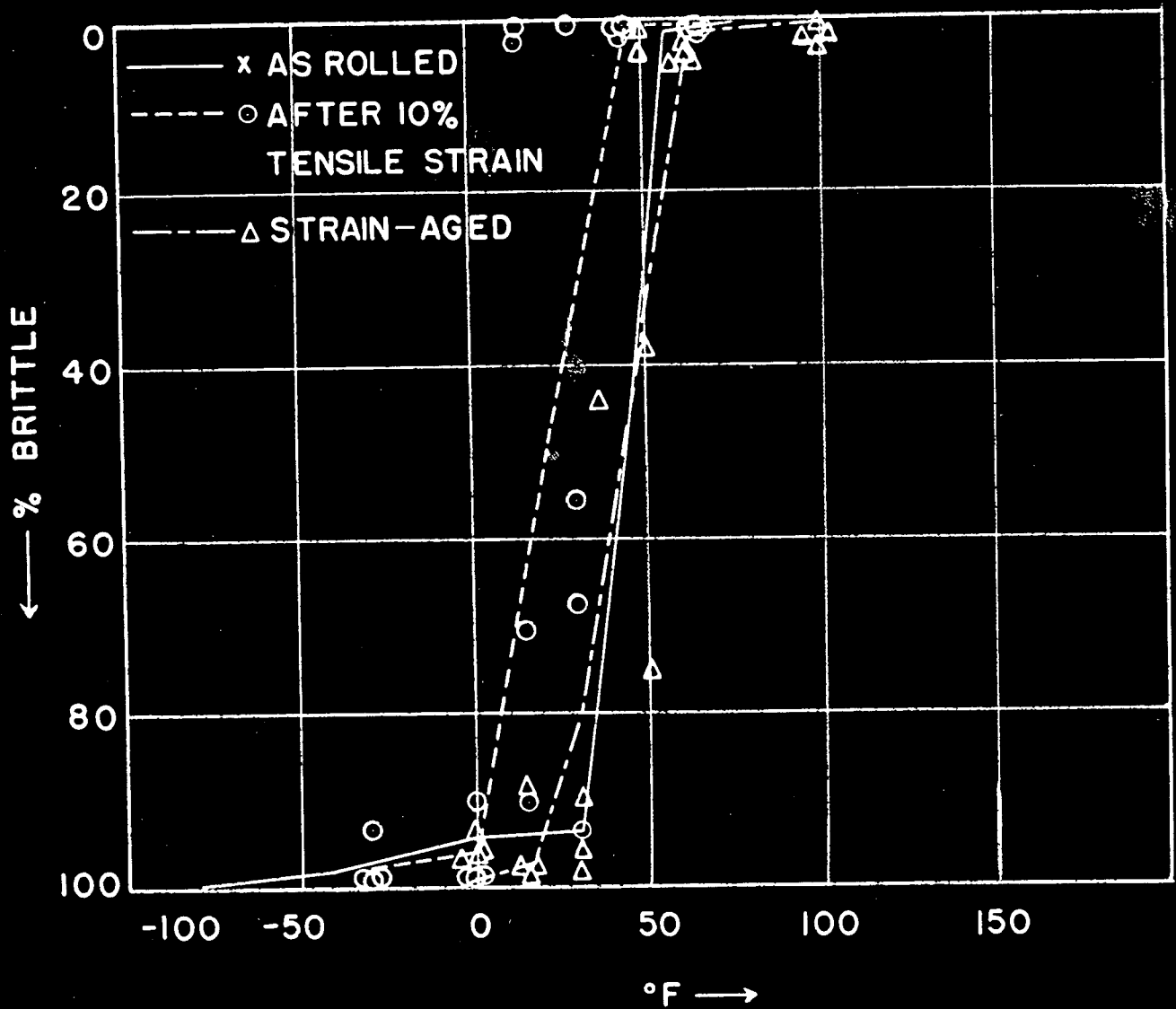


FIG. 23 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL

S. S. C. BEND TEST

CRITERION: % BRITTLE

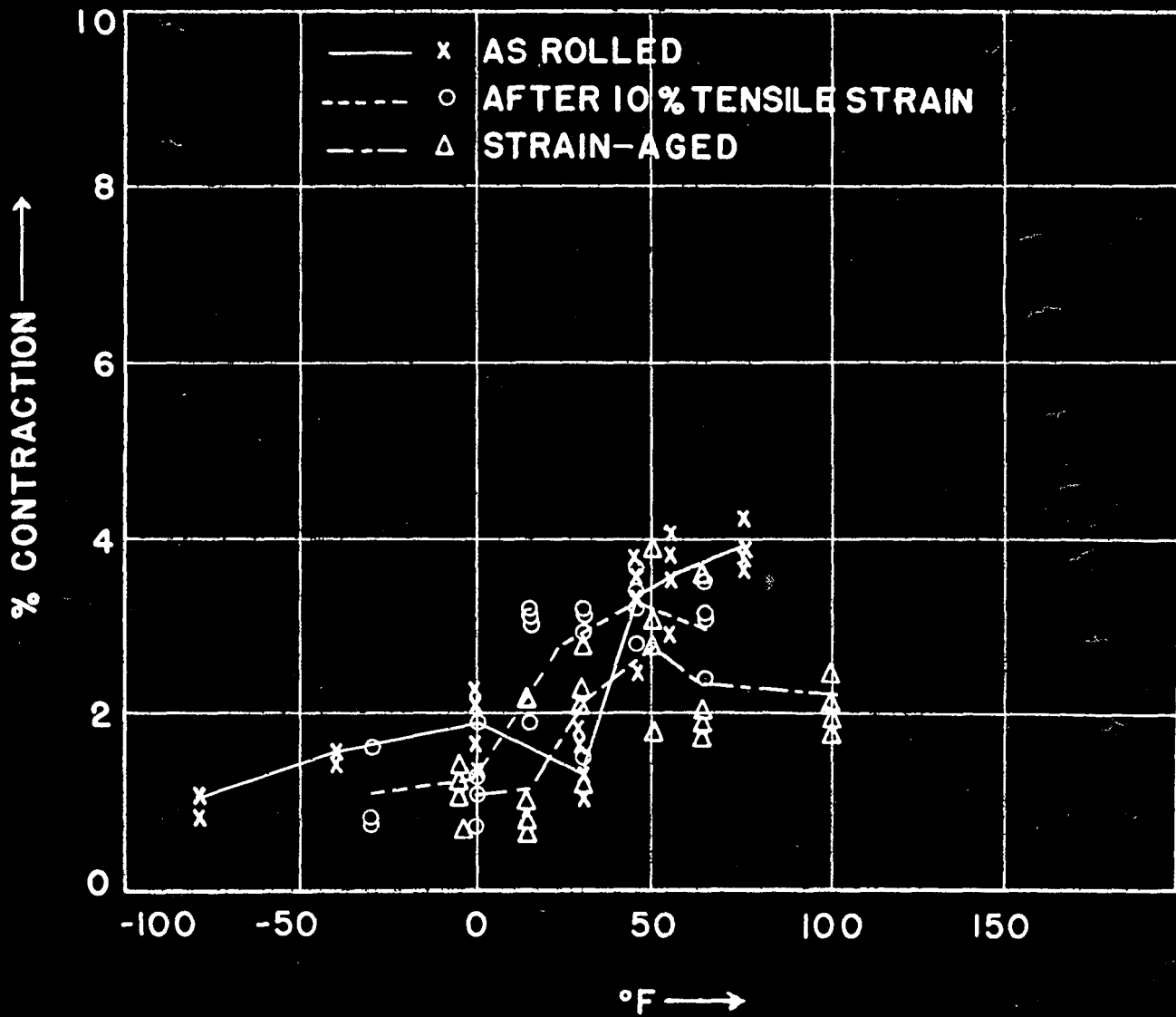


FIG. 24 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL
 S. S. C. BEND TEST
 CRITERION: % CONTRACTION BELOW NOTCH

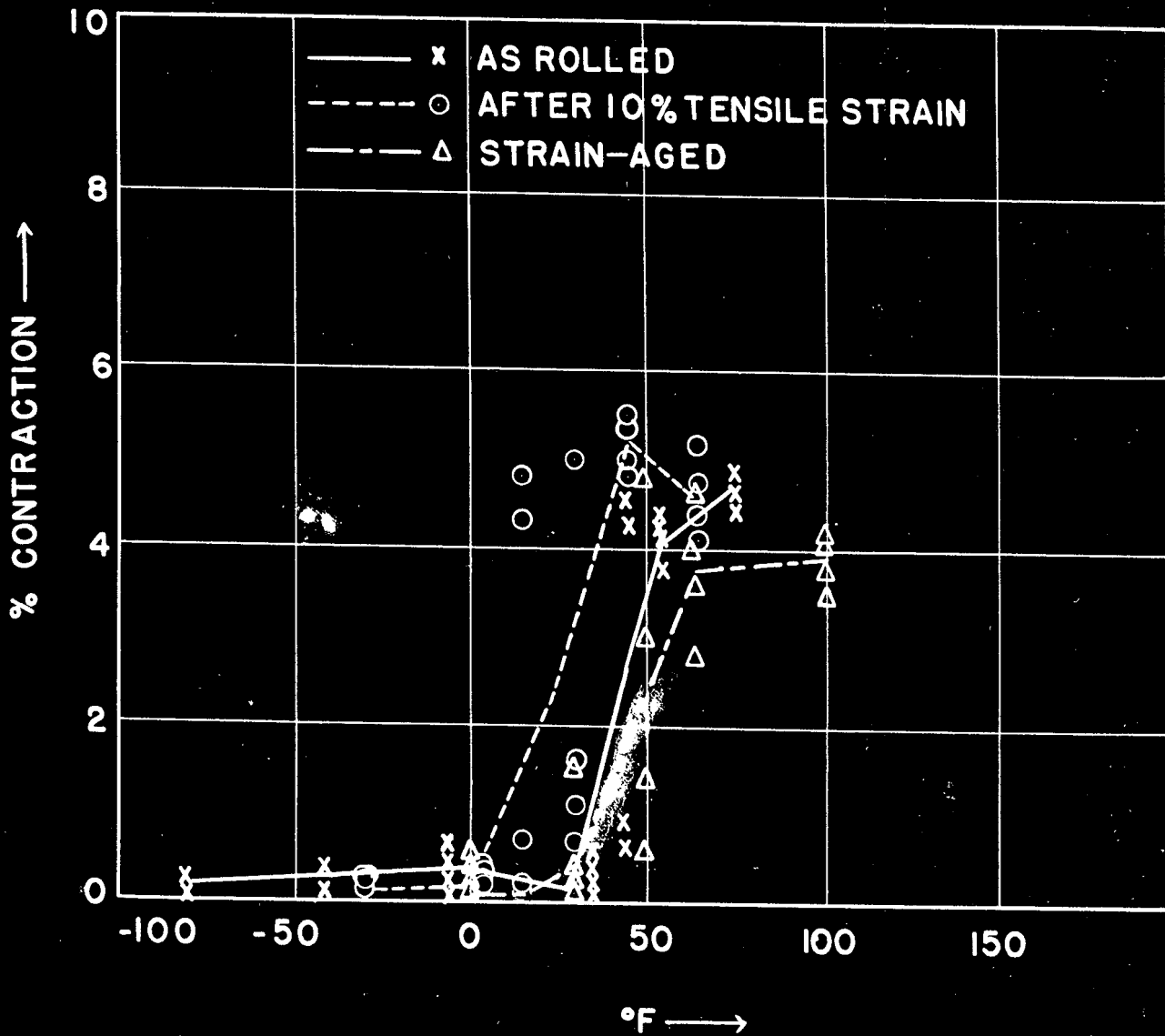


FIG. 25 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL
 S. S. C. BEND TEST
 CRITERION: % CONTRACTION BELOW DRILL HOLE

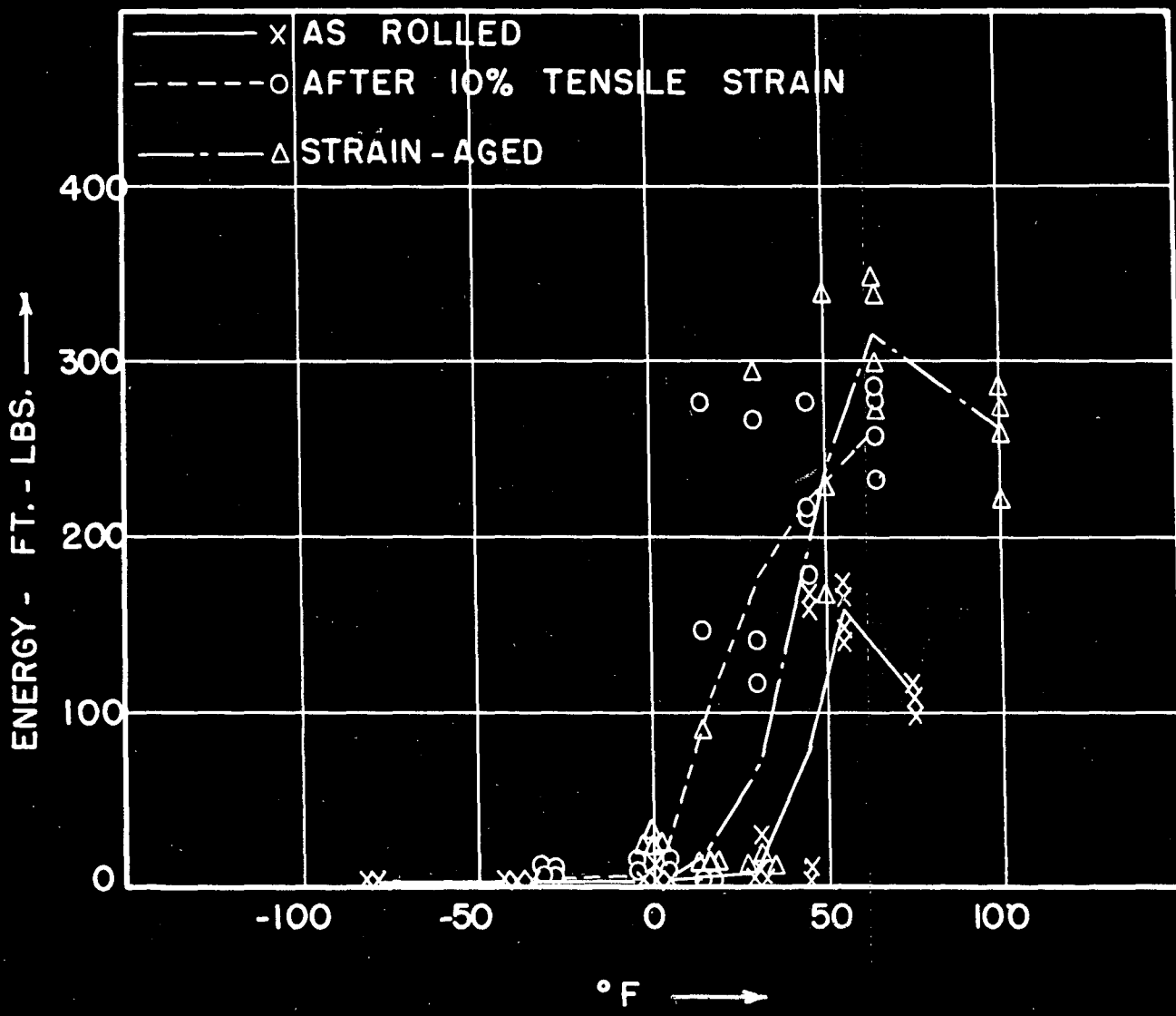


FIG.26 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL
 S. S. C. BEND TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

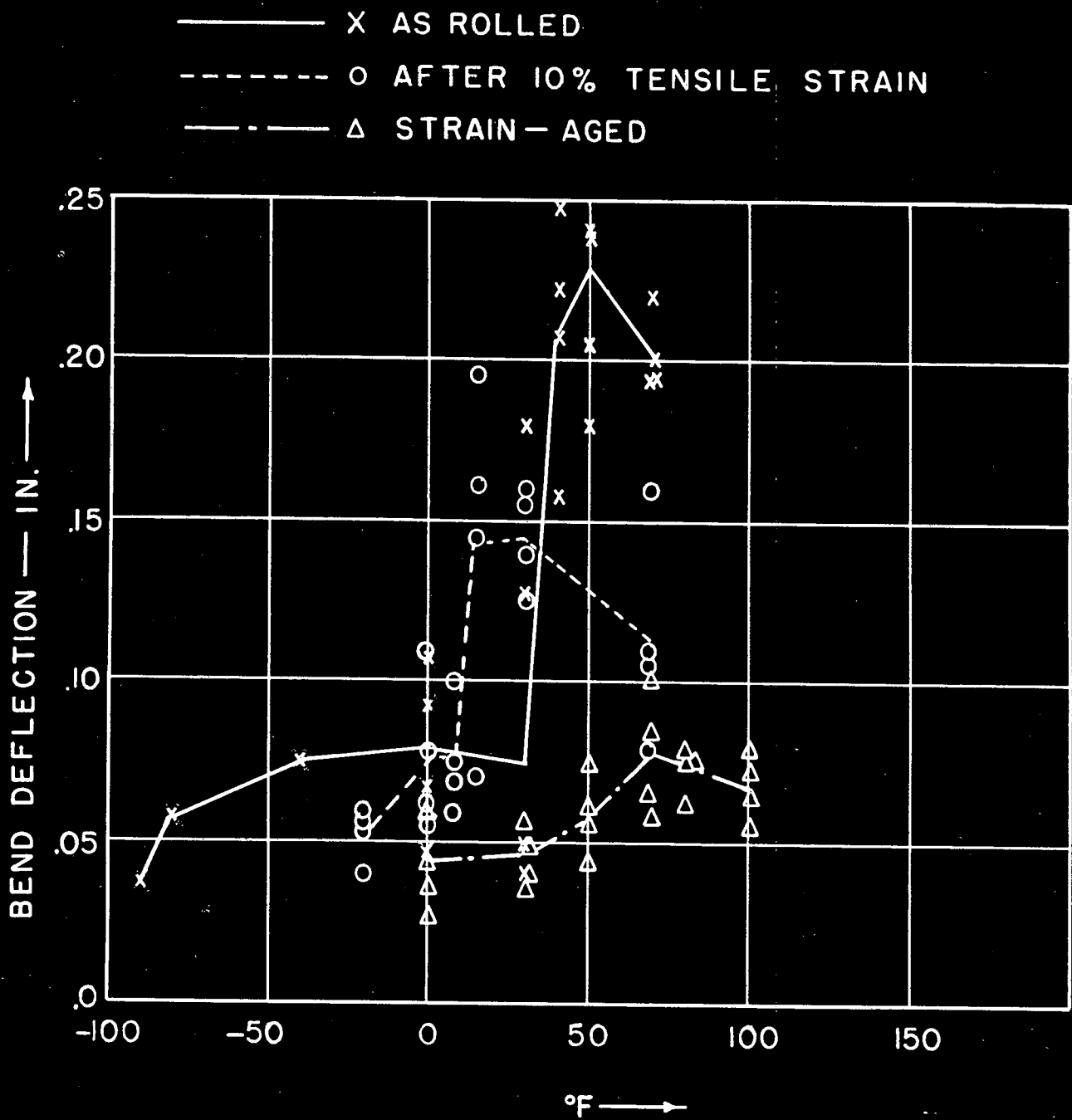


FIG. 27 TRANSITION CURVES FOR A-70 5/8" MATERIAL
 S.S.C. BEND TEST
 CRITERION: BEND DEFLECTION

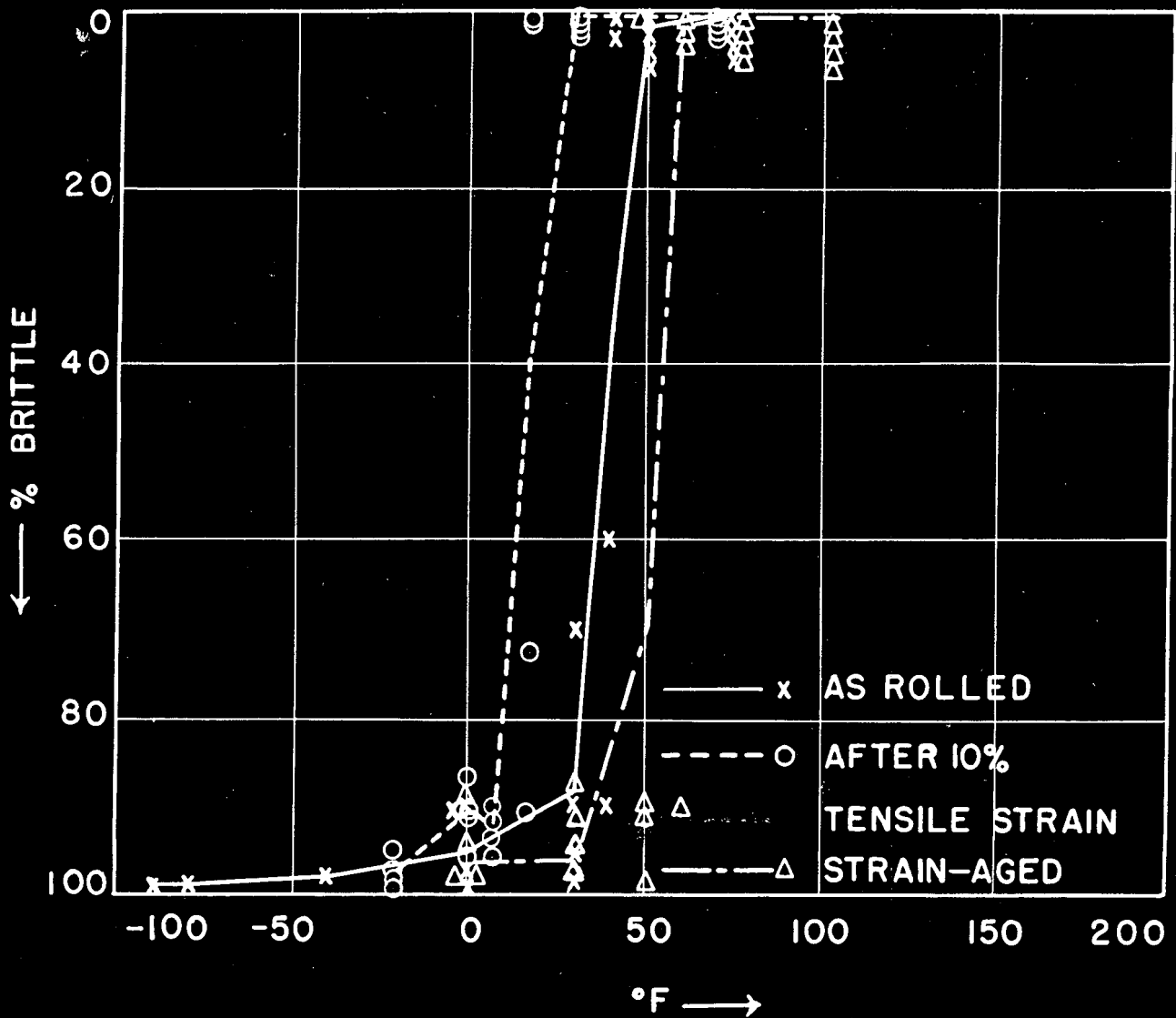


FIG. 28 TRANSITION CURVES FOR A-70, 5/8" MATERIAL

S. S. C. BEND TEST

CRITERION: % BRITTLE

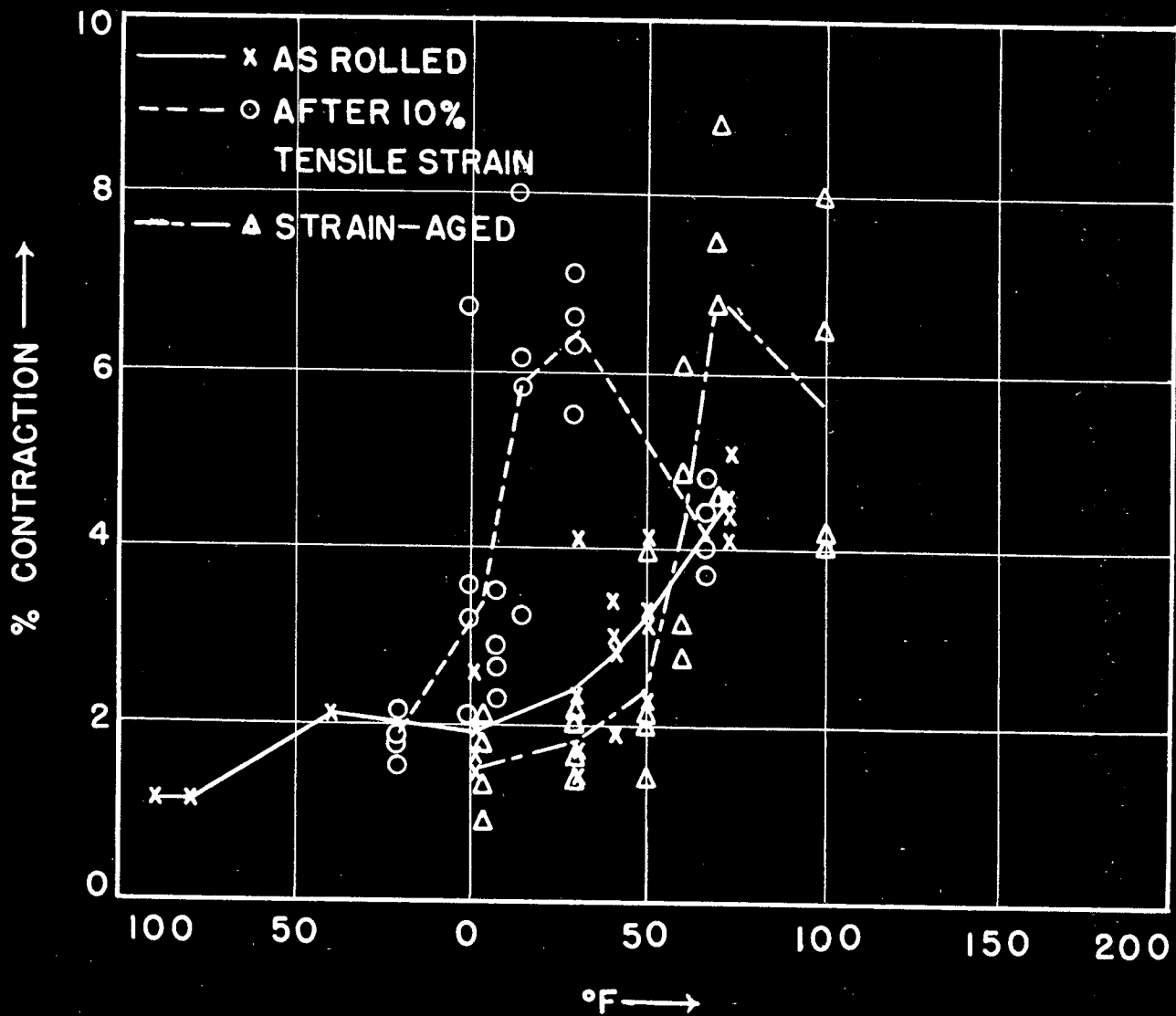


FIG. 29 TRANSITION CURVES FOR A-70, 5/8" MATERIAL

S. S. C. BEND TEST

CRITERION: % CONTRACTION BELOW NOTCH

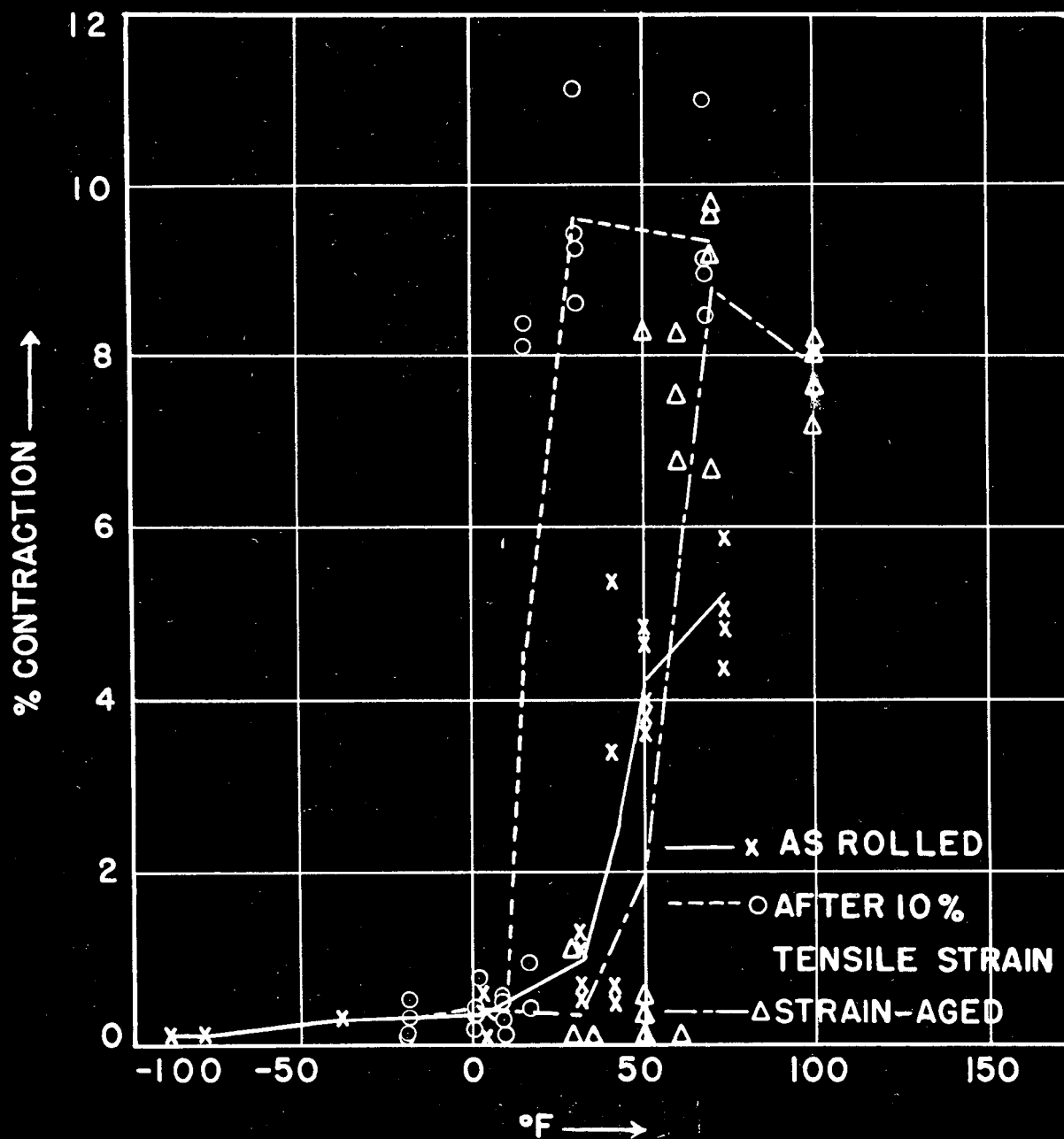


FIG. 30 TRANSITION CURVES FOR A-70, 5/8" MATERIAL

S. S. C. BEND TEST

CRITERION: % CONTRACTION BELOW DRILL HOLE

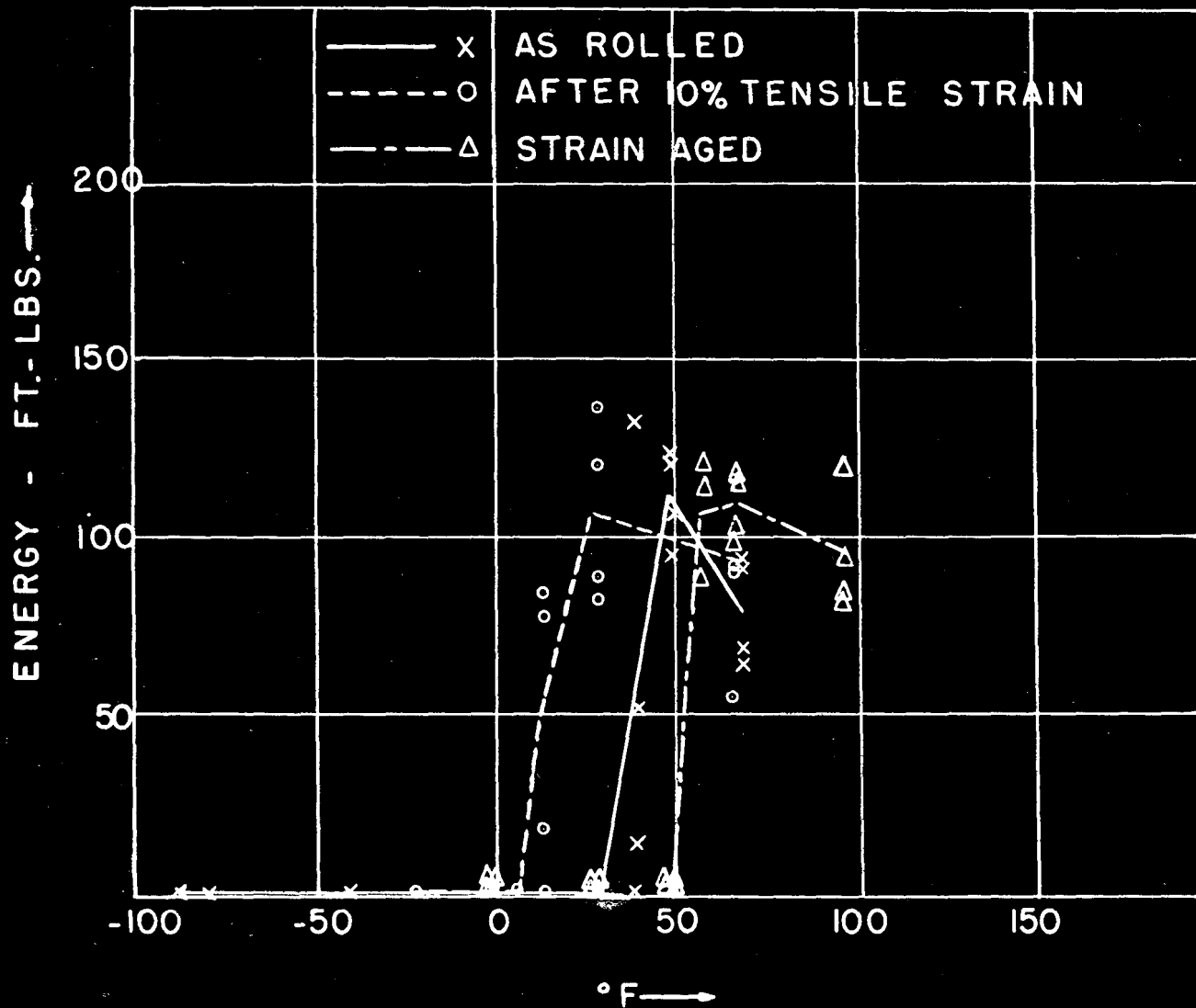


FIG.31 TRANSITION CURVES FOR A-70, 5/8" MATERIAL

S. S. C. BEND TEST

CRITERION: ENERGY AFTER MAXIMUM LOAD

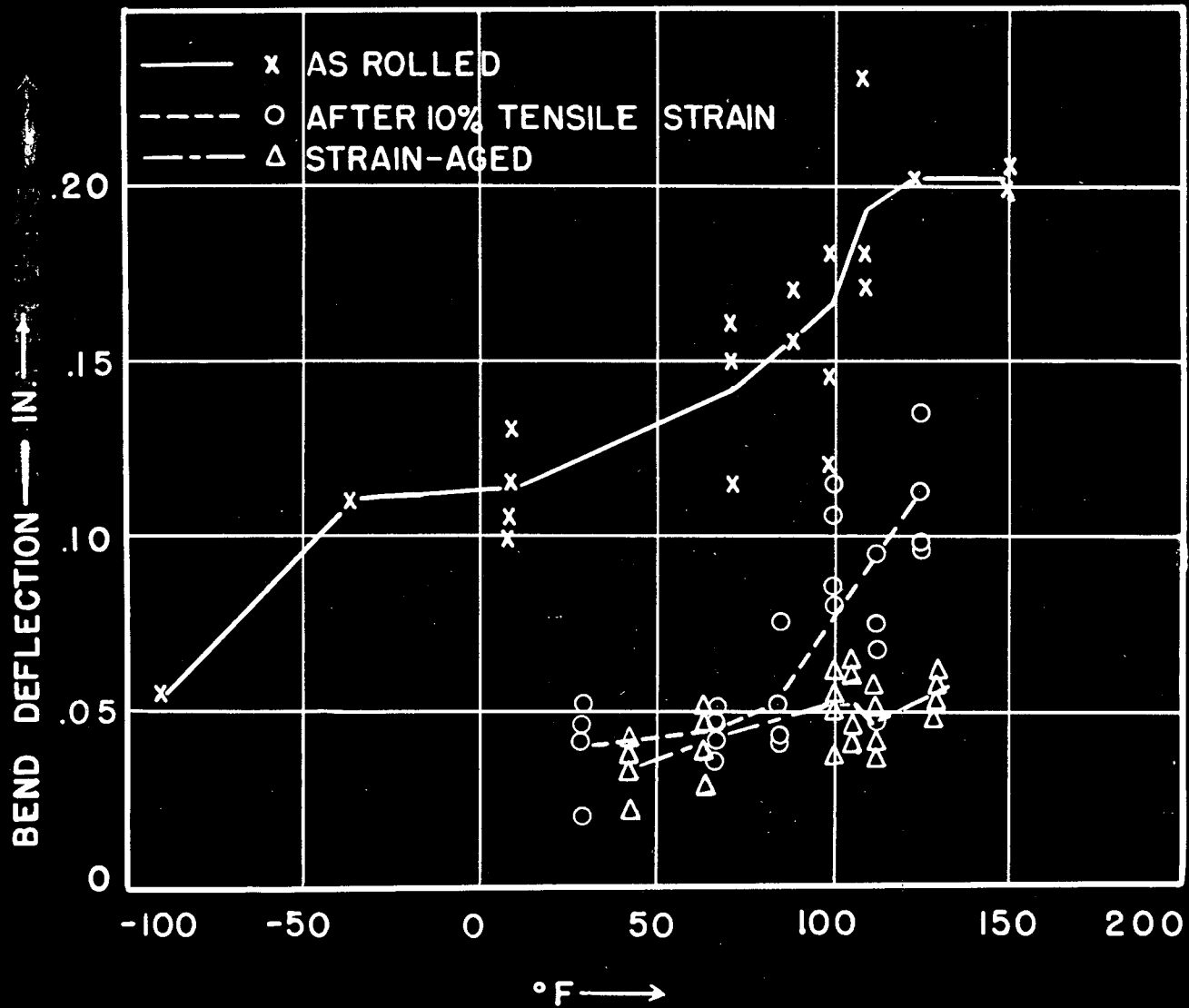


FIG. 32 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL

S. S. C. BEND TEST

CRITERION: BEND DEFLECTION

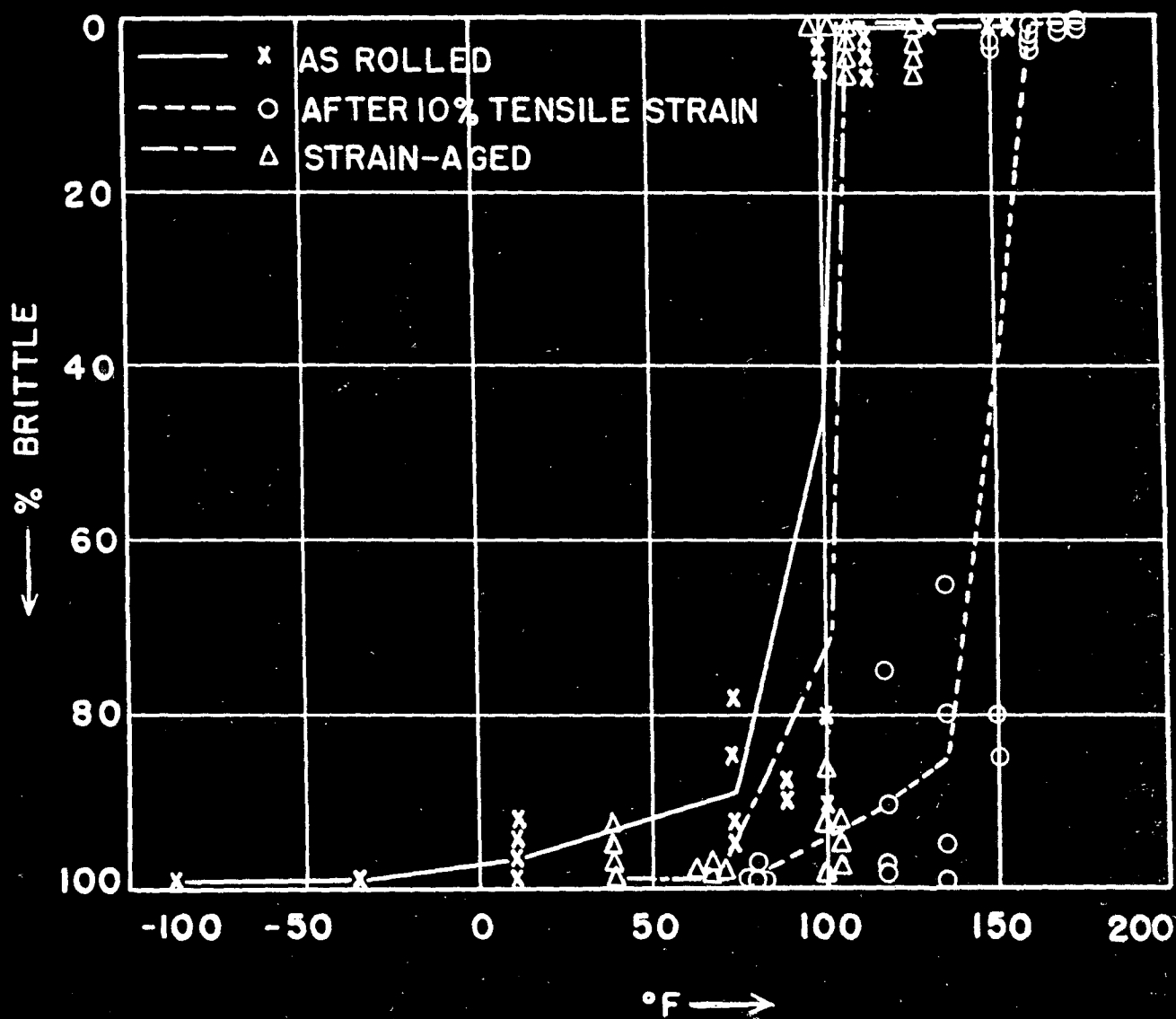


FIG. 33 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL

S. S. C. BEND TEST

CRITERION: % BRITTLE

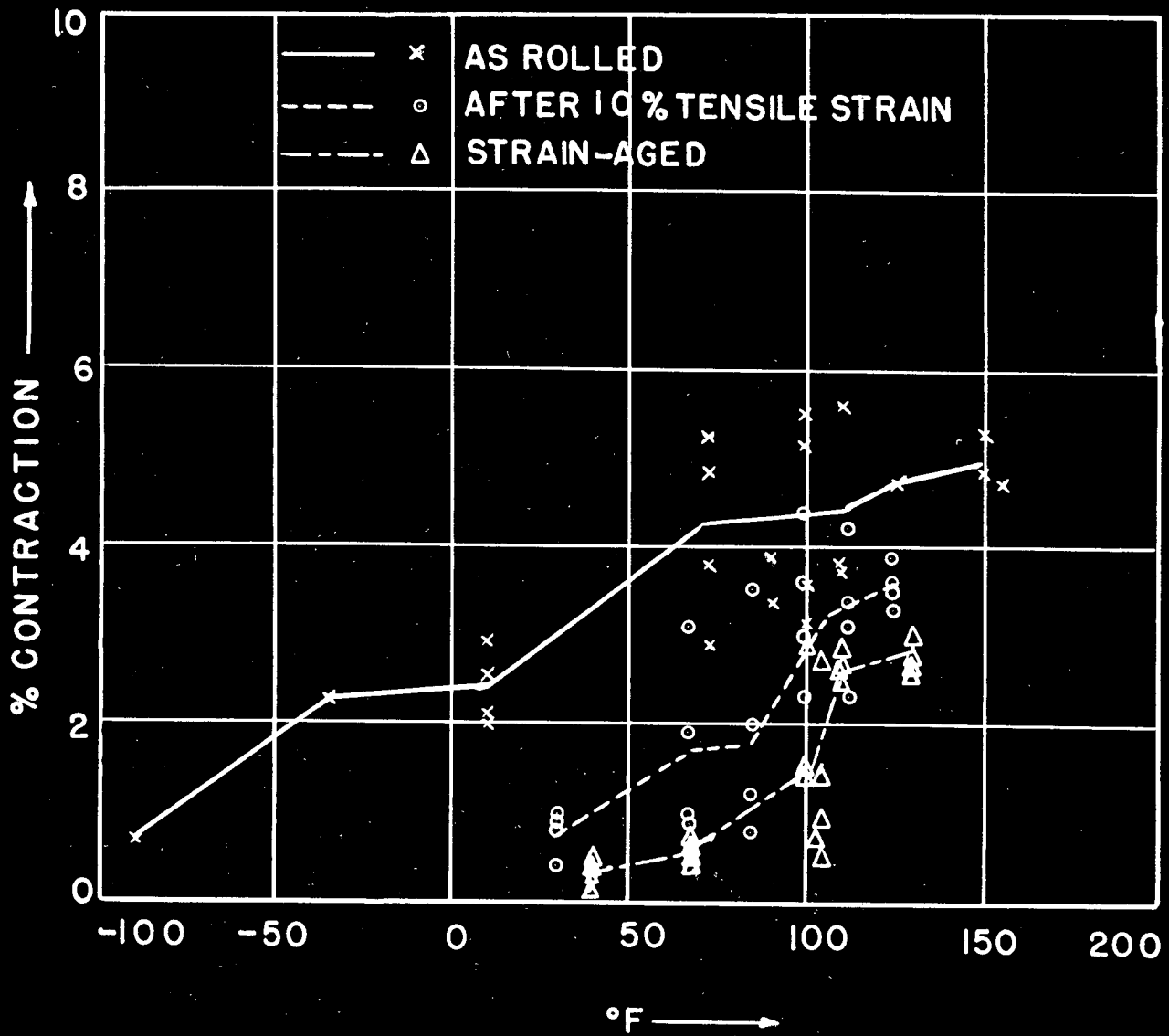


FIG. 34 TRANSITION CURVES FOR A 70, 11/4" MATERIAL
 S. S. C. BEND TEST
 CRITERION: % CONTRACTION BELOW NOTCH

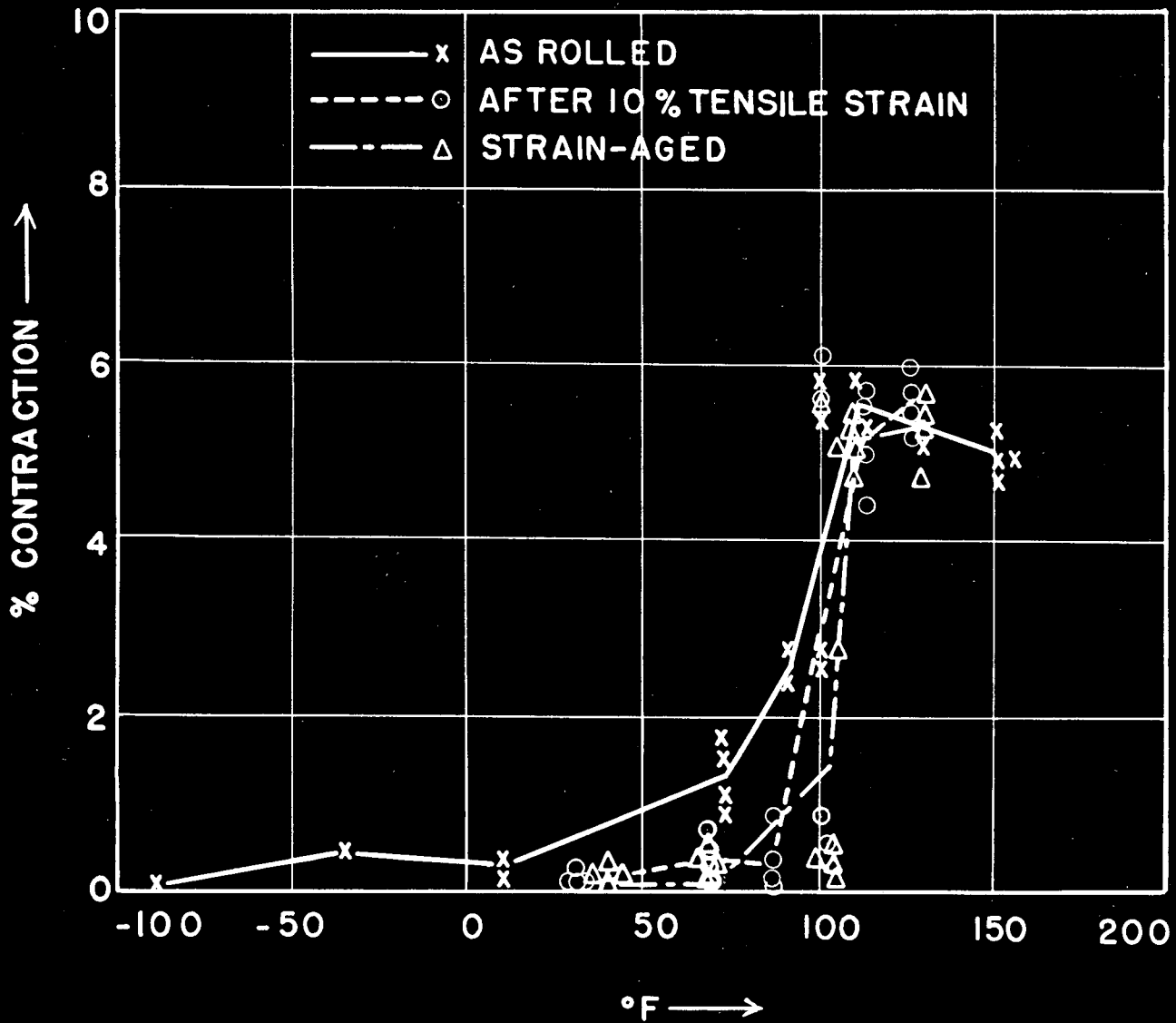


FIG. 35 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL

S. S. C. BEND TEST

CRITERION: % CONTRACTION BELOW DRILL HOLE

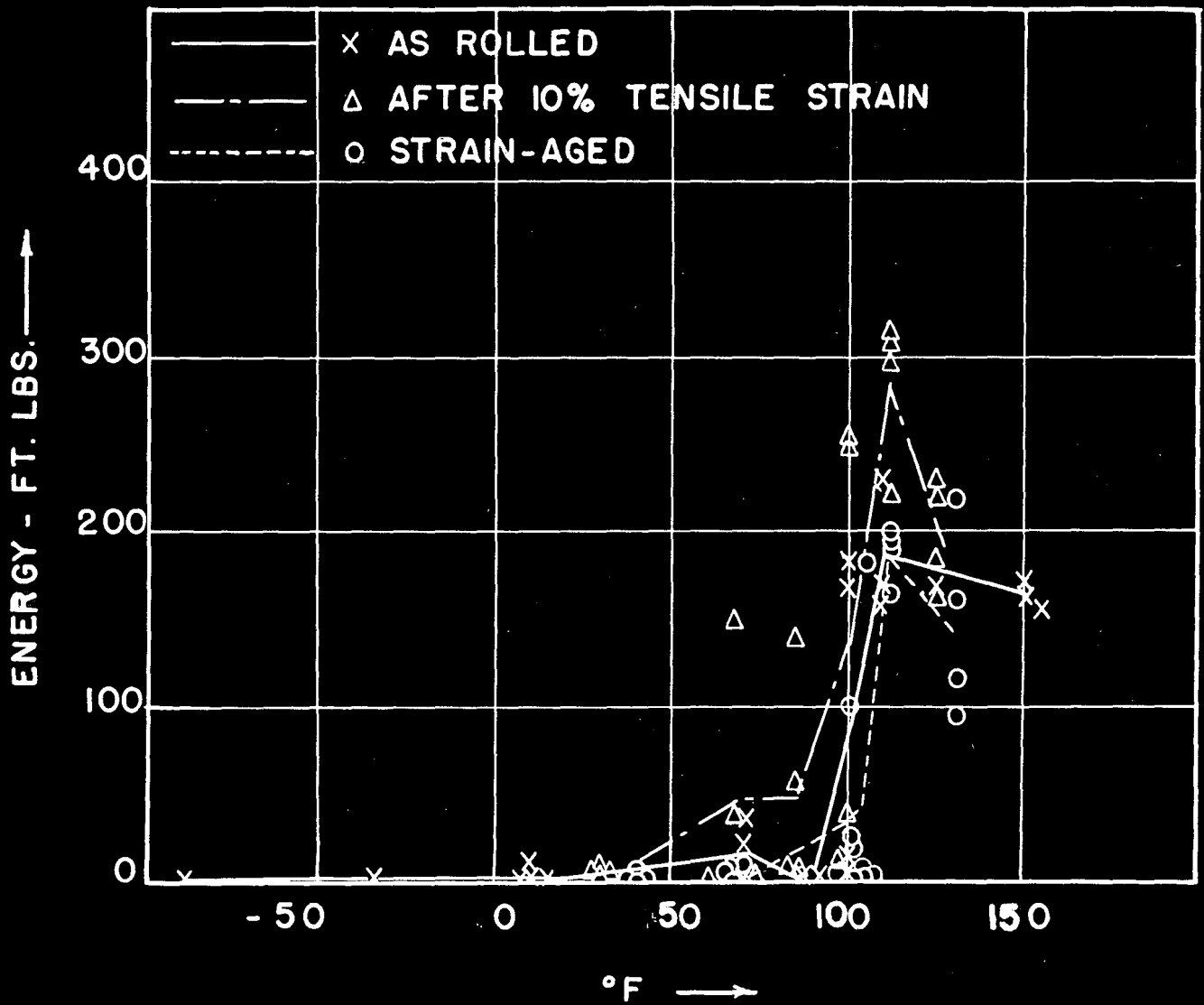


FIG. 36 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL
 S.S.C. BEND TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

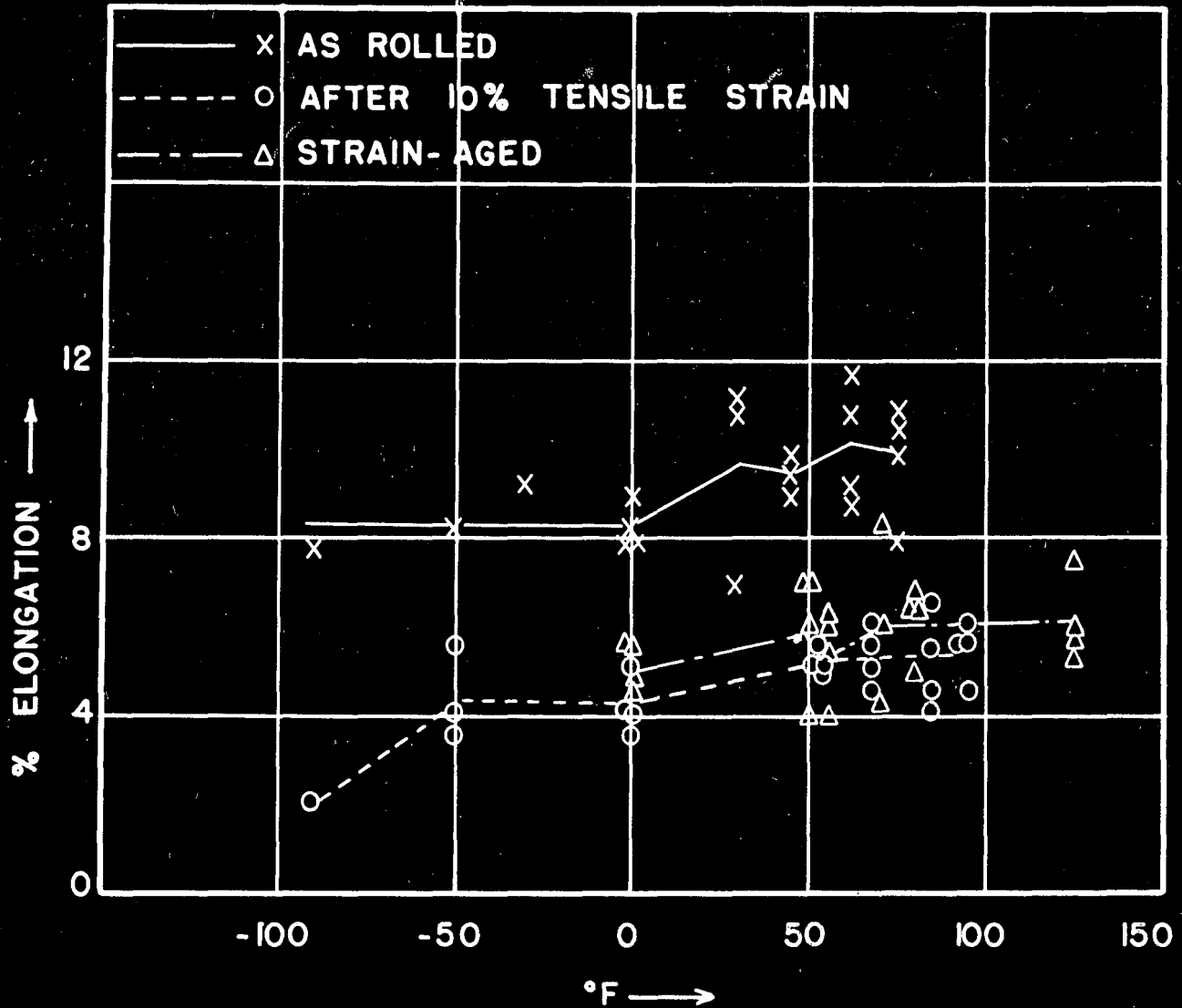


FIG. 37 TRANSITION CURVES FOR A-201, 5/8" MATERIAL

KAHN TEAR TEST

CRITERION: % ELONGATION 1/4" BELOW NOTCH

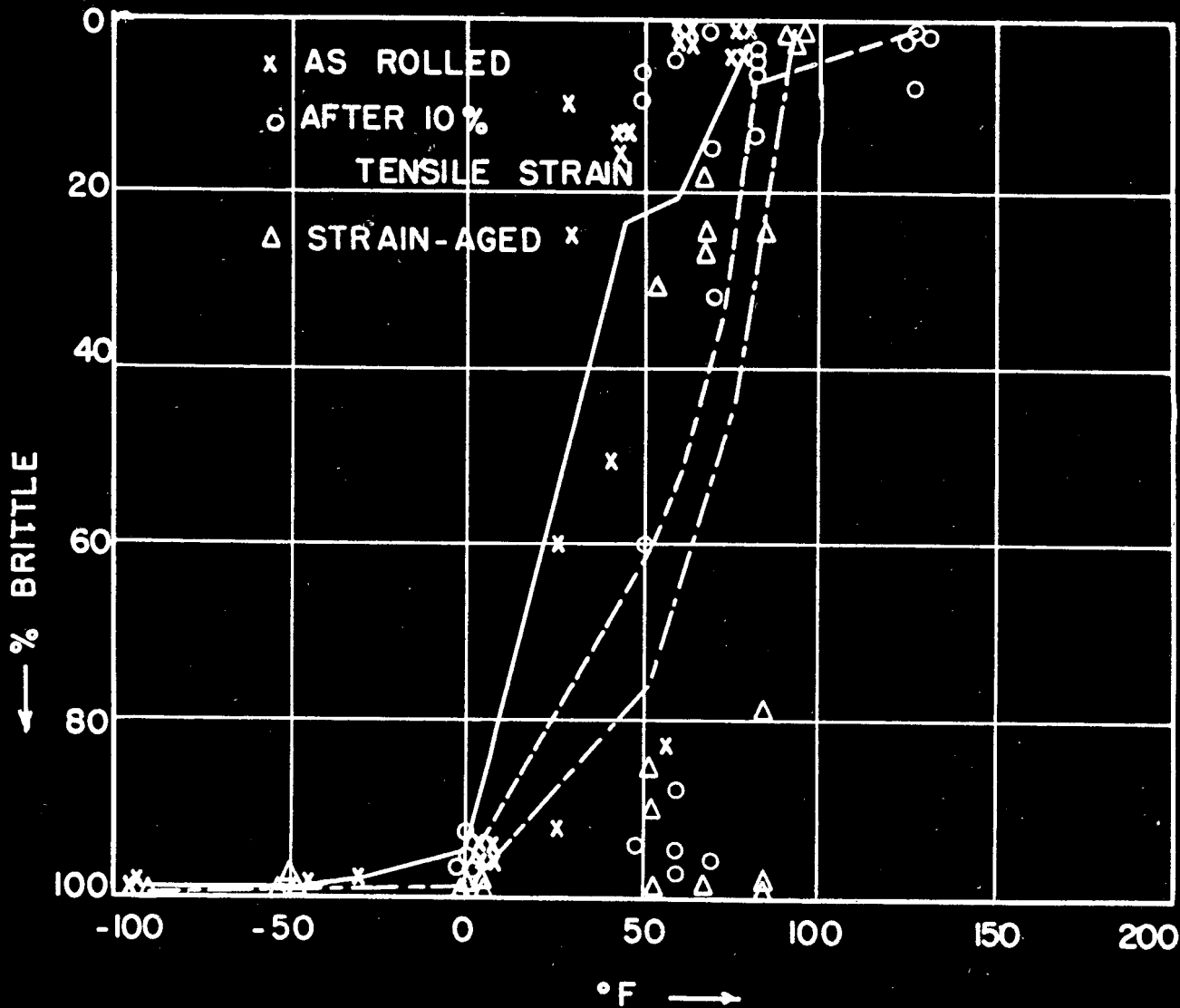


FIG. 38 TRANSITION CURVES FOR A-201, 5/8" MATERIAL
 KAHN TEAR TEST
 CRITERION: % BRITTLE

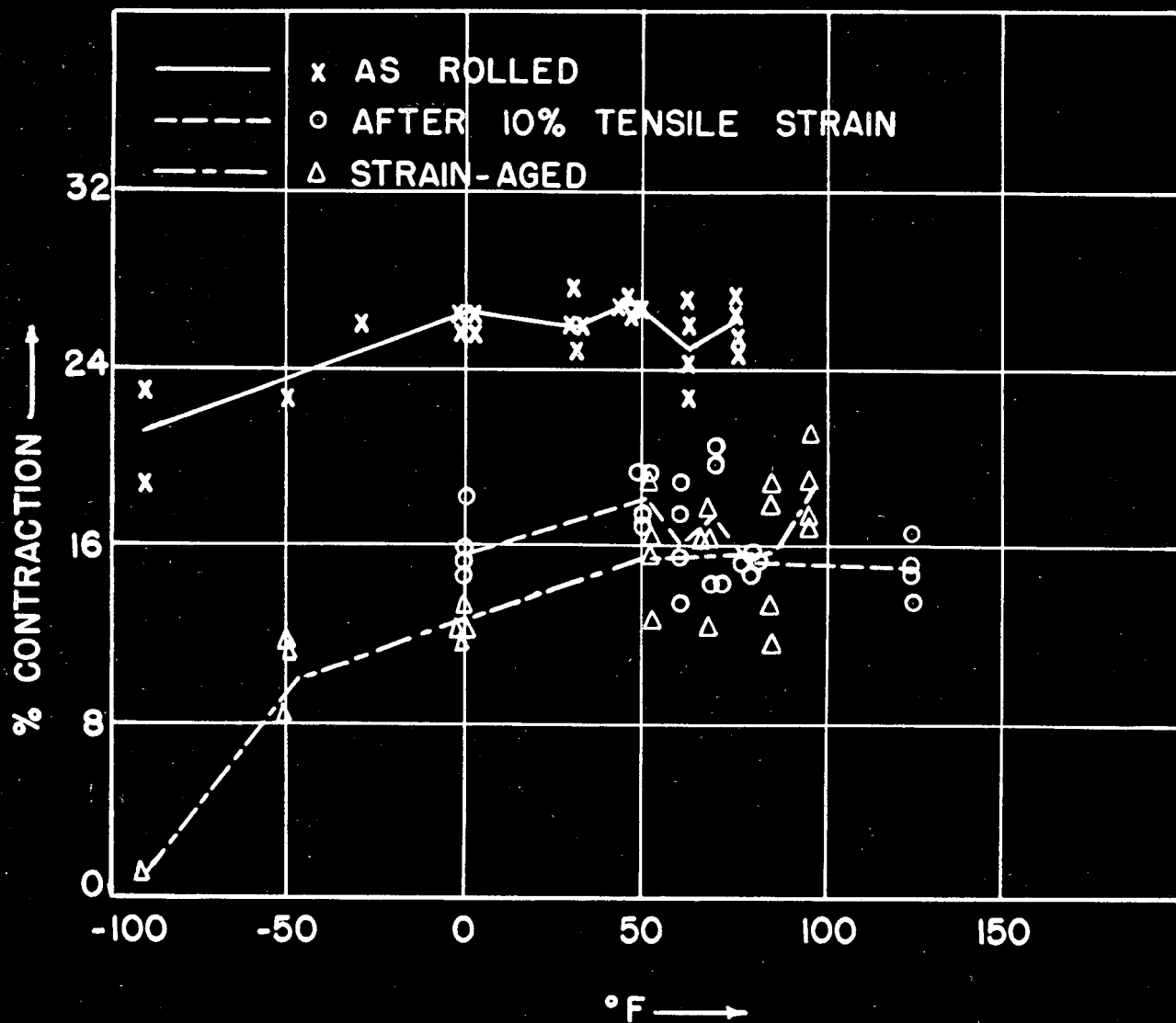


FIG.39 TRANSITION CURVES FOR A-201, 5/8" MATERIAL

KAHN TEAR TEST

CRITERION: % CONTRACTION BELOW NOTCH

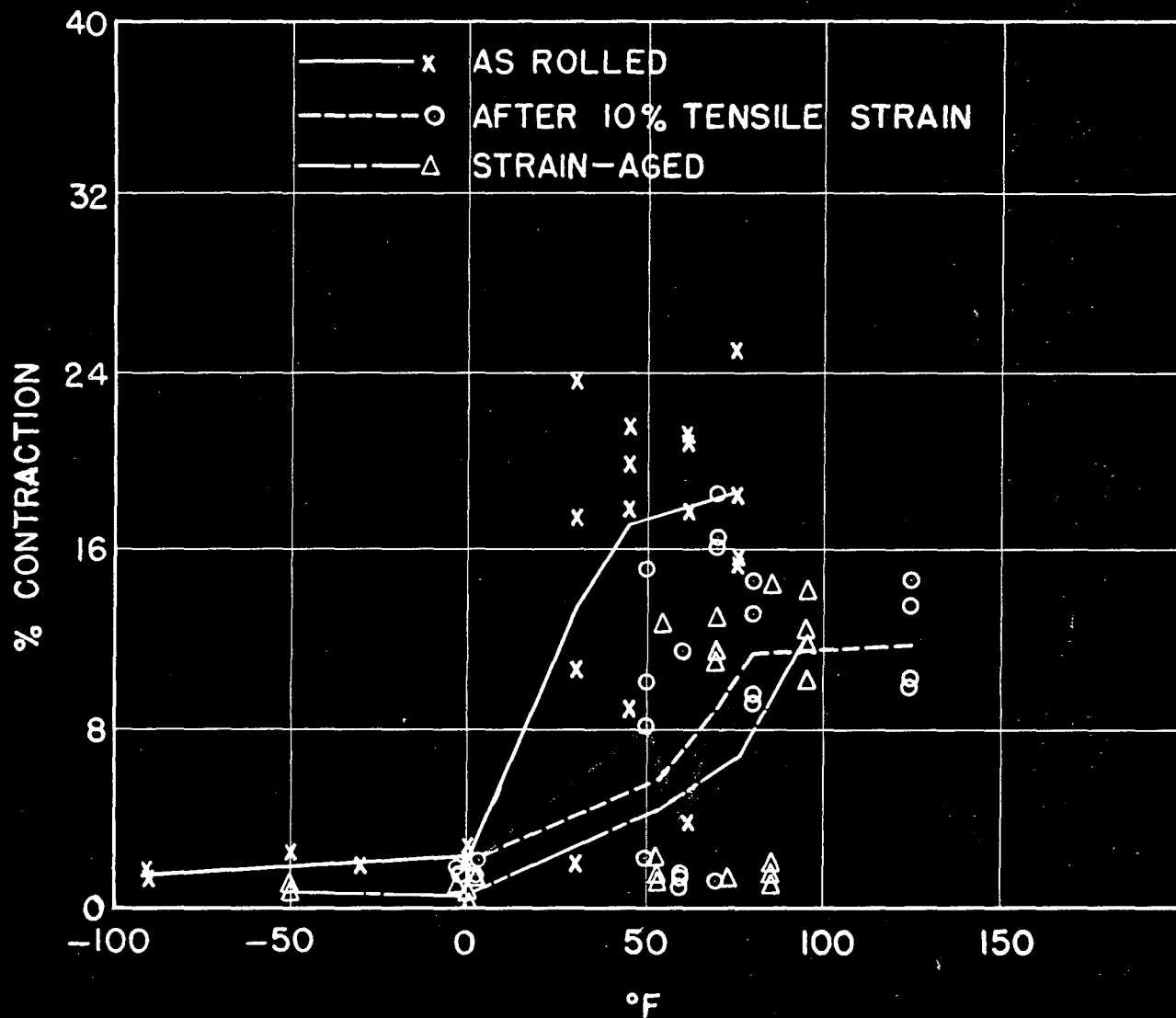


FIG. 40 TRANSITION CURVES FOR A-201 5/8" MATERIAL

KAHN TEAR TEST

CRITERION: % CONTRACTION AT MIDPOINT

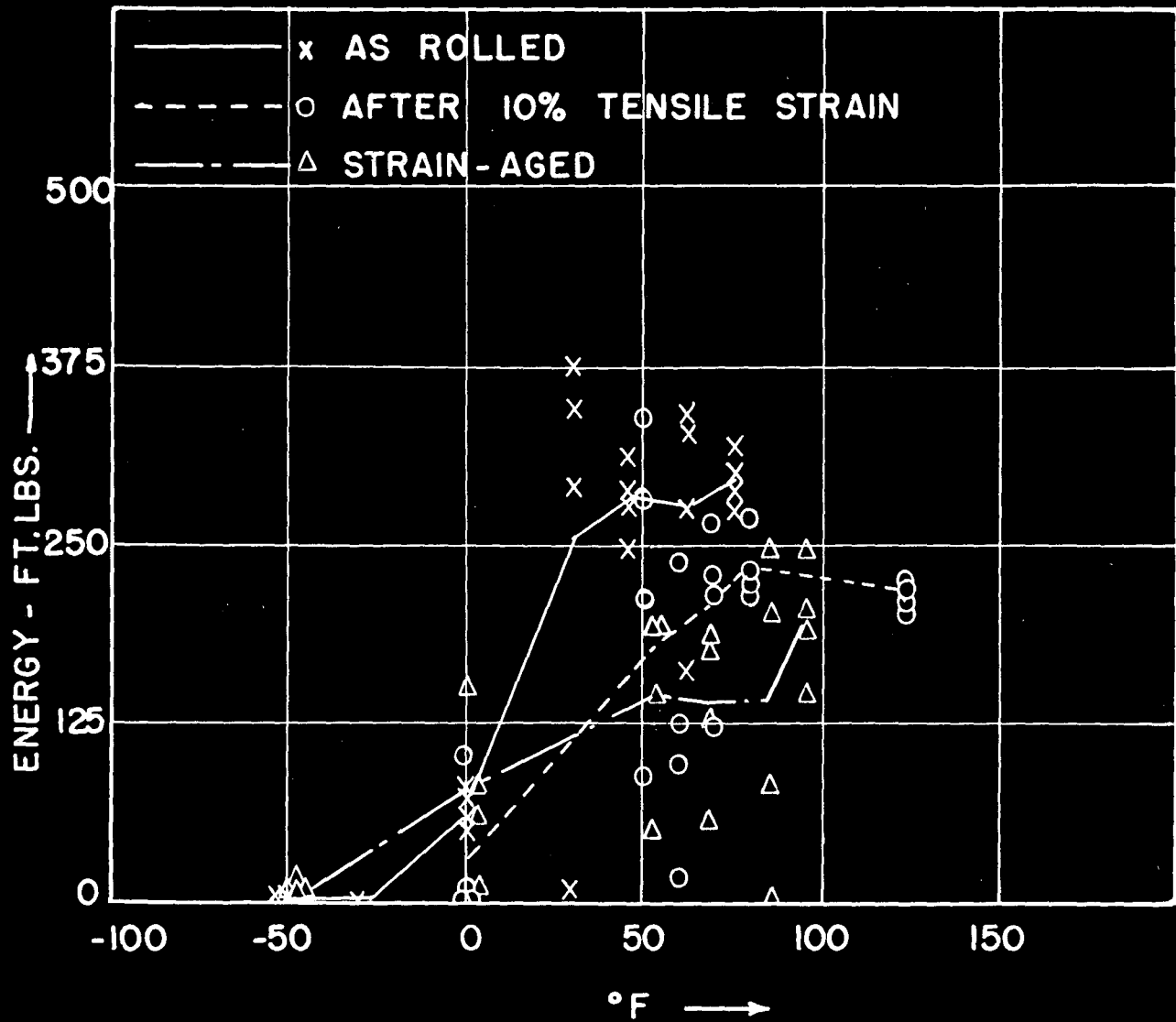


FIG. 41 TRANSITION CURVES FOR A-201, 5/8" MATERIAL
 KAHN TEAR TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

1/4"

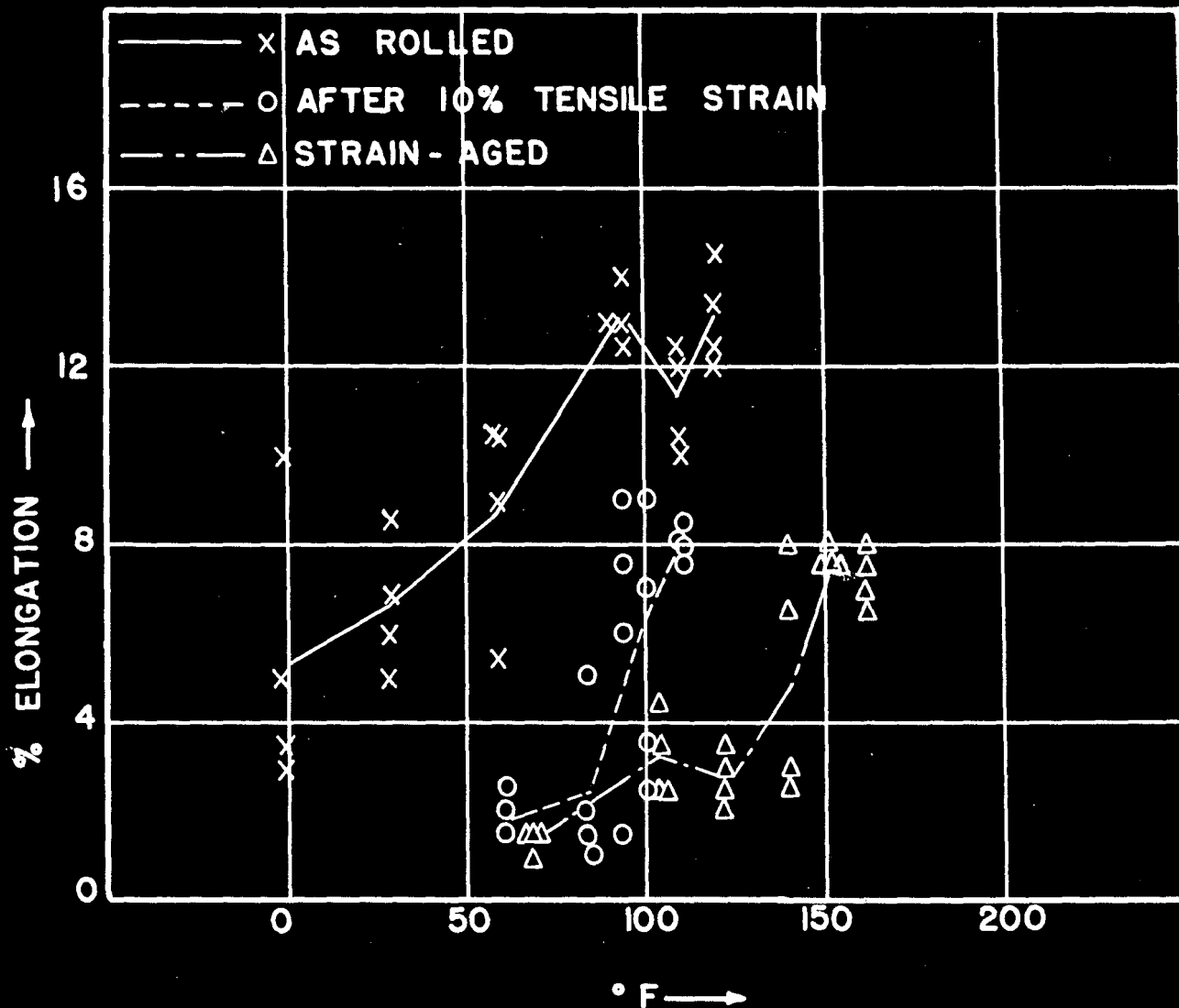


FIG. 42 TRANSITION CURVES FOR A-201, 1/4" MATERIAL
KAHN TEAR TEST
CRITERION: % ELONGATION 1/4" BELOW NOTCH

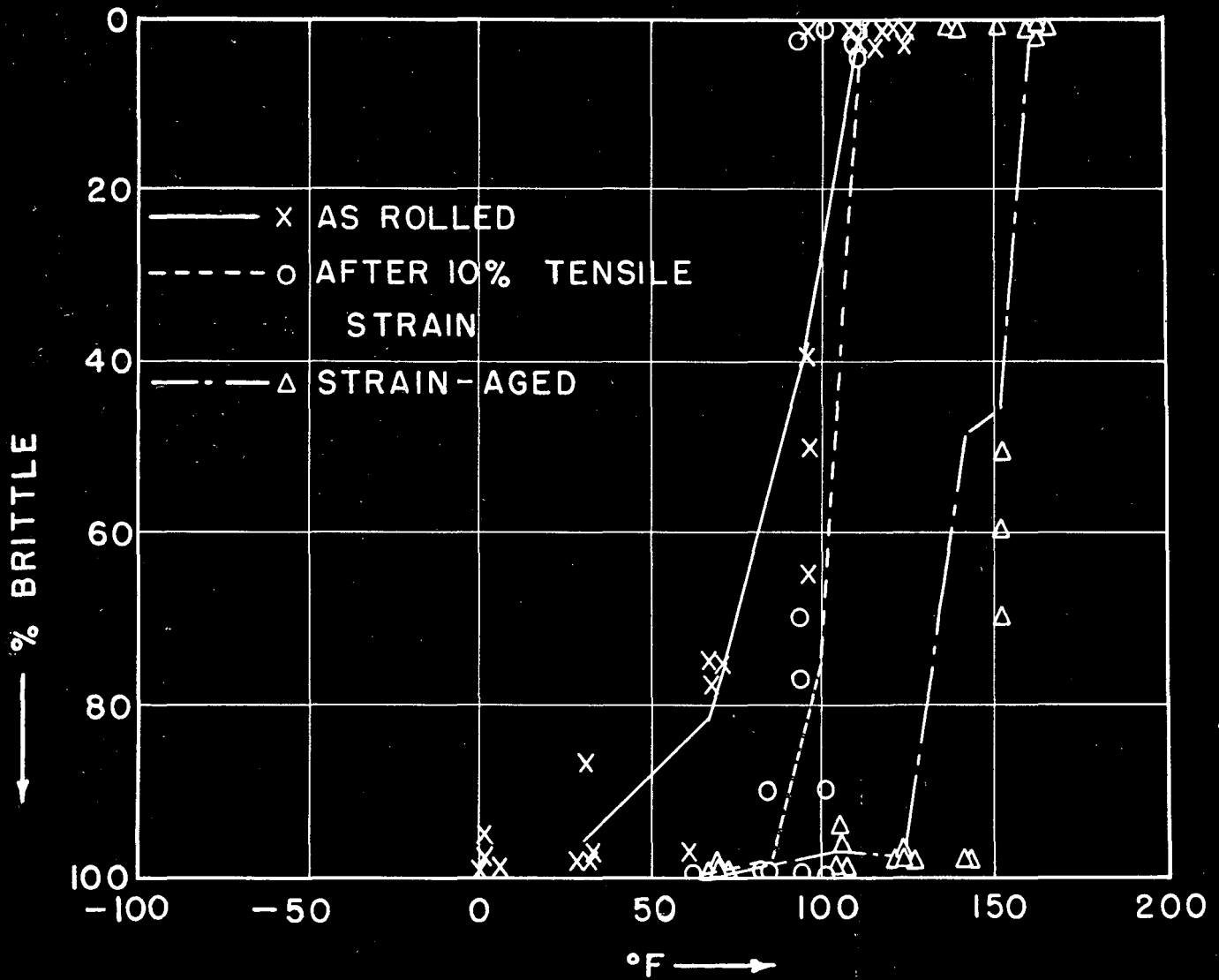


FIG.43 TRANSITION CURVES FOR A-201 1 1/4" MATERIAL

KAHN TEAR TEST

CRITERION: % BRITTLE

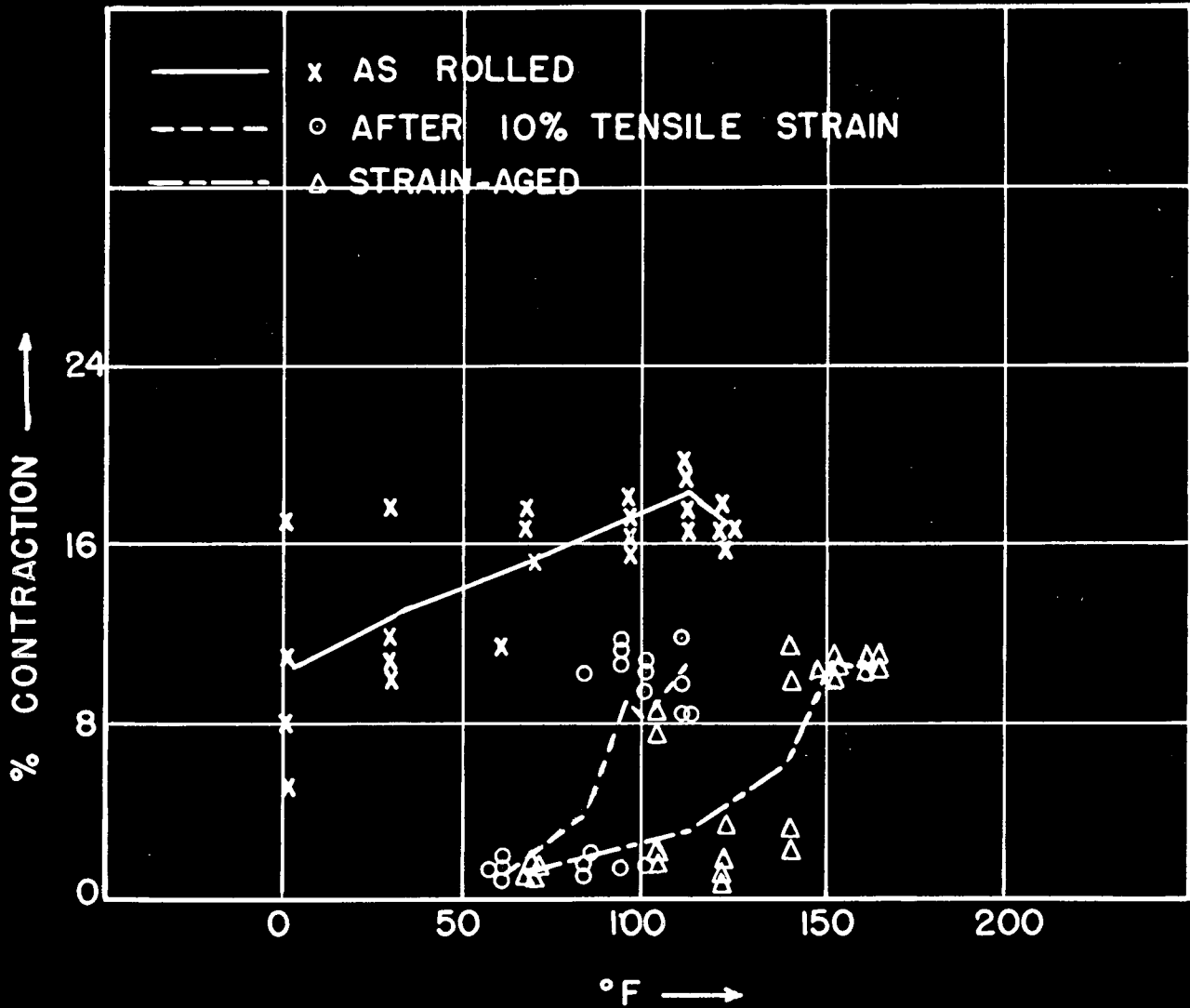


FIG. 4.4 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL

KAHN TEAR TEST

CRITERION: % CONTRACTION BELOW NOTCH

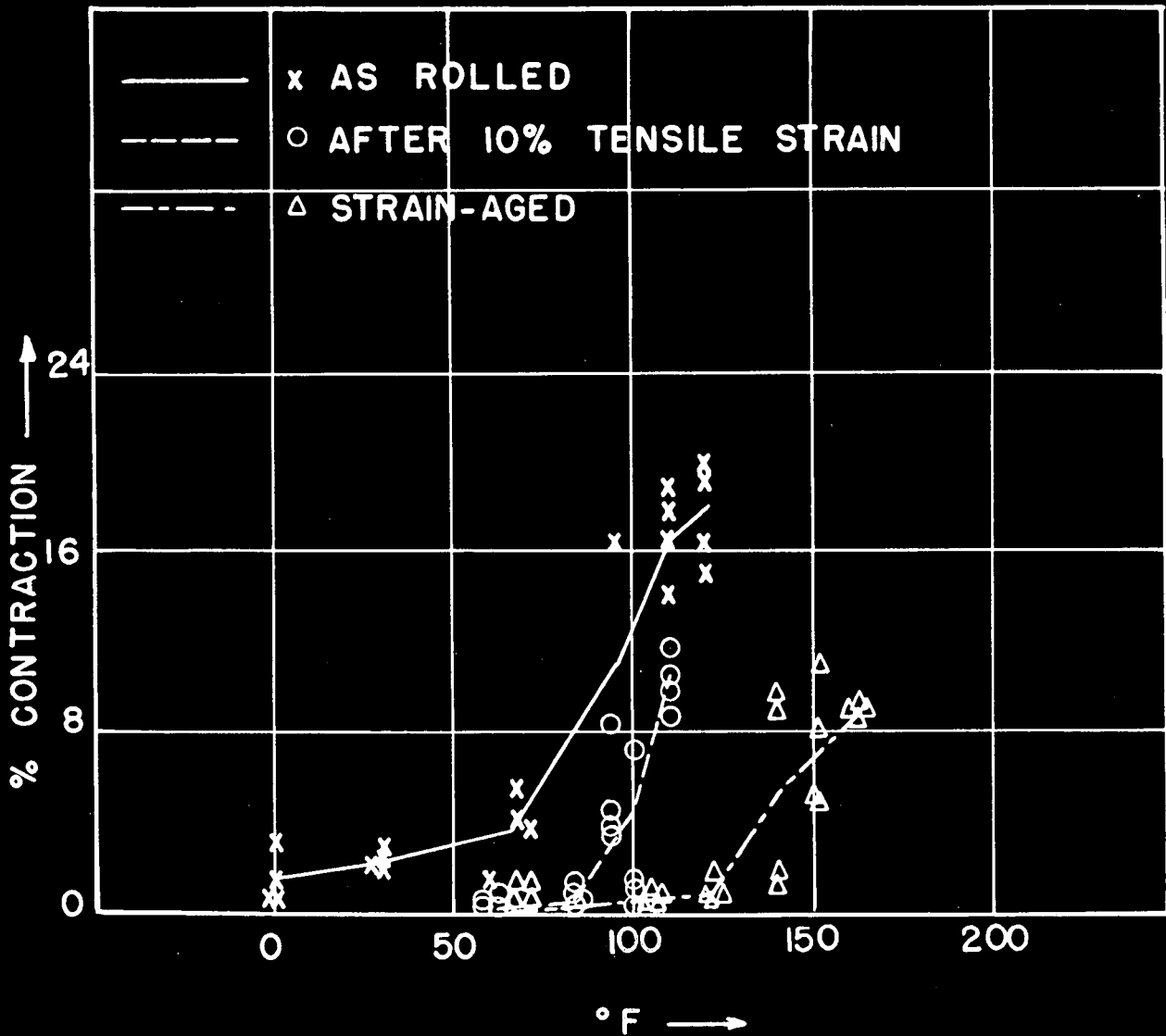


FIG.45 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL

KAHN TEAR TEST

CRITERION: % CONTRACTION AT MIDPOINT

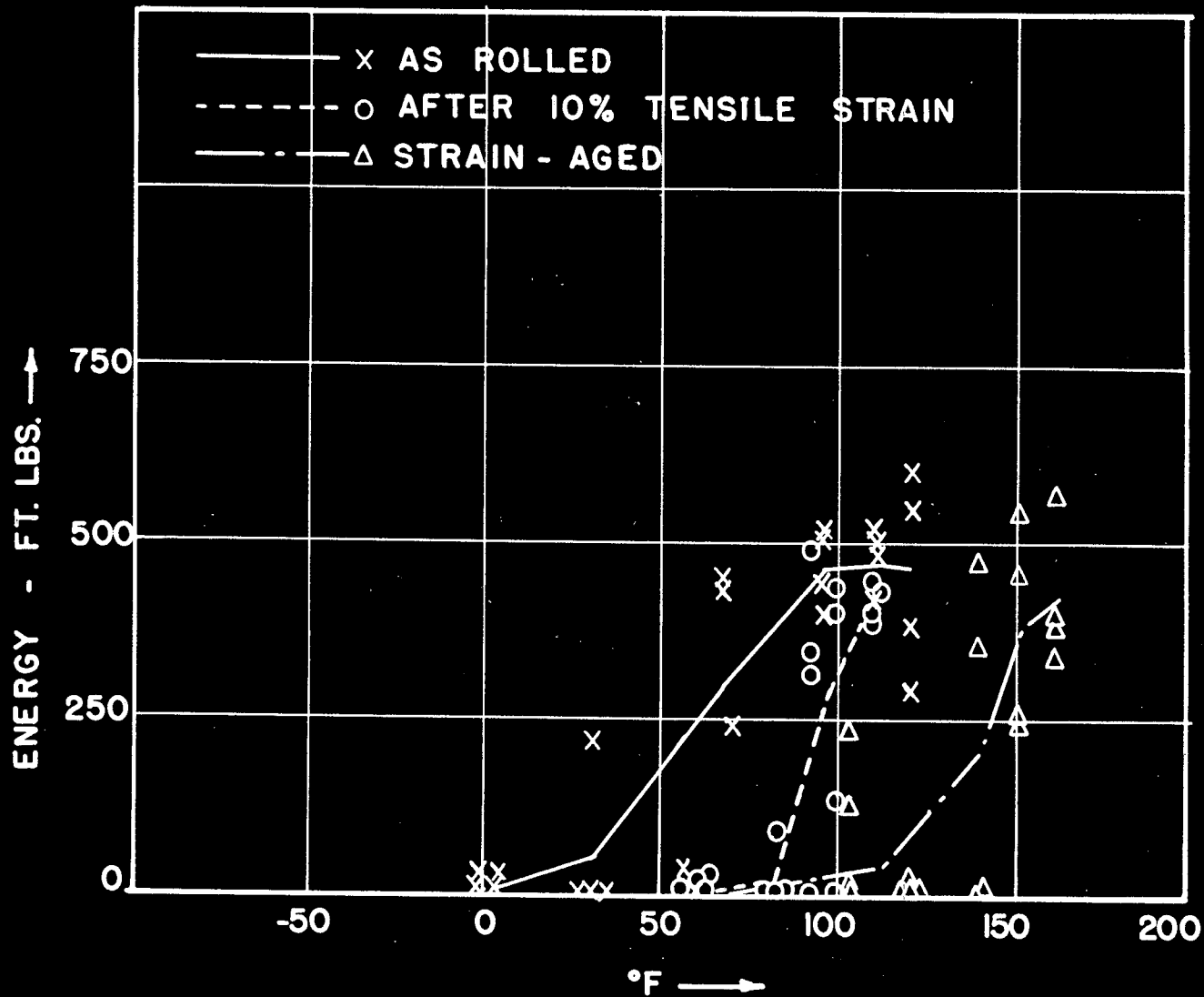


FIG. 46 TRANSITION CURVES FOR A-201, 1 1/4" MATERIAL

KAHN TEAR TEST

CRITERION: ENERGY AFTER MAXIMUM LOAD

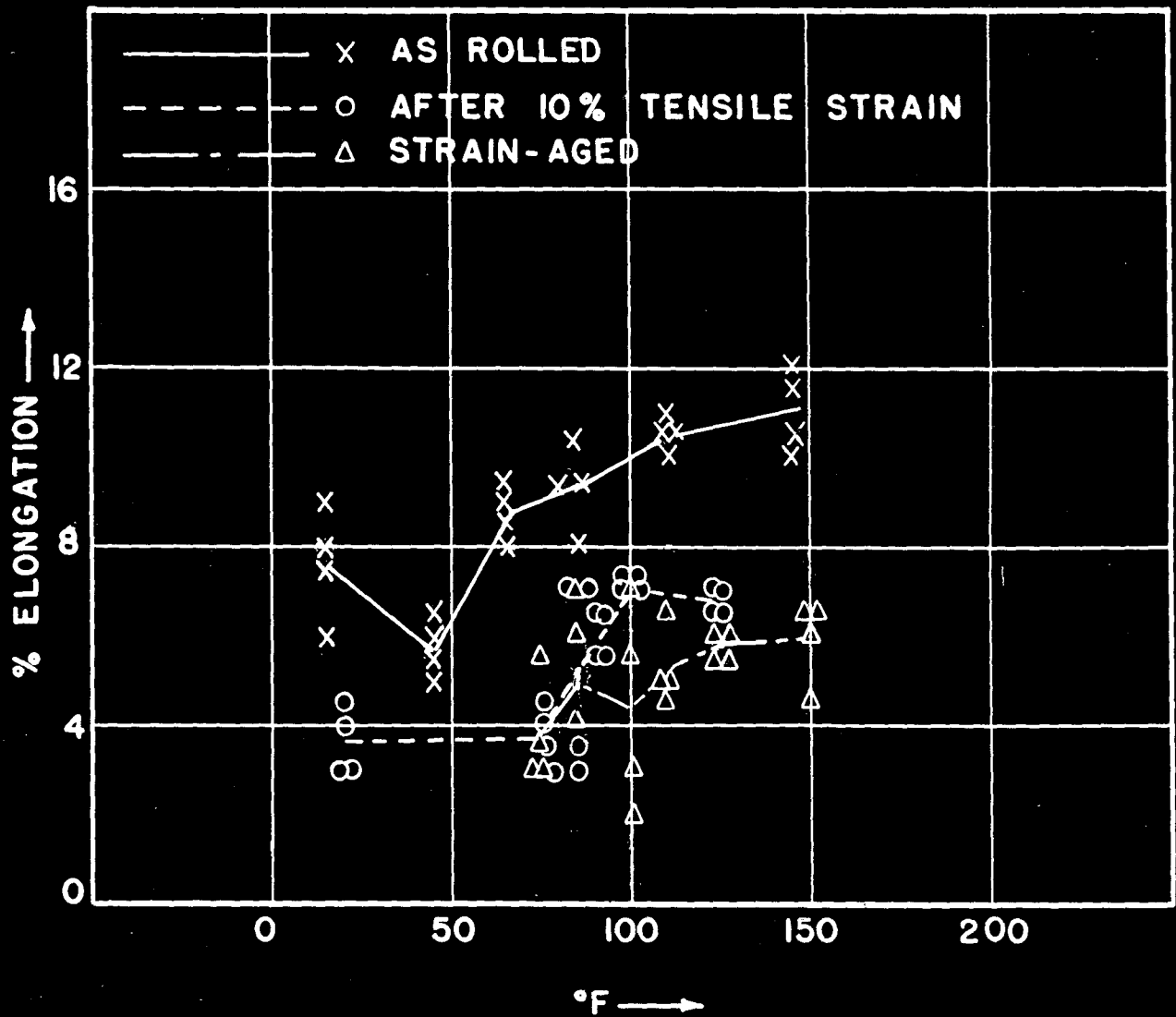


FIG. 47 TRANSITION CURVES FOR A-70, 5/8" MATERIAL

KAHN TEAR TEST

CRITERION: % ELONGATION 1/4" BELOW NOTCH

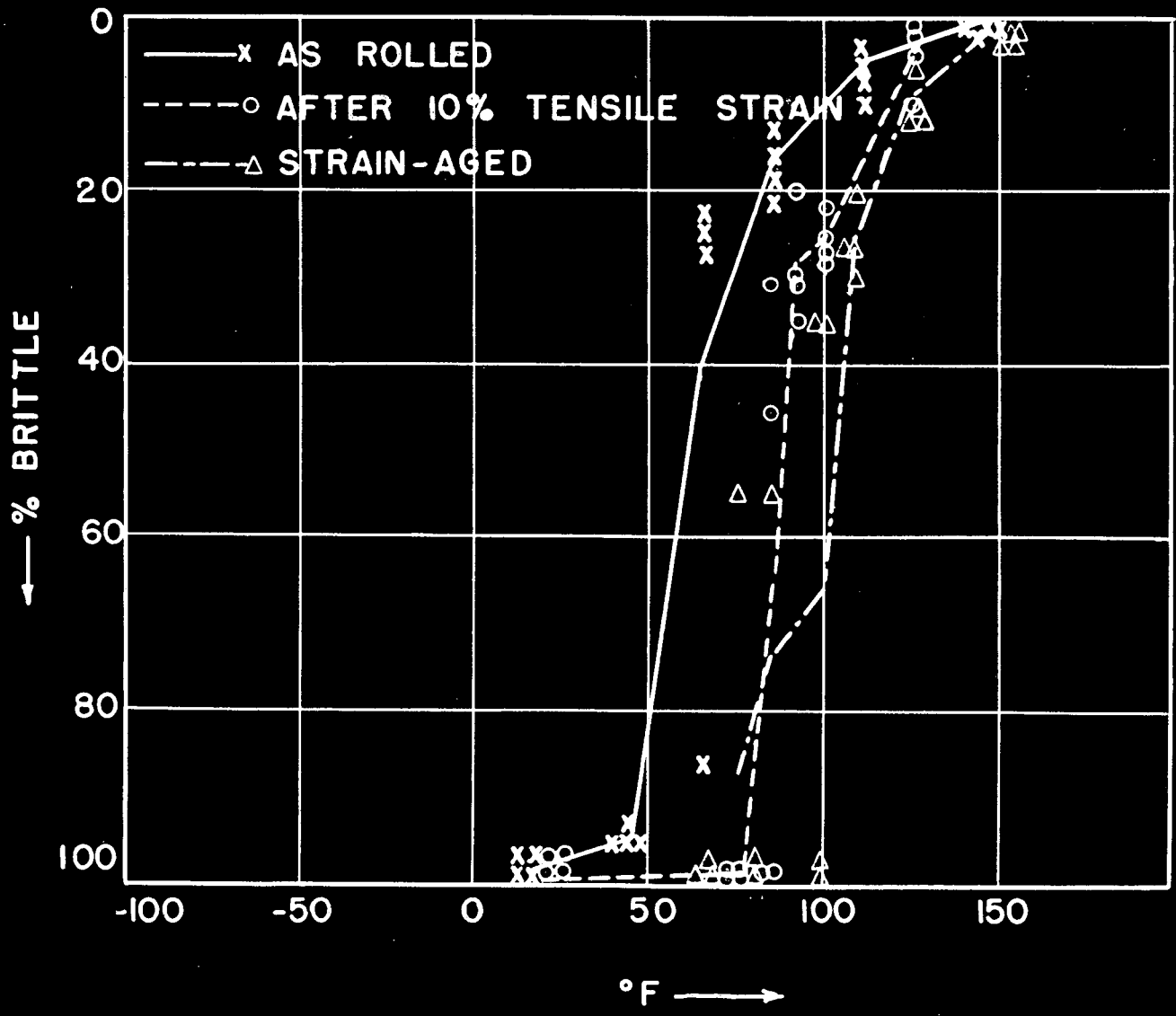


FIG. 48 TRANSITION CURVES FOR A-70, 5/8" MATERIAL
 KAHN TEAR TEST
 CRITERION: % BRITTLE

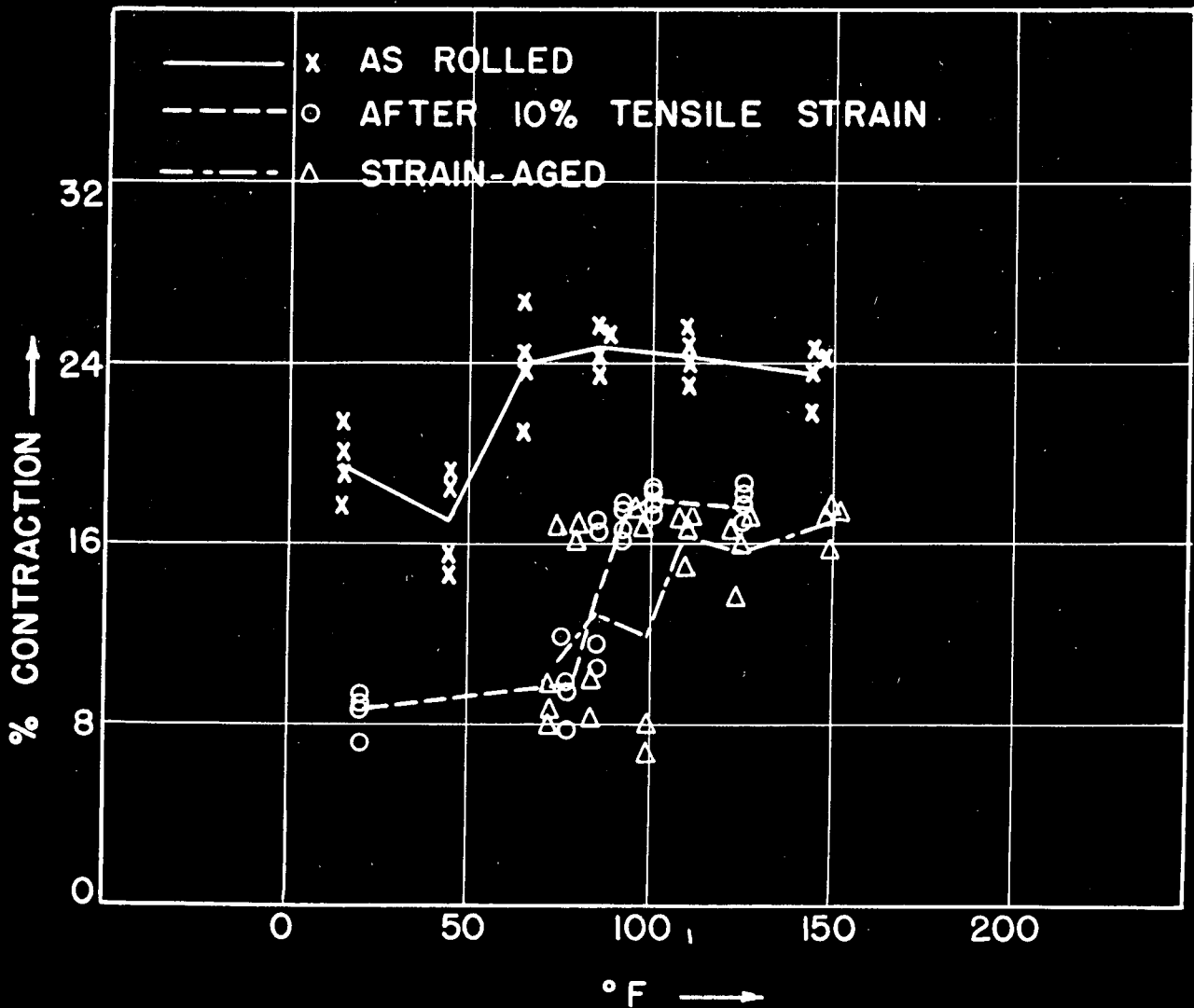


FIG.49 TRANSITION CURVES FOR A-70, 5/8" MATERIAL
 KAHN TEAR TEST
 CRITERION: % CONTRACTION BELOW NOTCH

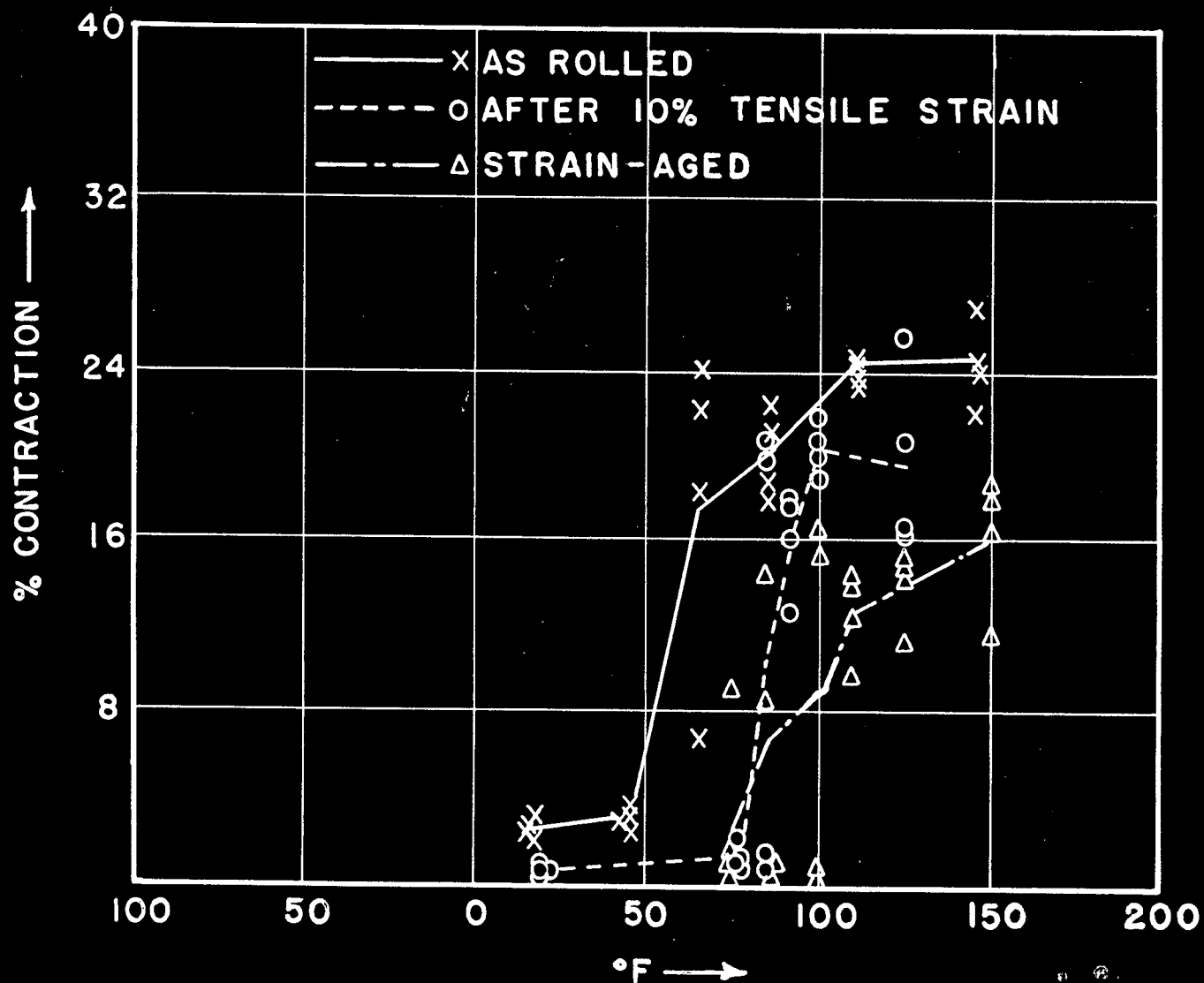


FIG.50 TRANSITION CURVES FOR A-70 5/8" MATERIAL

KAHN TEAR TEST

CRITERION: % CONTRACTION AT MIDPOINT

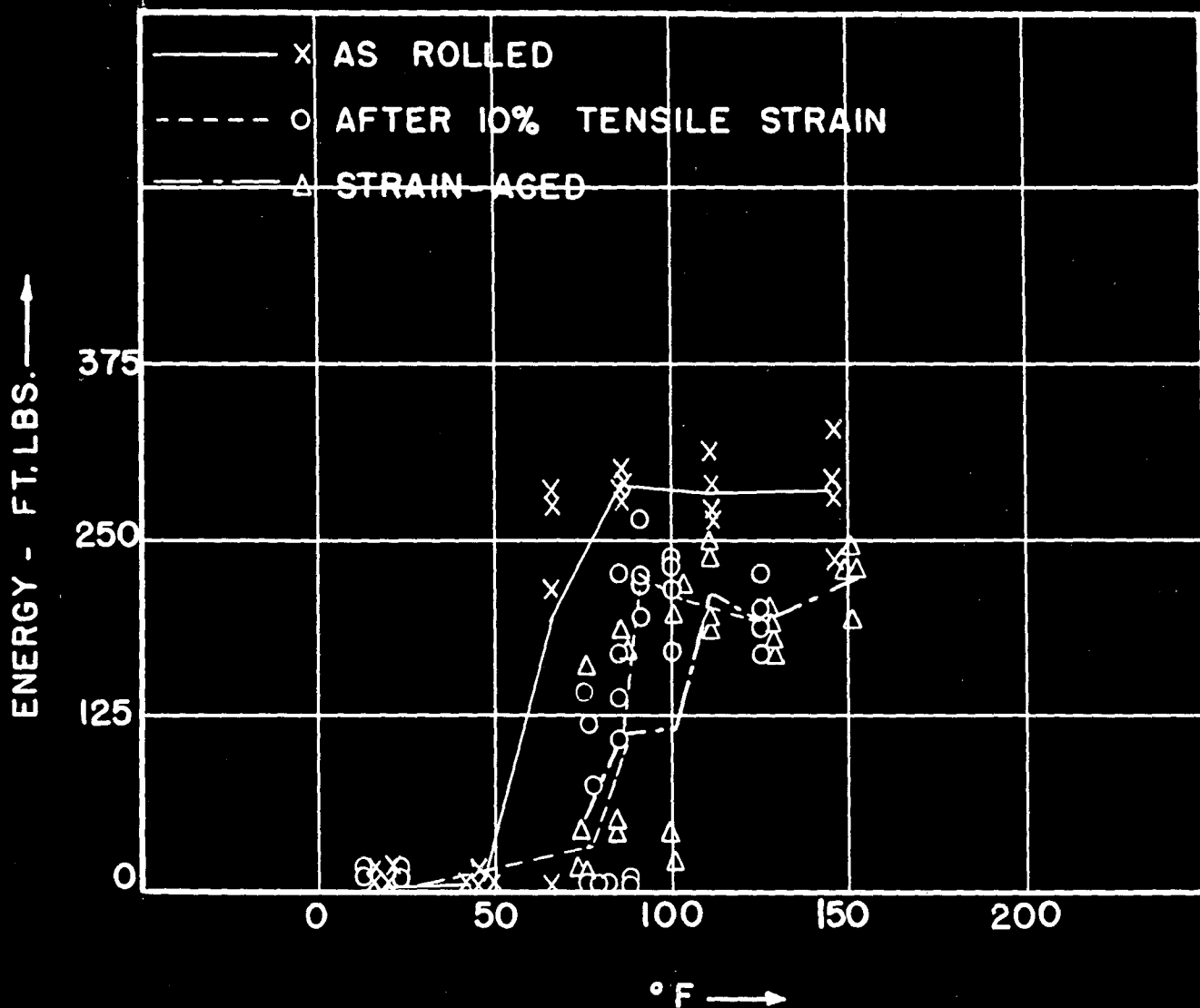


FIG. 51 TRANSITION CURVES FOR A-70, 5/8" MATERIAL
 KAHN TEAR TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD

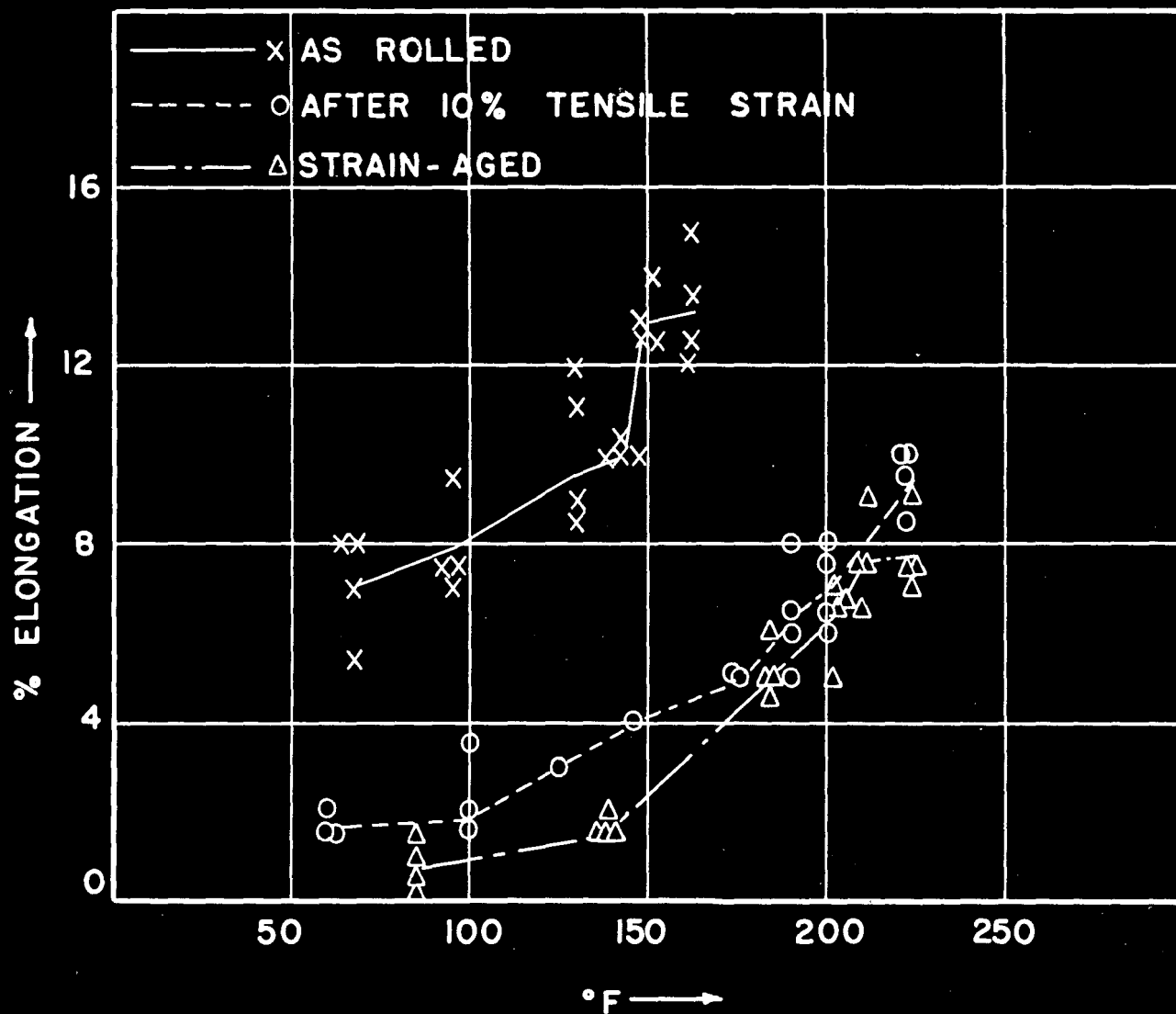


FIG.52 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL

KAHN TEAR TEST

CRITERION: % ELONGATION 1/4" BELOW NOTCH

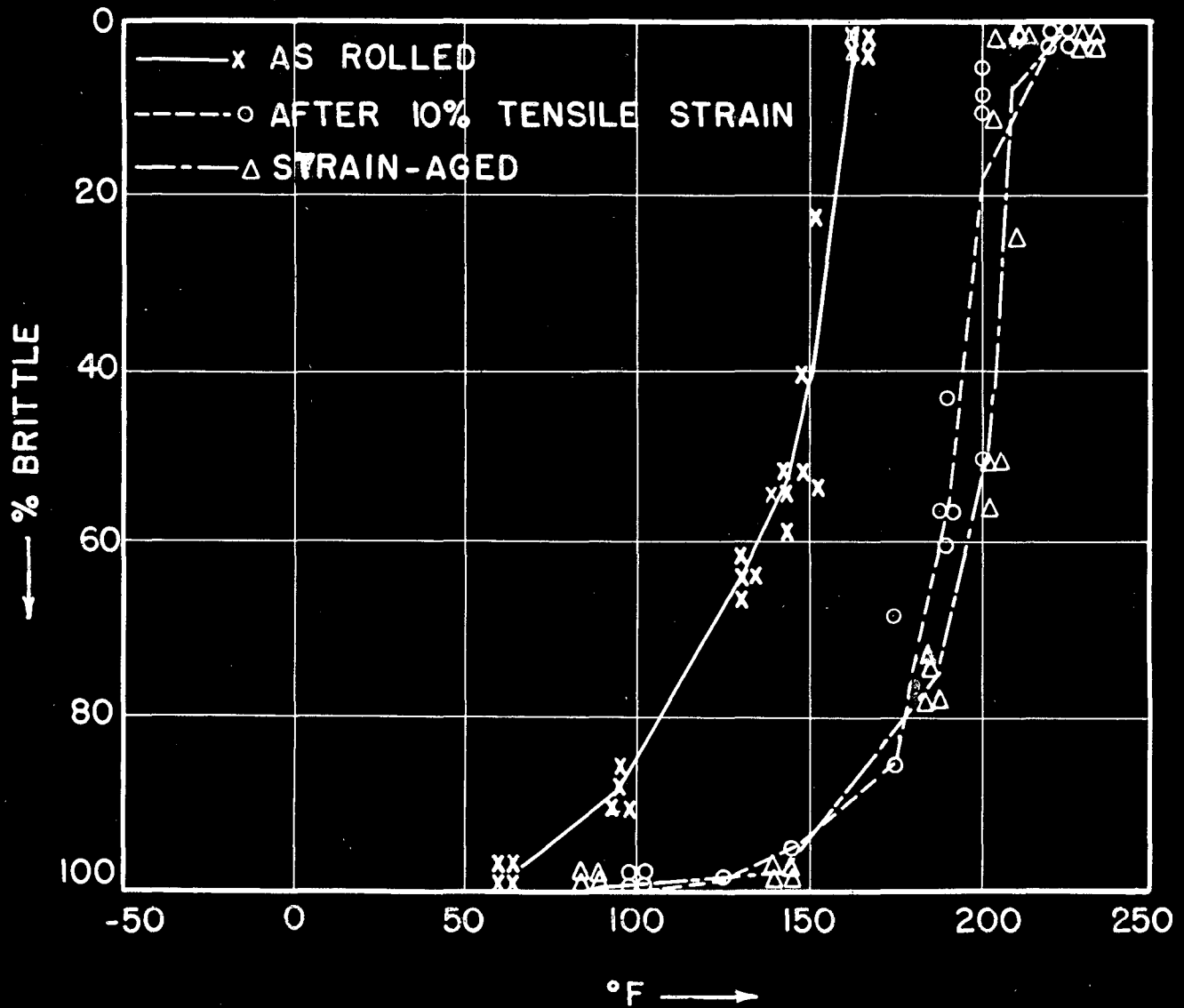


FIG.53 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL
 KAHN TEAR TEST
 CRITERION: % BRITTLE

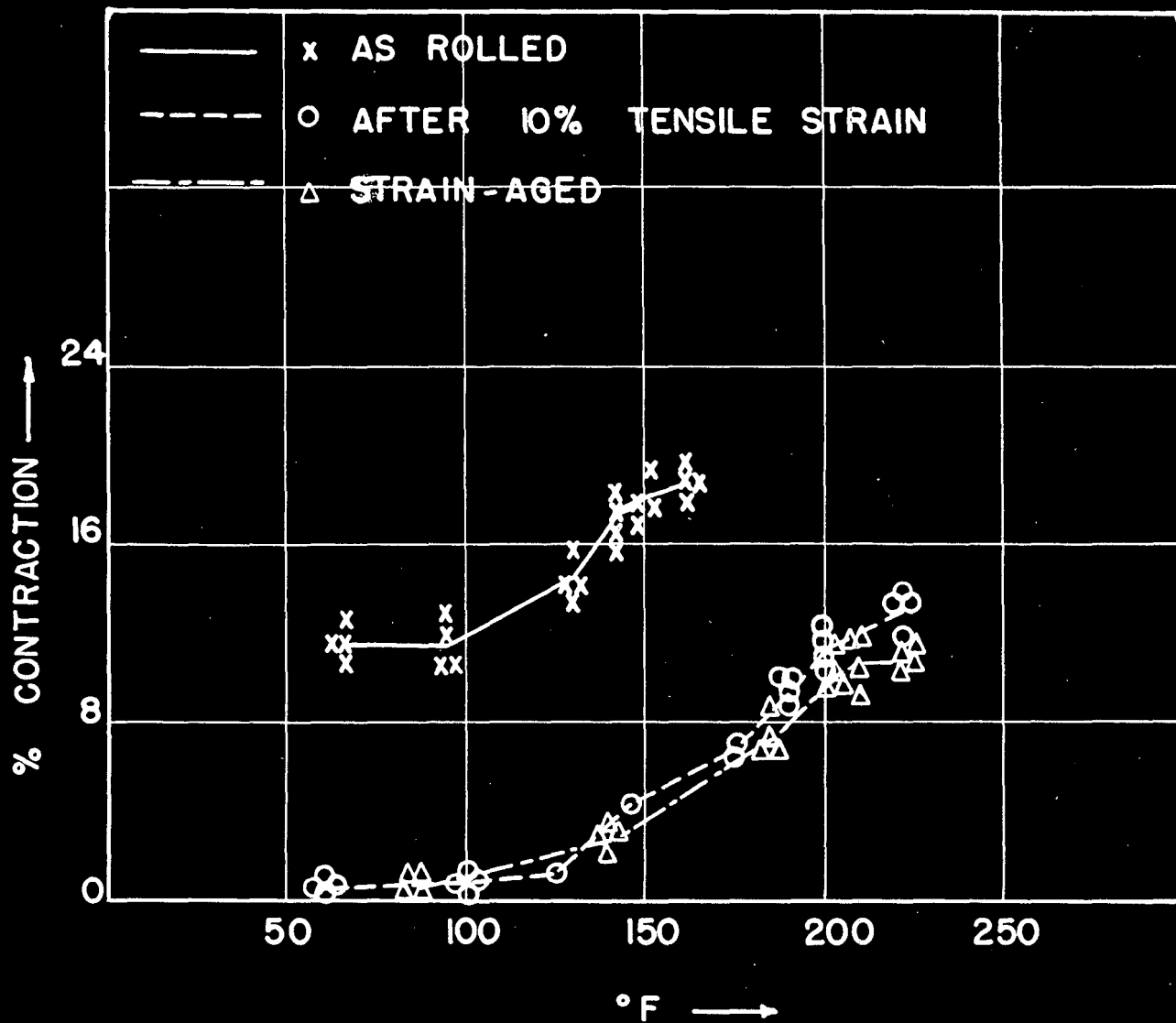


FIG. 54 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL
 KAHN TEAR TEST
 CRITERION: % CONTRACTION BELOW NOTCH

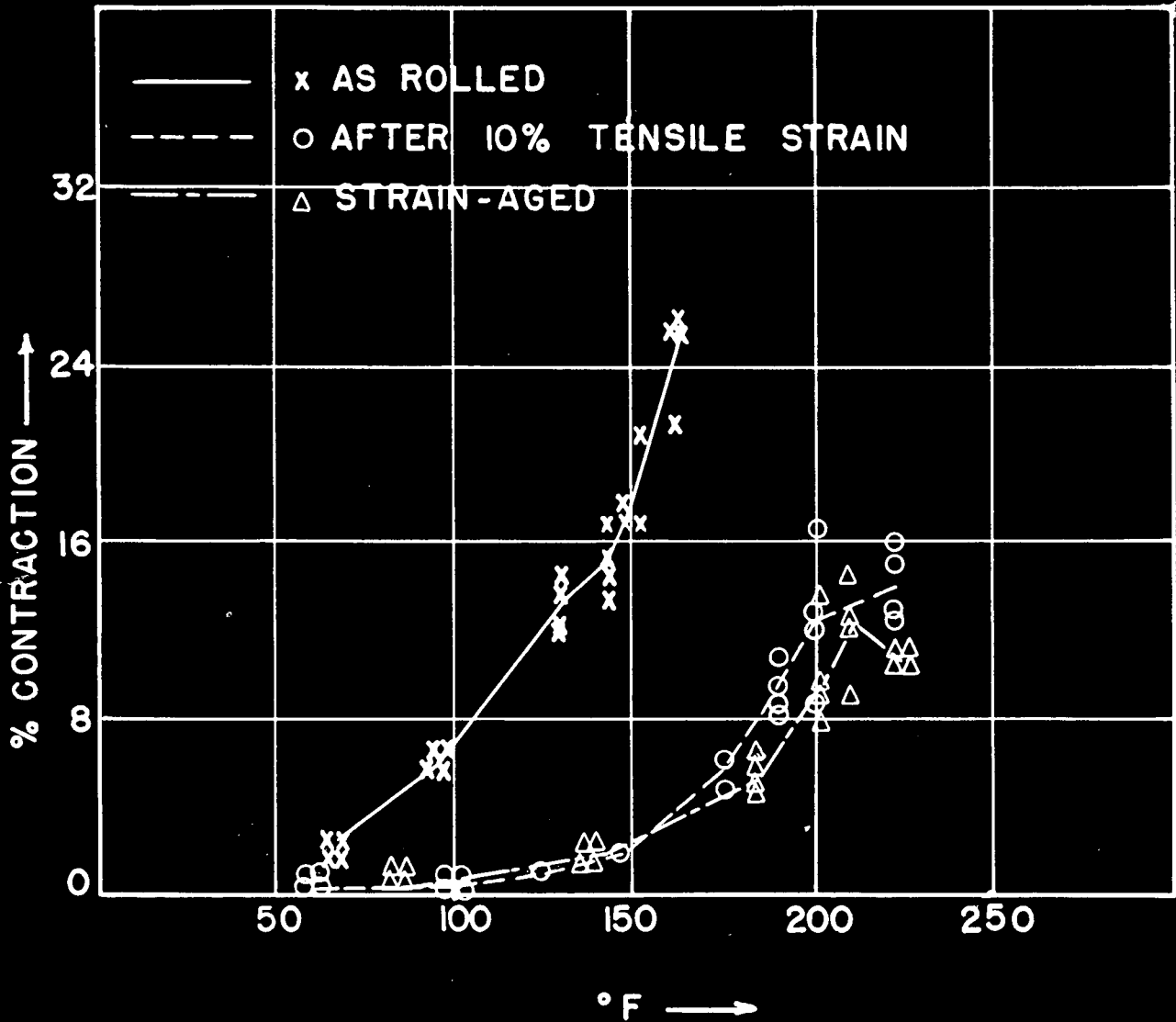


FIG.55 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL

KAHN TEAR TEST

CRITERION: % CONTRACTION AT MIDPOINT

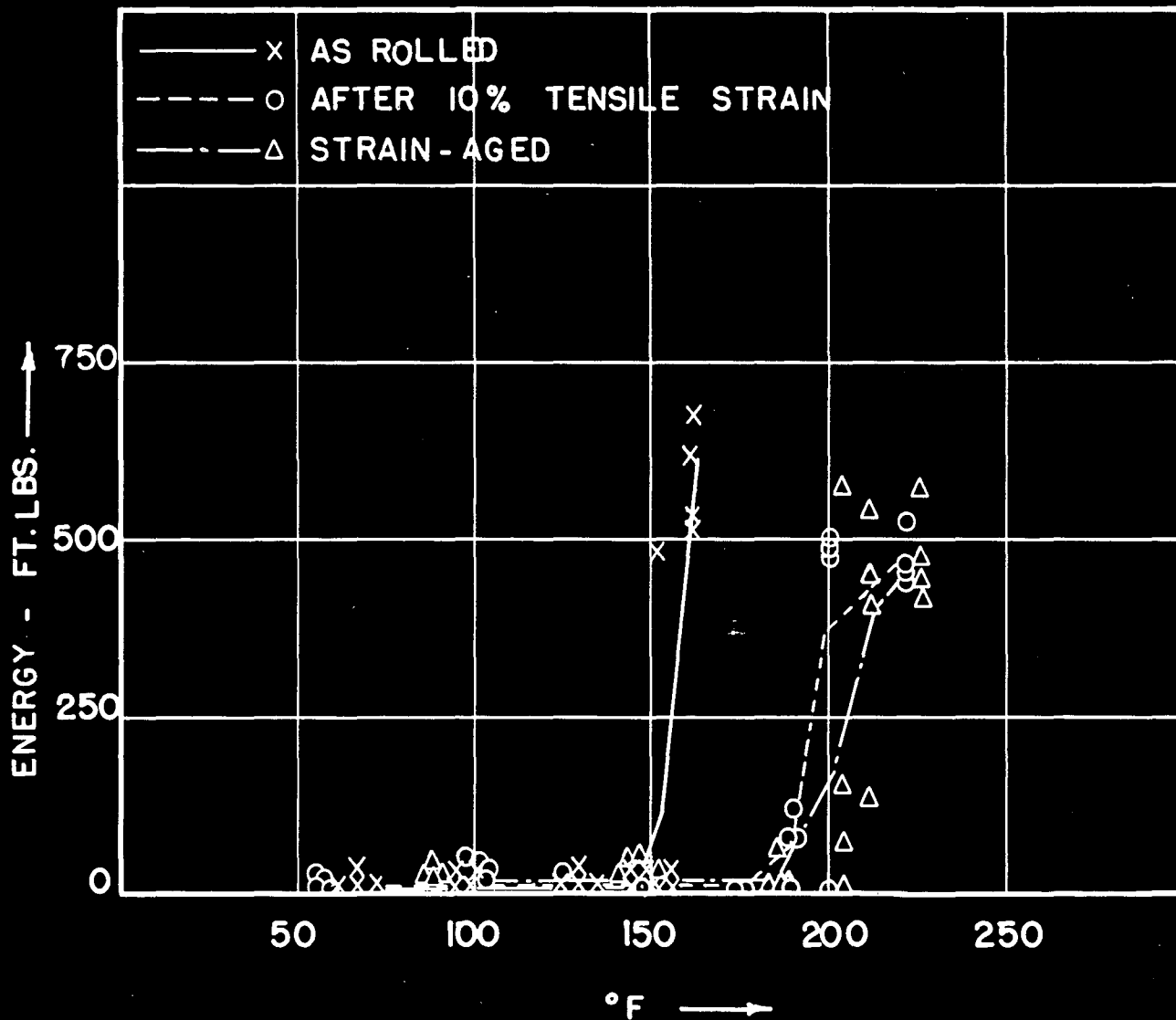


FIG.56 TRANSITION CURVES FOR A-70, 1 1/4" MATERIAL
 KAHN TEAR TEST
 CRITERION: ENERGY AFTER MAXIMUM LOAD