THE UNIVERSITY OF MICHIGAN RESEARCH INSTITUTE
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Final Report

THE SHEAR MODULI OF Ni-SPAN-C AT ELEVATED TEMPERATURES

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ABSTRACT

The shear moduli have been determined for ten samples from nine heats of Ni-Span-C alloy at room and elevated temperatures up to about 1250°F. A preliminary metallographic examination of structure has been carried out on one sample with two different heat treatments.

OBJECTIVE

The purpose of this investigation was to determine shear moduli for ten samples of Ni-Span-C.

EXPERIMENTAL PROCEDURE

The test equipment and the experimental and data analysis procedures have been described in Reports 2629-1-T and 2629-2-T covering shear moduli of Haynes 25 alloy and Inconel-X alloy.

SUMMARY

Shear moduli of ten specimens from nine heats of Ni-Span-C have been determined as a function of temperature from room temperature to about 1250°F. The chemical composition of the nine heats may be found in Table I and the ten specimen dimensions, in Table II.

Graphs showing the shear moduli as a function of test temperature are shown in Figs. 1 through 10. All data show a nonlinear relationship between shear moduli and temperature. The data also indicate that a material instability of some type exists. This is pronounced in Fig. 5 which shows data for two runs. The specimen of Fig. 5 was heat-treated for 10 hr at 835°F between the first and second runs. The data of Fig. 6 include five runs without any intermediate heat-treating and indicate that the material stabilizes after several runs, in this case, four.

The data of Fig. 7 were obtained using different inertia members. The broken curve was determined using a heavy pendulum and represents the first run on the specimen. The solid curve was determined using a light pendulum on the second run. The light pendulum was necessary to minimize creep in the finer wire specimens at the higher temperatures. The difference in shear moduli between these runs cannot be attributed to the pendulum used in view of the variation in data for other specimens for which the same pendulum was used for each run.

All data show double values of shear modulus at room temperature due to some material change which has occurred at the higher testing temperatures. The higher modulus values at room temperature on the first-run curves, denoted by open circles, are check points after testing at the elevated temperatures. A metallurgical change apparently occurred at the elevated test temperatures in the specimens. For this reason a microstructural study was begun on the specimen of Fig. 5. Figures 11 and 12 show the structure of the specimen in the as-received, as-tested and heat-treated (for 10 hr at 835°F) conditions. These photomicrographs do not indicate any marked change in structure. It was not anticipated that optical microscopy would clearly indicate the change and electron microscopy was begun simultaneously. However, this work was not completed prior to the request for termination of the work from the Research and Development Division of Associated Spring Corporation.

TABLE I

CHEMICAL COMPOSITIONS OF Ni-SPAN-C HEATS

Heat Number	Ni	Cr	C	Mn	Si	Fe	Al	Ti
1638	41.24	5.23	.02	.52	.56	49.48	.57	2.25
3313	41.73	5.01	.02	.47	.52	49.20	.64	2.29
4167	41.54	5.43	.02	.18	.49	49.47	.33	2.48
5358	41.84	5.68	.03	.19	.51	48.83	.57	2.28
5662	40.60	5.69	.03	.19	.52	49.98	.55	2.29
7359	42.27	5.25	.02	.31	.46	48.79	.55	2.25
7360	42.99	5.15	.02	.32	.48	48.22	.51	2.22
7423	42.31	5.12	.02	.39		48.22	.74	2.53
7538	41.54	5.28	.03	.42	.47	49.09	.66	2.4

TABLE II

SHEAR MODULI SPECIMEN DIMENSIONS

Heat Number	Specimen Diameter, in.	Figure Number
1638	.0605	1
3313	.1056	2
4167	.1087	3
5358	.1068	4
5662	.0606	5
5662	.1063	6
7359	.0540	7
7360	.1088	8
7423	.0542	9
7538	.0682	10

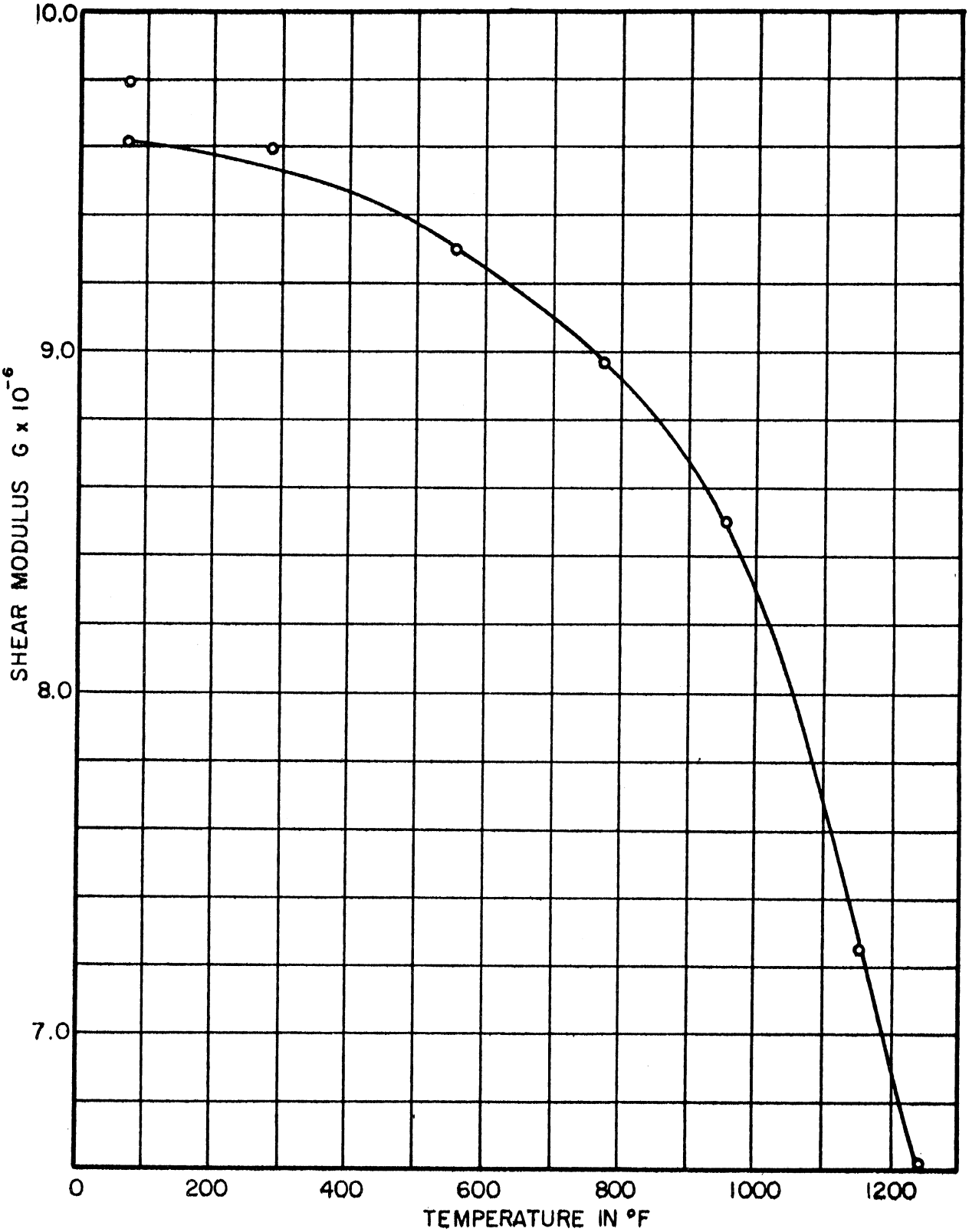

Fig. 1. Shear Modulus vs. Temperature
Specimen No. 1638 (.0605 Dia.)
2 Hrs. @ 1250 °F

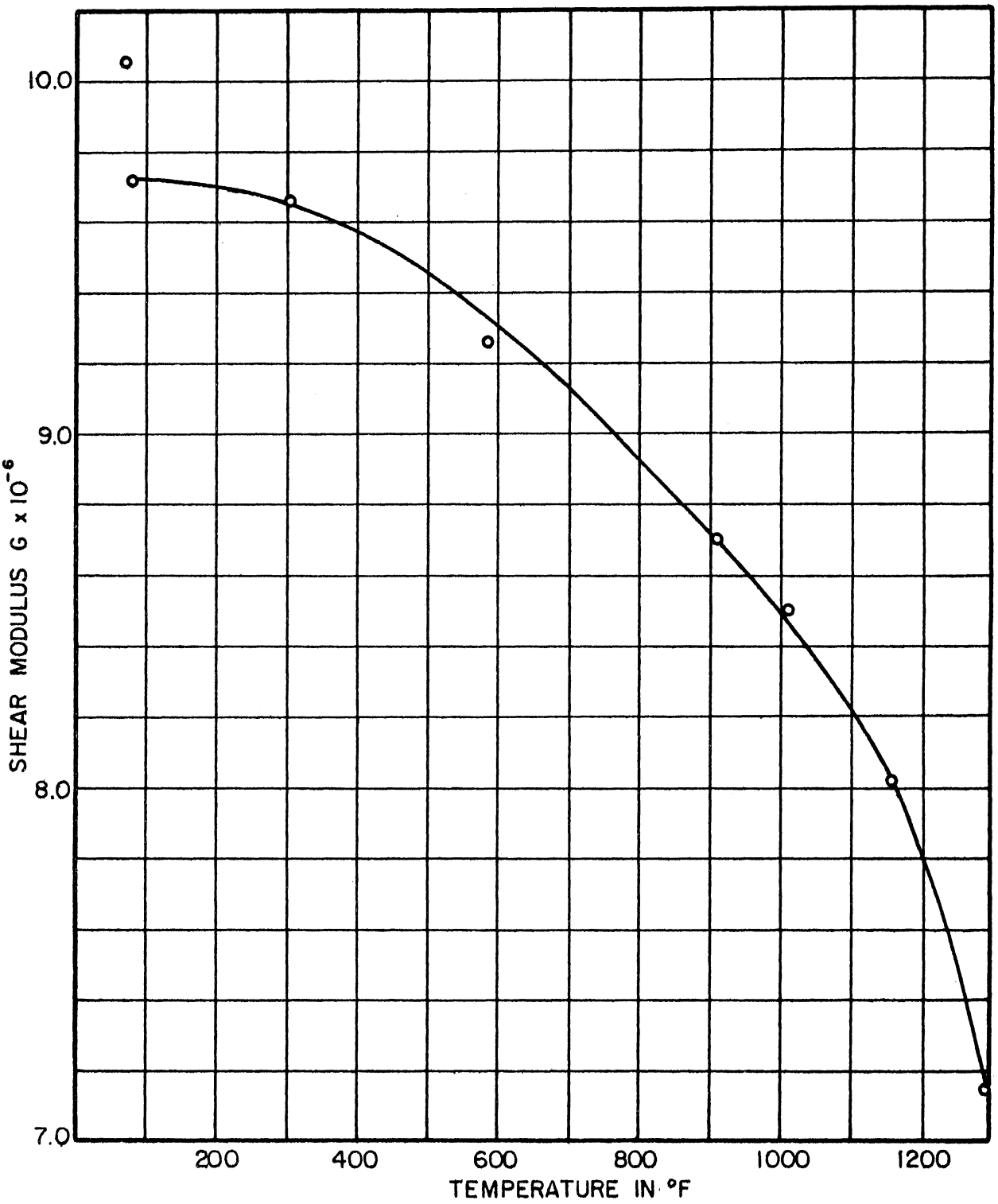

Fig. 2. Shear Modulus vs. Temperature
Specimen No. 3313 (.1056 Dia.)
2 Hrs. @ 1185 °F

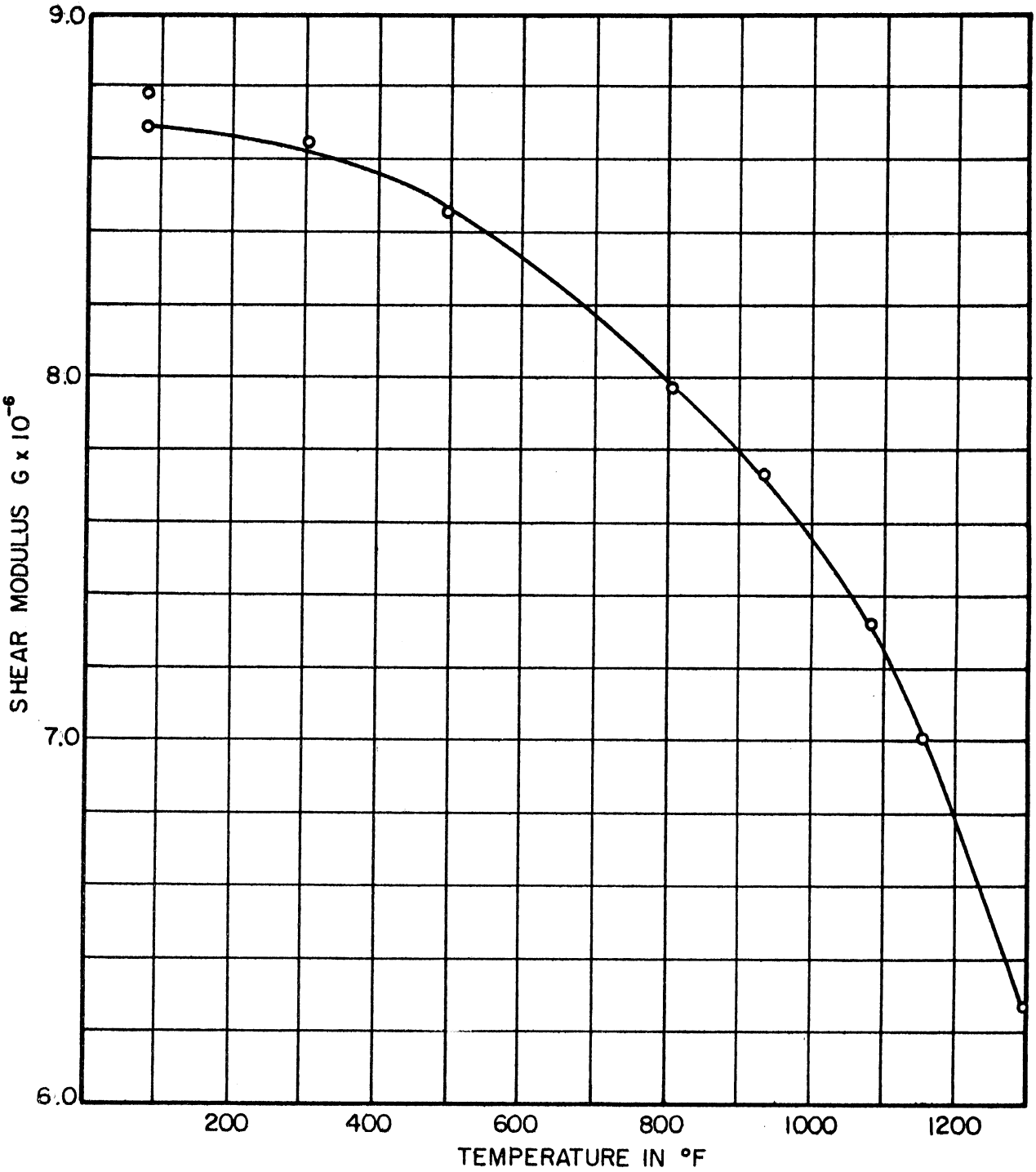

Fig. 3. Shear Modulus vs. Temperature
Specimen No. 4167 (.1087 Dia.)
2 Hrs. @ 1310 °F

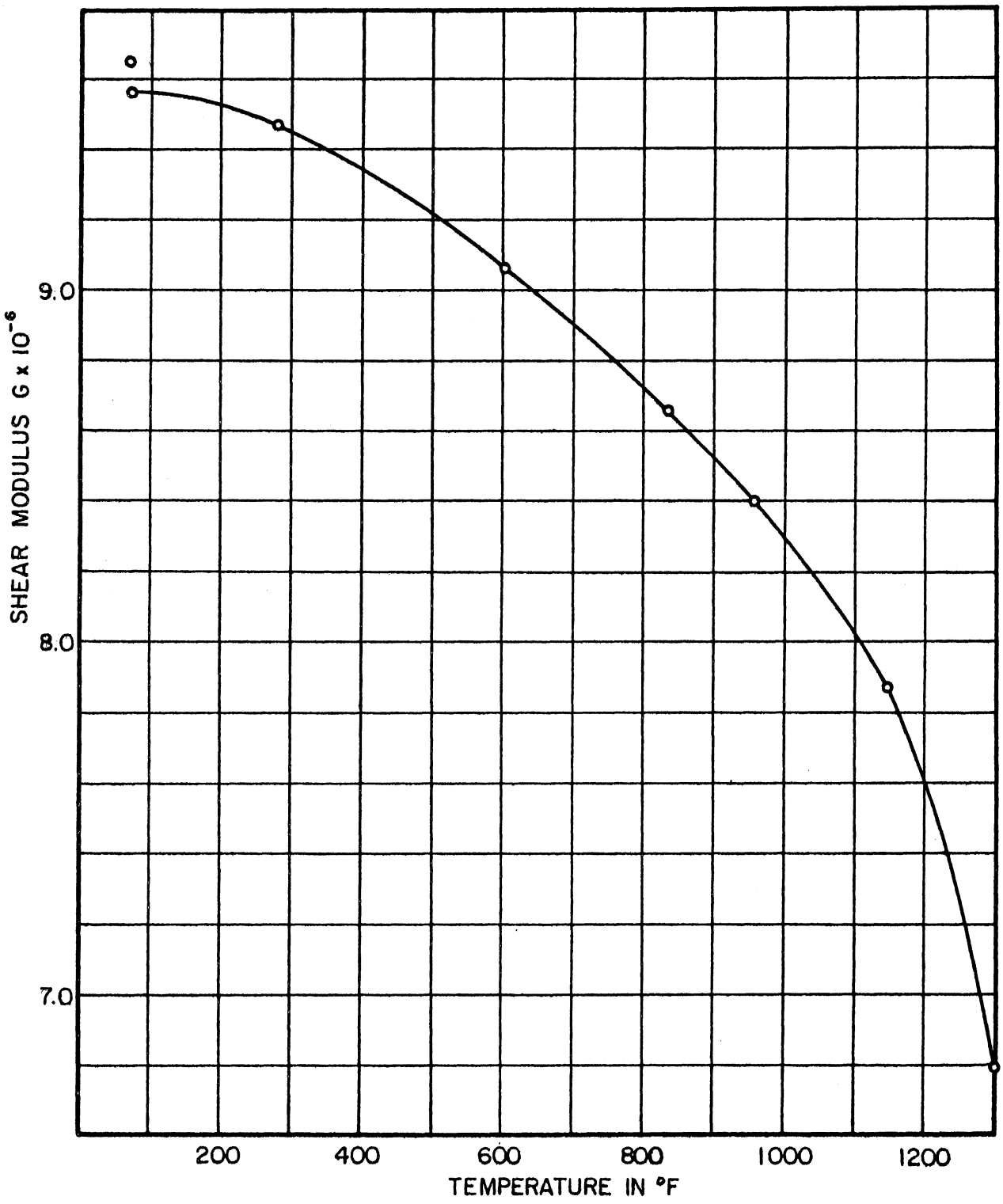

Fig. 4. Shear Modulus vs. Temperature
Specimen No. 5358 (.1068 Dia.)
2 Hrs. @ 1310 °F

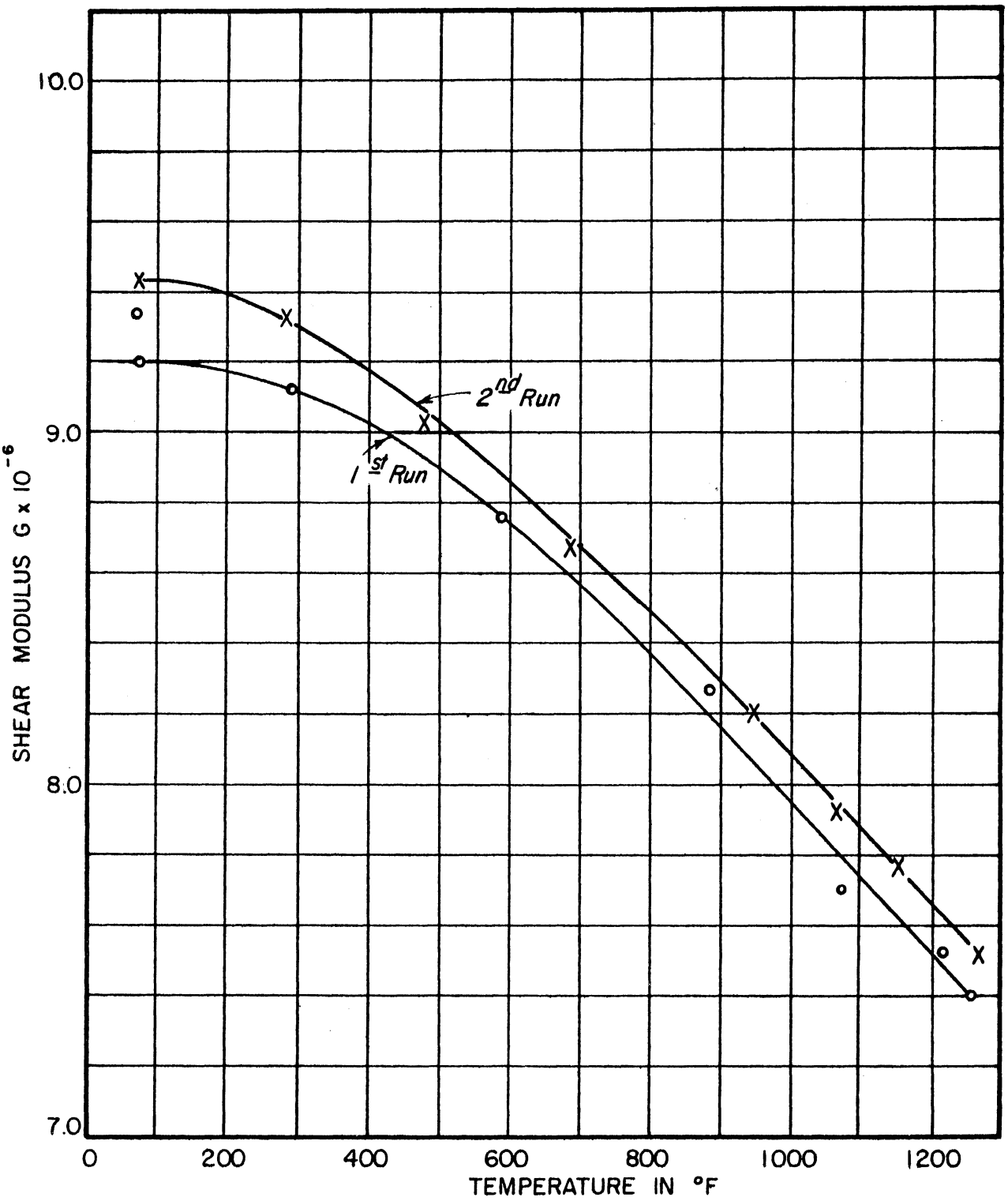

Fig. 5. Shear Modulus vs. Temperature
Specimen No. 5662 (.0606 Dia.)
2 Hrs. @ 1310 °F

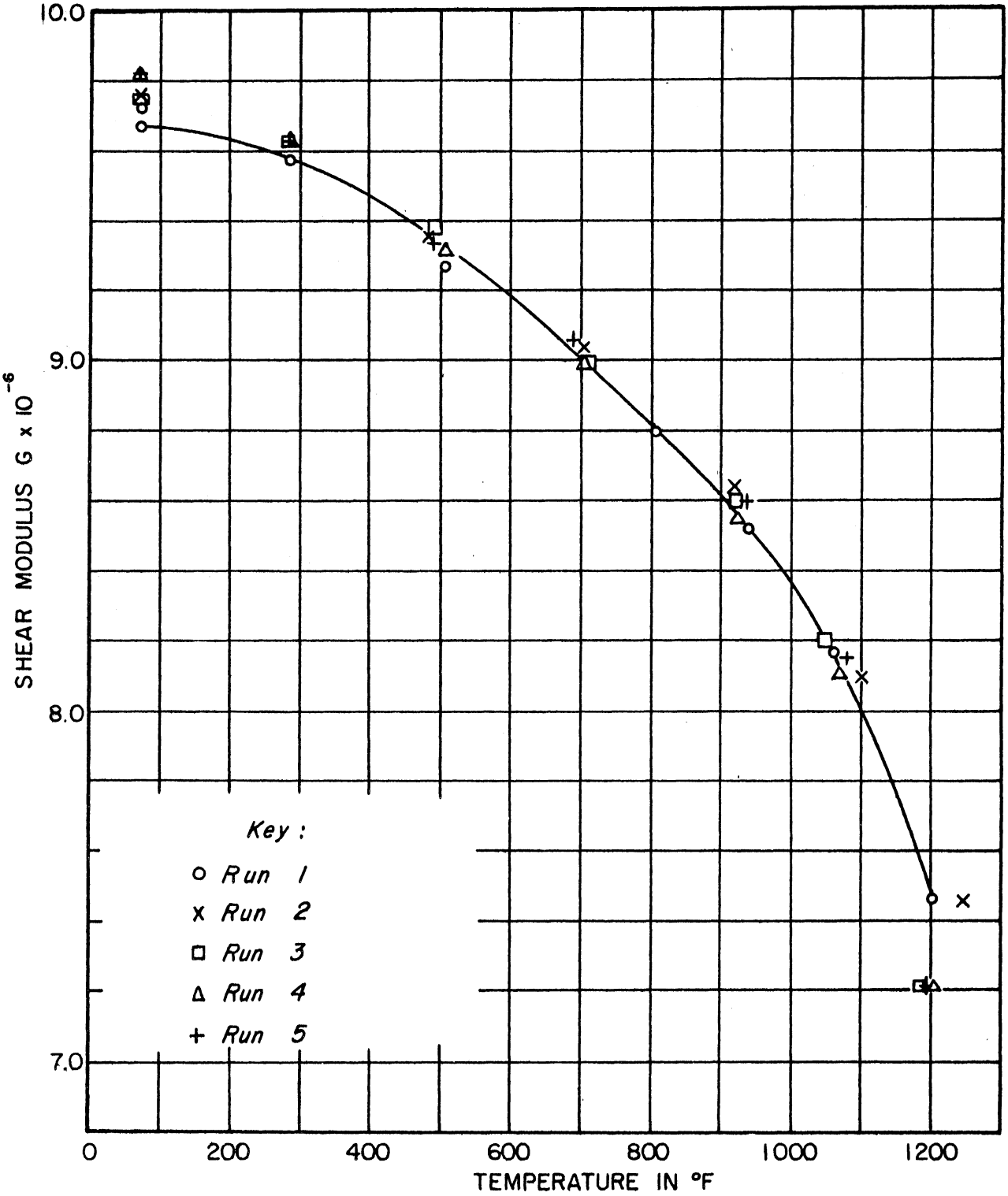

Fig. 6. Shear Modulus vs. Temperature
Specimen No. 5662 (.1063 Dia.)
2 Hrs. @ 1310 °F

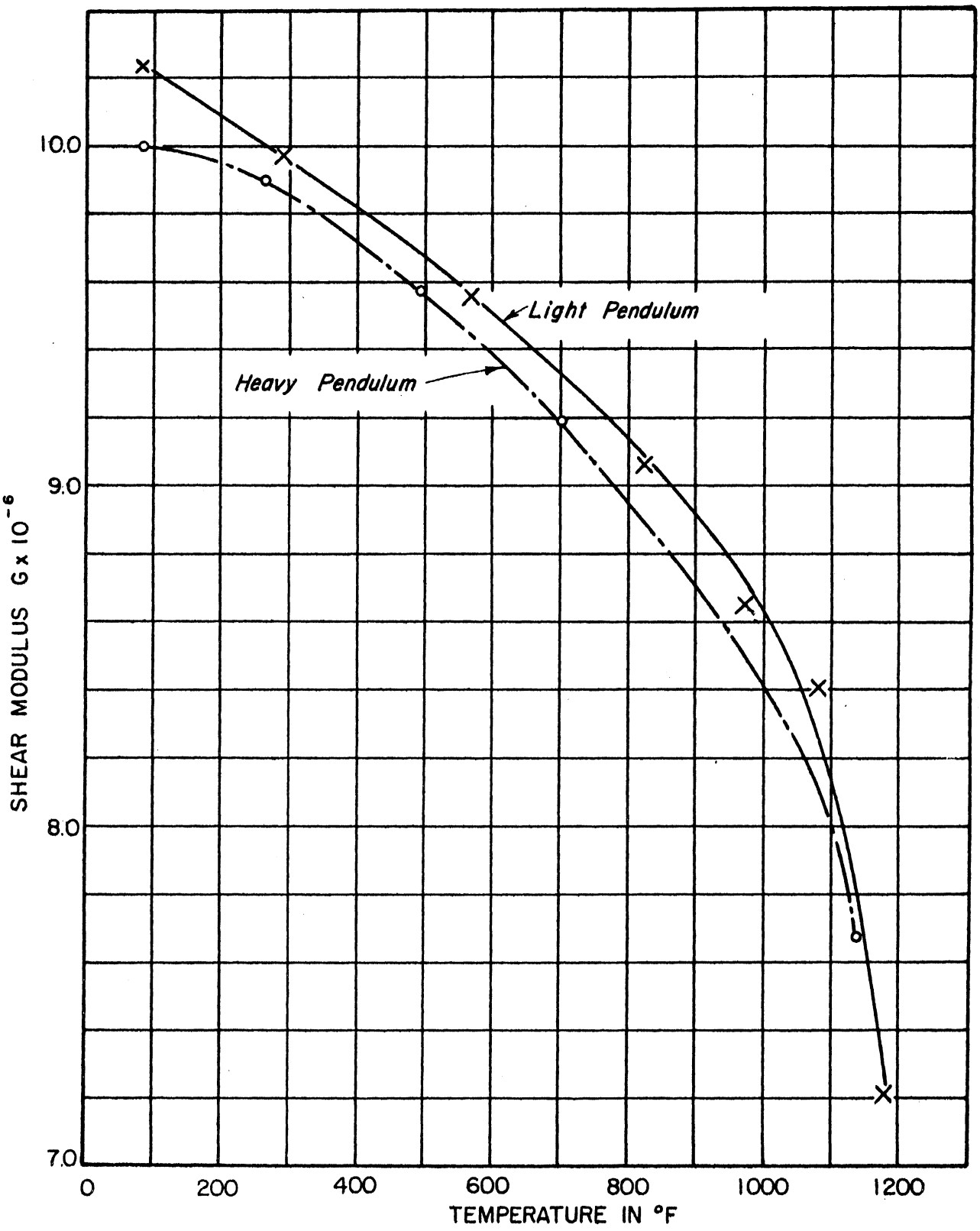

Fig. 7. Shear Modulus vs. Temperature
Specimen No. 7359 (.0540 Dia.)
2 Hrs. @ 1185 °F

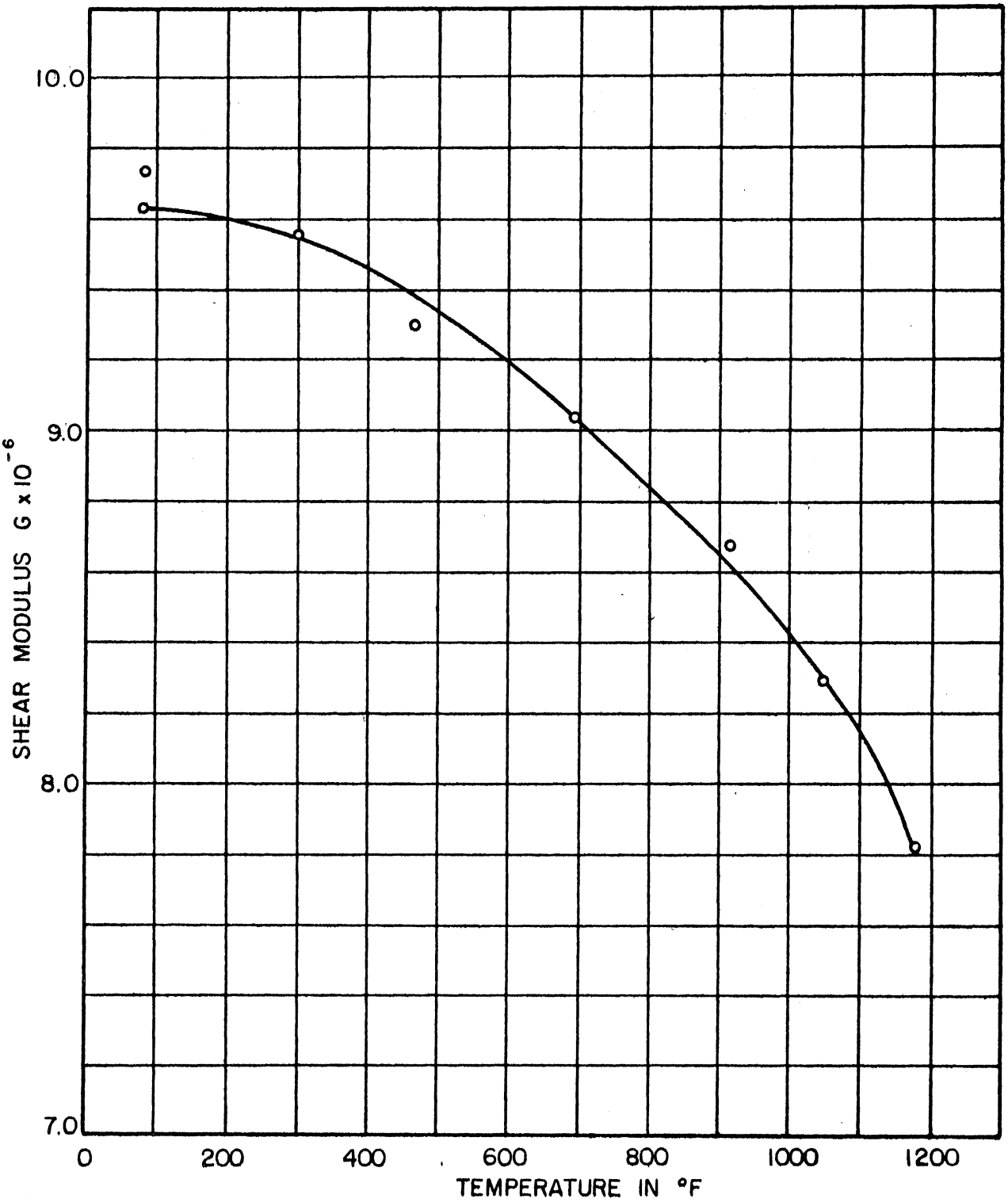

Fig. 8. Shear Modulus vs. Temperature
Specimen No. 7538 (.0682 Dia.)
2 Hrs. @ 1250 °F

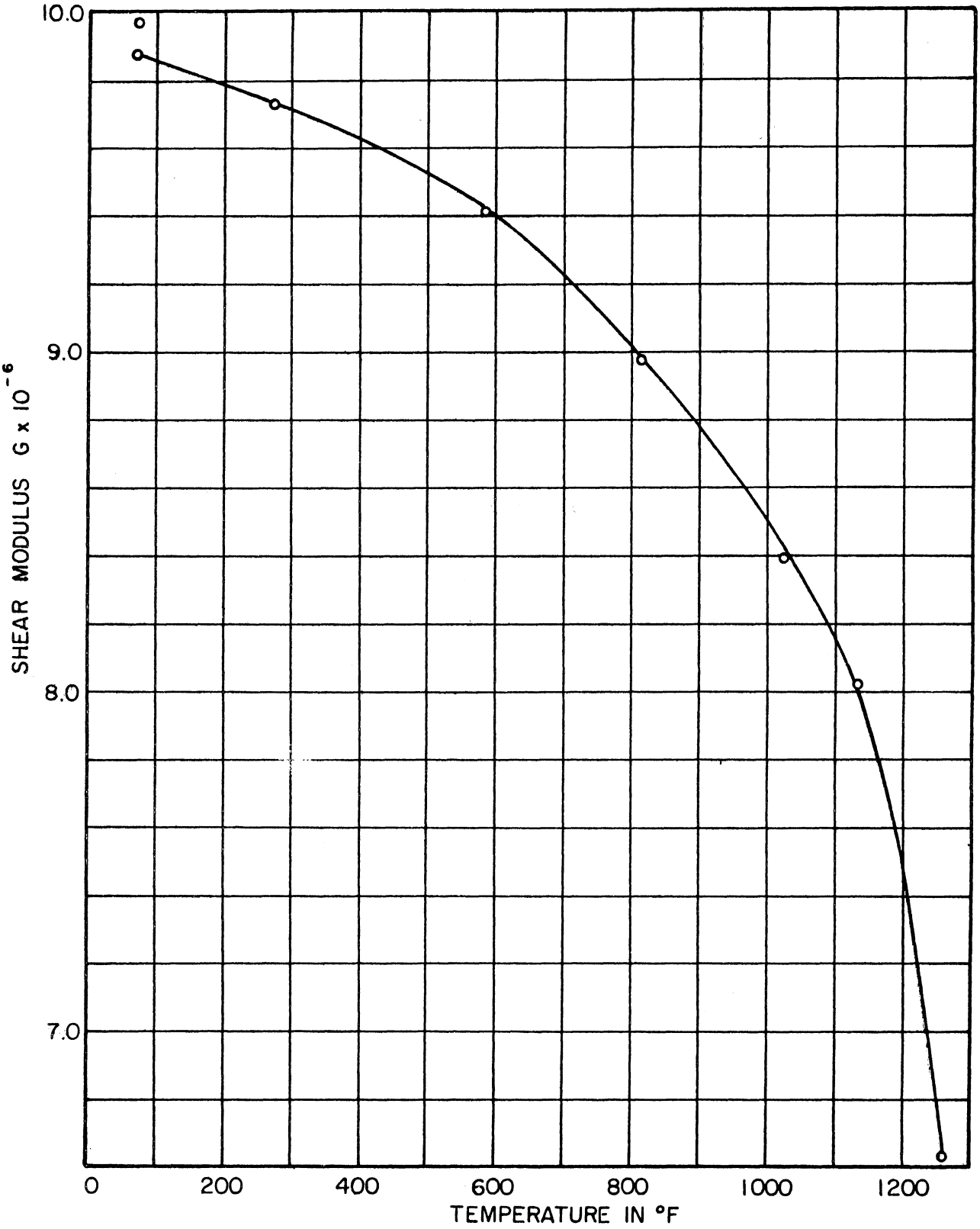

Fig. 9. Shear Modulus vs. Temperature
Specimen No. 7423 (.0542 Dia.)
2 Hrs. @ 1250 °F

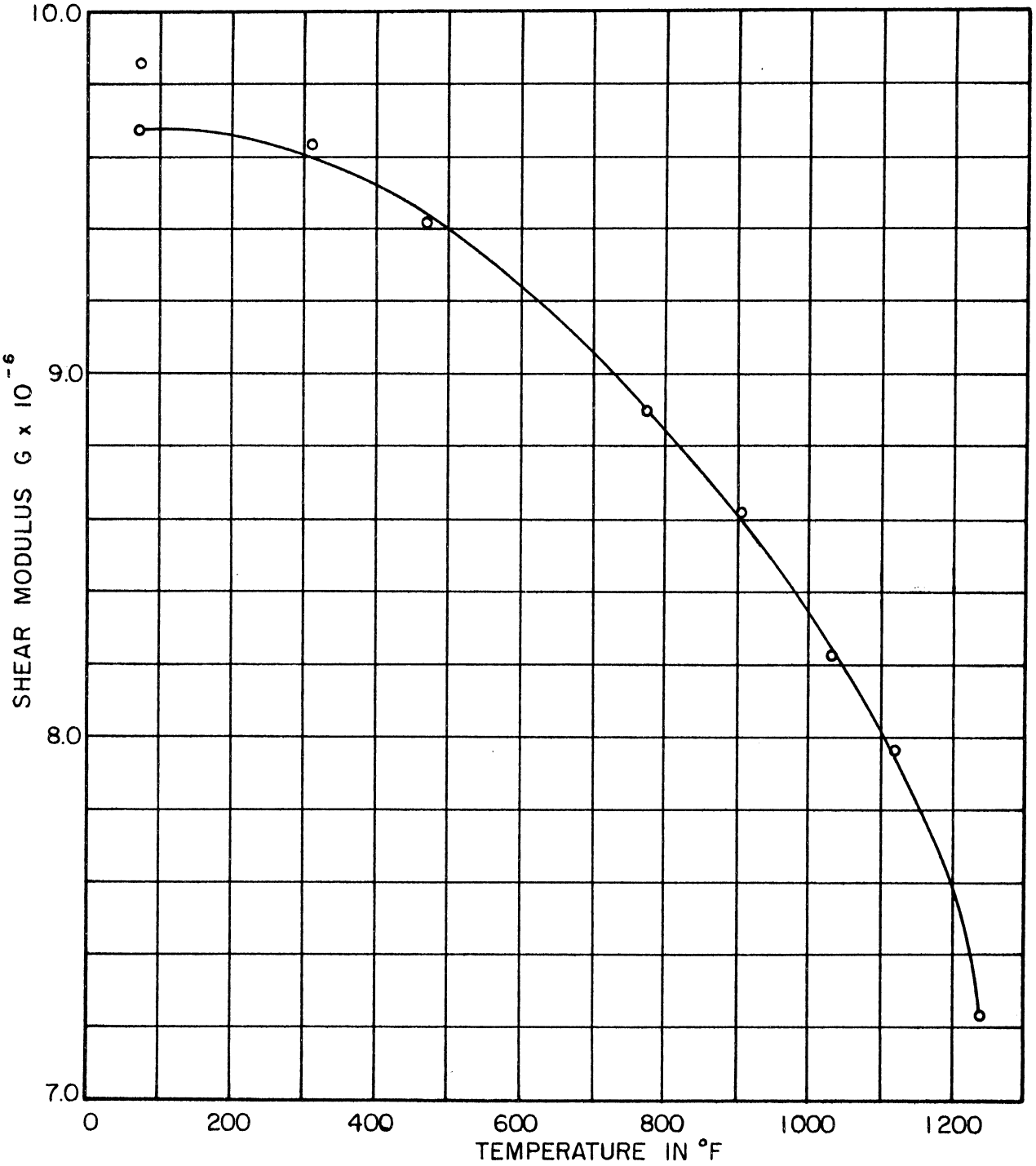

Fig. 10. Shear Modulus vs. Temperature
Specimen No. 7360 (.1088 Dia.)
2 Hrs. a 1160 °F

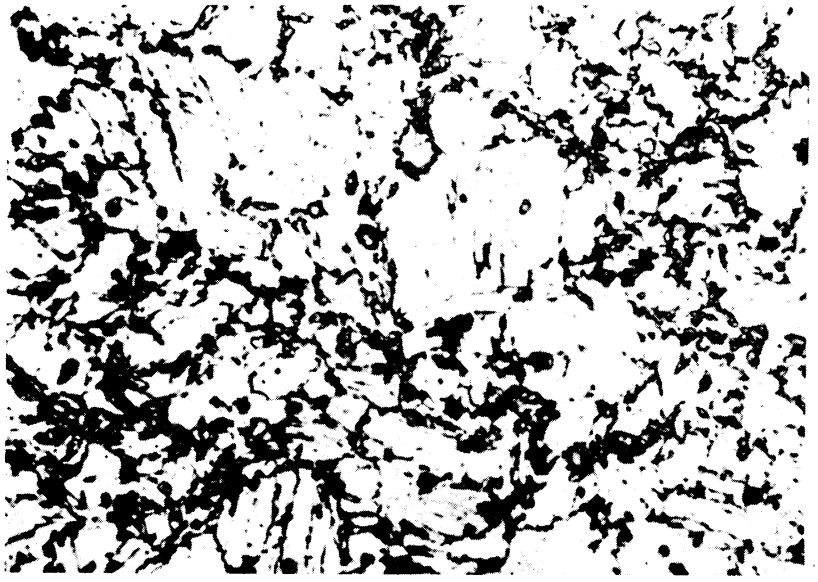

Fig. 11. Photomicrograph showing structure of Ni-Span-C heat 5662 as-received. Modified aqua regia etch. 1000X.

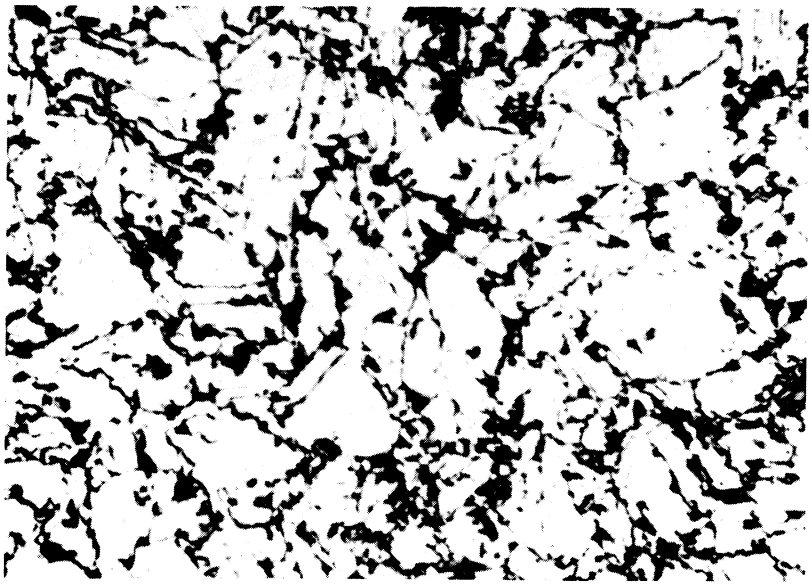

Fig. 12. Photomicrograph showing structure of Ni-Span-C heat 5662 after one run and 10 hr at 835°F. Modified aqua regia etch. 1000X.