REPORT

ON

CREEP STRENGTH OF "17-22-A"V STEEL AT 1000° AND 1100°F

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PROJECT 842
REPORT 206

September 10, 1954

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CREEP STRENGTH OF "17-22-A"V STEEL AT 1000° AND 1100°F

Creep tests were carried out on specimens from a commercial heat of "17-22-A"V steel at 1000° and 1100°F as a continuation of a program for the development of a low alloy steel for use in forged discs of the type used as rotors in the gas turbines in the jet aircraft industry. All previous investigations concerned with the development of "17-22-A"V steel had been confined to rupture tests. The establishment of creep characteristics was carried out to obtain information concerning the load carrying ability of the alloy for limited deformations and for extrapolation for long time applications.

The material used for the investigation was bar stock taken from a commercial arc furnace heat. All samples were normalized at 1800°F and tempered at 1200°F, the treatment which appeared to give the best properties on the basis of rupture tests at the time the investigation was undertaken.

SUMMARY AND CONCLUSIONS

Appraisal of the data obtained from creep tests at 1000° and 1100°F may be summarized as follows:

1. The creep tests indicated that "17-22-A"V steel has approximately the following creep strengths:

Temp (°F)	Stress for Creep Rate of 0.1%/1000 hours	Stress for Creep Rate of 0.01%/1000 hours
1000	(34,000)	20,500
1100	13,000	5,300

2. The creep strength at 1100°F of "17-22-A"V steel is considerably higher than that obtained for either "17-22-A" or "17-22-A"S steels. The margin did not appear to be as large at 1000°F.

3. As near as could be determined, the strength of the "17-22-A"V test material was somewhat low in comparison to the strength when the material properly responds to heat treatment.

4. The "17-22-A"V material was quite stable at 1000°F, except for some loss in impact strength. Considerable tempering occurred at 1100°F during 2000 hours of creep testing.

TEST MATERIALS

Machined 0.505-inch diameter tensile specimens were supplied from a heat of "17-22-A"V steel (Heat 11625) reported to have the following chemical composition:

C	Mn	P	S	Si	Cr	Ni	Mo	V
.26	.62	.016	.014	.68	1.34	.34	.51	.77

The material for these test specimens were normalized from 1800°F in 1-inch round bars 7 inches long and tempered for 6 hours at 1200°F to 331/341 Brinell. The tensile specimens were coded 11625-1812 by the Timken Roller Bearing Company.

Comparative creep properties from previous reports are used in this report for "17-22-A" and "17-22-A"S steels. These steels differ from "17-22-A"V steel in that they contain only 0.25 percent vanadium and their carbon contents are a nominal 0.30 and 0.45 percent, respectively.

RESULTS AND DISCUSSION

The time-elongation curves for the creep tests at 1000° and 1100°F are presented in Figures 1 and 2. Creep rates which existed at selected time periods are presented in Table I. The stress and minimum creep rate values are plotted as usual logarithmic curves in Figure 3. The creep strengths derived from these curves are given in the following tabulation:

Steel	Test Temp (°F)	B H N	Stress for Indicated Creep Rate (psi) 0.1%/1000 hrs	0.01%/1000 hrs	Source of Data
"17-22-A"V	1000	331/341	(34,000)	20,500	--
"17-22-A"	1000	285	--	14,000	Rpt. 165
"17-22-A"	1000	315	--	17,500	Rpt. 99
"17-22-A"V	1100	331/341	13,000	5,300	--
"17-22-A"	1100	311/341	9,500	3,600	Rpt. 198
"17-22-A"S	1100	311/331	7,200	2,800	Rpt. 198

The tabulation also includes comparative values from previous investigations of "17-22-A" and "17-22-A"S steels. The greater creep resistance of "17-22-A"V steel is evident from this comparison.

The data from the stability tests on the specimens after creep testing are shown in Table II. The tensile and hardness data clearly indicate that considerable tempering had occurred during testing, particularly at 1100°F. It is also evident that exposure to stress at 1000°F considerably reduced impact strength, although there was little evidence of tempering at 1000°F.

The microstructures before and after creep testing at both temperatures are shown in Plates 1 through 3. The material had a very fine grain size and apparently had originally been very fine grained bainite before tempering. The metallographic examination of the structure shows very little difference between the original structure and the structure after creep testing, despite the fact that the mechanical tests indicated that a considerable amount of tempering had occurred at 1100°F. This agrees with previous experience that there appears to be very little visible change in structure within quite a range in hardness by tempering for the same normalizing condition.

DISCUSSION

The creep tests indicated a substantial superiority for "17-22-A"V over "17-22-A" or "17-22-A"S type steels at 1100°F. Past experience with the rupture properties of "17-22-A"V steel, however, have indicated that the strength may be sensitive to normalizing temperature. Specimens from the same heat and given the same treatment as those used for the creep tests were rupture tested for Report 204. The indicated stress of 38,000 psi for rupture in 100 hours at 1100°F was considerably lower than had been obtained for "17-22-A"V steel from other heats or from the same heat with other heat treatments. The indications are, therefore, that the particular lot of specimens subjected to creep tests are not representative of "17-22-A"V steel with maximum strength. The assumption, therefore, is that a material which would have rupture strengths at 1100°F for 1000 hours in excess of 32,000 psi, as is considered typical of "17-22-A"V steel, would show considerably higher creep strengths than were obtained for the specimens used in this investigation.

The comparative data for "17-22-A"V and "17-22-A"S steels at 1000°F do not show as great a superiority for "17-22-A"V as at 1100°F. The reason for this is uncertain. It could be due to relative stability being a smaller factor at 1000°F. Most probably, the major reason was the relatively low strength of the "17-22-A"V test material.

The reported creep strengths at 1100°F seem reasonably consistend with the probable rupture strength of the test material. The 10,000-hour rupture strength probably should not be less than 20,000 psi and the 100,000-hour estimated strength not less than 10,000 psi. The observed creep strengths are consistent with such values, but probably less than the stronger test materials in rupture tests conducted for previous investigations would have given. Tests have not been run for similar comparisons at 1000°F.

The instability of the alloy at 1100°F, as was evidenced by softening and loss of room temperature tensile strength apparently was responsible for the rather sharp drop in creep strength between 1000° and 1100°F. The possibility of embrittlement during service at temperatures below 1100°F, as indicated by the impact tests, should also receive due consideration for any such applications.

TABLE I

Stress - Creep Rate Data at 1000° and 1100°F for "17-22-A"V Steel

(Heat 11625 - Normalized from 1800°F and Tempered at 1200°F to 331/341 Brinell)

Stress (psi)	Discontinued after (hours)	Creep Rate (%/1000 hours)							
		500 hr	1000 hr	1500 hr	2000 hr	2500 hr	3000 hr	3500 hr	4000 hr
				1000°F					
28,000	2655	0.060	0.040	0.038	0.038	0.036	--	--	--
23,000	2197	0.042	0.034	0.030	0.022	--	--	--	--
20,000	4003	0.026	0.025	0.020	0.014	0.014	0.014	0.010	0.10
				1100°F					
16,000	2679	0.190	0.183	0.170	0.204	0.240	--	--	--
12,000	2198	0.094	0.091	0.092	0.084	--	--	--	--
7,000	2470	0.037	0.034	0.026	0.024	0.022*	--	--	--

* at 2400 hours.

TABLE II

Room Temperature Tensile Properties of "17-22-A"V Steel before and after Creep Testing

(Heat 11625 - 1" Diameter Bars - Normalized 1800°F and Tempered at 1200°F to 331/341 Brinell)

Creep Testing Conditions			Tensile Strength	Yield Strength		Proportional Limit	Elongation	Reduction of Area	Izod Impact Strength	Brinell Hardness
Test Temp (°F)	Stress (psi)	Duration of Test (hours)	(psi)	0.1% Offset (psi)	0.2% Offset (psi)	(psi)	(%)	(%)	Ft.-Lb**	
Original Material			156,800	145,000	146,200	132,000	17.5	54.5	39 38	331/ 341
1000	28,000	2655	--	--	--	--	--	--	21 22	308*
1000	23,000	2197	150,900	141,300	144,200	122,000	17.0	53.0	--	--
1000	20,000	4003	144,200	131,000	132,500	117,000	17.5	53.5	--	--
1100	16,000	2679	--	--	--	--	--	--	41 42	247*
1100	12,000	2198	120,500	110,000	112,500	87,000	19.5	61.0	--	--
1100	7,000	2470	117,800	102,500	106,000	86,000	20.0	59.5	--	--

* Hardness measured in the gage section after creep testing - converted from Vickers diamond pyramid hardness.
** 0.365-inch square with a 0.050-inch deep V-notch.

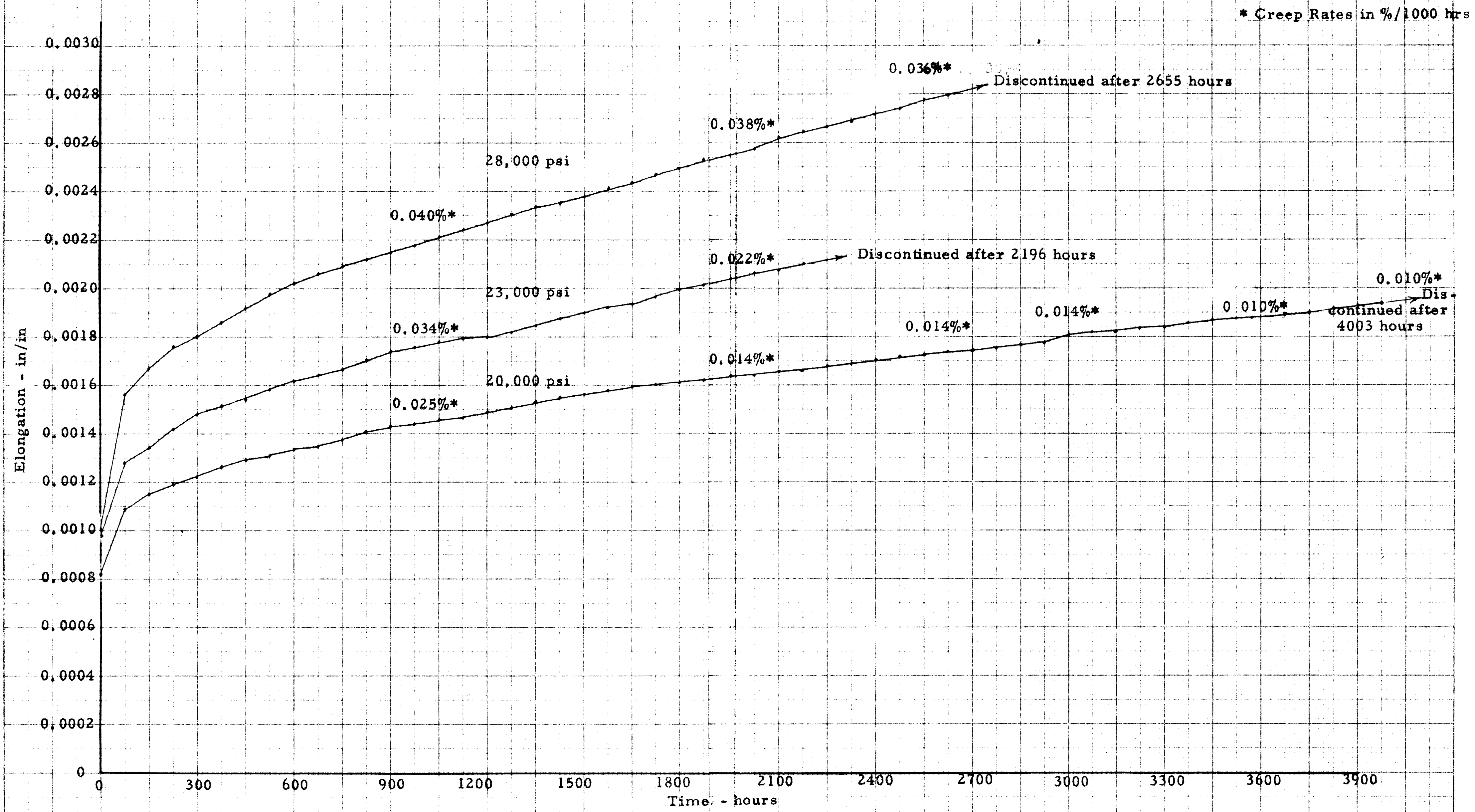


Figure 1. - Time - Elongation Curves from Creep Tests at 1000°F on "17-22-A"V Steel, Heat 11625. Normalized from 1800°F and tempered for 6 hours at 1200°F to 331/341 Brinell.

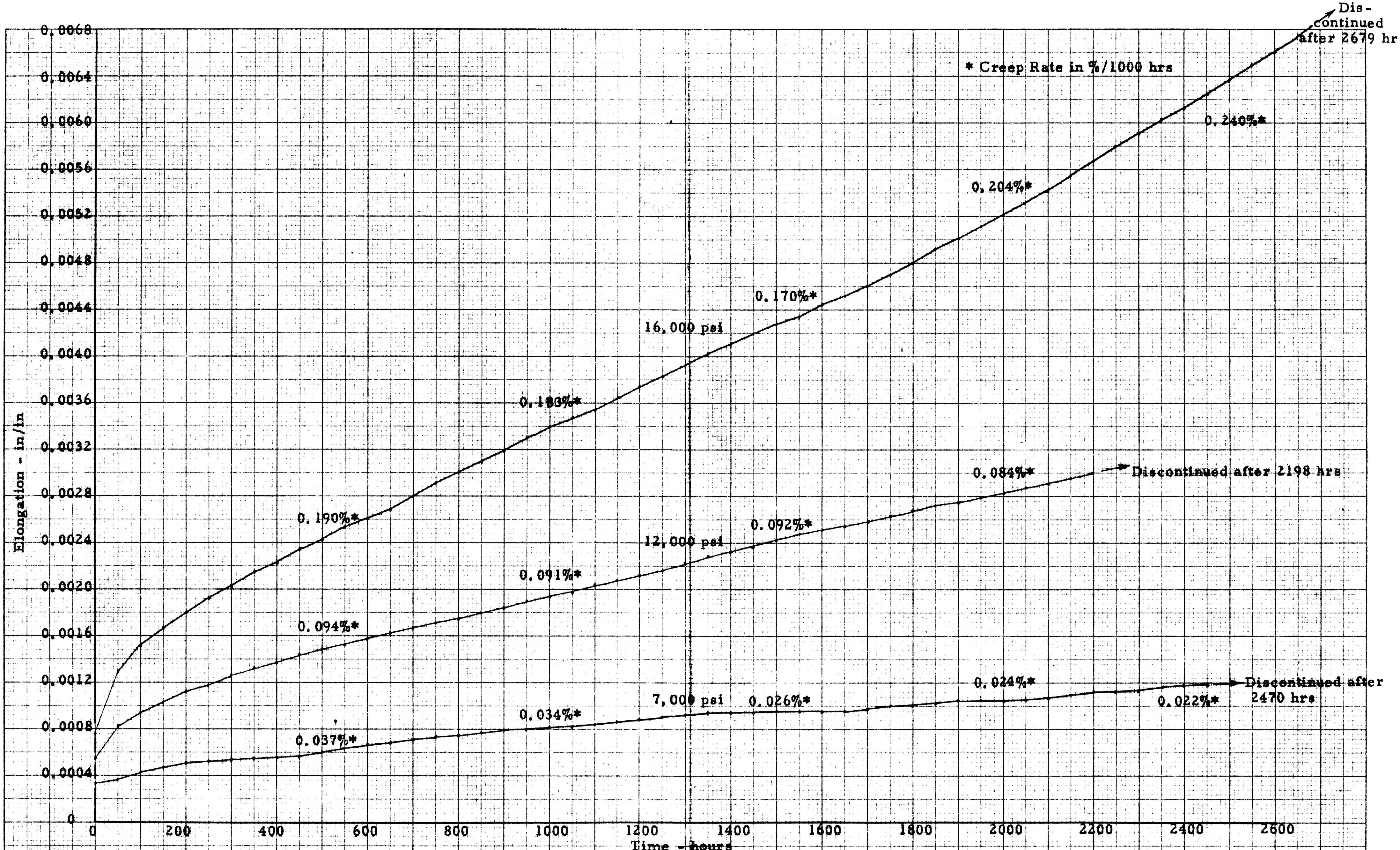


Figure 2. - Time - Elongation Curves from Creep Tests at 1100°F on "17-22-A"V Steel, Heat 11625. Normalized from 1800°F and tempered for 6 hours at 1200°F to 331/341 Brinell.

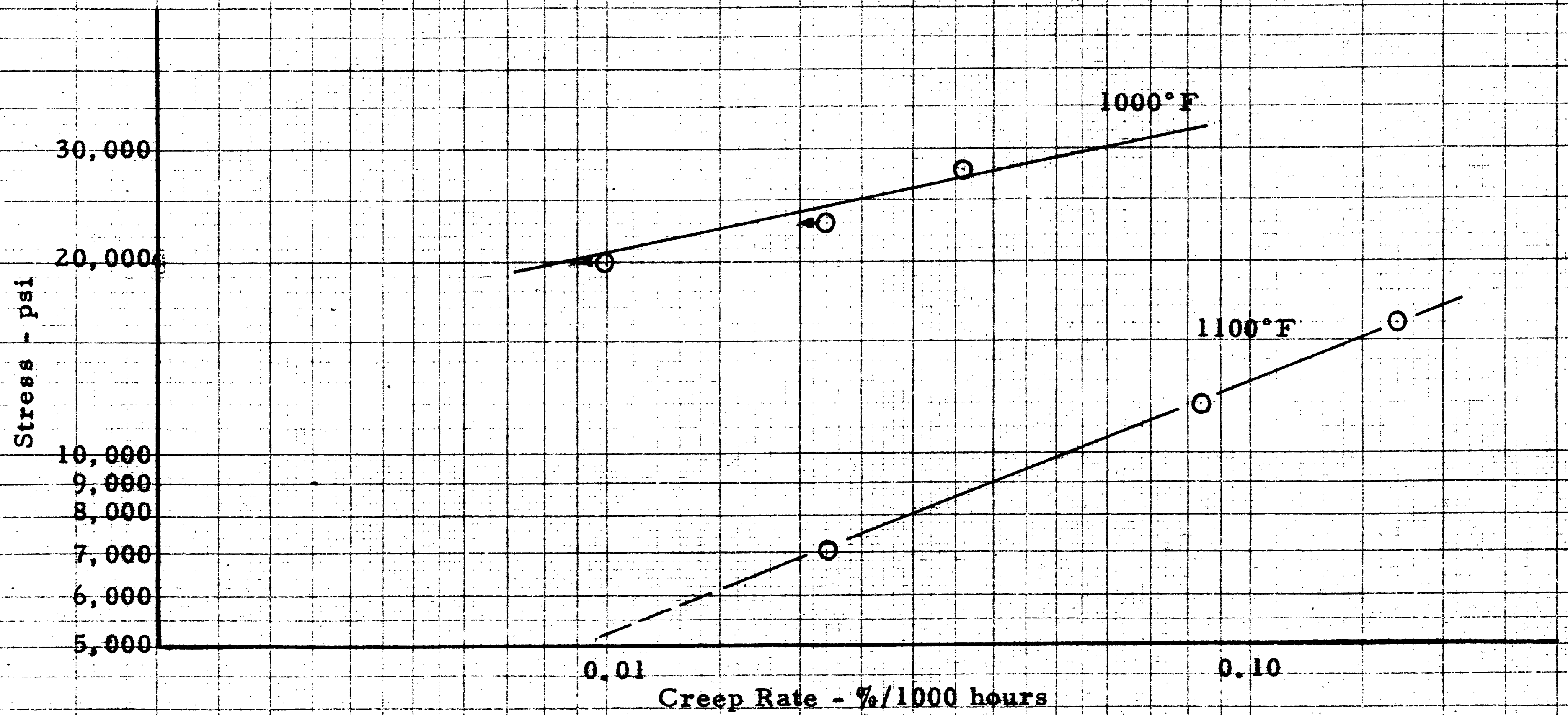
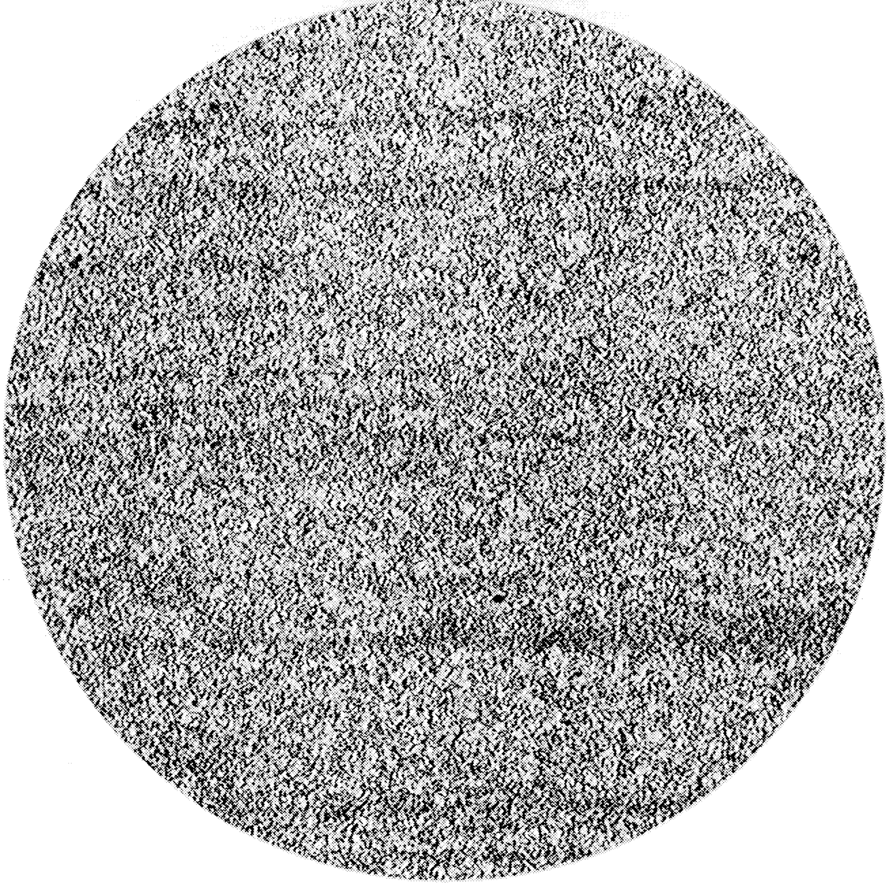


Figure 3. - Stress - Creep Rate Curves from Creep Tests at 1000° and 1100°F for "17-22-A"V Steel, Heat 11625. Normalized from 1800°F and tempered for 6 hours at 1200°F to 331/341 Brinell.



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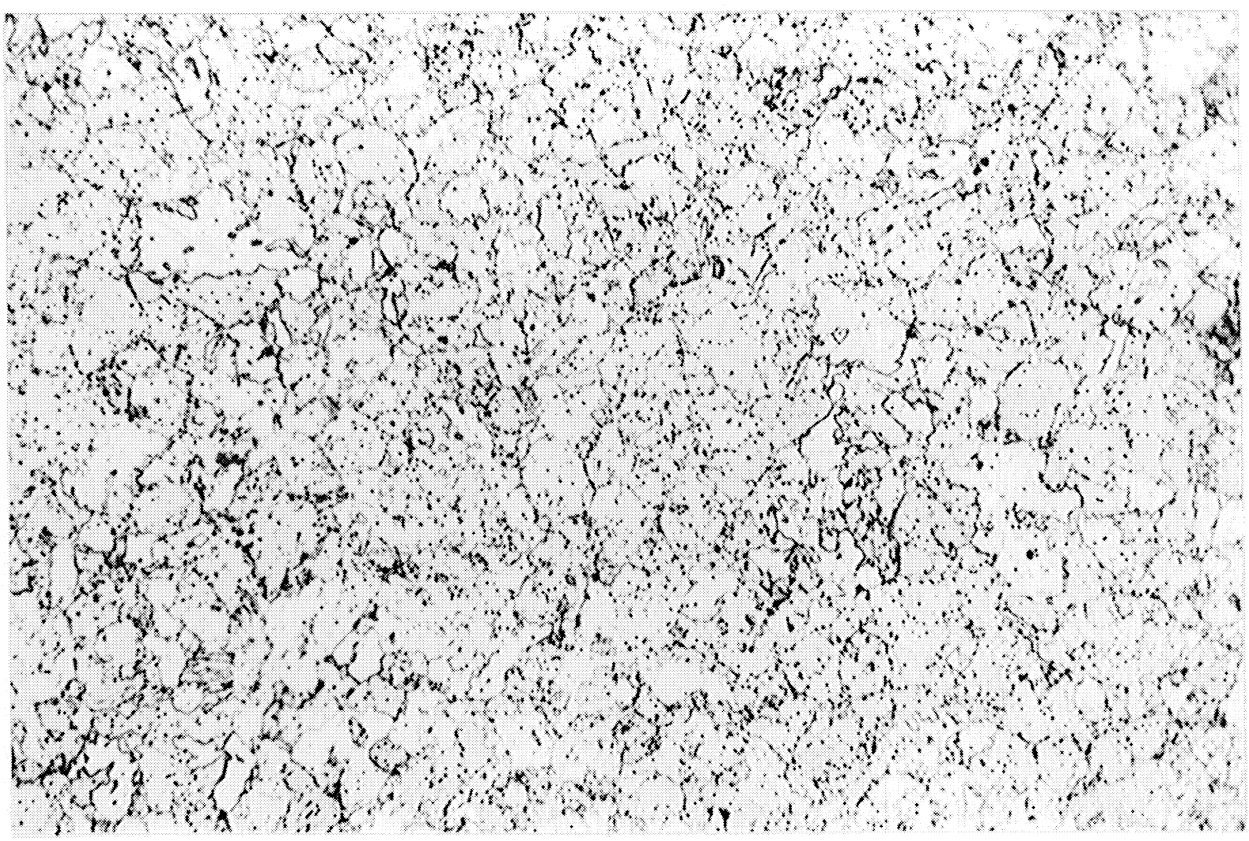
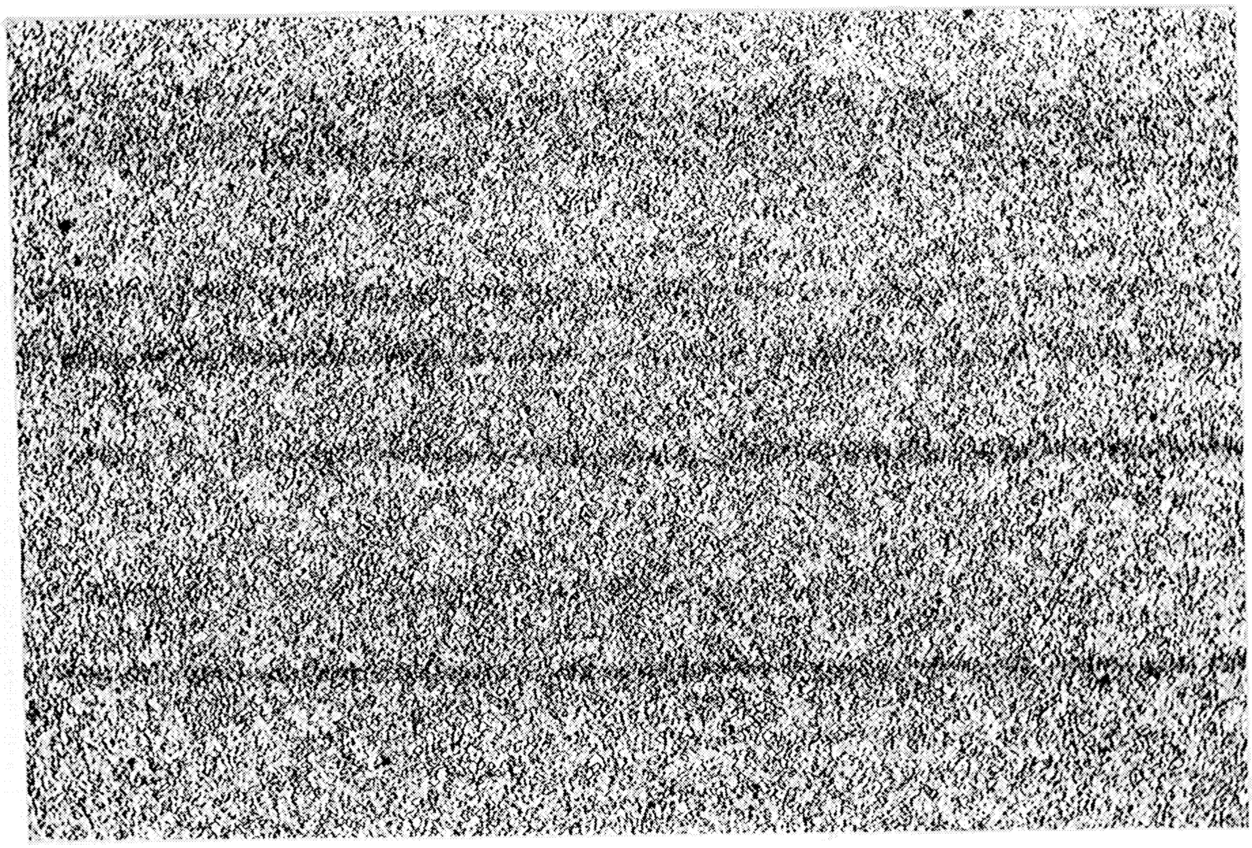


X1000D

Plate No. 1. Original Microstructure of "17-22-A"V Steel, Heat 11625. One-inch round bars normalized from 1800°F and tempered for 6 hours at 1200°F to 331/341 Brinell.



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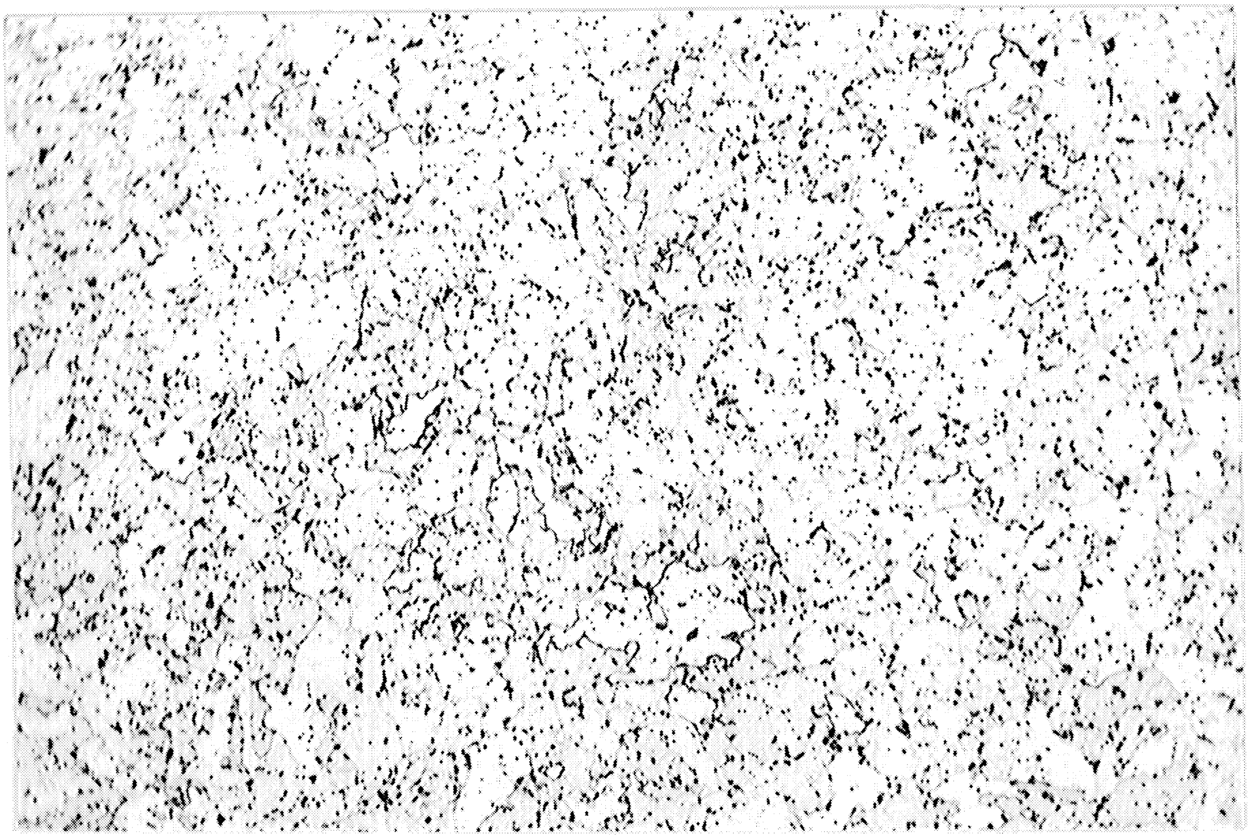
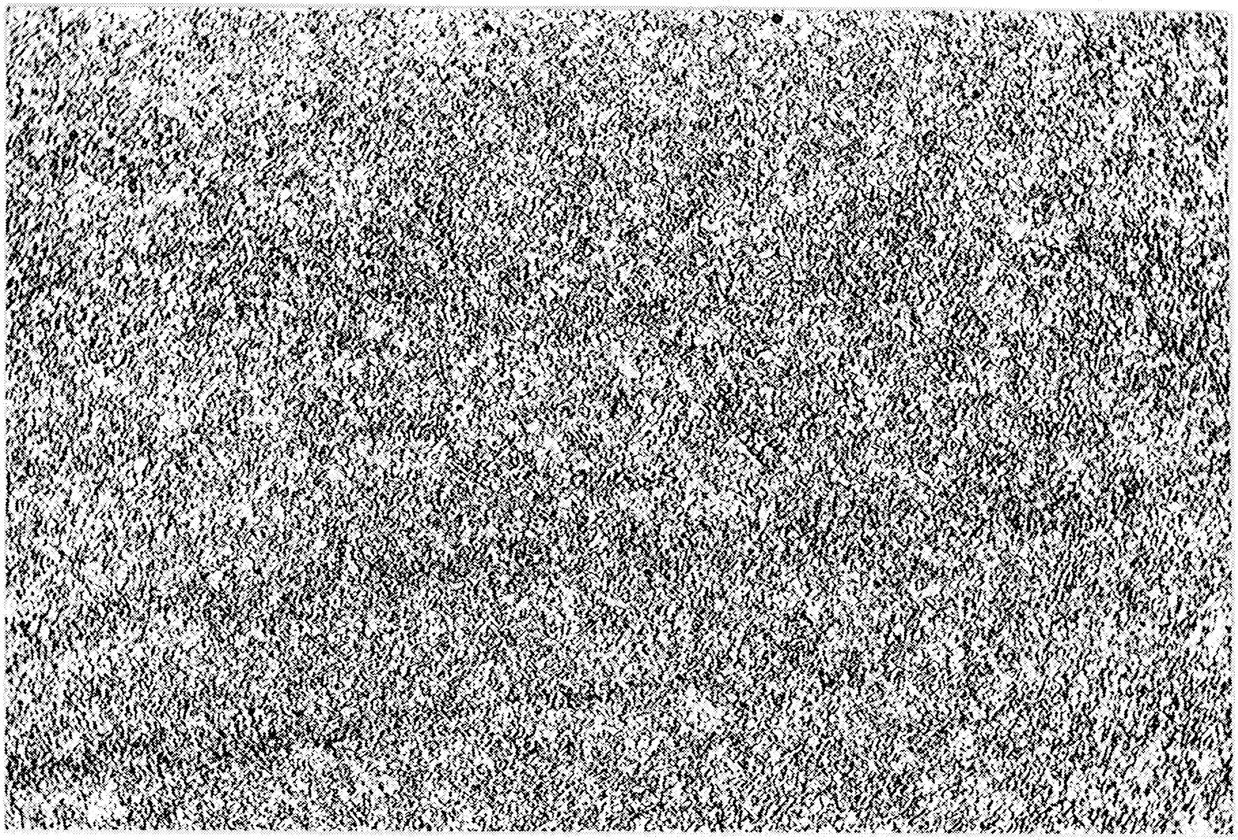


X1000D

Plate No. 2. Microstructure of "17-22-A"V Steel, Heat 11625. One-inch round bars normalized from 1800°F and tempered for 6 hours at 1200°F to 331/341 Brinell. Creep tested for 2655 hours at 28,000 psi and 1000°F. 308 Brinell hardness after testing.



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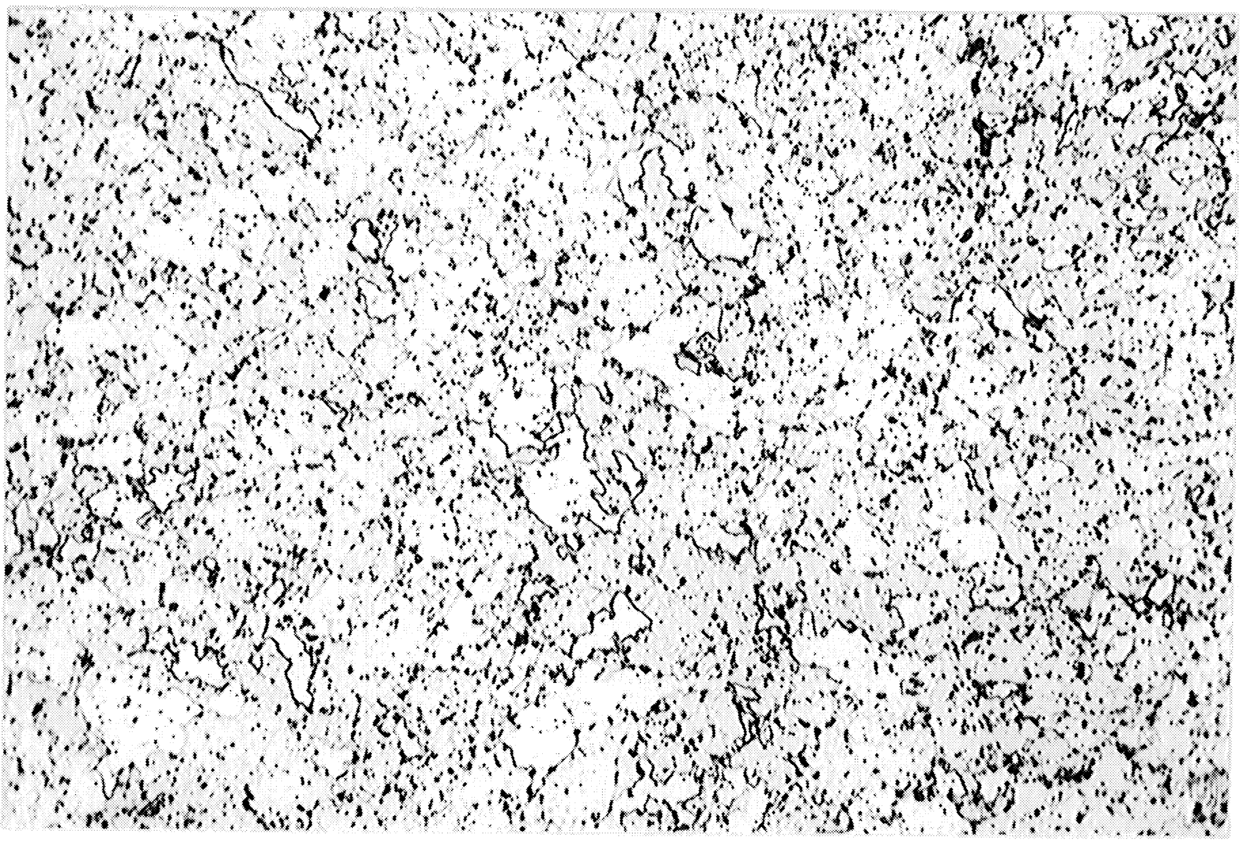

X1000D

Plate No. 3. Microstructure of "17-22-A"V Steel, Heat 11625. One-inch round bars normalized from 1800°F and tempered for 6 hours at 1200°F to 331/341 Brinell. Creep tested for 2679 hours at 16,000 psi and 1100°F. 247 Brinell hardness after testing.