



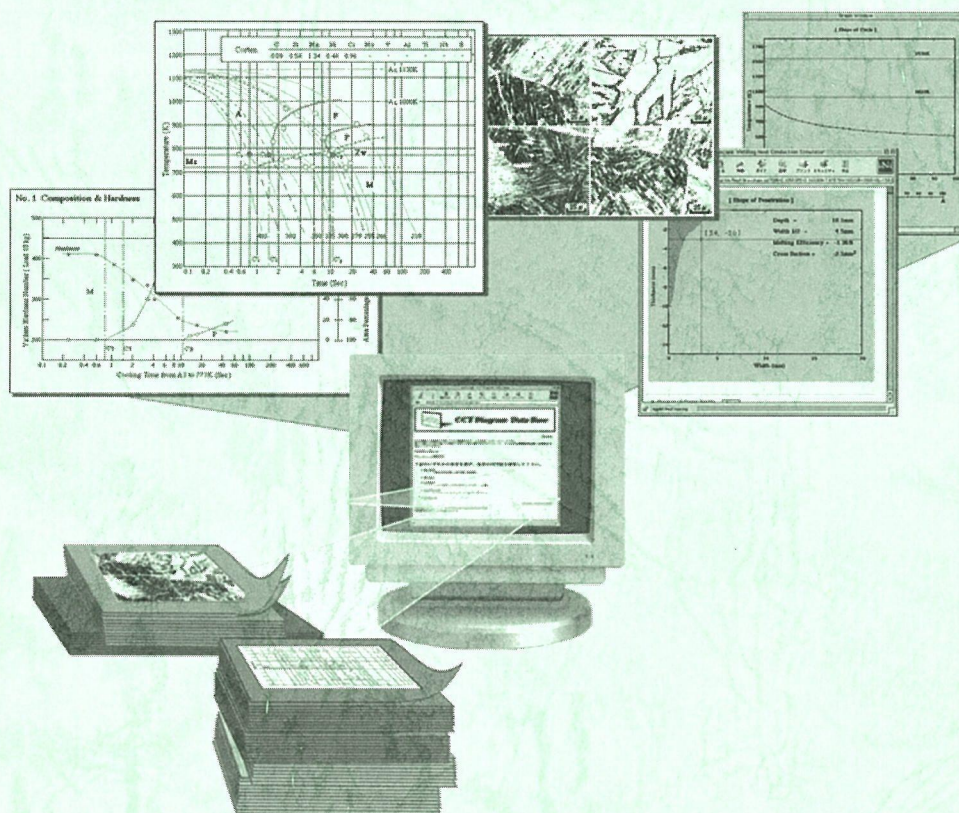
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NIMS-MITS-special report

Atlas of CCT Diagrams for Welding (II)

Edited by

Tadashi ISHIKAWA, Nobutaka YURIOKA
Masayoshi YAMAZAKI and Mitsutane FUJITA



2008

National Institute for Materials Science
Materials Database Station

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National Institute for Materials Science
Materials Database Station
2008

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NIMS-MITS Special Report 2008

Atlas of CCT Diagrams for Welding (II)

Edited by

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This “Atlas of CCT diagrams for welding (II)” has been edited and published under the cooperation between the Nippon Steel Corporation and the National Institute for Materials Science. These diagrams consists of 37 diagrams from “Continuous Cooling Transformation Diagrams” published by the Fundamental Research Laboratories, R and D Bureau, Nippon Steel Corporation, in 1972 and 22 diagrams in “Seitetsu Kenkyu” and “Shin-nittetsu-gihou” published by the Technical Development Planning Div., Technical Development Bureau, Nippon Steel Corporation.

According to the layout used in “Atlas of CCT diagrams (I)” published in 1999, each data set for each steel consists of a CCT diagram, a chart showing the change of hardness and area fraction of microstructures as transformation products against cooling time, and photos of microstructures corresponding to the cooling curves in the CCT diagram.

The CCT diagrams were collected and edited to perform a scheme of the construction of a database accessible through the Internet which is a part of the database construction project in the Japan Science and Technology Corporation (JST). The CCT database is now accessible at WWW (<http://inaba.nrim.go.jp/Weld/>).

It would be great pleasure for the editors if this Atlas could assist welding engineers to better understand metallurgical behaviors during welding cooling. Many colleagues gave valuable suggestions for editing this Atlas and the editors would express a sincere gratefulness to them.

Mitsutane FUJITA
Nobtaka YURIOKA

April 2008

Note for Symbols used in CCT diagrams

A	Austenite
B	Bainite
F	Ferrite
F _A	Acicular Ferrite
FP	Polygonal Ferrite
M	Martensite
M*	High carbon martensite island
P	Pearlite
P'	Quasi pearitic structure
Zw	Intermediate-stage structure (Zwischenstufe)

Cz--Cz' Starting time of bainite transformation on cooling from A₃ or Ac₃ to 773K

Cf--Cf' Starting time of ferrite transformation on cooling from A₃ or Ac₃ to 773K

Cp--Cp' Starting time of pearite transformation on cooling from A₃ or Ac₃ to 773K

Ce--Ce' Ending time of all transformations

HT CCT diagram to be used the purpose of heat treatment.

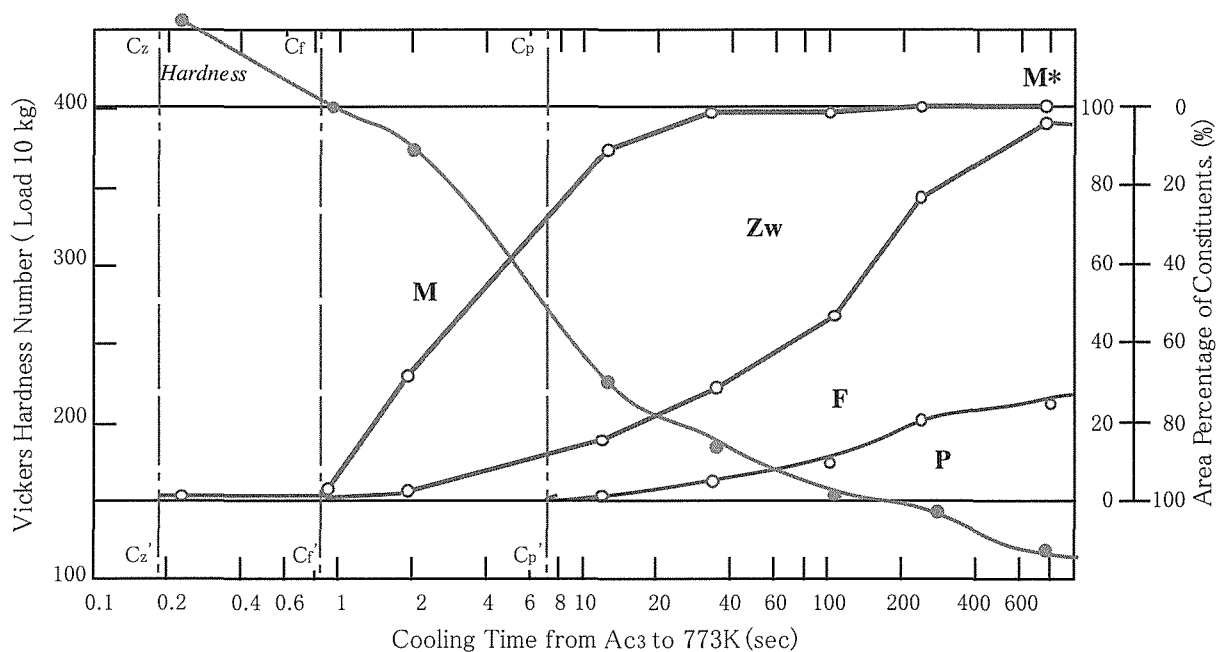
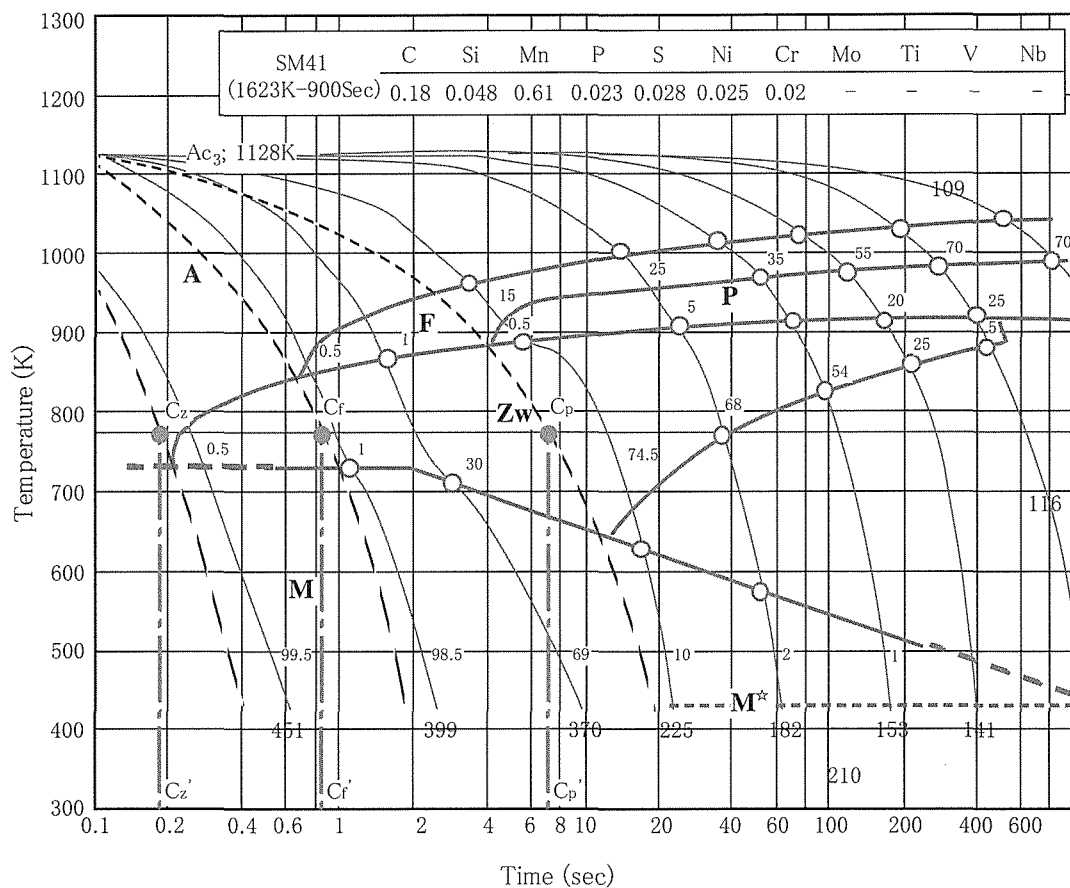
Heating at temperature below 1623K for welding.

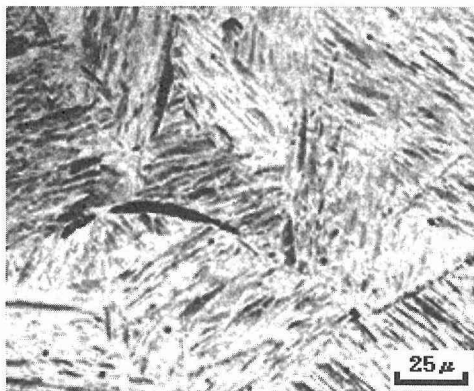
CCT Diagrams for Welding

Rolled Steel for General and Welded Structure

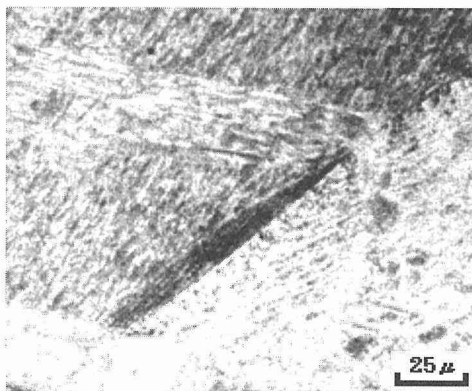
Steel	Chemical Composition (wt%)															Page	Ref.
	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Nb	B	O		
SM41 [201-A]	0.18	0.048	0.61	0.023	0.028	-	0.025	-	-	-	-	-	-	-	-	2	1
SM50(A) [241-A]	0.16	0.39	1.48	0.021	0.015	-	-	-	-	-	-	-	-	-	-	4	1
SM50(B) [241-B] HT	0.16	0.39	1.48	0.021	0.015	-	-	-	-	-	-	-	-	-	-	6	1
SM50Y [111S-A]	0.13	0.07	1.2	0.015	0.015	-	-	-	-	-	-	-	0.07	-	-	8	1
SS55 [201S-A]	0.2	0.03	1.3	0.018	0.022	-	-	-	0.056	-	-	-	0.05	-	-	10	1

HT: CCT diagram to be used the purpose of heat treatment. Heating at temperature below 1623K for welding.

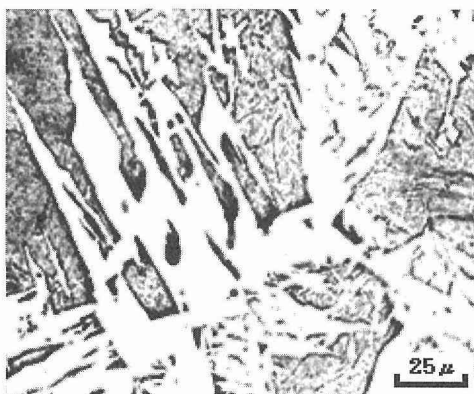




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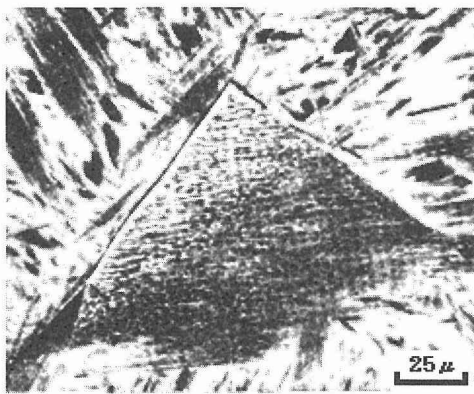
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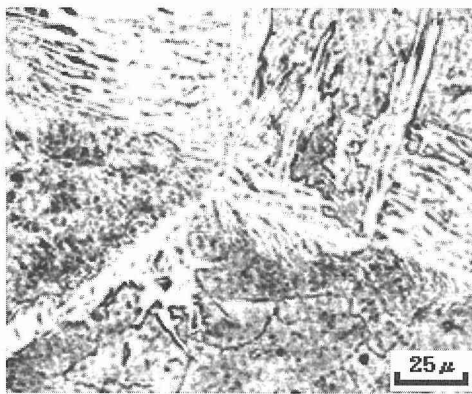
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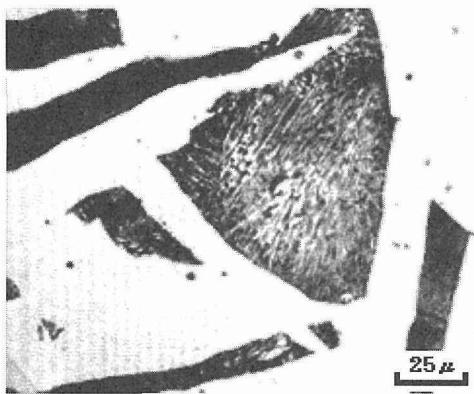
Hv 141



Hv 370



Hv 225

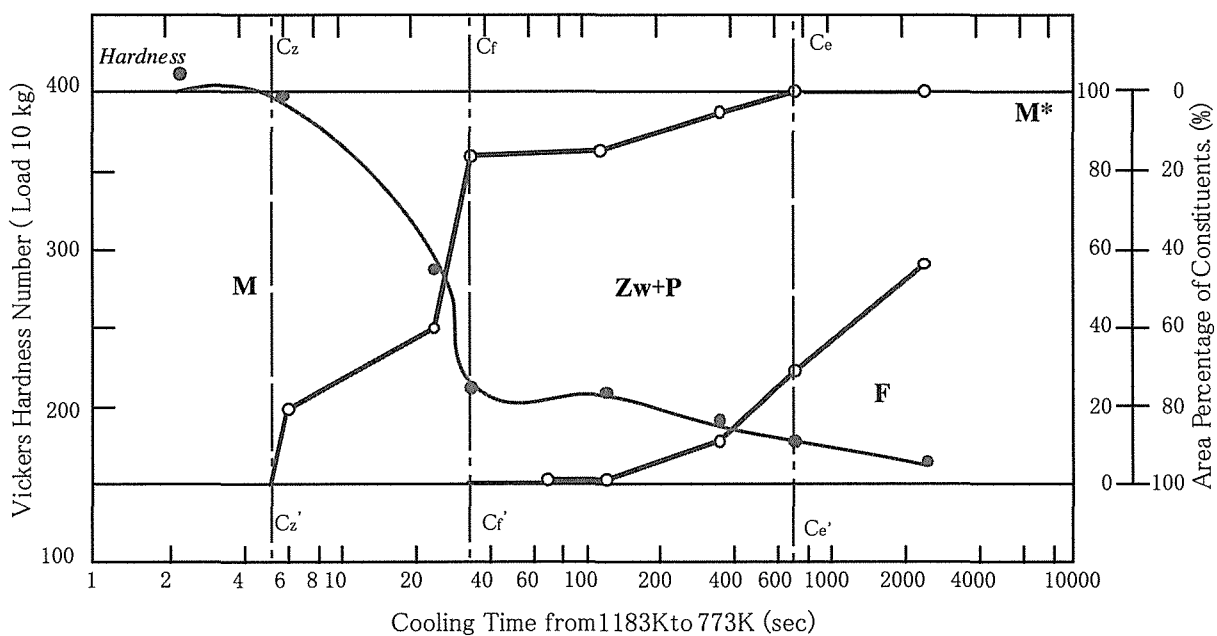
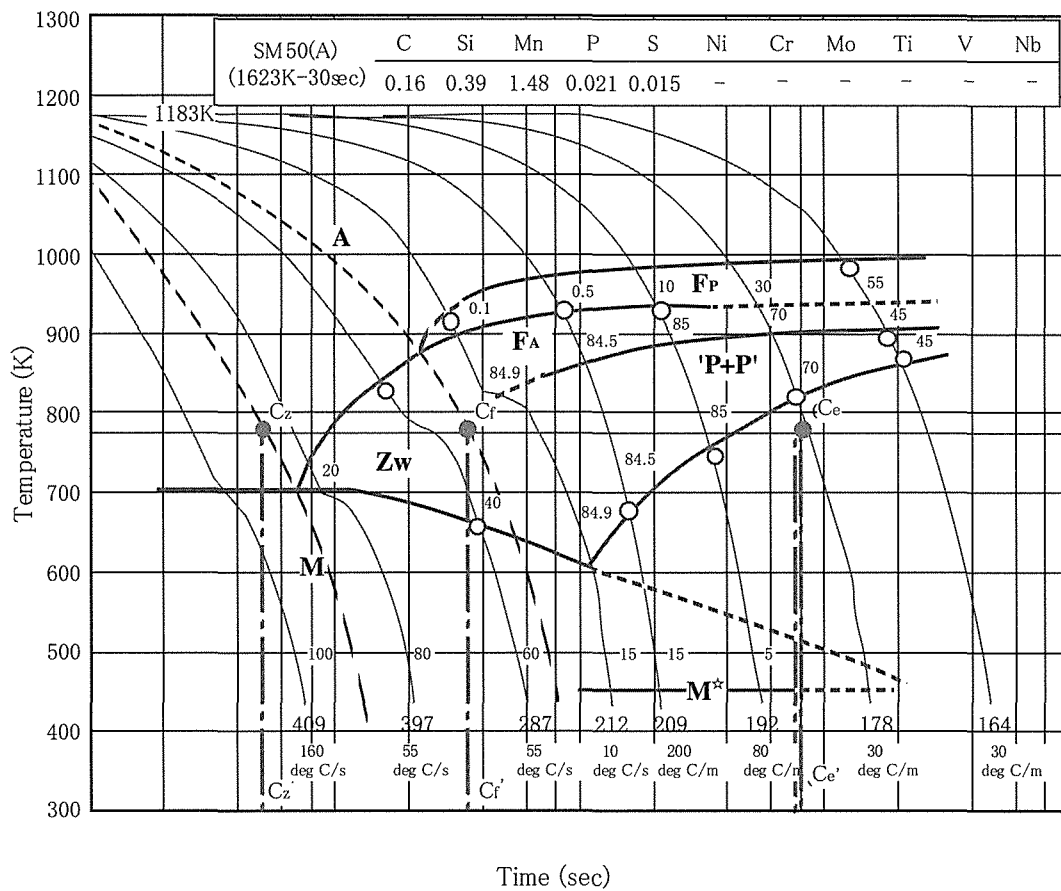


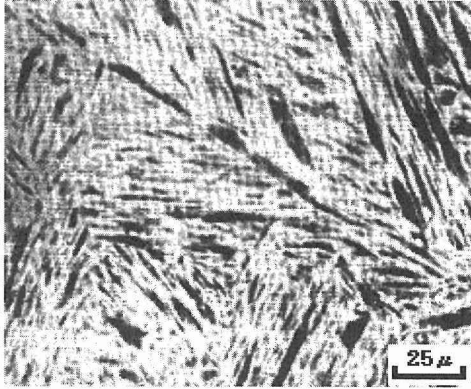
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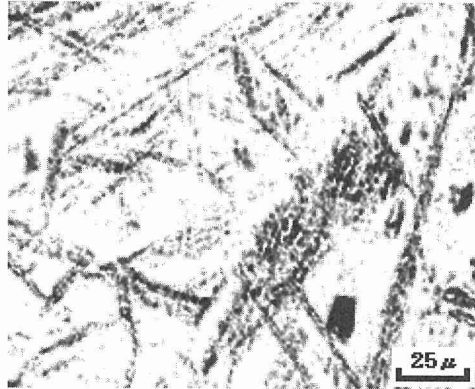
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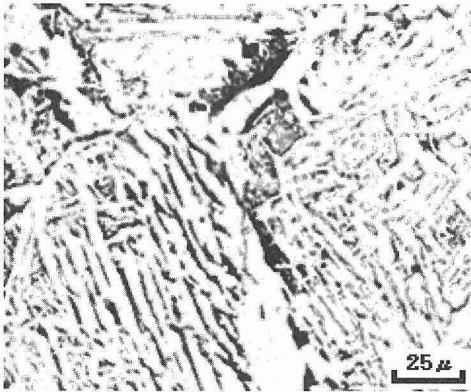
160 deg C/s

Hv 409



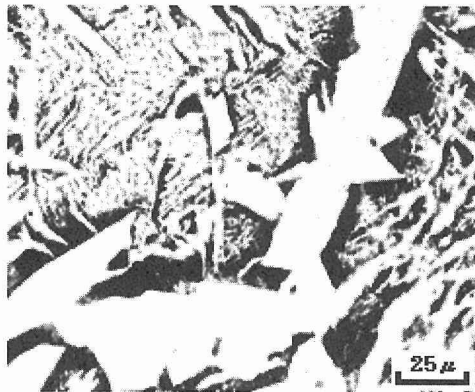
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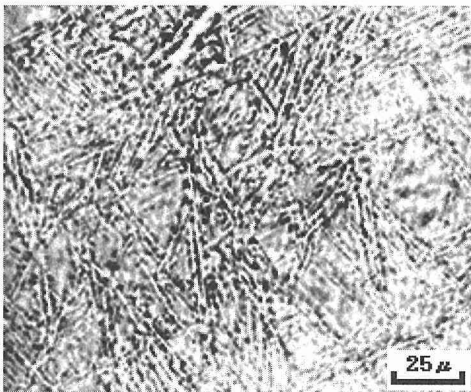
200 deg C/m

Hv 209



30 deg C/m

Hv 178



14 deg C/s

Hv 287



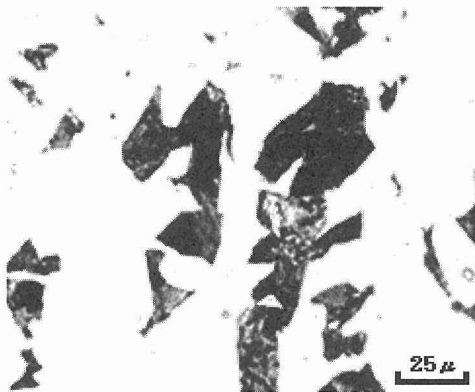
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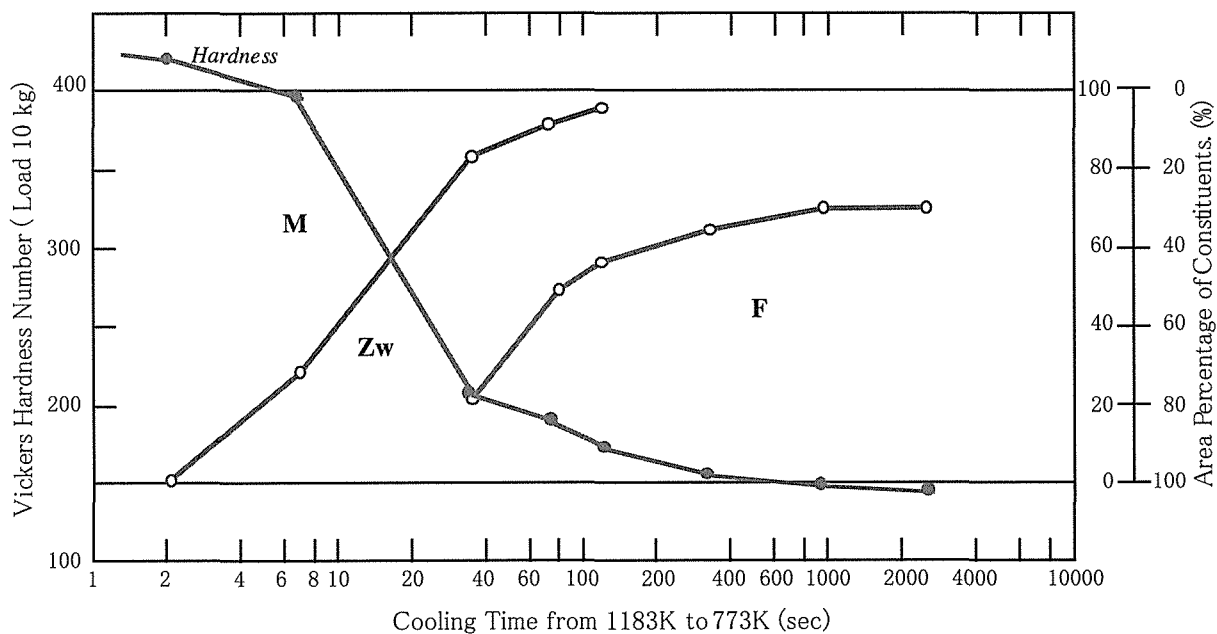
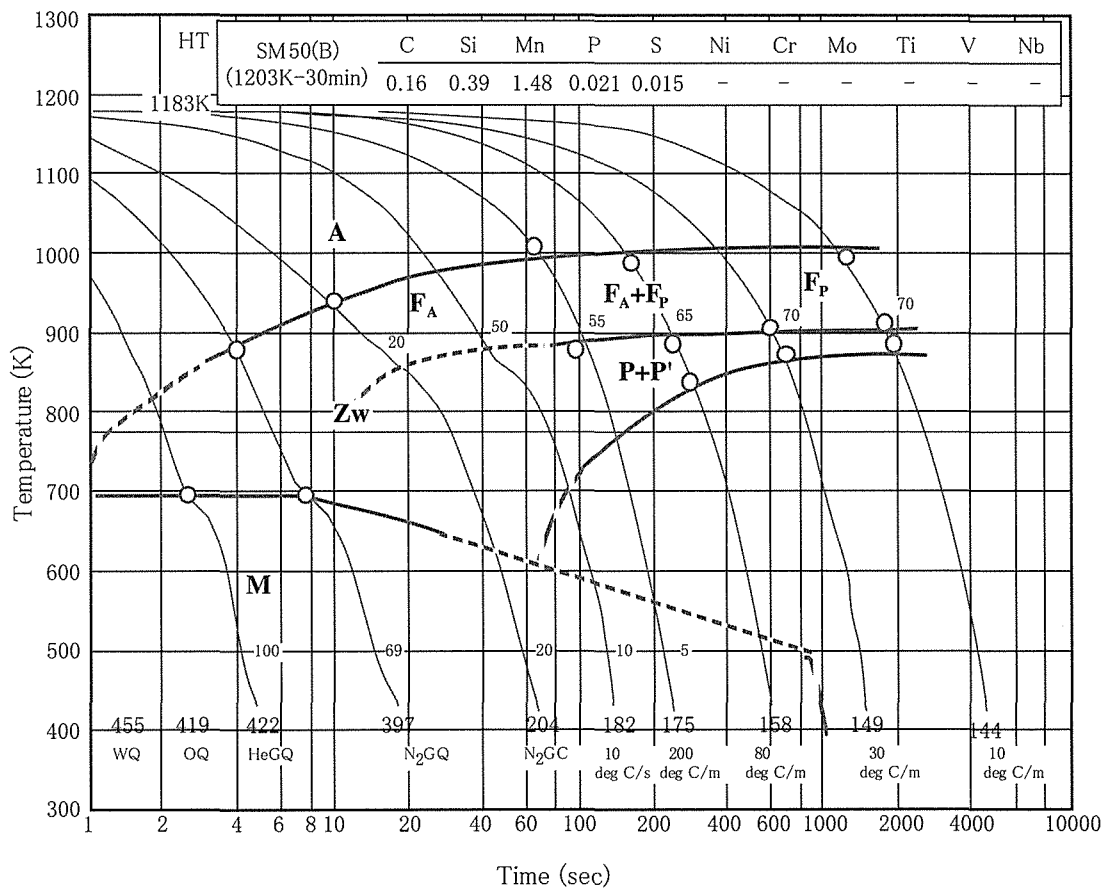
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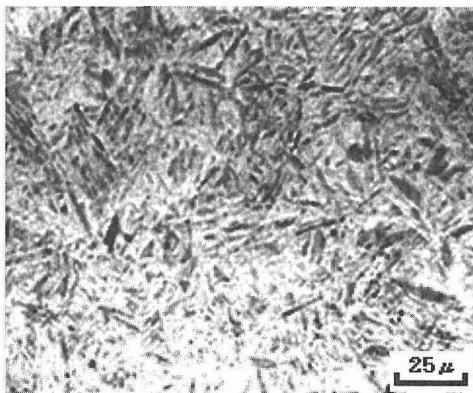
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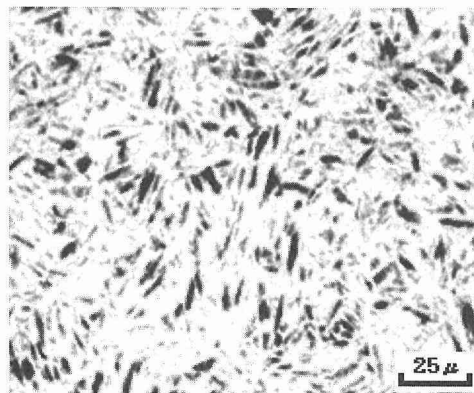
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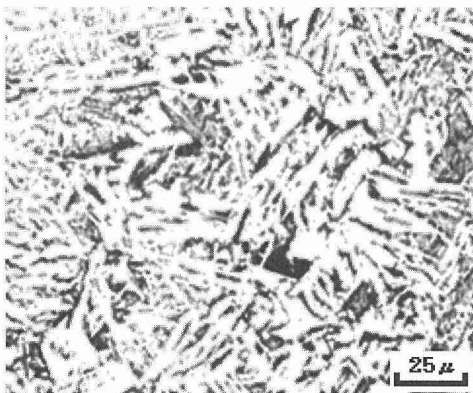
WQ

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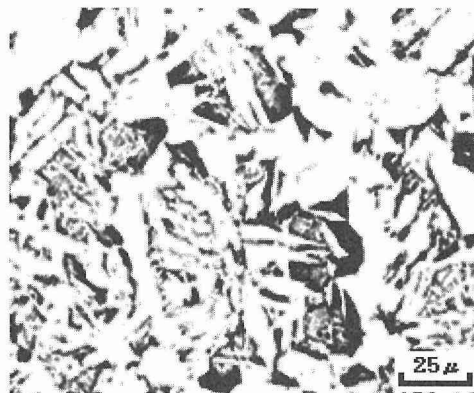
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Hv 419



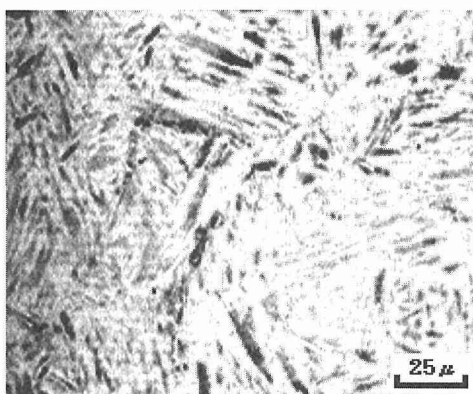
N₂GC

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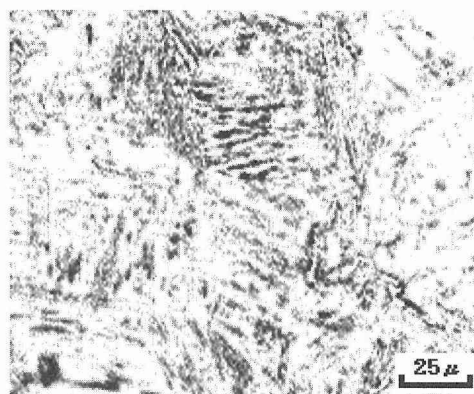
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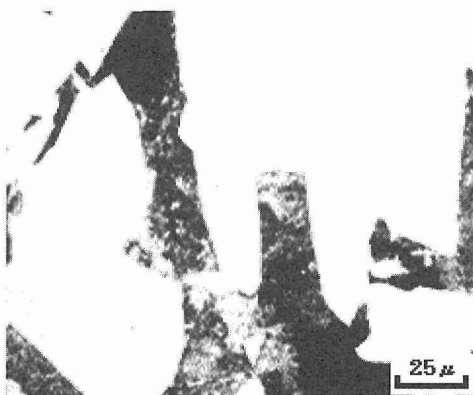
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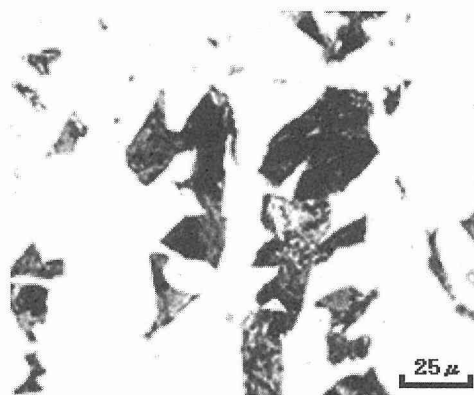
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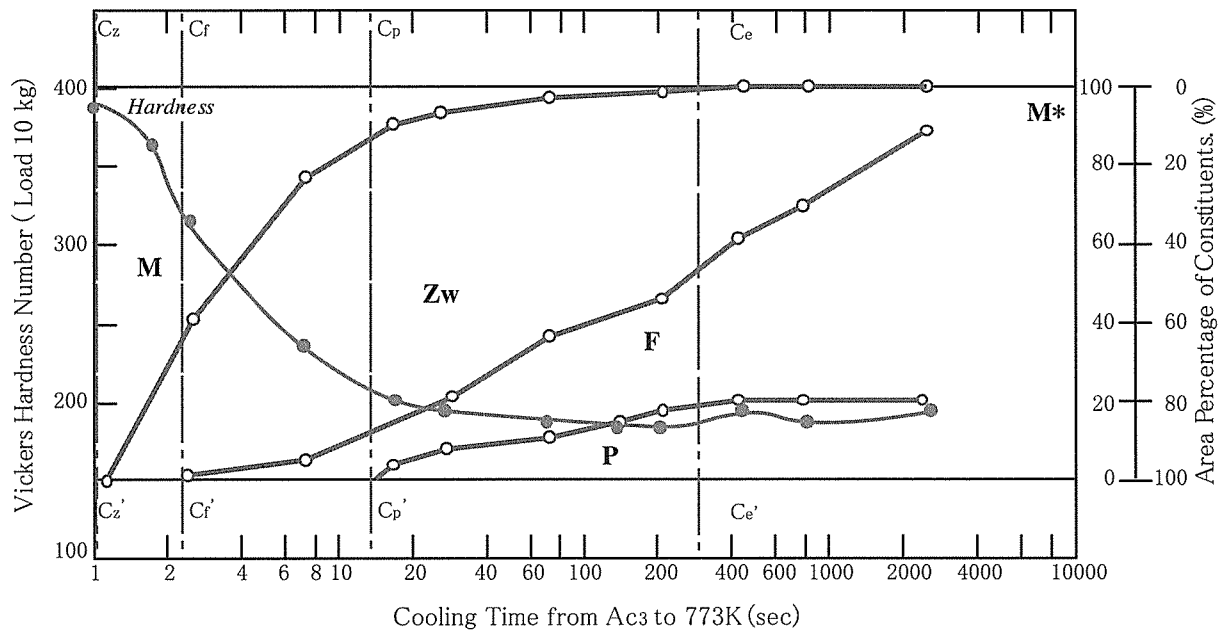
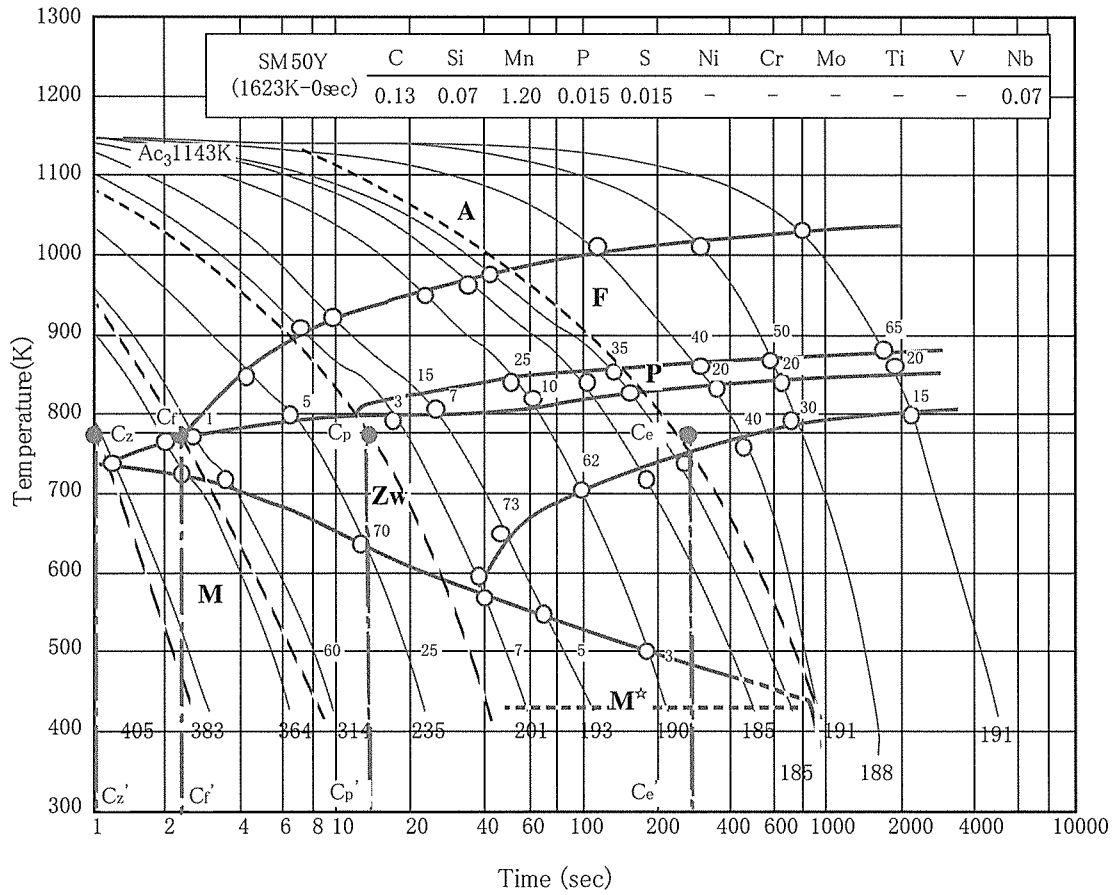
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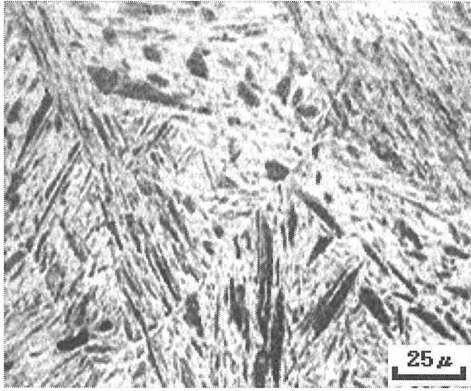
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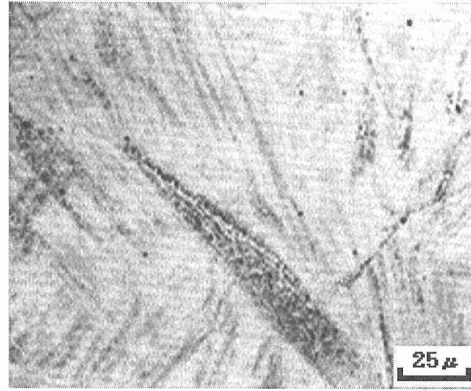
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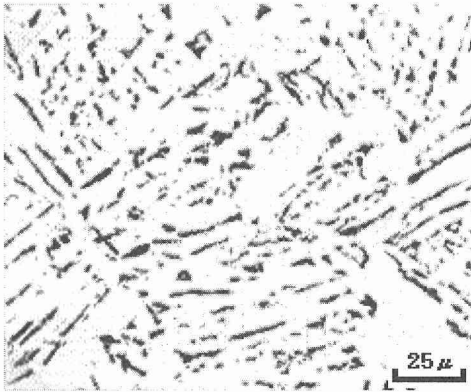




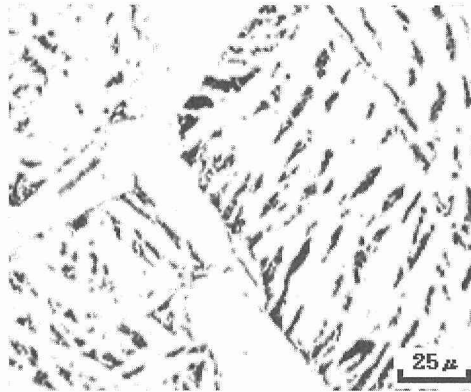
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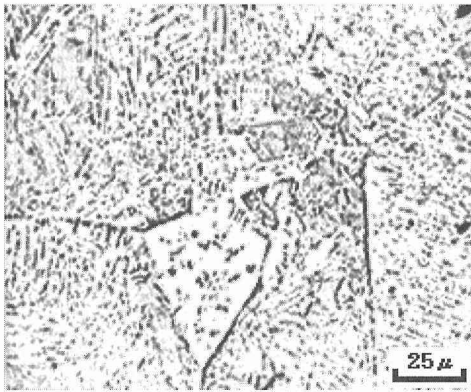
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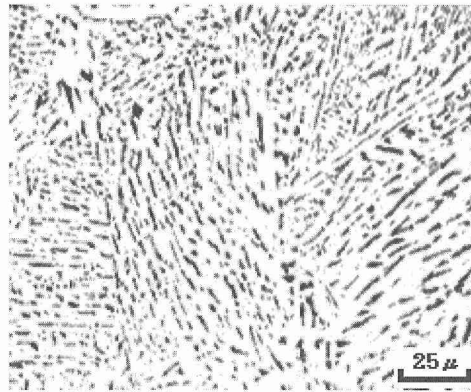
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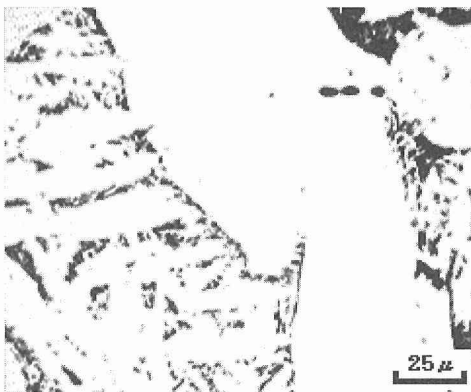
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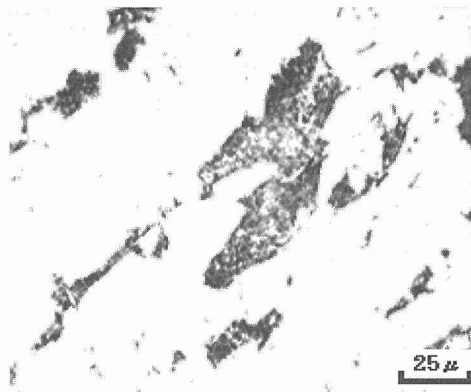
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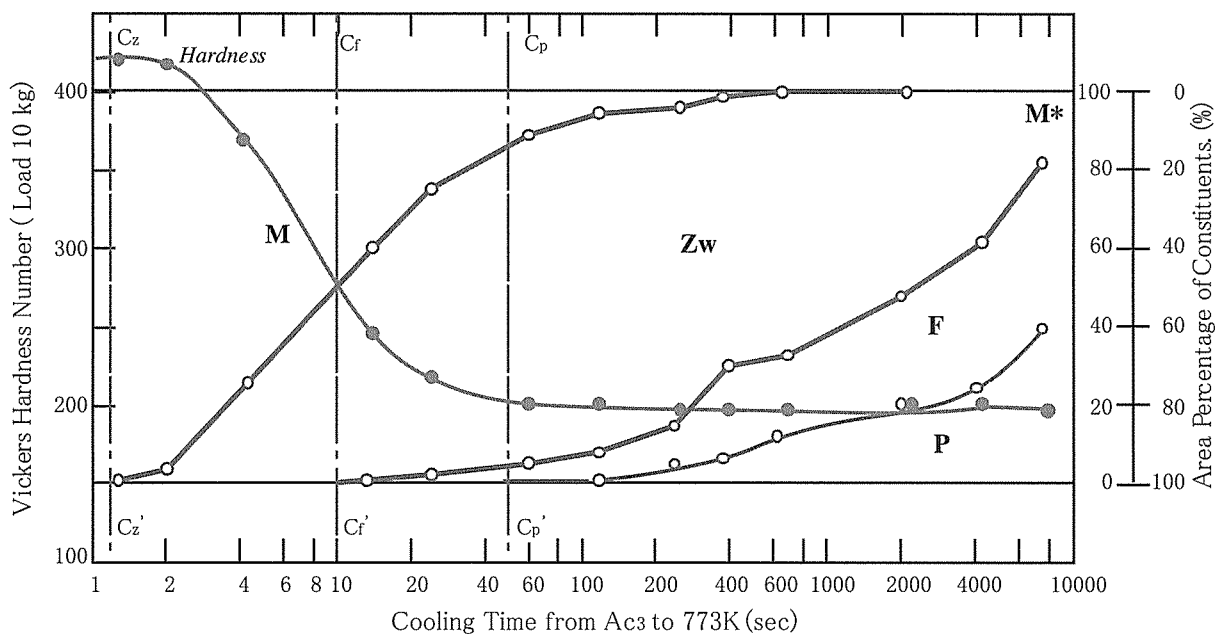
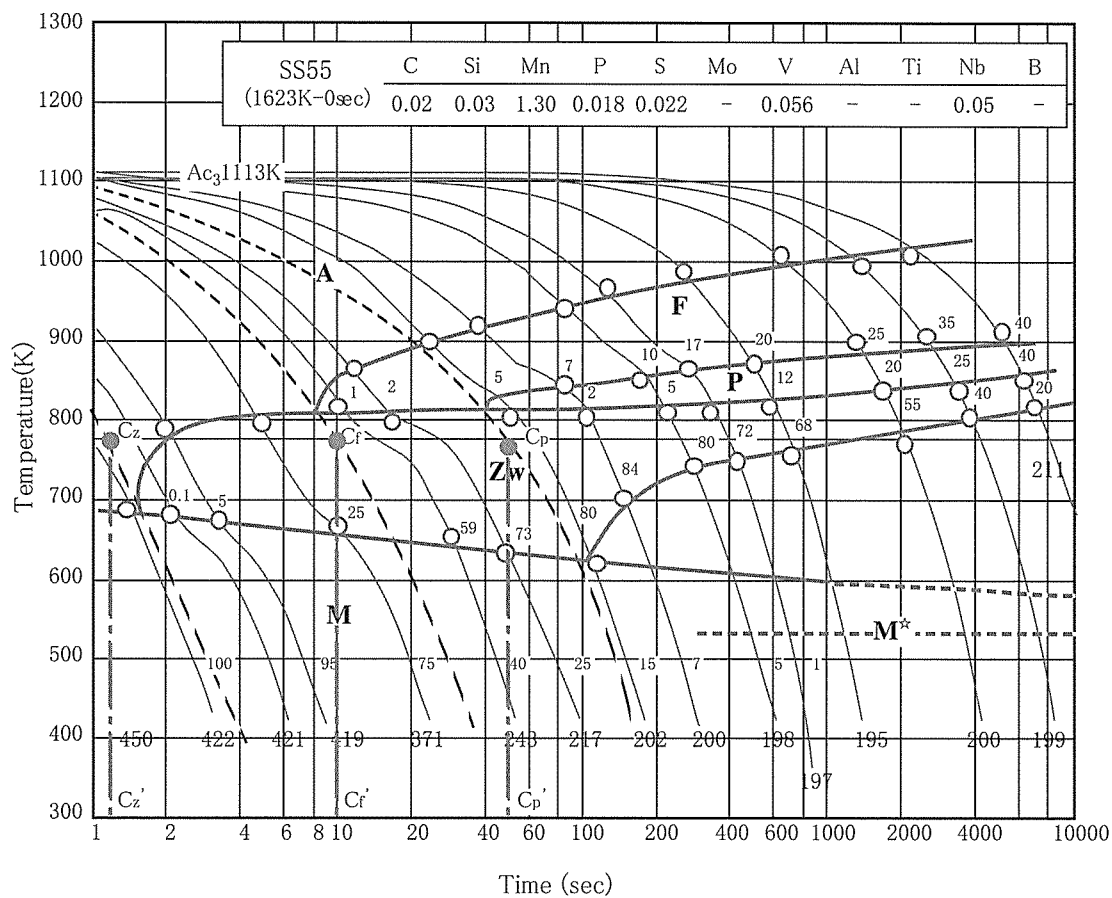


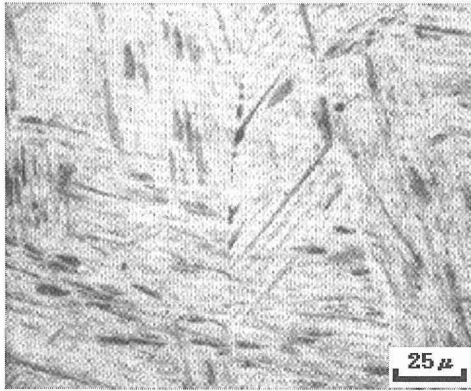
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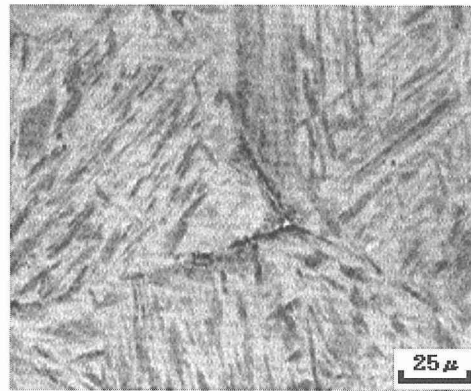
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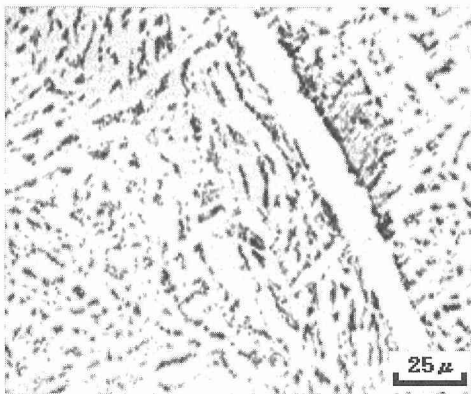




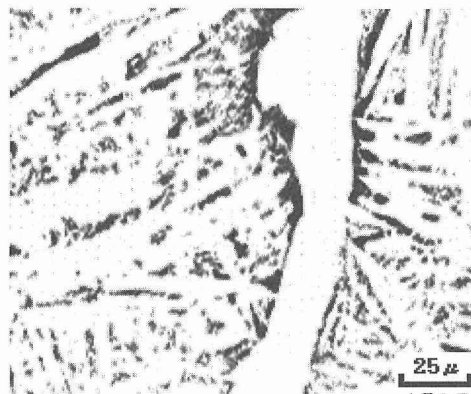
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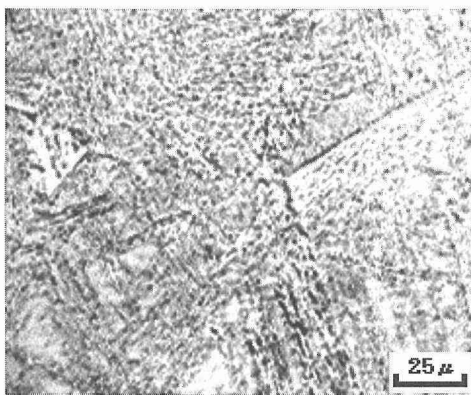
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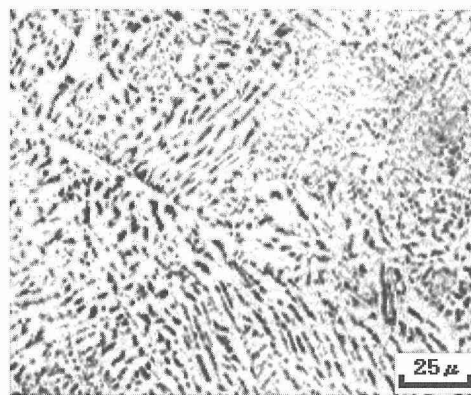
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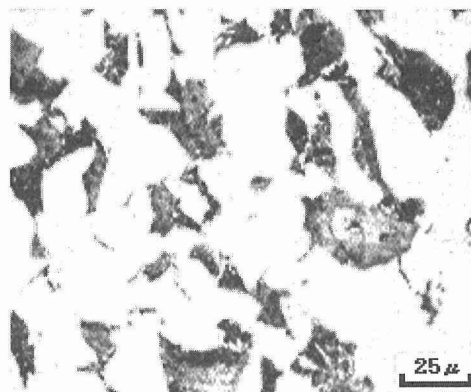
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Hv 202



Hv 211



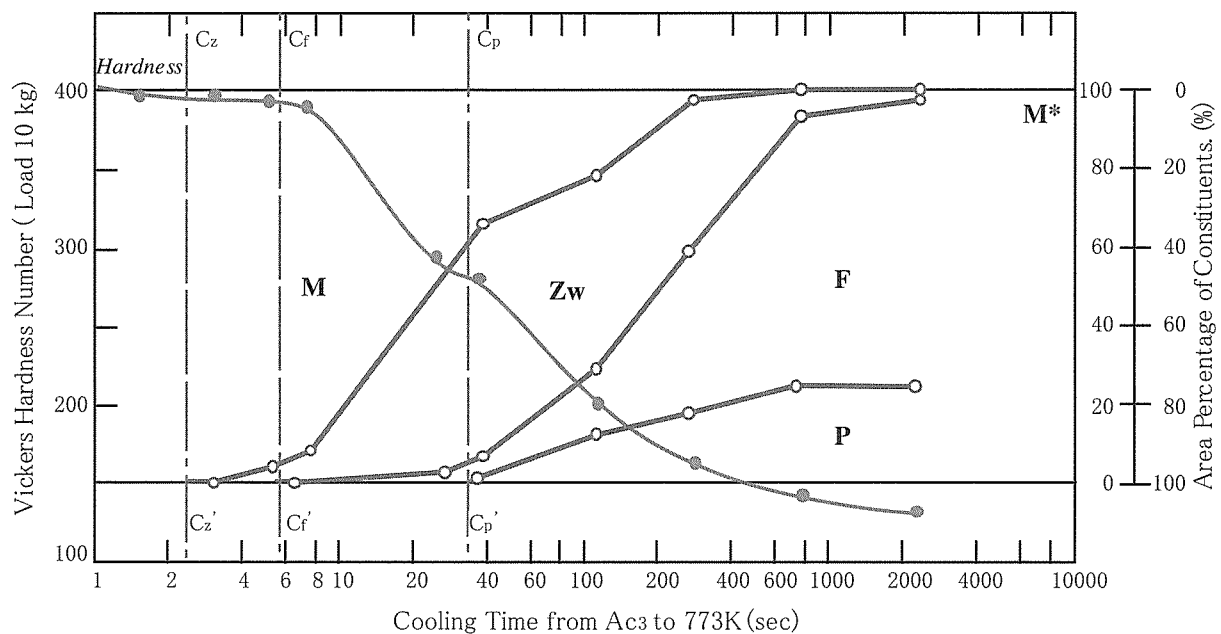
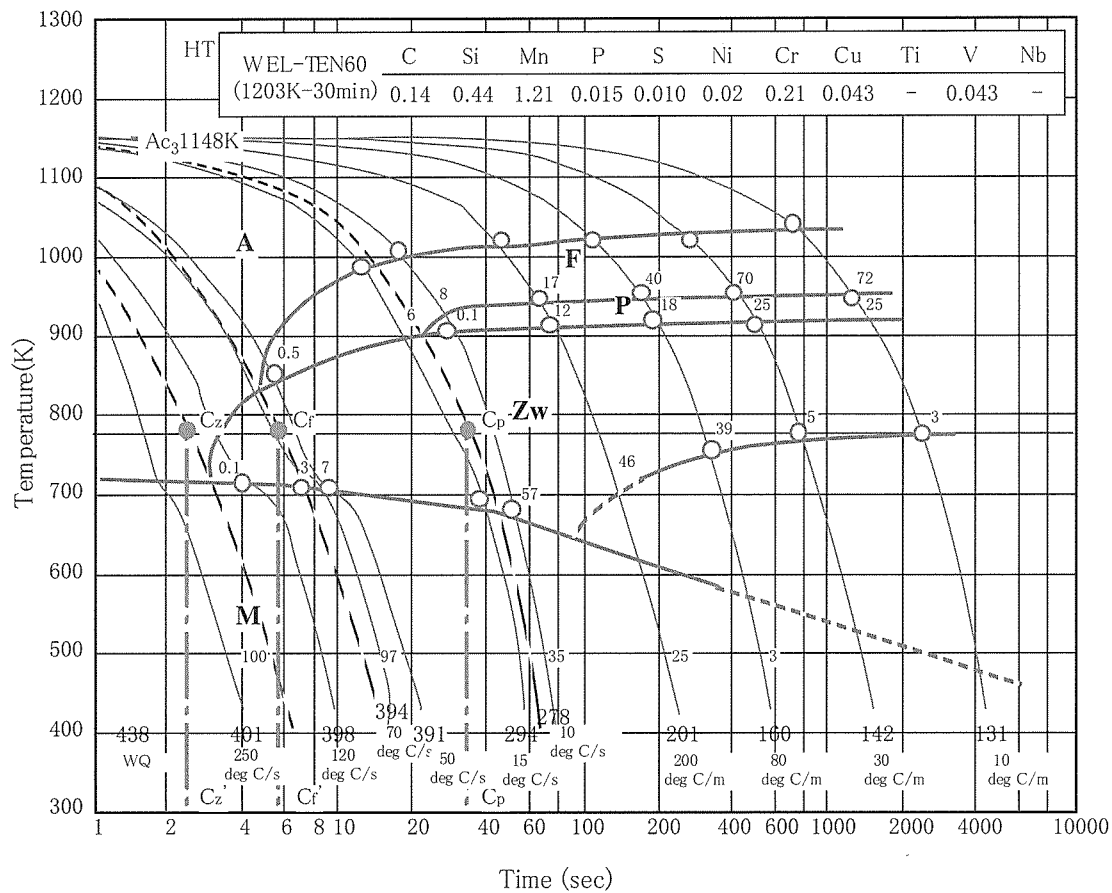
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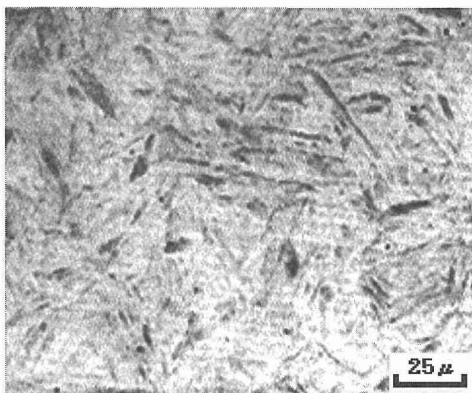
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High Tensile Strength Steel WEL-TEN series

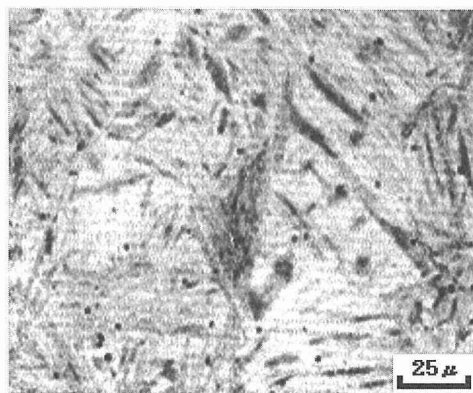
Steel	Chemical Composition (wt%)															Page	Ref.
	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Nb	B	O		
WEL-TEN60 [141CS4-B] HT	0.14	0.44	1.21	0.015	0.01	0.043	0.02	-	0.043	-	-	-	-	-	-	14	1
WEL-TEN60R [141CS3-A]	0.13	0.4	1.33	0.014	0.006	0.29	0.01	-	-	-	-	-	-	-	0.066	16	1
WEL-TEN60H [152NS-A]	0.14	0.47	1.5	0.015	0.003	-	0.57	-	0.05	-	-	-	0.05	-	-	18	1
WEL-TEN62 [151CS-A]	0.12	0.48	1.32	0.014	0.003	-	-	-	0.065	-	-	-	-	-	-	20	1
WEL-TEN74 [141CM2-A]	0.13	0.41	0.95	0.009	0.003	-	-	0.21	-	-	-	-	0.028	-	-	22	1
WEL-TEN74 [141CM2-B] HT	0.13	0.41	0.95	0.009	0.003	-	-	0.21	-	-	-	-	0.028	-	-	24	1
BHT80 [042NS-A]	0.033	0.42	1.98	0.008	0.003	0.76	0.77	-	-	-	0.029	-	0.049	-	-	26	1
WEL-TEN80 [131NCMS-A]	0.12	0.33	0.77	0.003	0.003	0.25	0.92	0.49	0.02	-	-	-	-	-	-	28	1
WEL-TEN80 [131NCMS-B] HT	0.12	0.33	0.77	0.003	0.003	0.25	0.92	0.49	0.02	-	-	-	-	-	-	30	1
WEL-TEN80C [131CMS-A]	0.13	0.33	0.86	0.006	0.005	0.27	0.05	0.45	0.049	-	-	-	-	-	-	32	1
WEL-TEN80C [131CMS-B] HT	0.13	0.33	0.86	0.006	0.005	0.27	0.05	0.45	0.049	-	-	-	-	-	-	34	1
WEL-TEN80S-A [161CMS-A]	0.074	0.57	1.35	0.009	0.003	0.12	0.06	0.52	0.06	-	0.026	-	-	-	-	36	1
WEL-TEN80S-B [161NCMS-A]	0.086	0.56	1.47	0.014	0.006	0.12	0.95	0.52	0.06	-	0.017	-	-	-	-	38	1
WEL-TEN80S-B [161NCMS-B] HT	0.086	0.56	1.47	0.014	0.006	0.12	0.95	0.52	0.06	-	0.017	-	-	-	-	40	1
WEL-TEN100N [231NCMS-A]	0.15	0.25	0.82	0.009	0.007	0.24	0.93	0.54	0.06	-	-	-	-	-	-	42	1

HT: CCT diagram to be used the purpose of heat treatment. Heating at temperature below 1623K for welding.

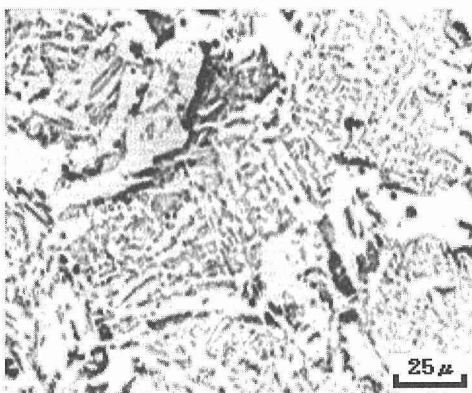




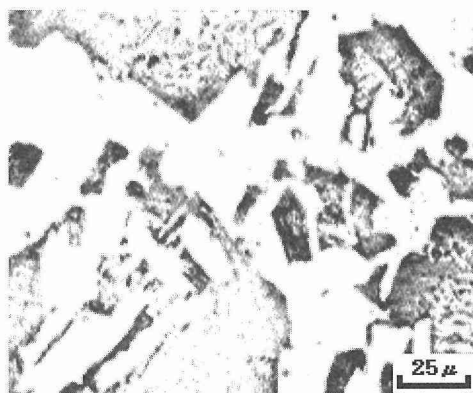
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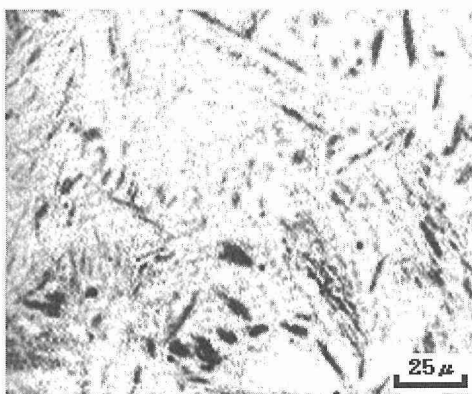
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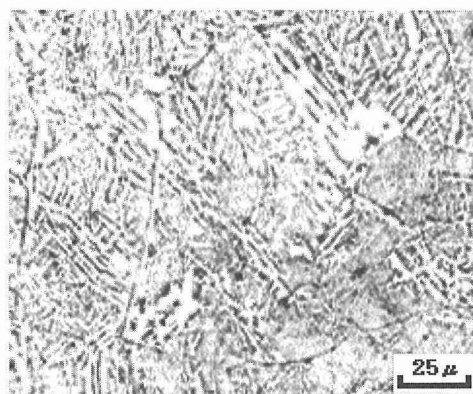
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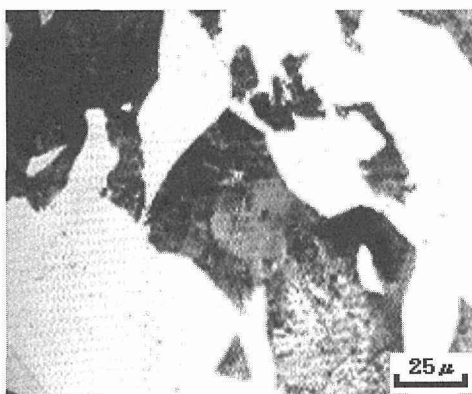
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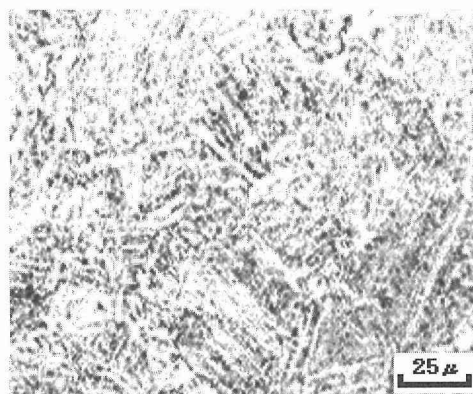
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Hv 278

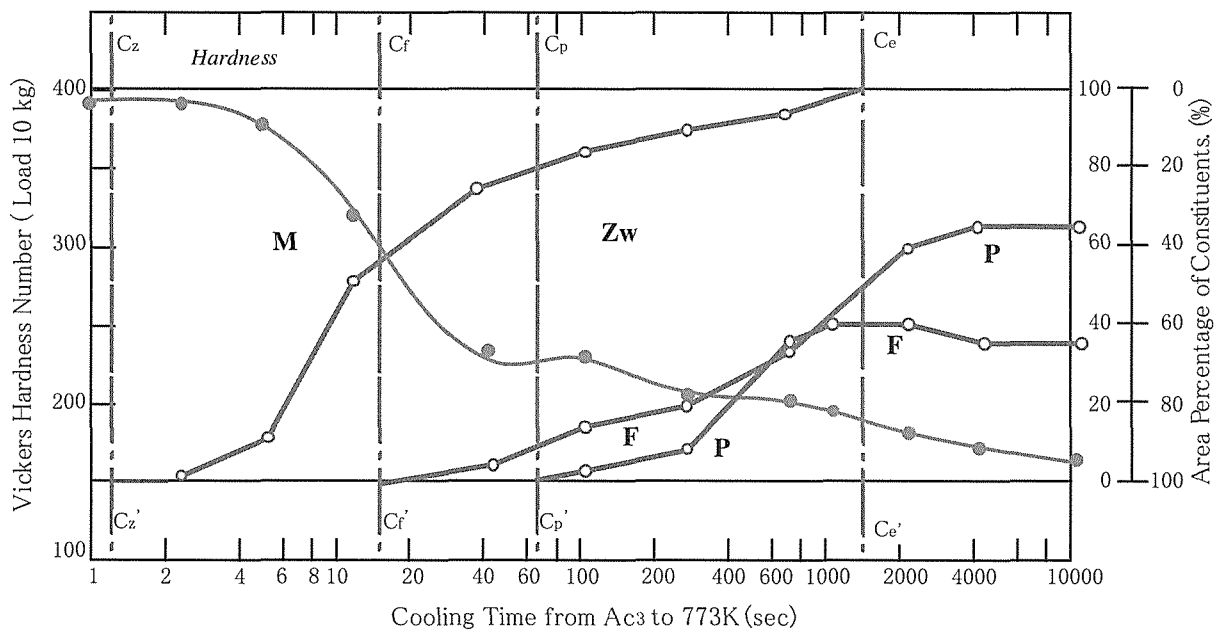
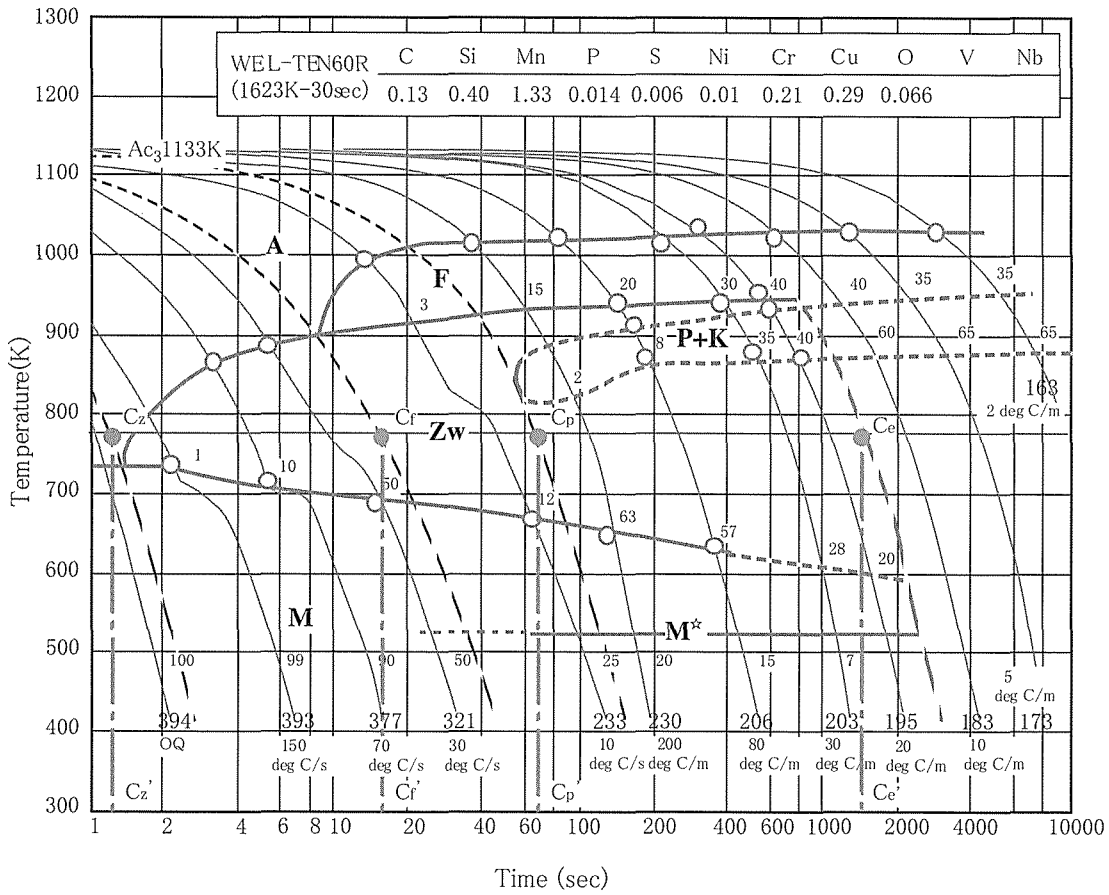


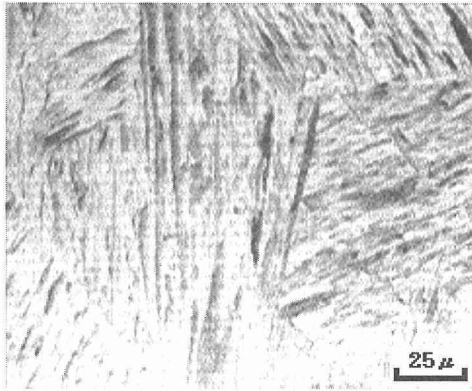
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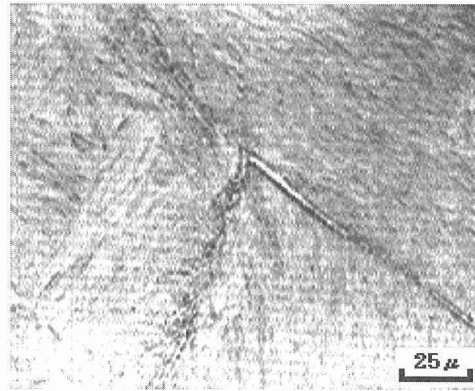
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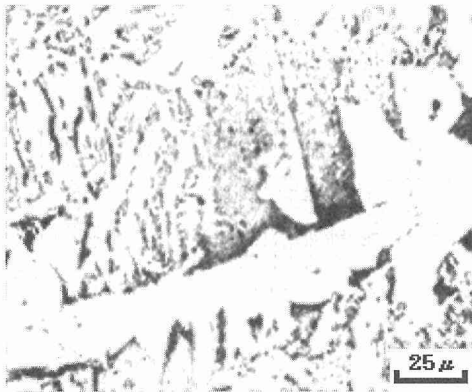
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Hv 394



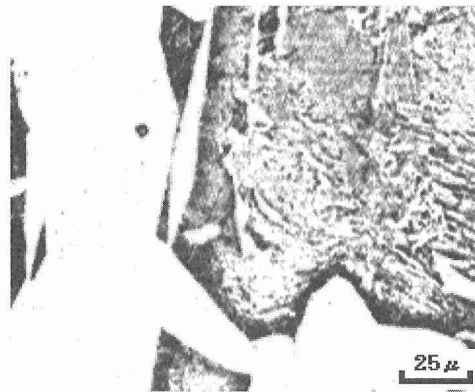
70 deg C/s

Hv 377



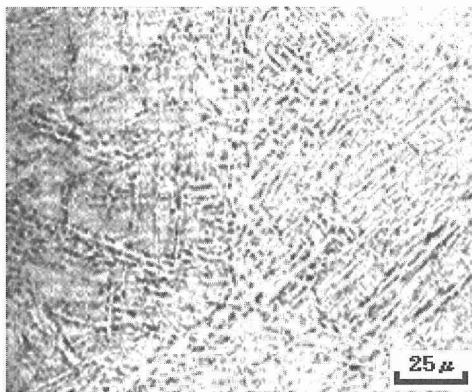
80 deg C/m

Hv 206



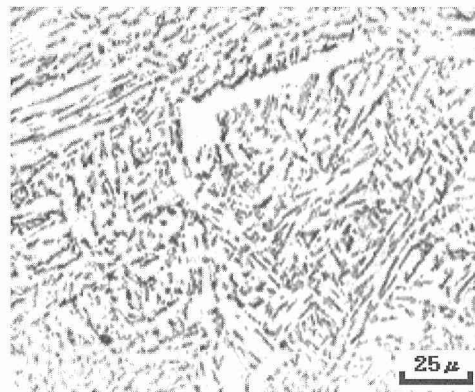
10 deg C/m

Hv 183



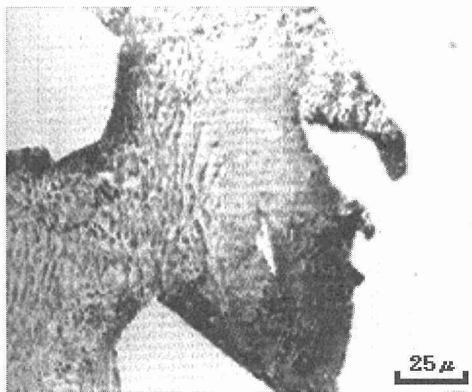
30 deg C/s

Hv 321



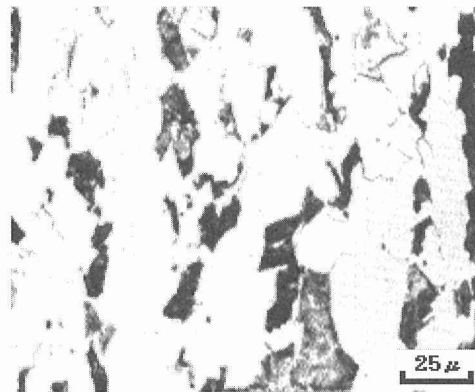
10 deg C/s

Hv 233



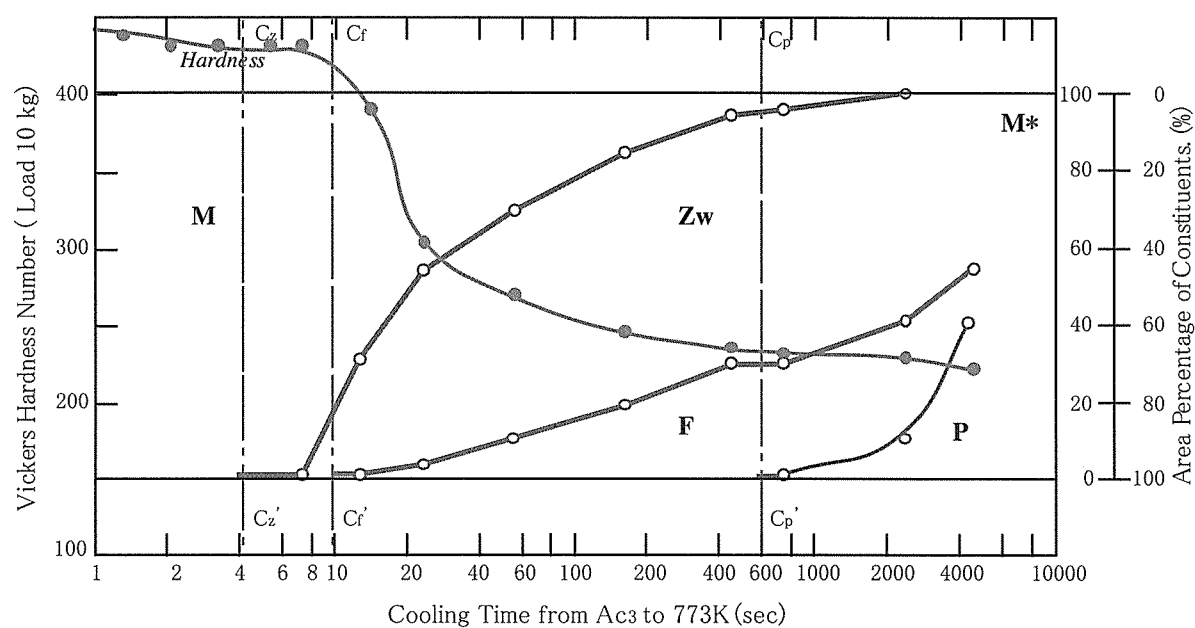
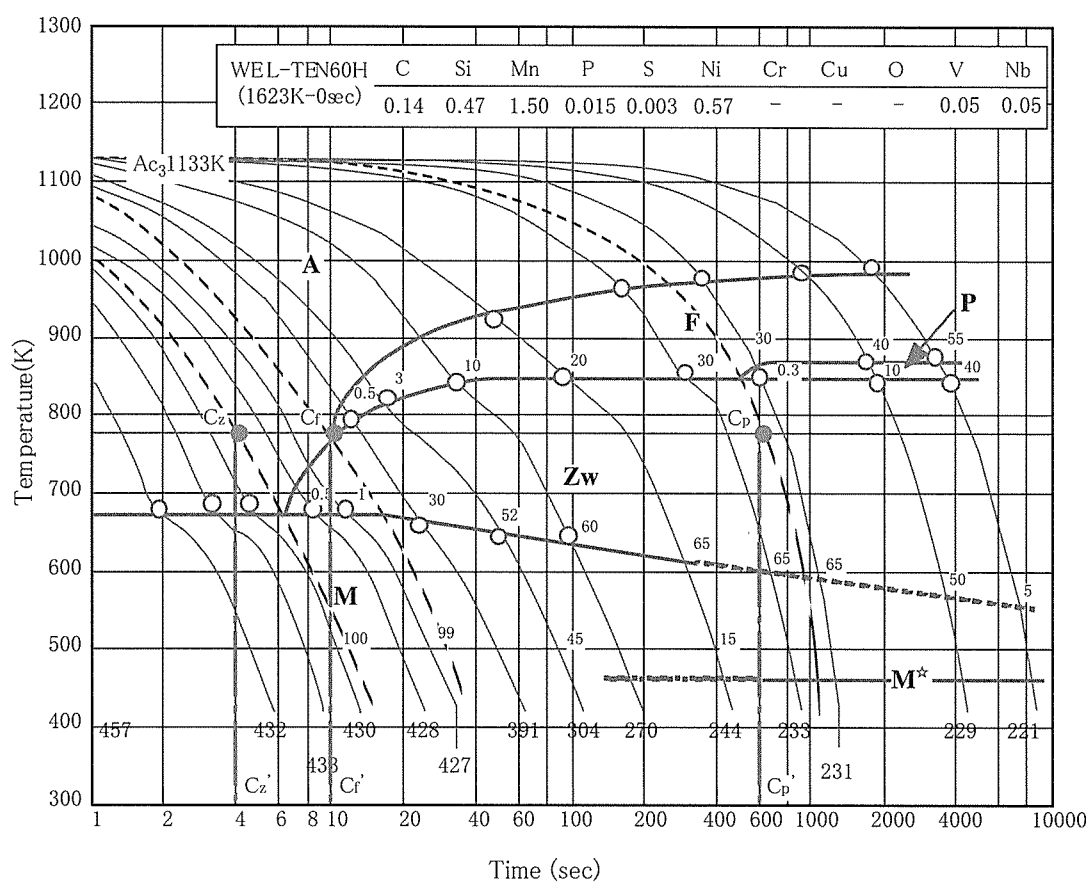
2 deg C/m

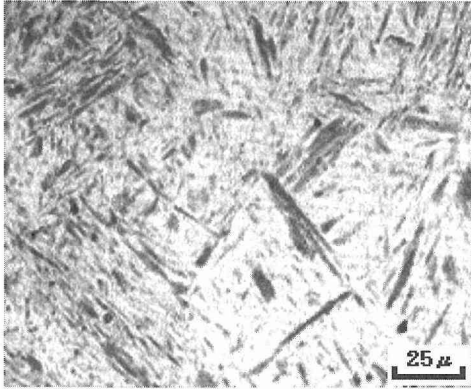
Hv 163



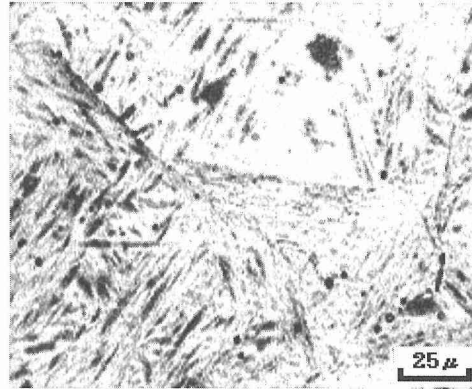
As received

Hv 189

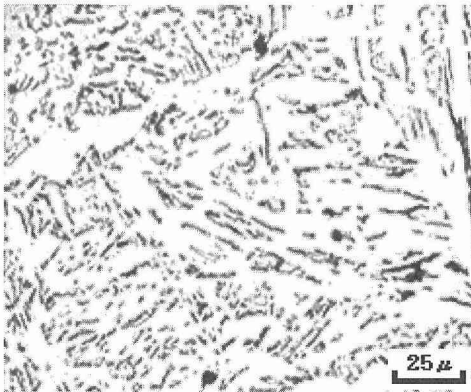




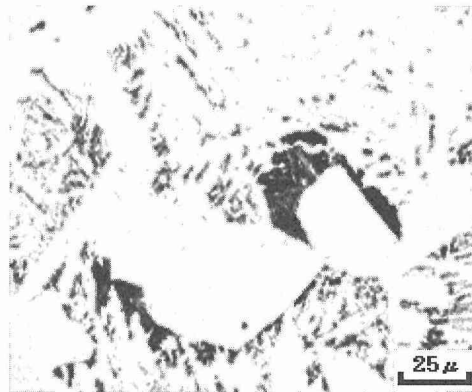
Hv 457



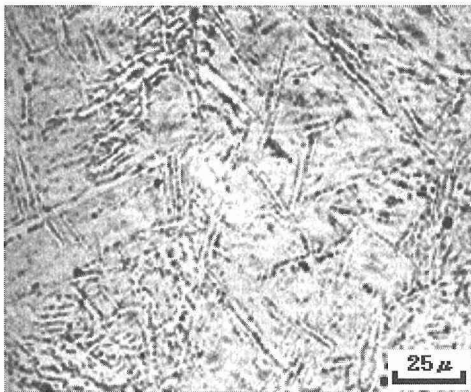
Hv 427



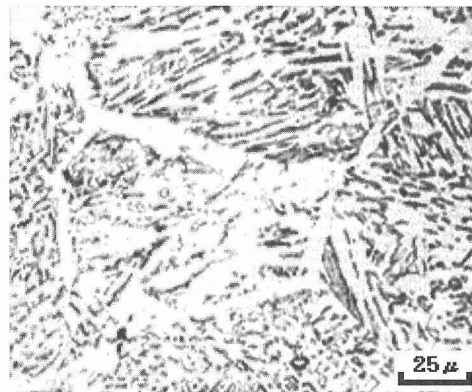
Hv 233



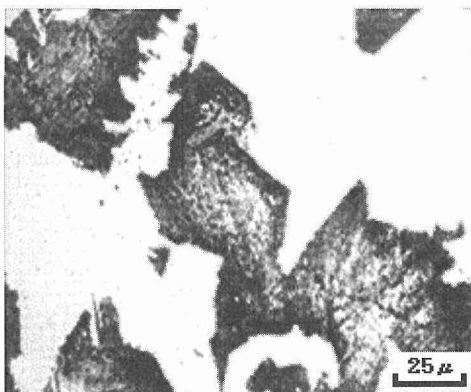
Hv 229



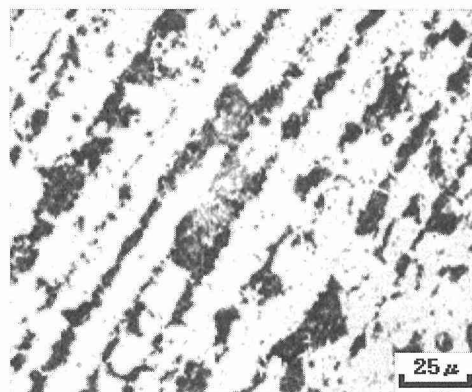
Hv 304



Hv 244

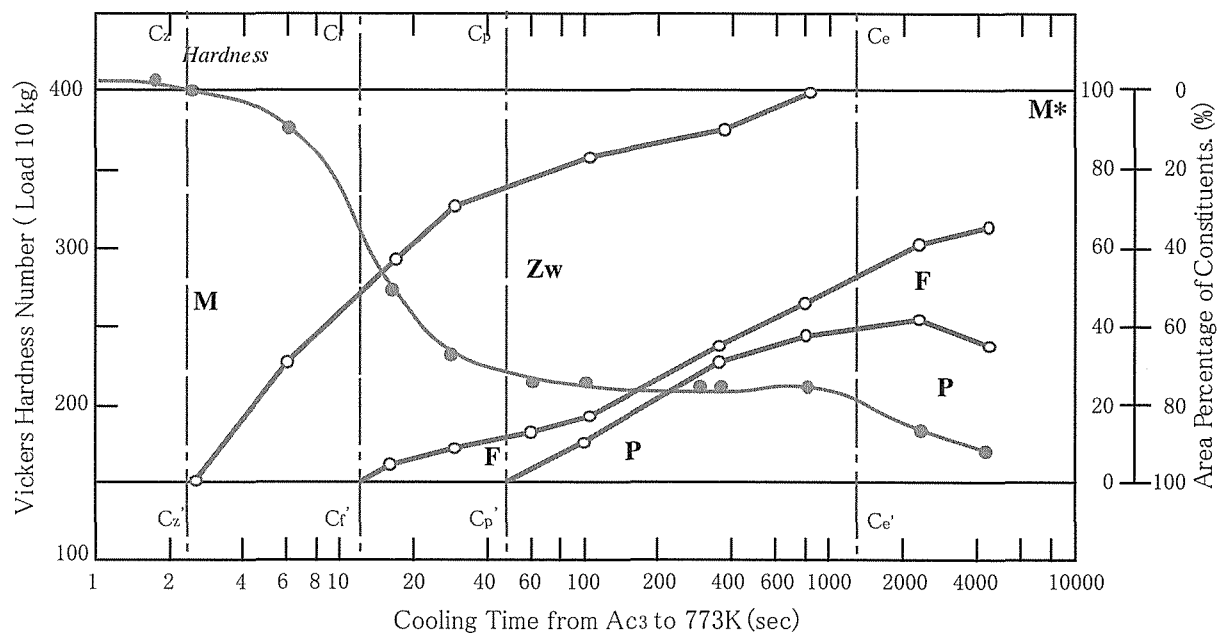
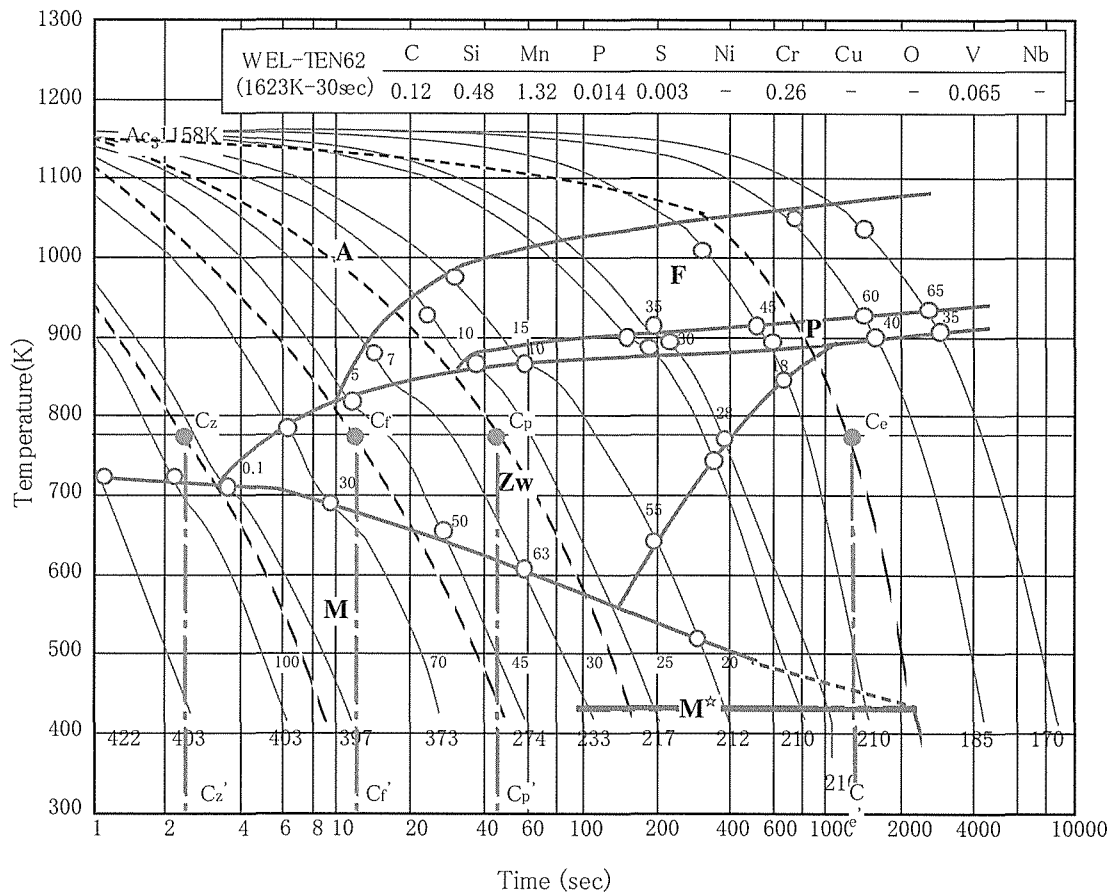


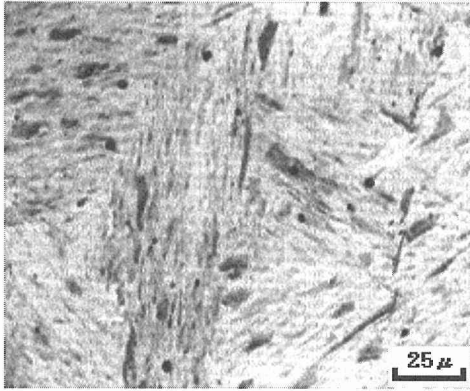
Hv 221



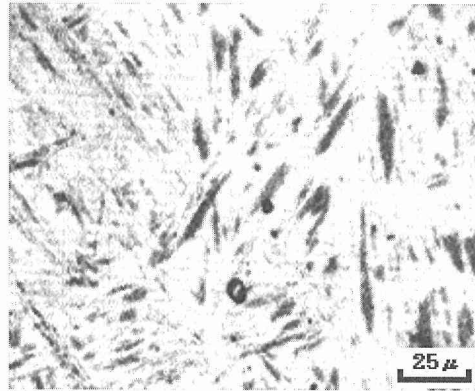
Hv 186

As received

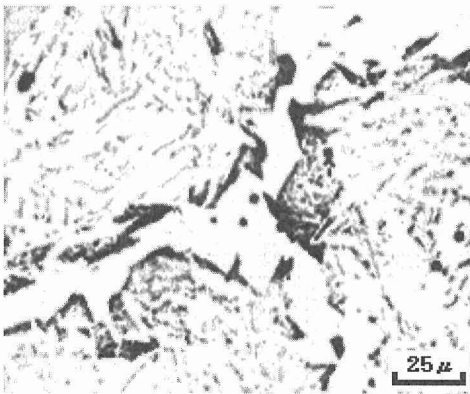




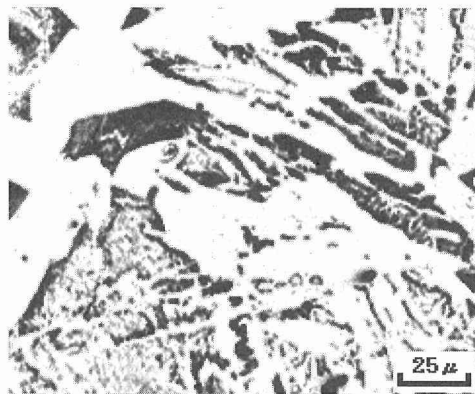
Hv 422



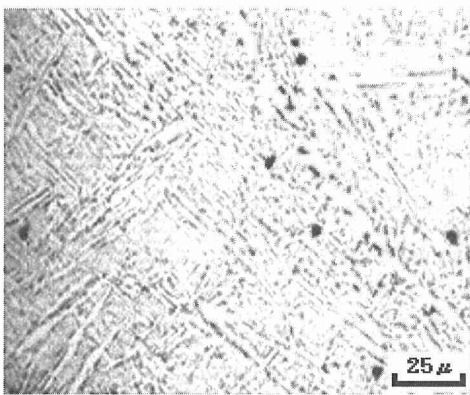
Hv 397



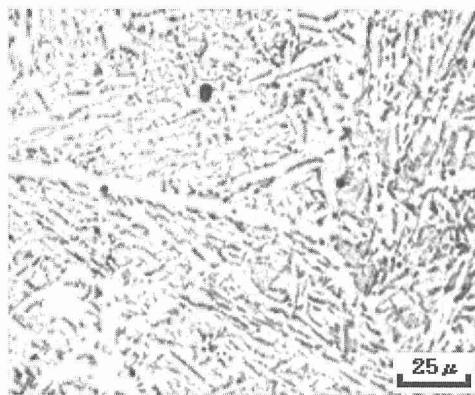
Hv 212



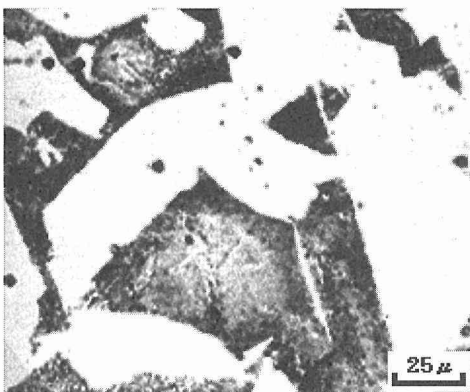
Hv 210



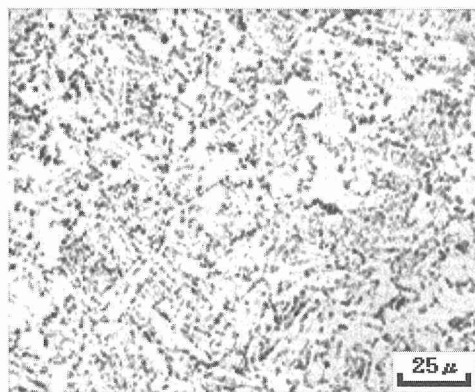
Hv 274



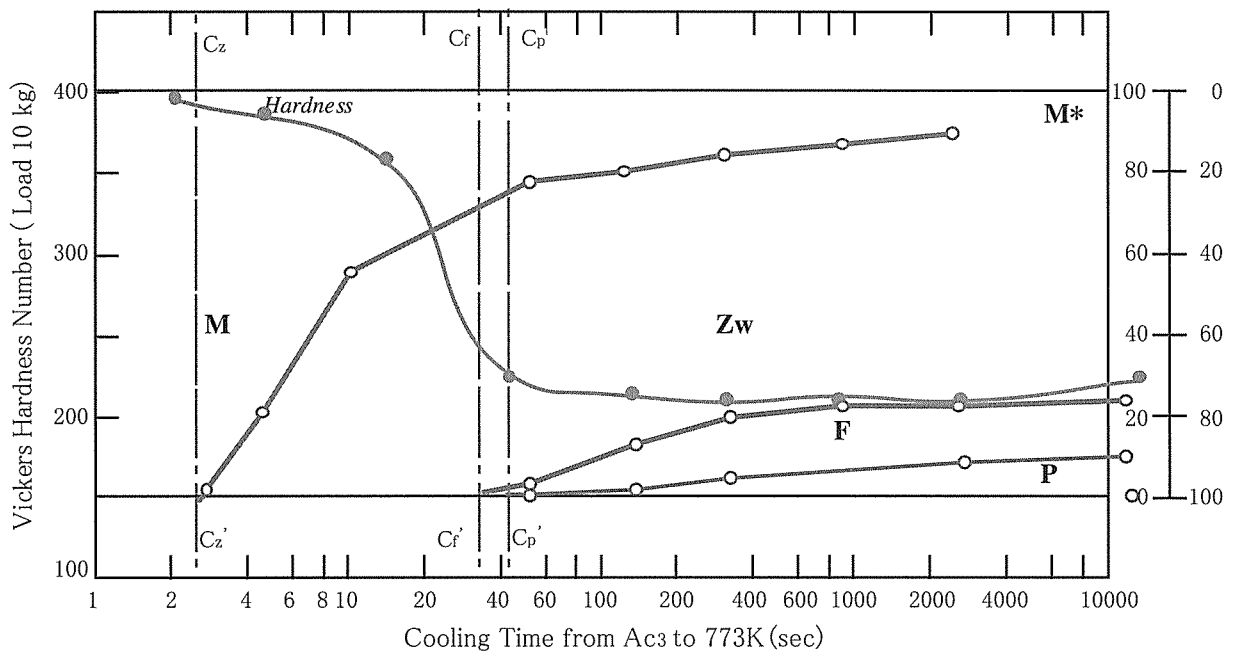
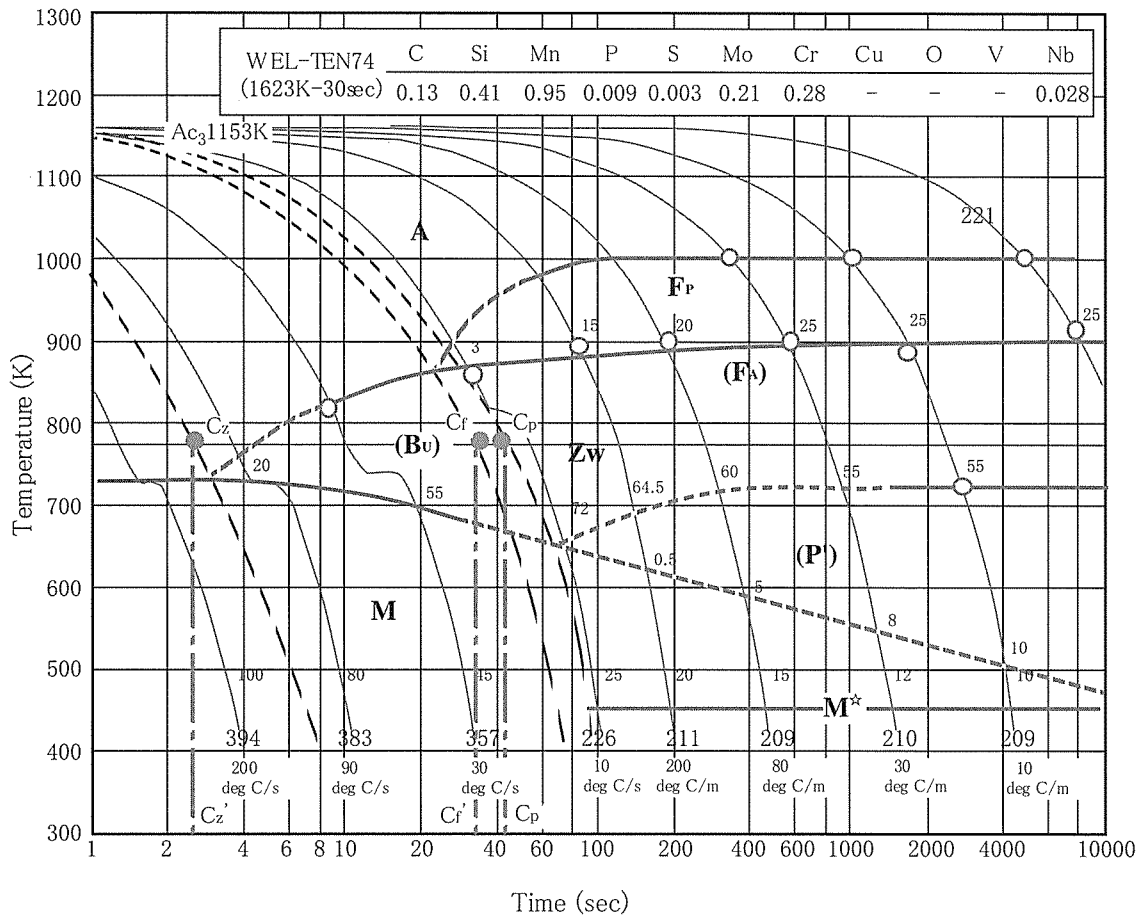
Hv 233

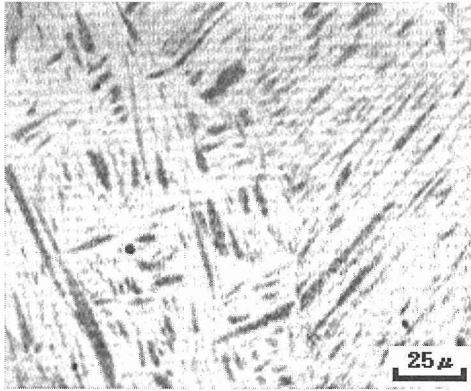


Hv 170



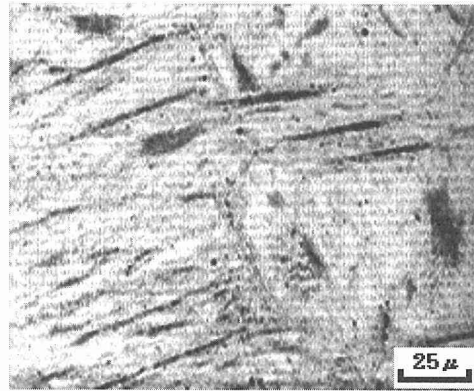
Hv 201





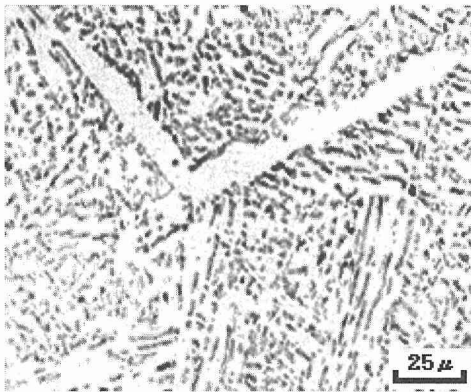
200 deg C/s

Hv 394



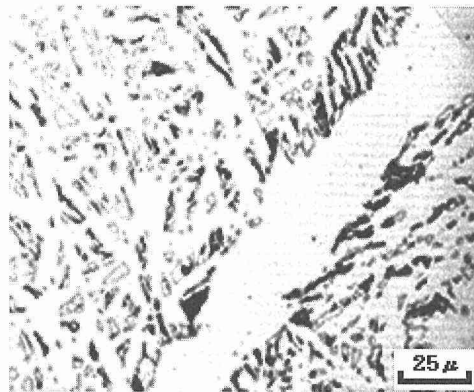
90 deg C/s

Hv 383



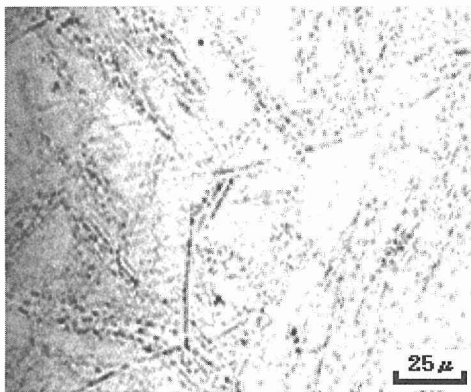
200 deg C/m

Hv 211



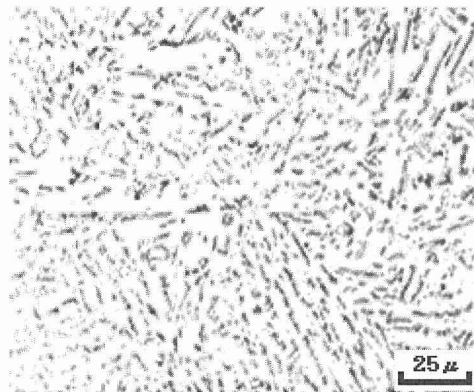
30 deg C/m

Hv 210



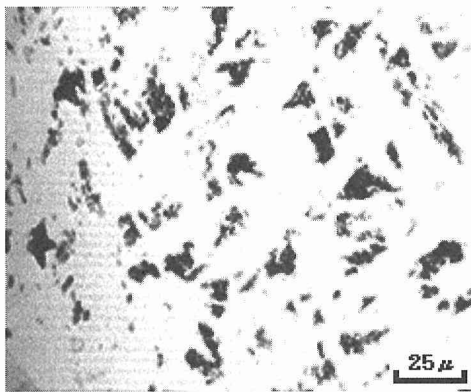
30 deg C/s

Hv 357



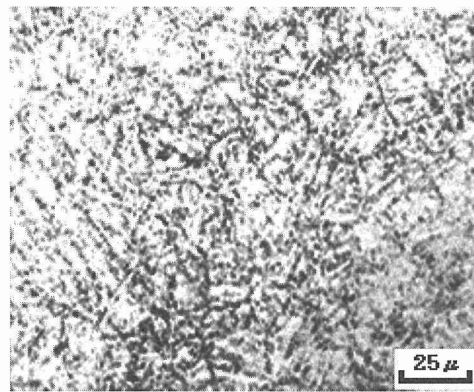
10 deg C/s

Hv 226



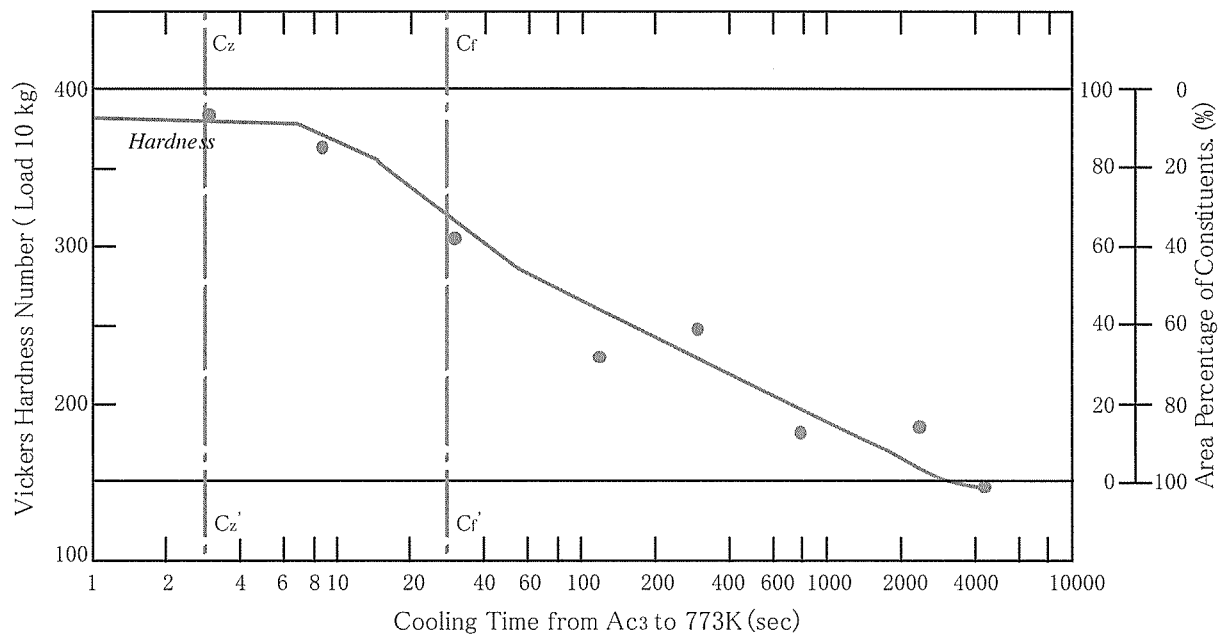
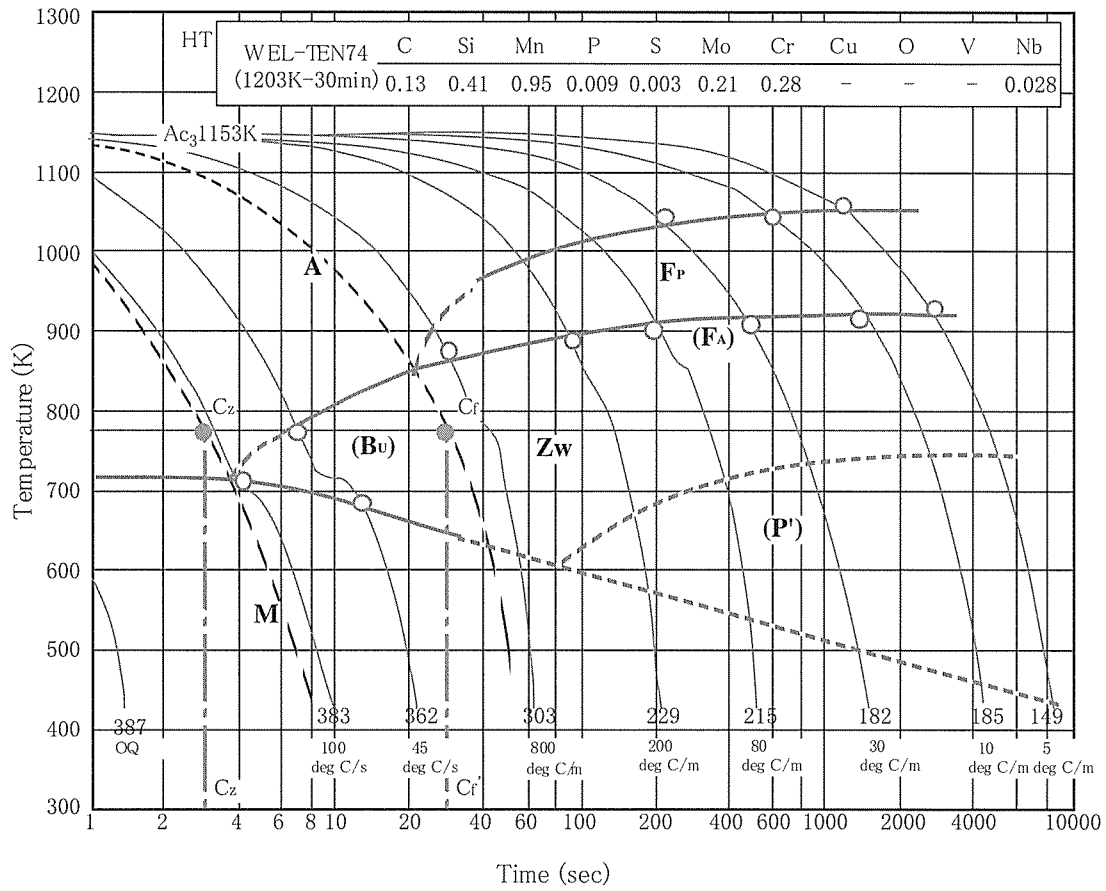
2 deg C/m

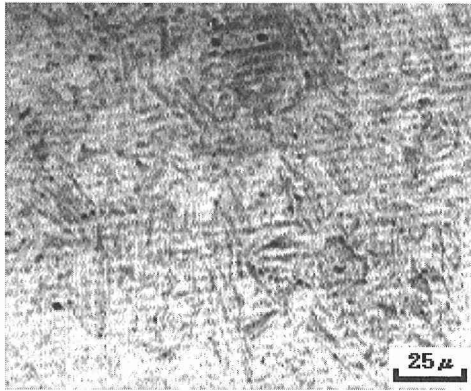
Hv 221



As received

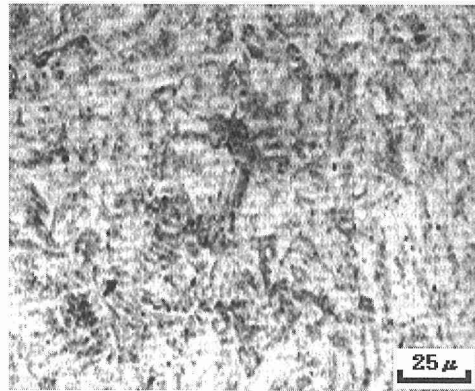
Hv 236





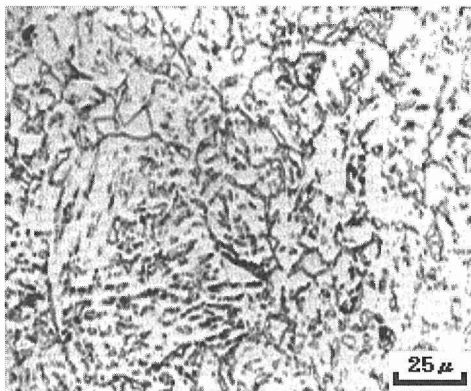
OQ

Hv 387



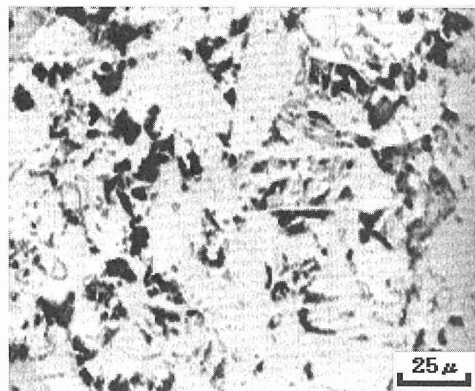
100 deg C/s

Hv 383



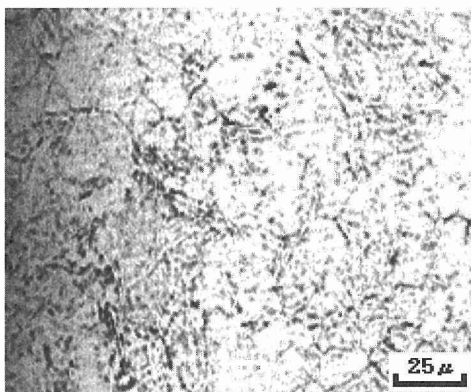
200 deg C/m

Hv 229



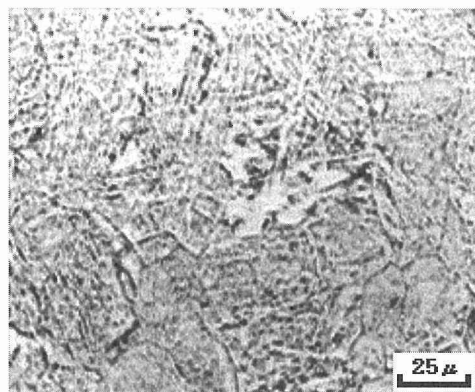
30 deg C/m

Hv 182



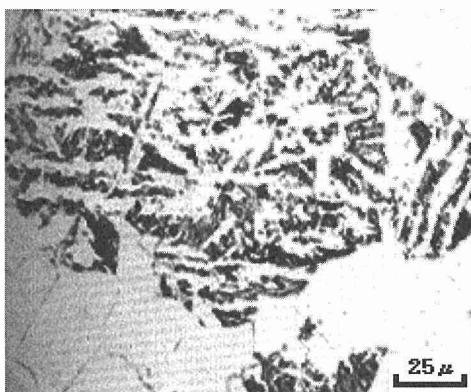
45 deg C/s

Hv 362



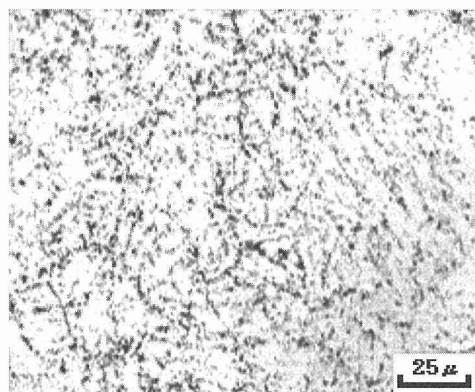
800 deg C/m

Hv 303



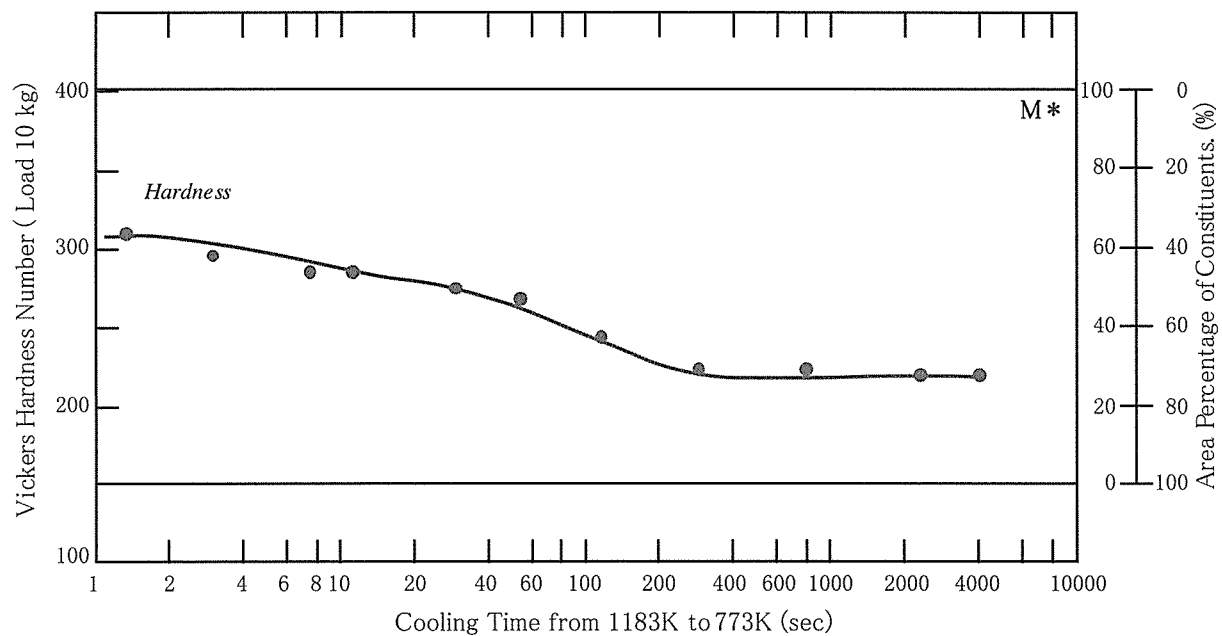
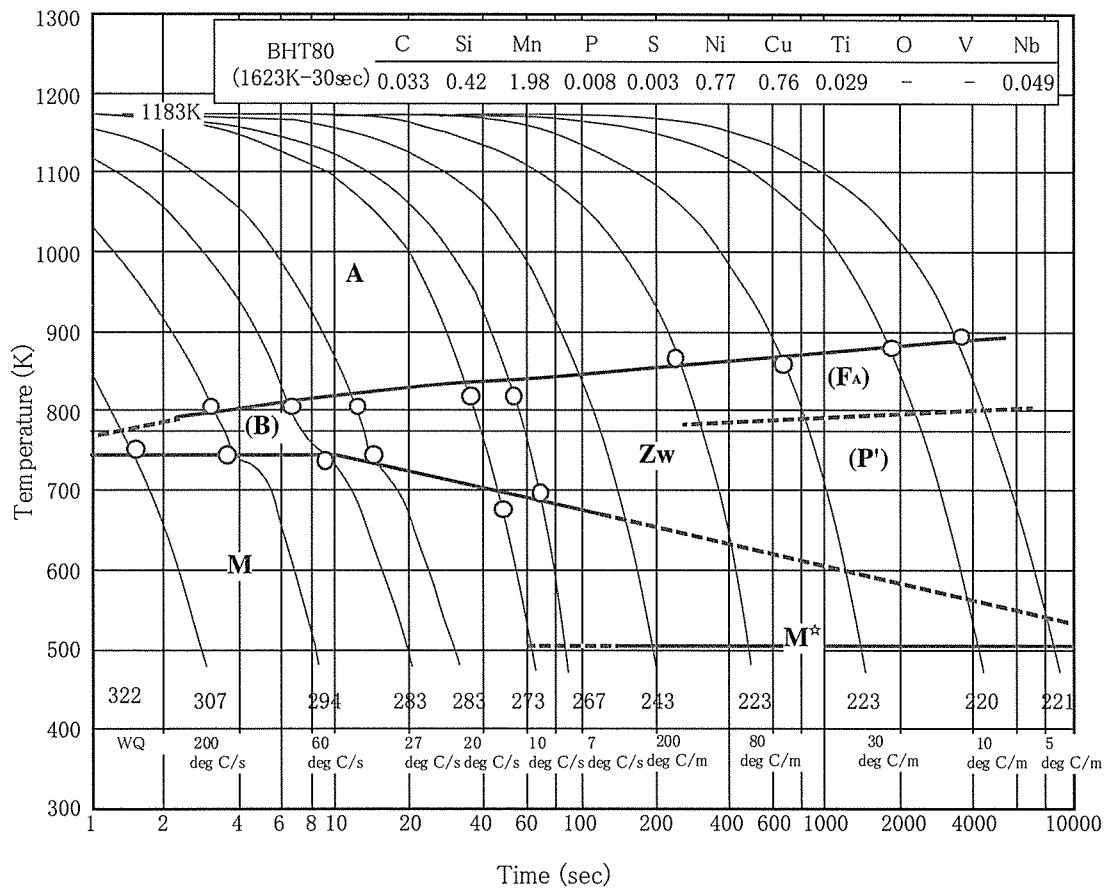
5 deg C/m

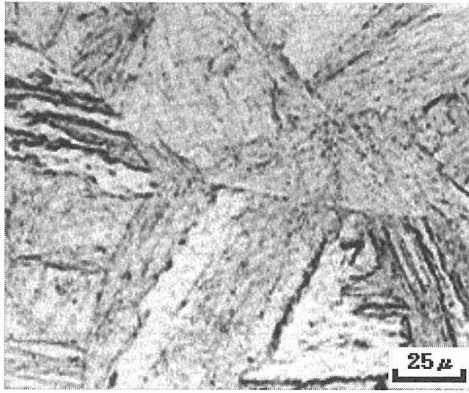
Hv 149



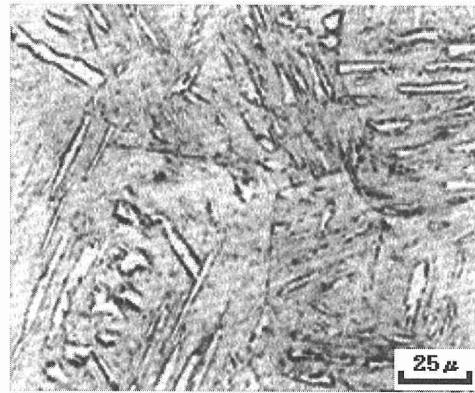
As received

Hv 236



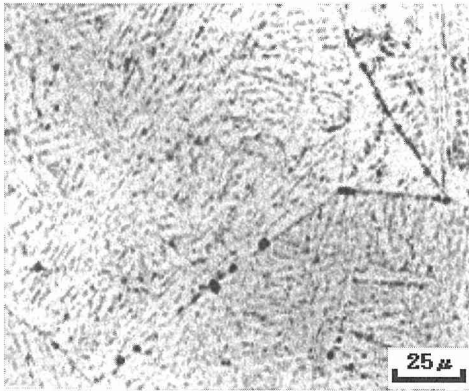


Hv 322



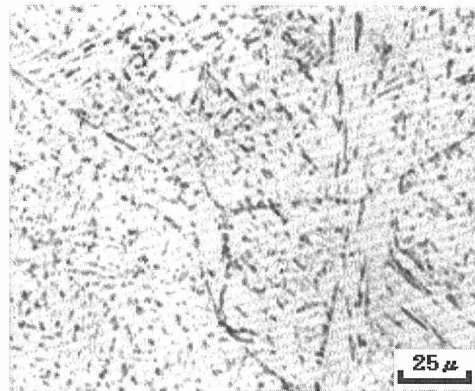
200 deg C/s

Hv 307



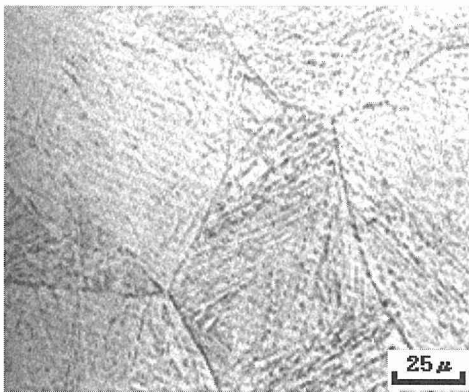
200 deg C/m

Hv 243



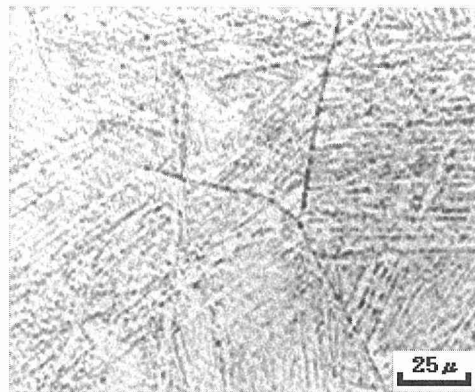
80 deg C/m

Hv 223



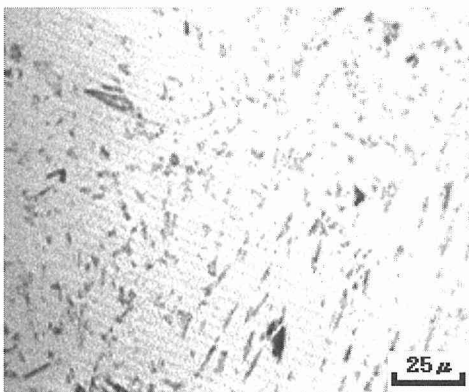
27 deg C/s

Hv 283



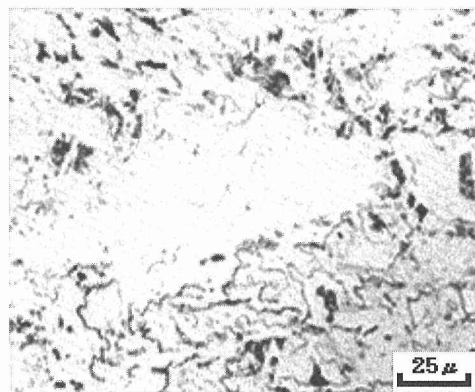
10 deg C/s

Hv 273



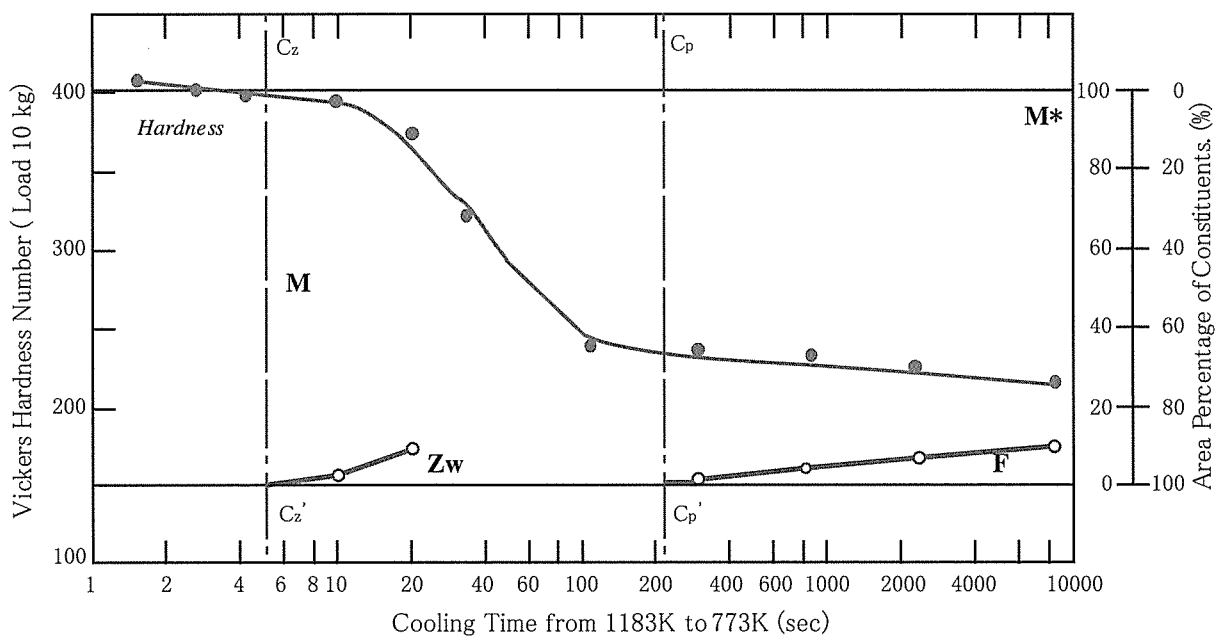
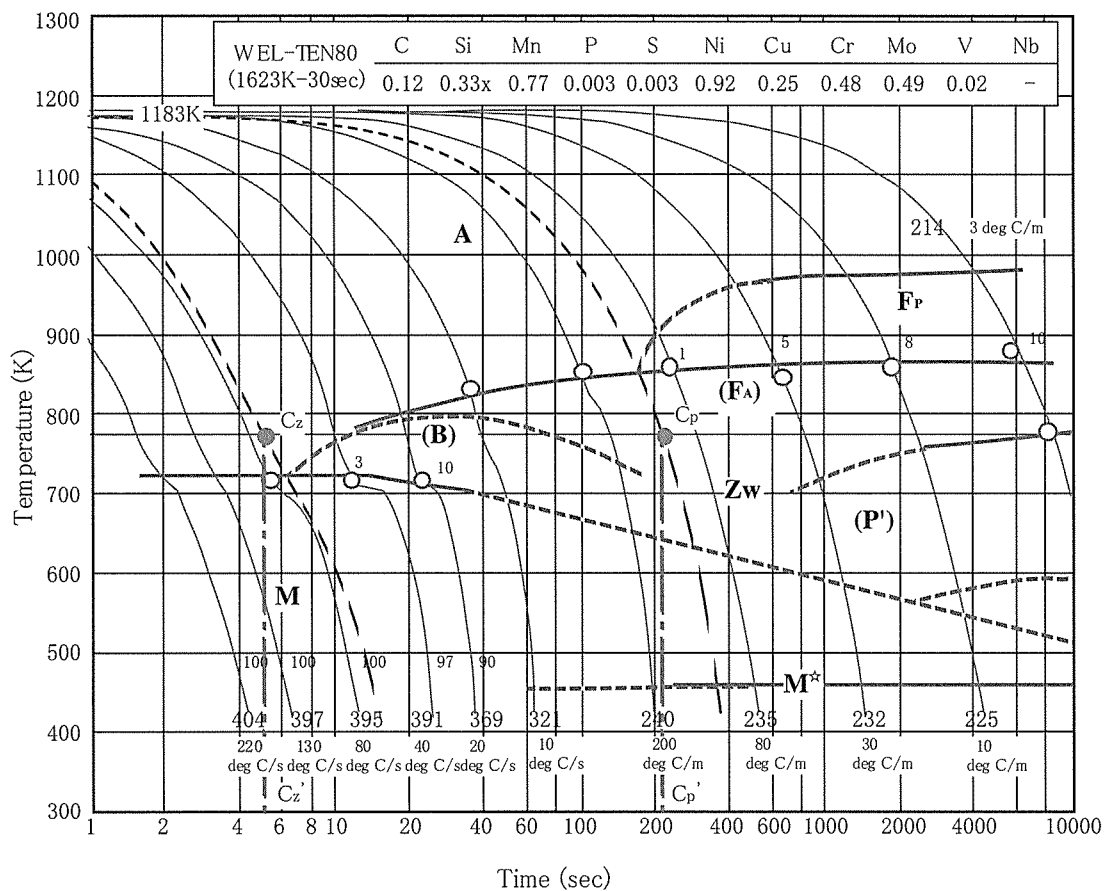
10 deg C/m

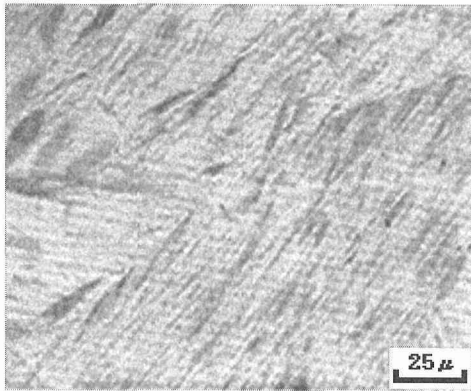
Hv 109



As received

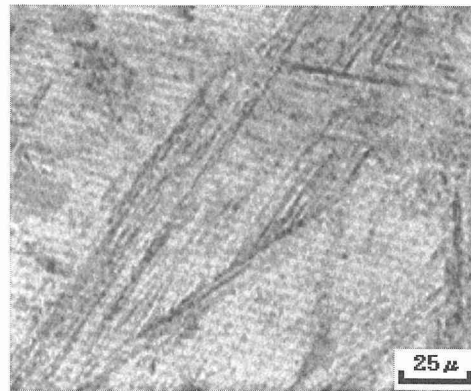
Hv 248





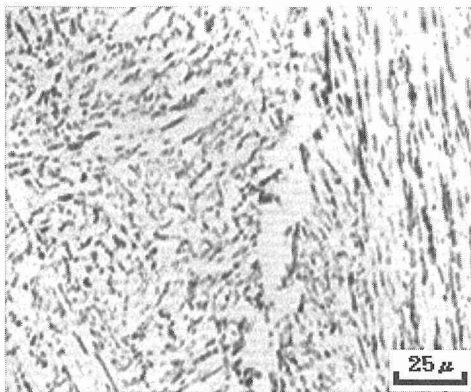
80 deg C/s

Hv 322



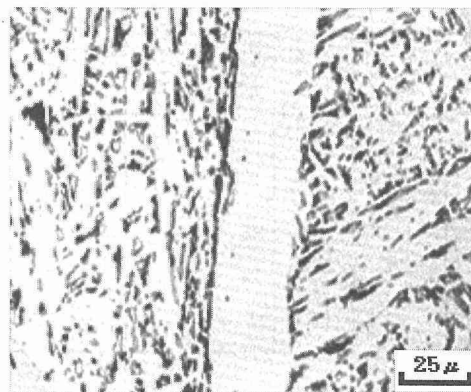
40 deg C/s

Hv 391



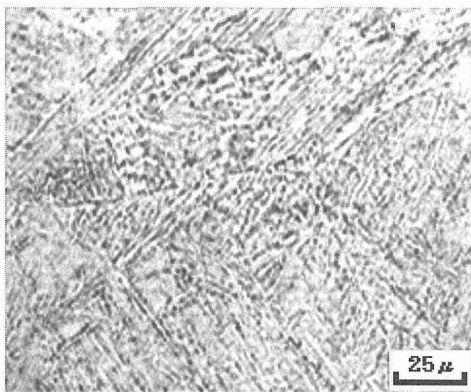
80 deg C/m

Hv 235



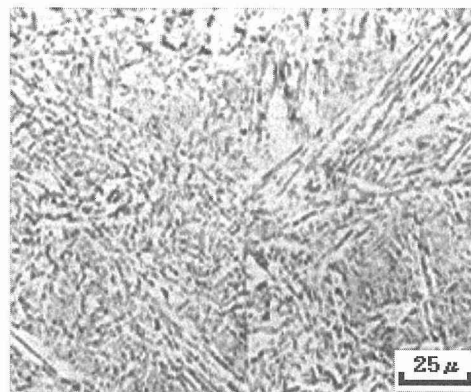
30 deg C/m

Hv 232



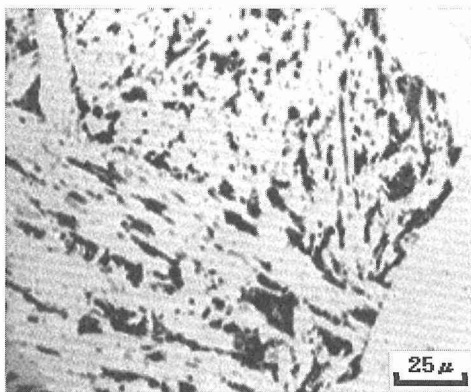
10 deg C/s

Hv 321



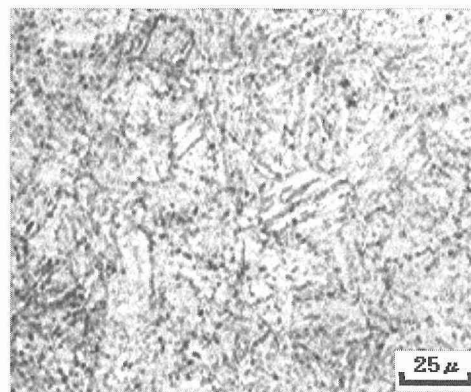
200 deg C/m

Hv 240



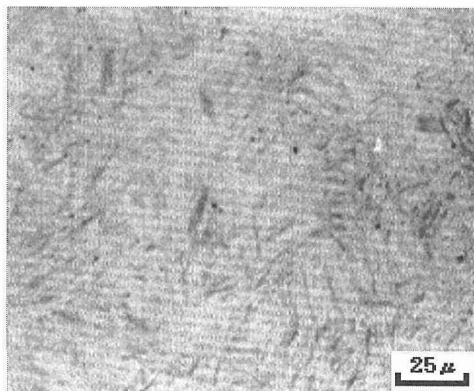
3 deg C/m

Hv 214



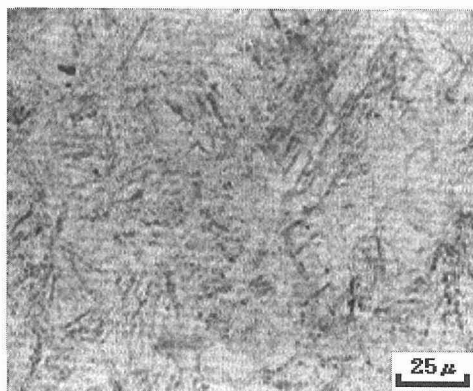
As received

Hv 260



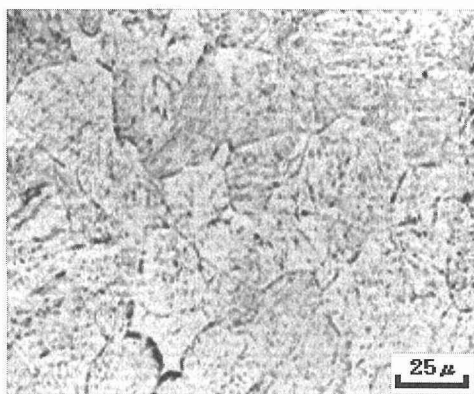
HeGQ

Hv 393



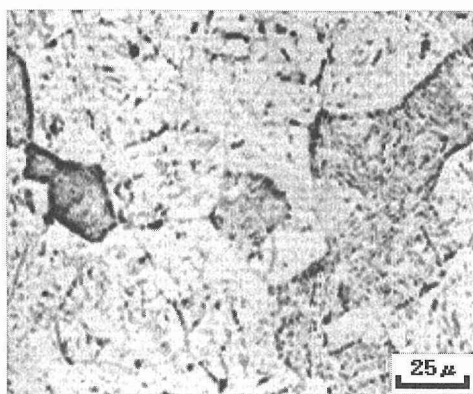
10 deg C/s

Hv 366



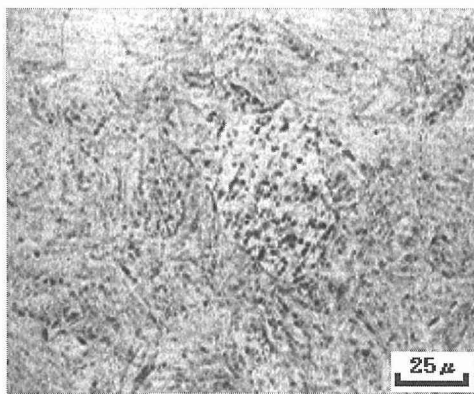
80 deg C/m

Hv 290



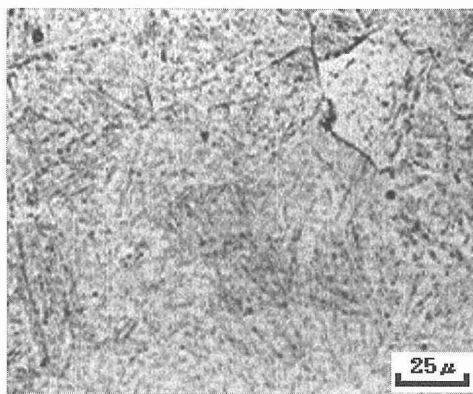
10 deg C/m

Hv 269



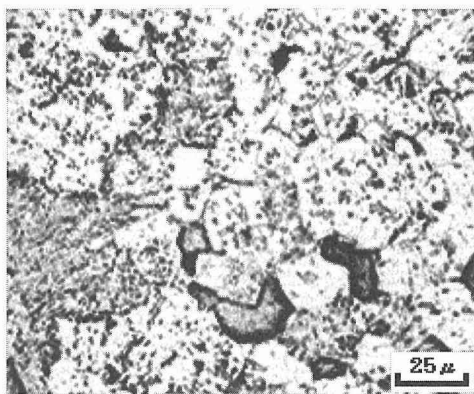
200 deg C/m

Hv 344



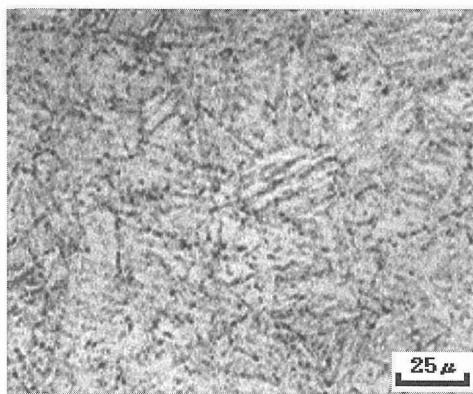
120 deg C/m

Hv 331



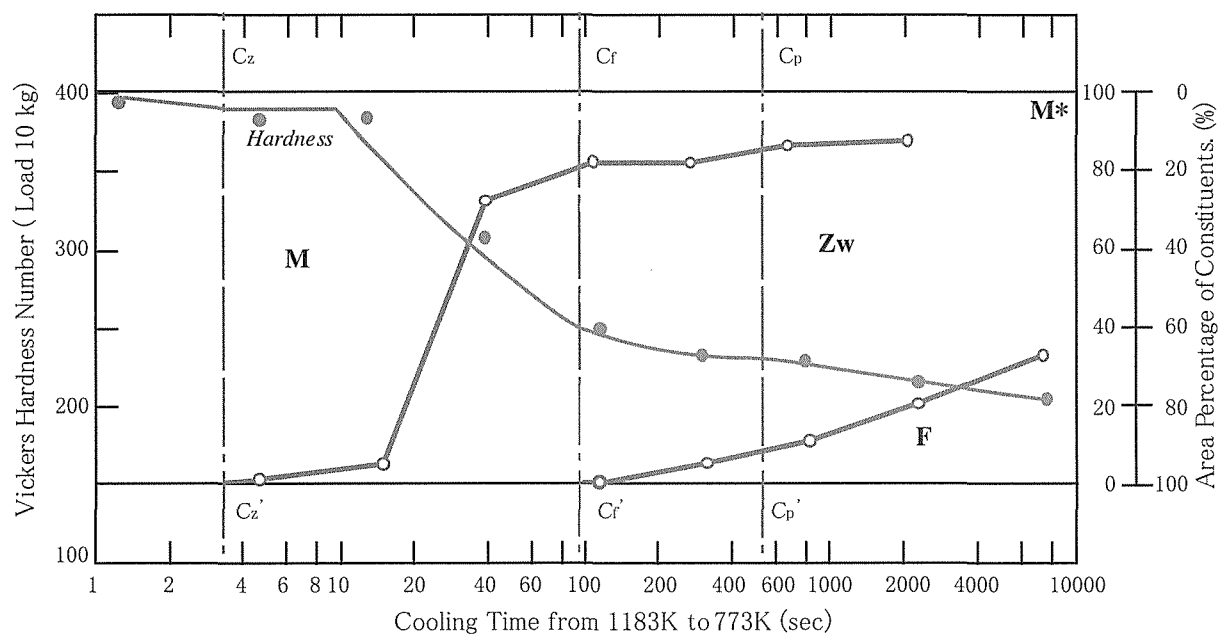
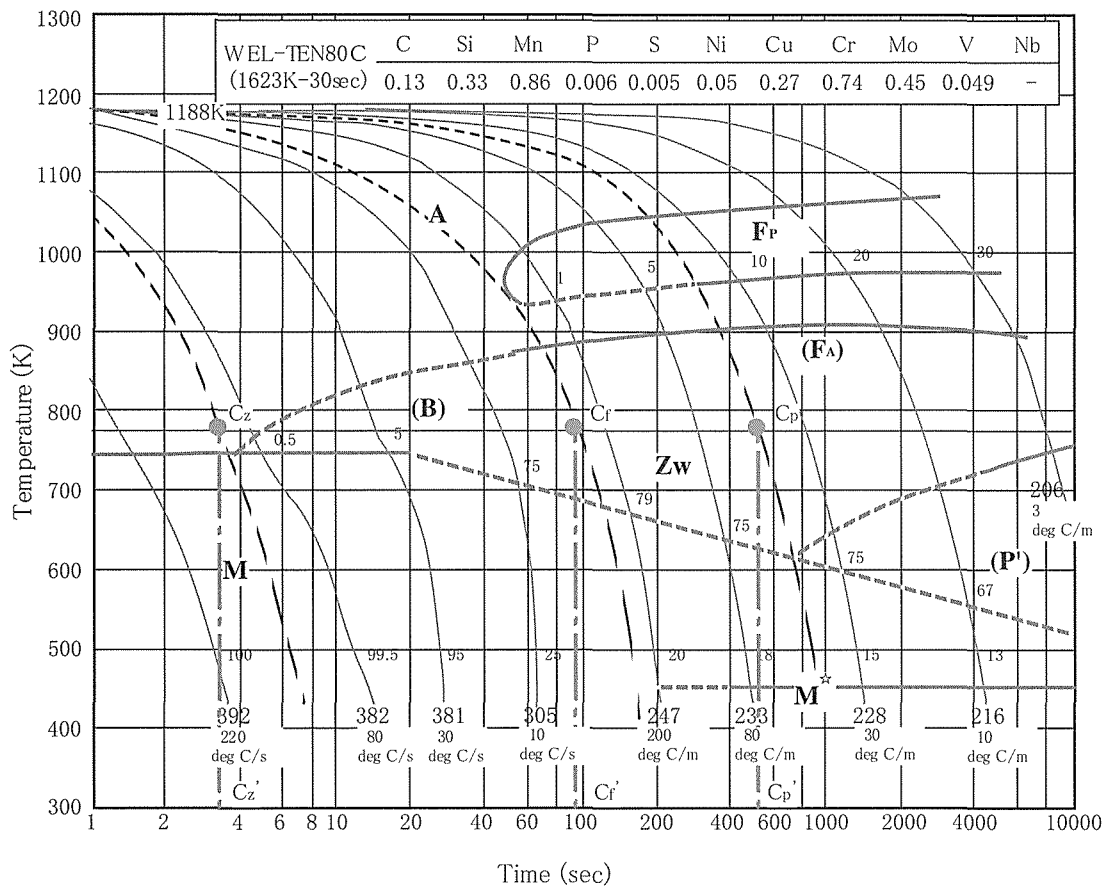
5 deg C/m

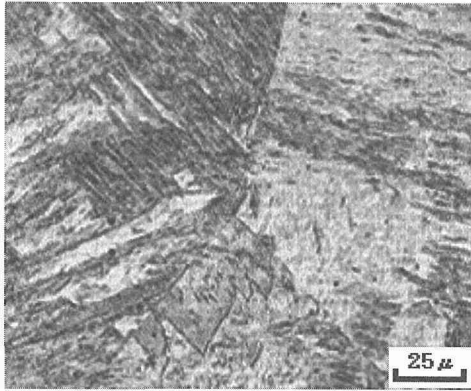
Hv 250



As received

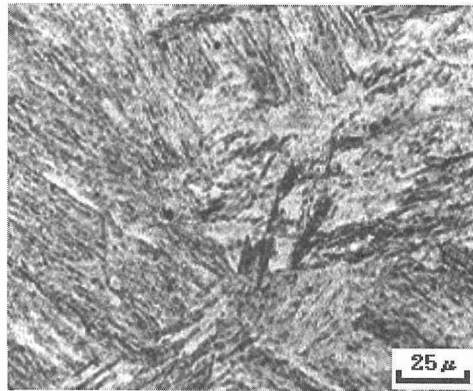
Hv 260





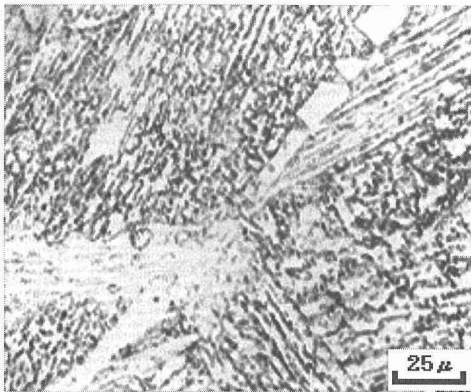
200 deg C/s

Hv 392



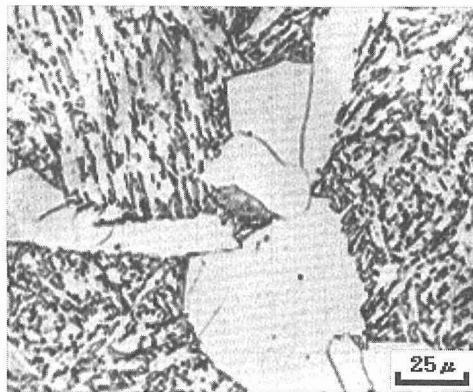
80 deg C/s

Hv 382



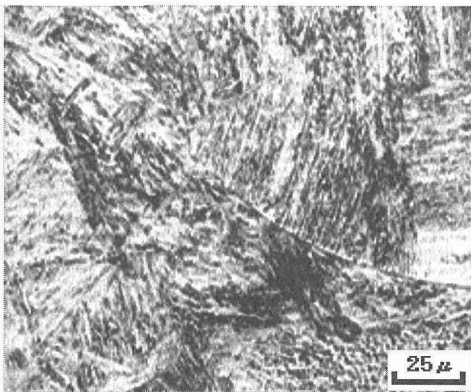
200 deg C/m

Hv 247



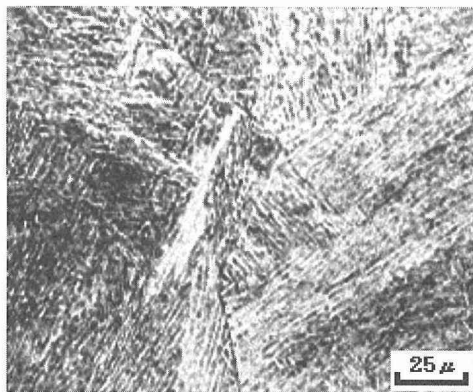
30 deg C/m

Hv 228



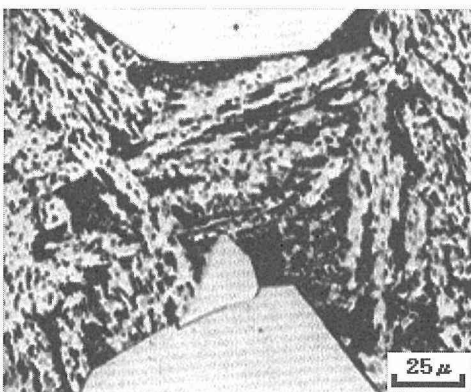
30 deg C/s

Hv 381



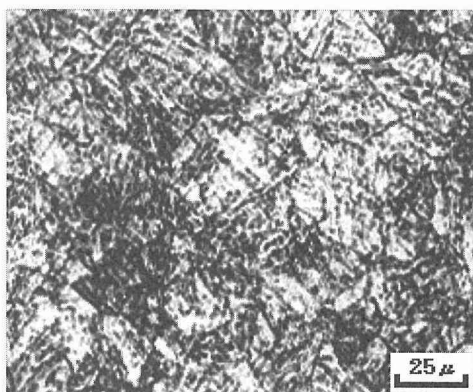
10 deg C/s

Hv 305



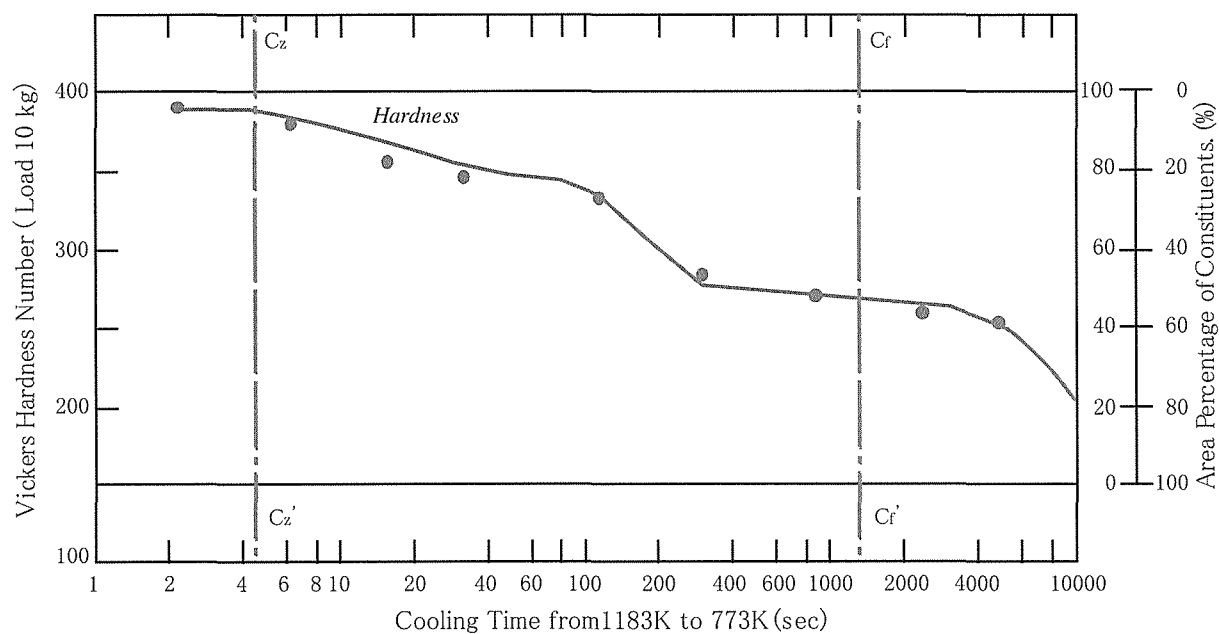
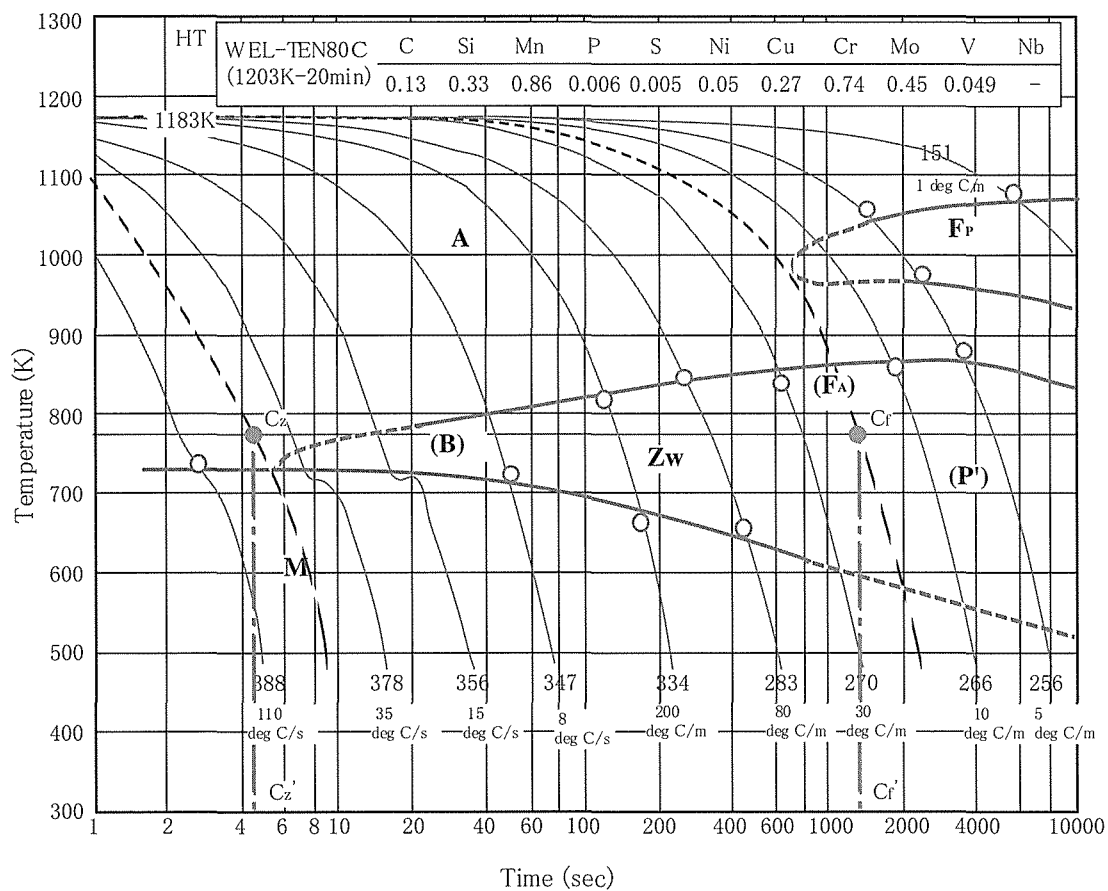
3 deg C/m

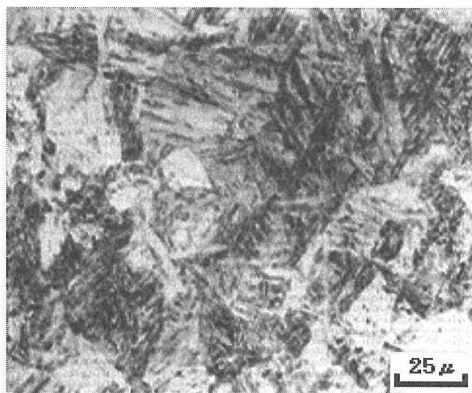
Hv 206



As received

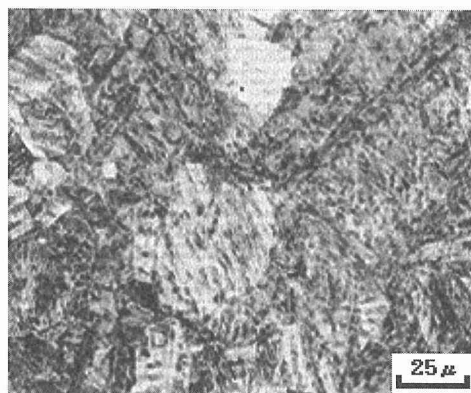
Hv 266





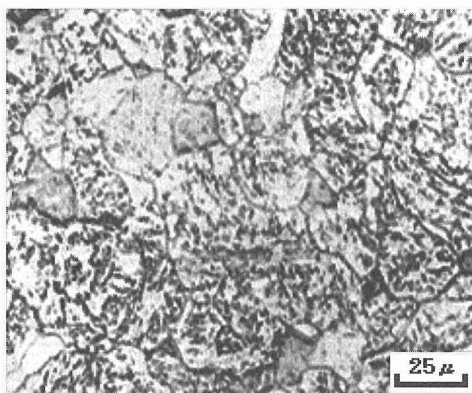
110 deg C/s

Hv 388



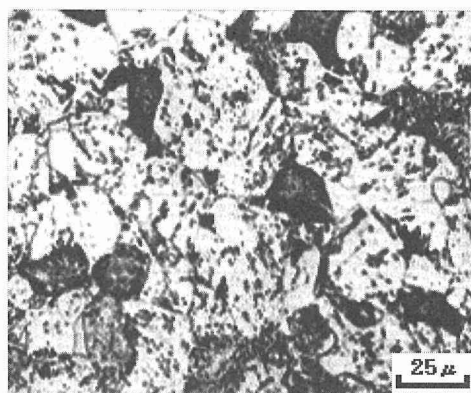
35 deg C/s

Hv 378



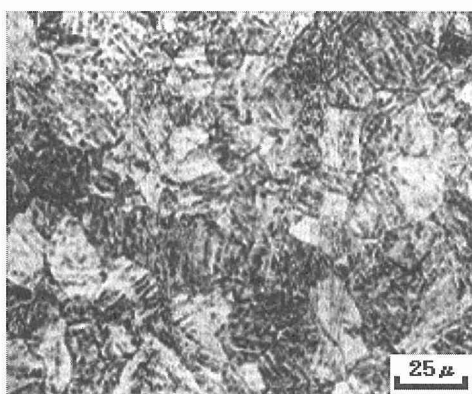
30 deg C/m

Hv 270



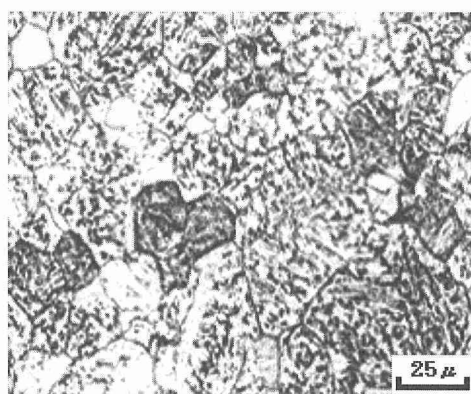
5 deg C/m

Hv 256



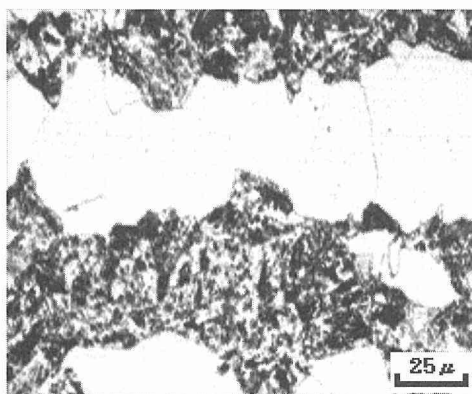
15 deg C/s

Hv 356



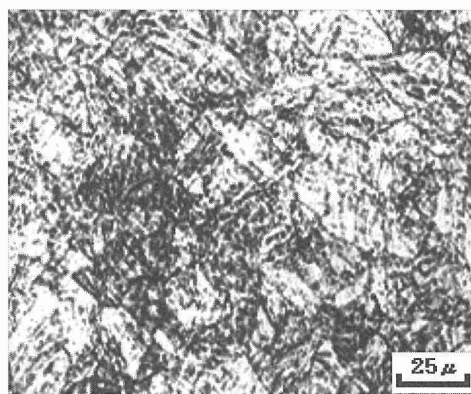
80 deg C/m

Hv 283



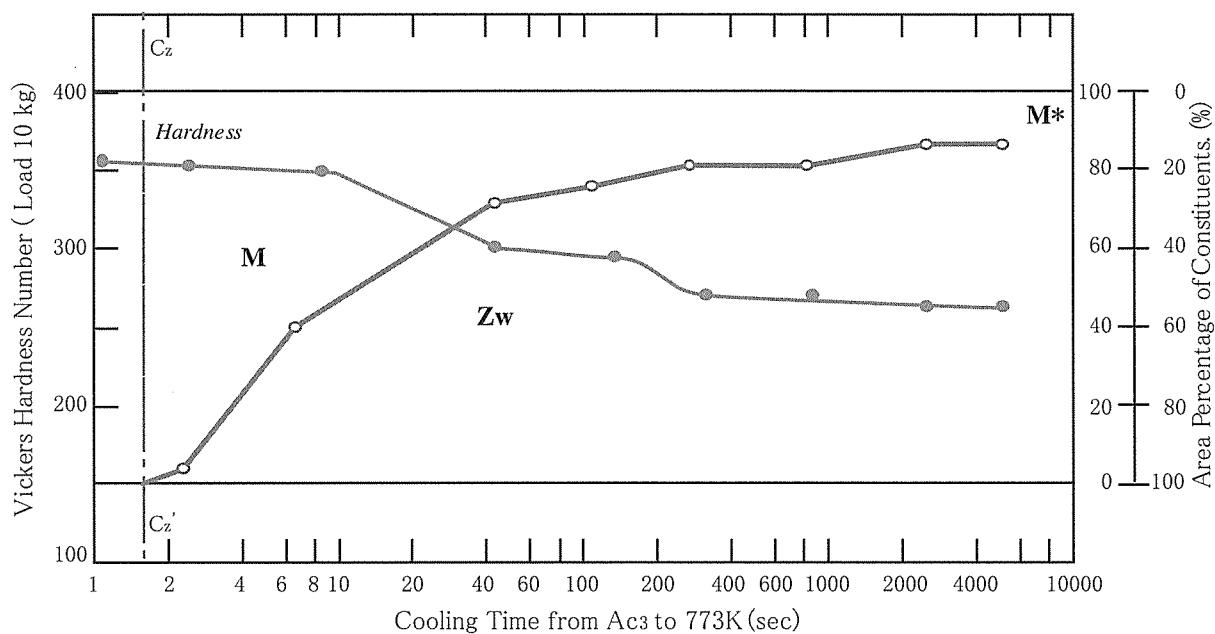
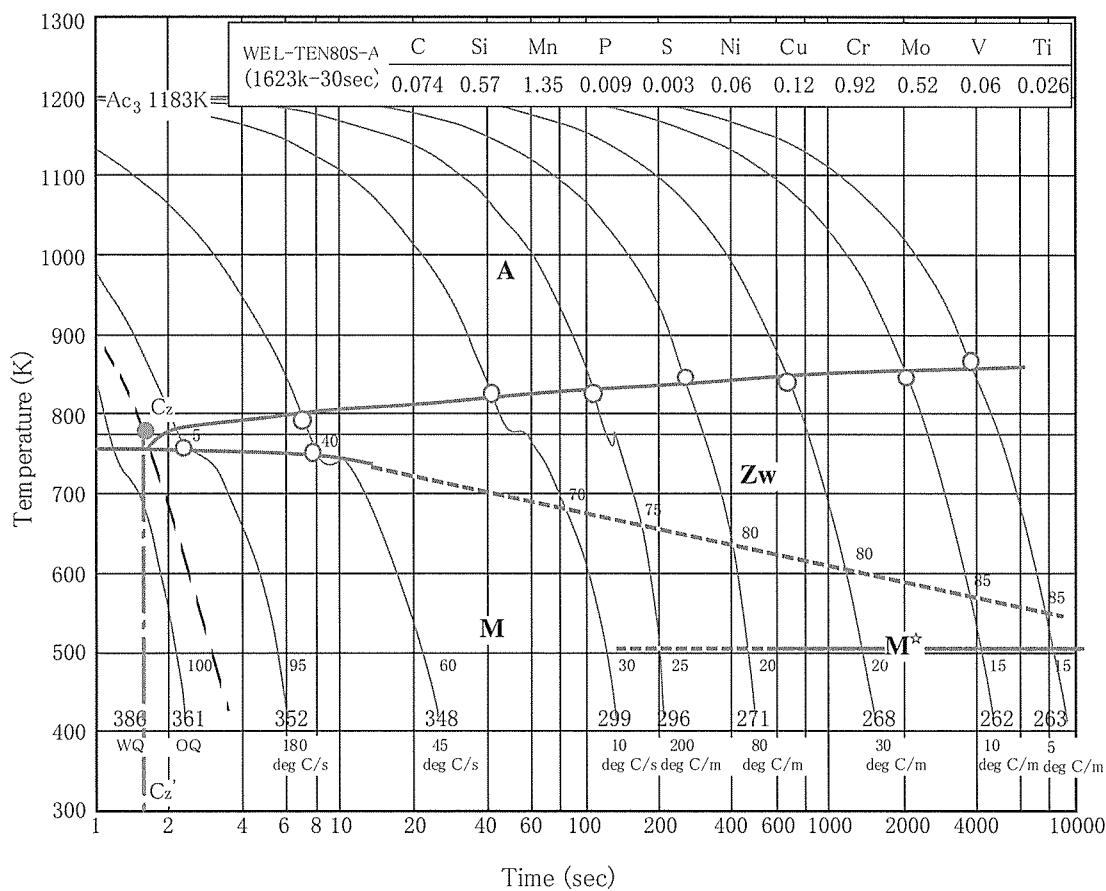
1 deg C/m

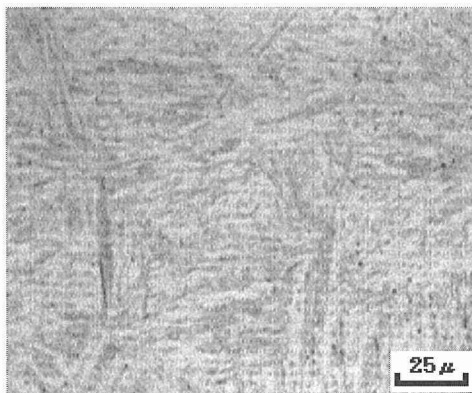
Hv 151



As received

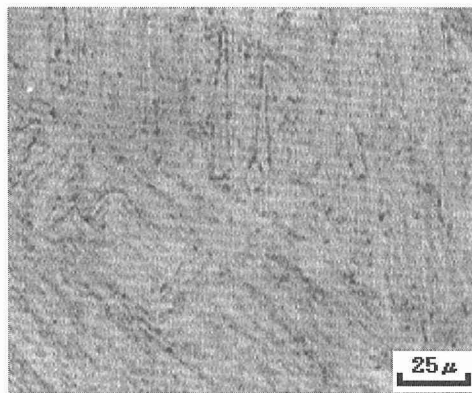
Hv 266





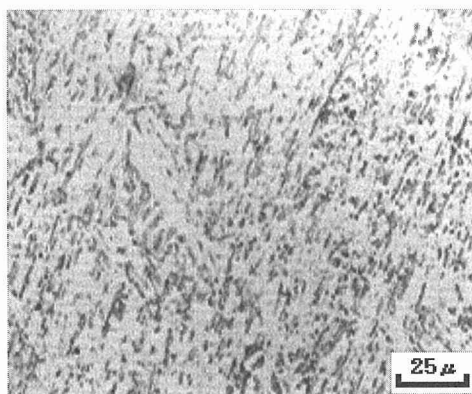
OQ

Hv 361



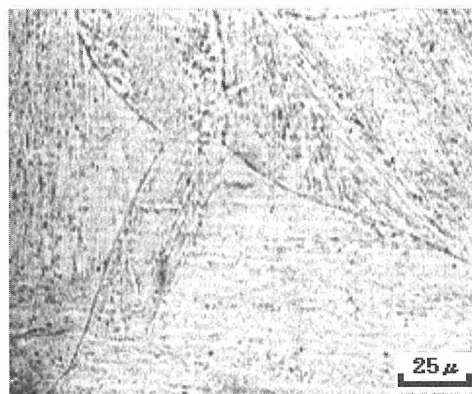
180 deg C/s

Hv 352



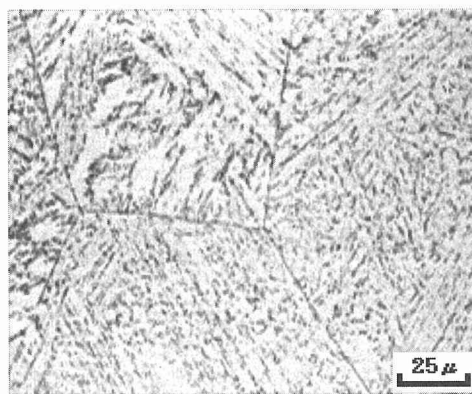
5 deg C/m

Hv 263



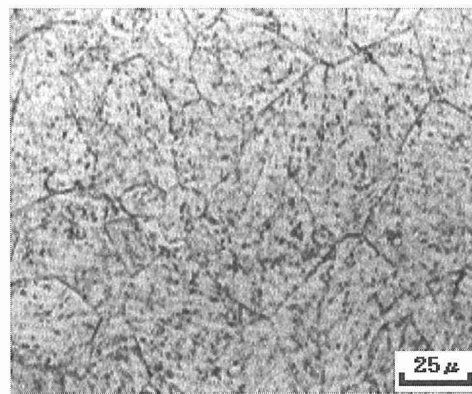
45 deg C/s

Hv 348



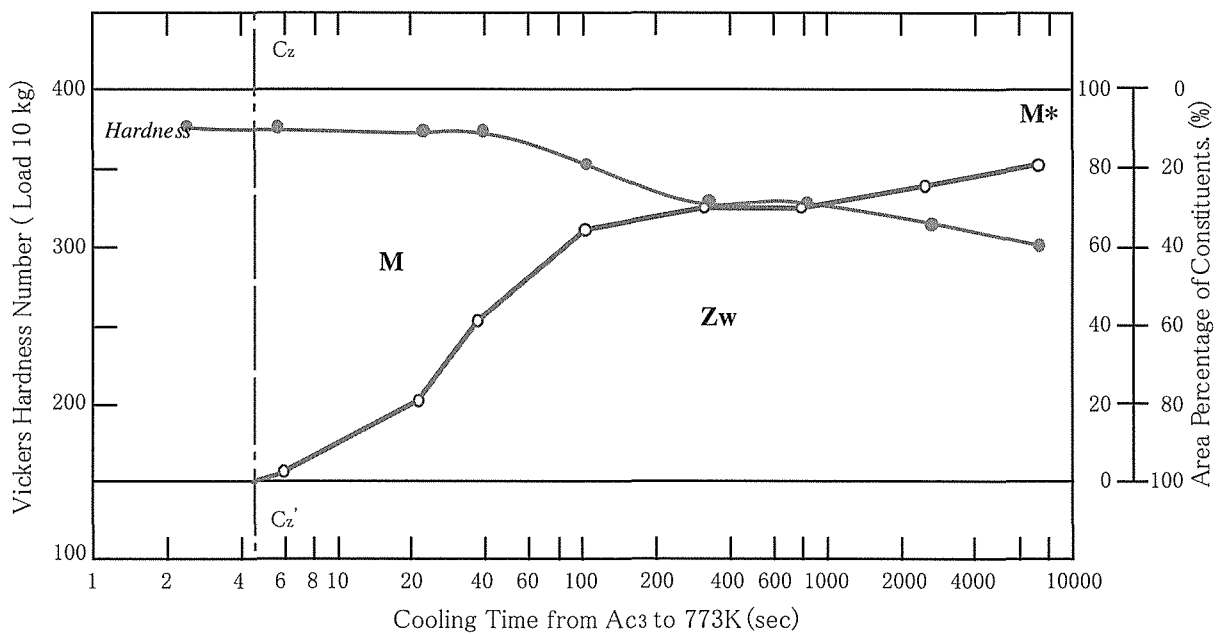
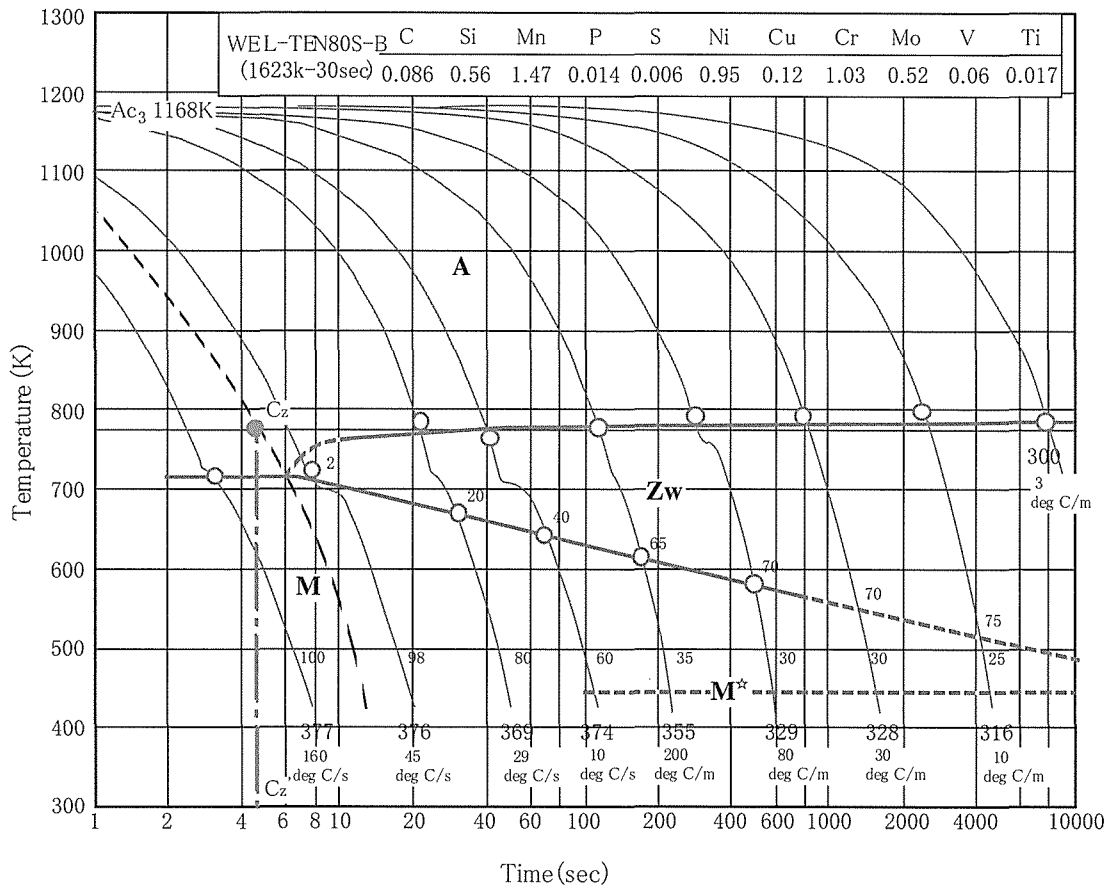
200 deg C/m

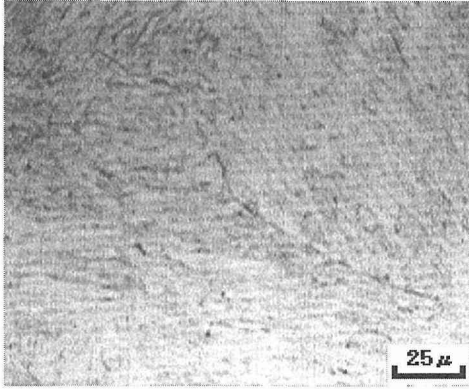
Hv 296



As received

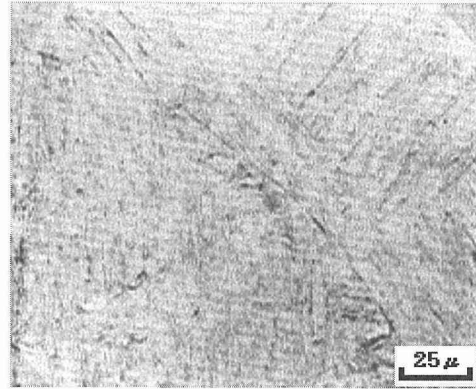
Hv 275





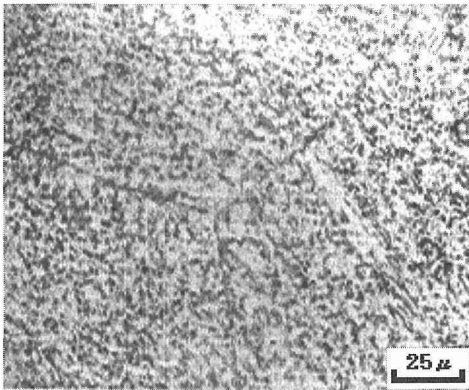
160 deg C/s

Hv 377



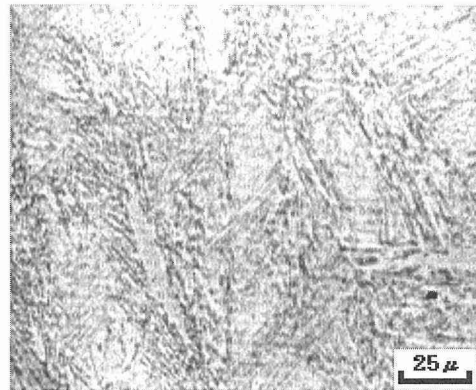
45 deg C/s

Hv 376



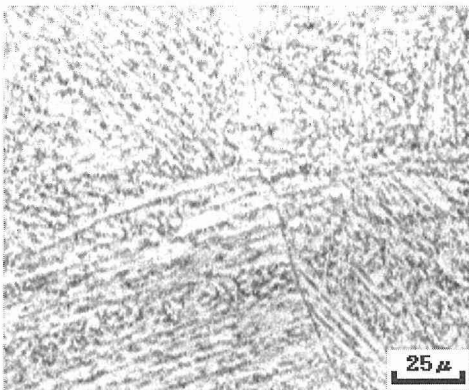
3 deg C/m

Hv 300



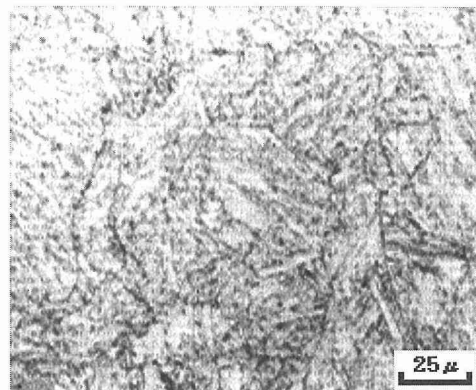
10 deg C/s

Hv 374



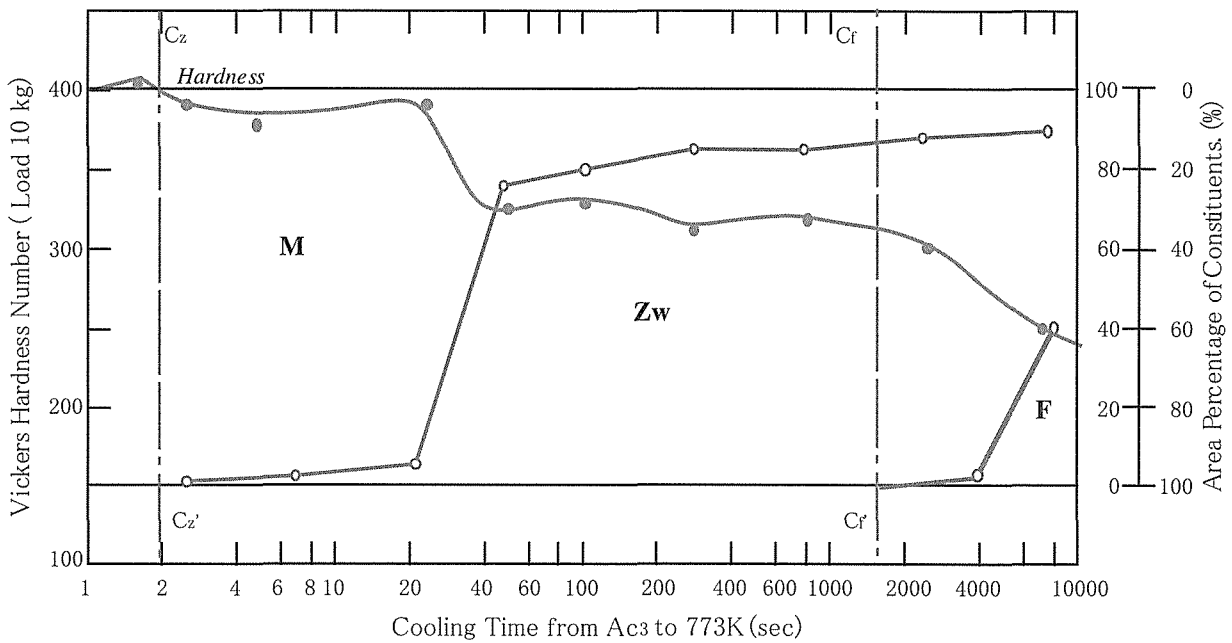
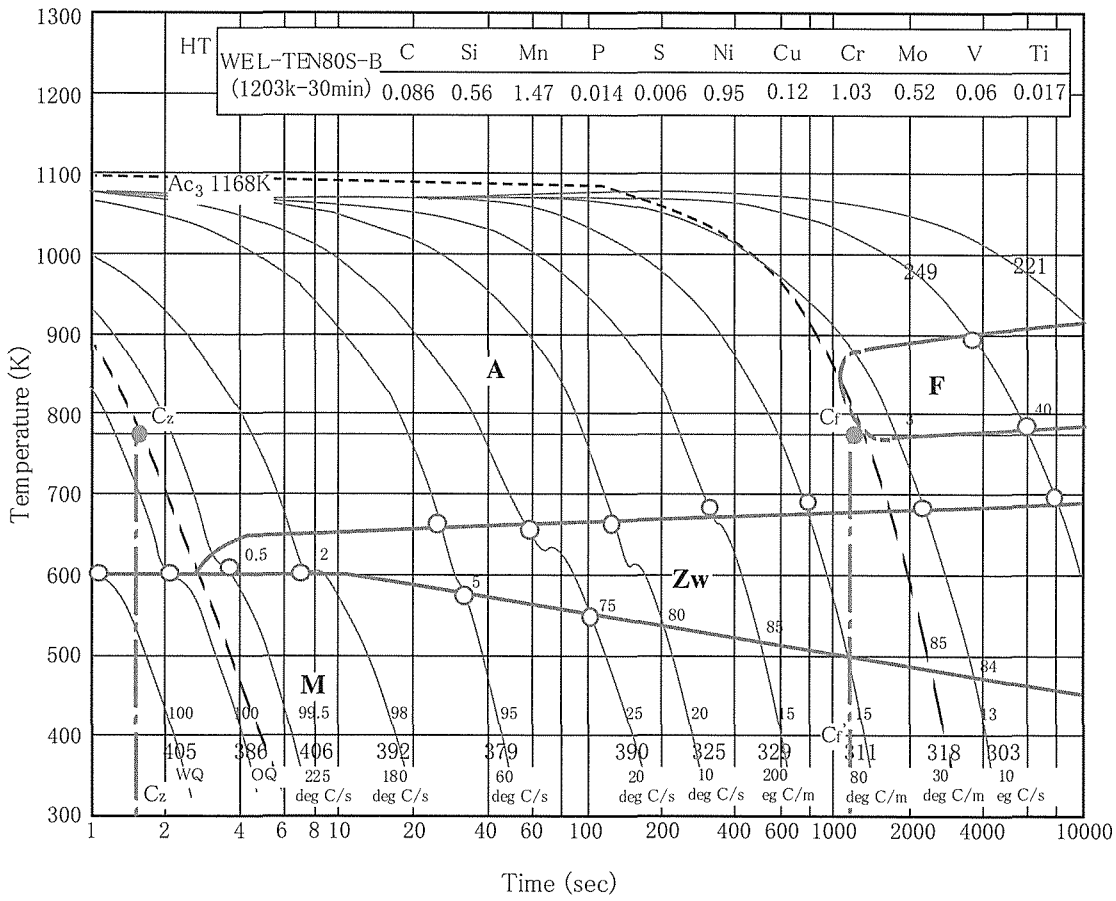
80 deg C/m

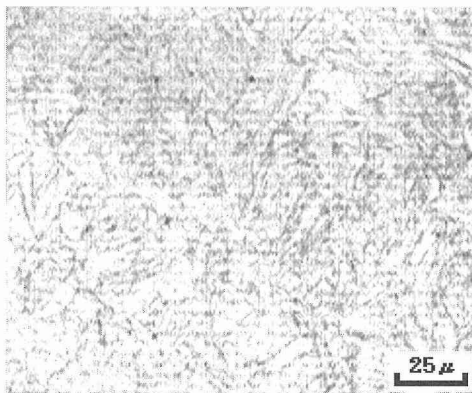
Hv 329



As received

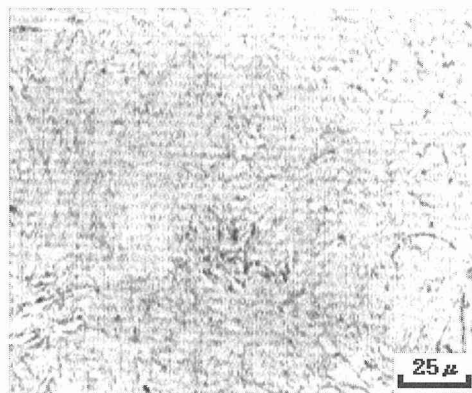
Hv 278





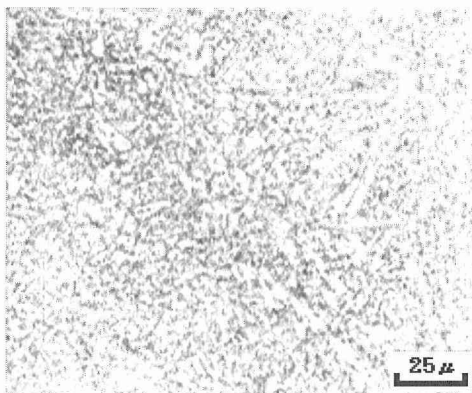
WQ

Hv 405



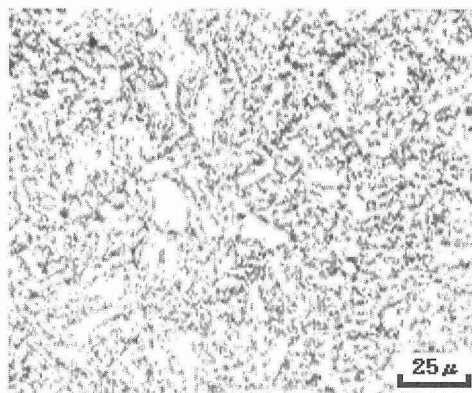
180 deg C/s

Hv 392



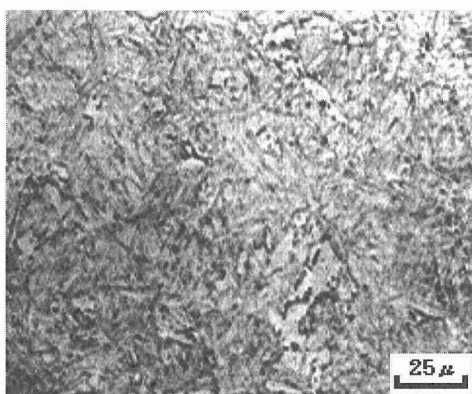
30 deg C/m

Hv 318



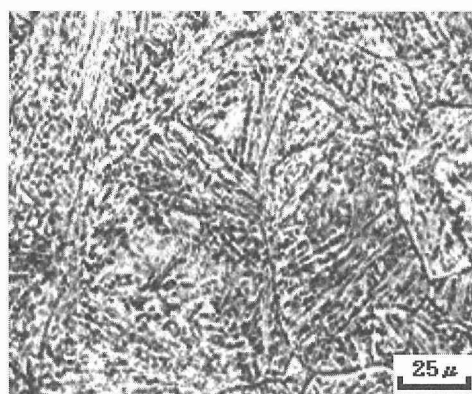
10 deg C/m

Hv 303



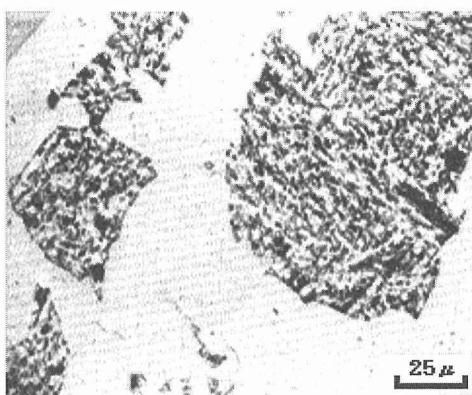
20 deg C/s

Hv 390



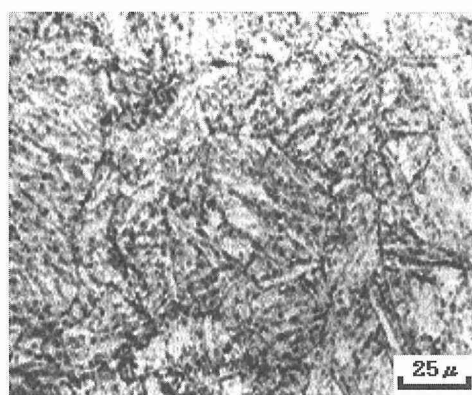
200 deg C/m

Hv 329



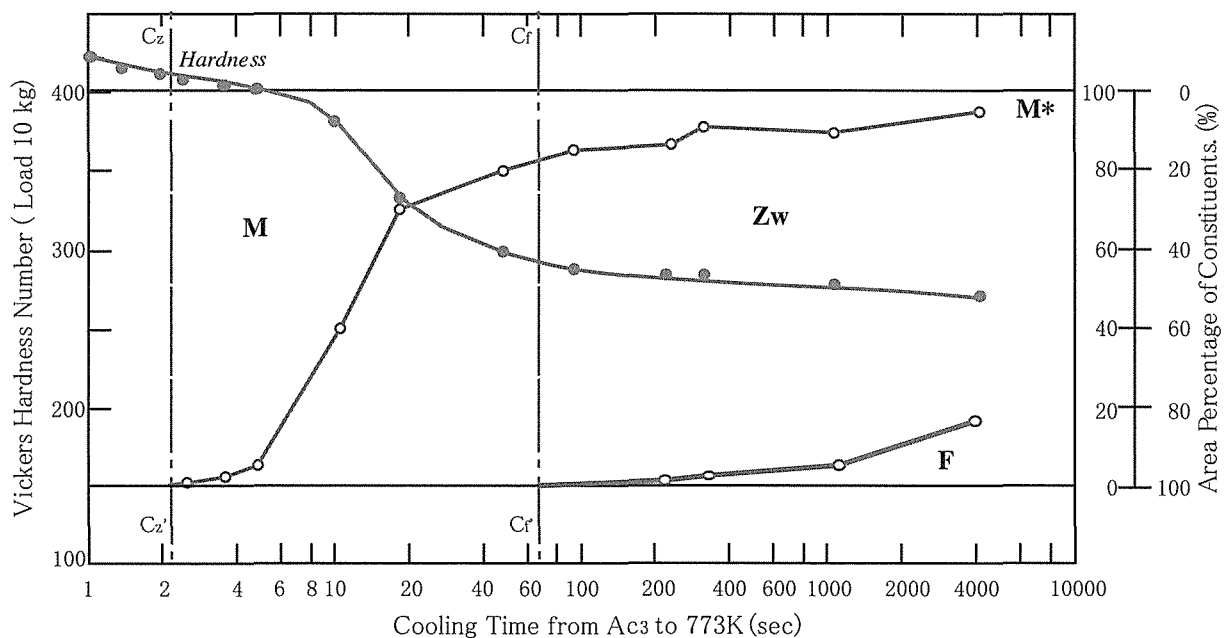
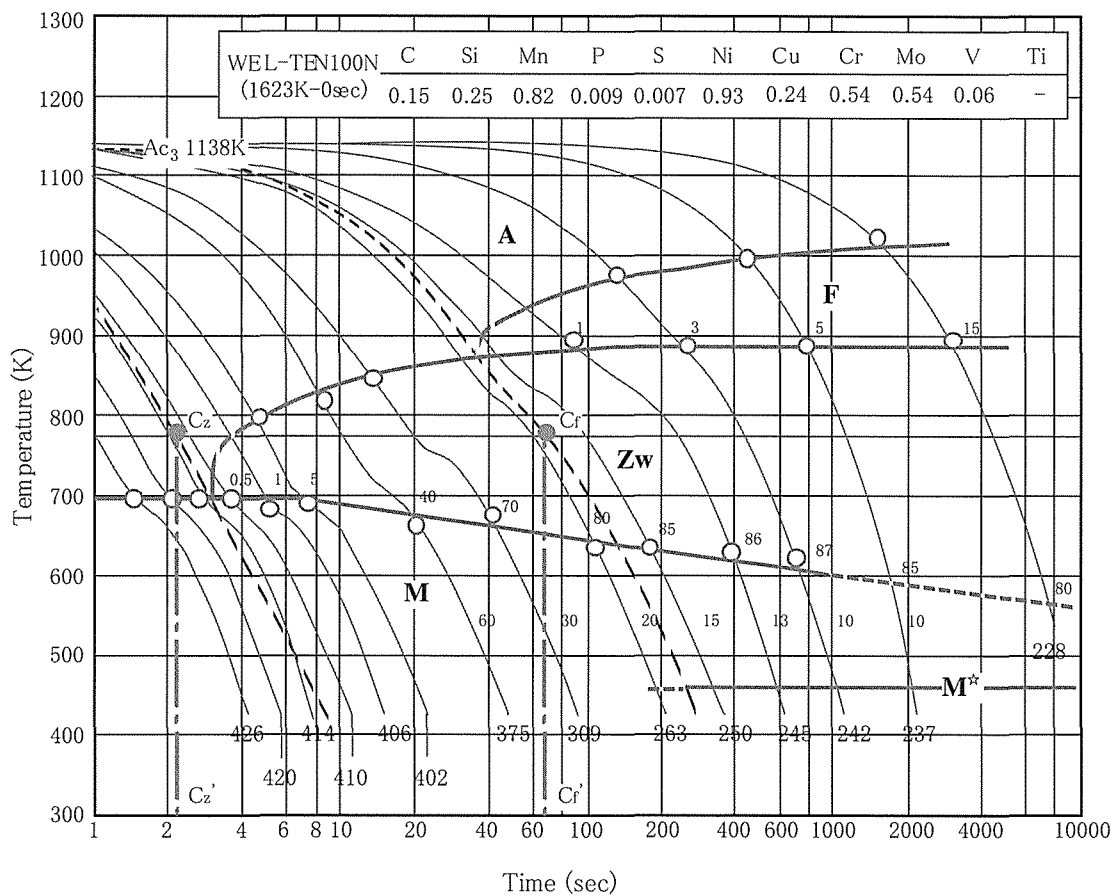
1 deg C/m

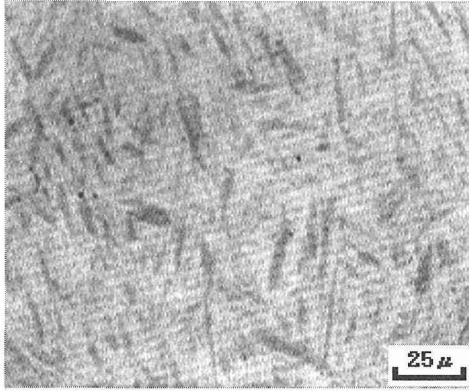
Hv 221



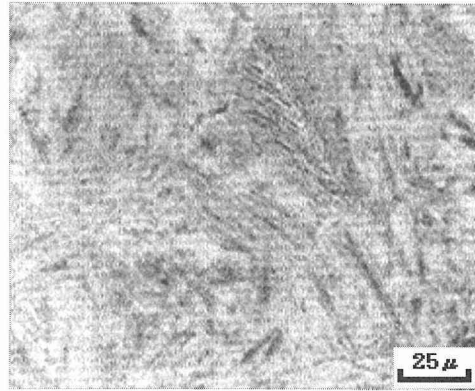
As received

Hv 278

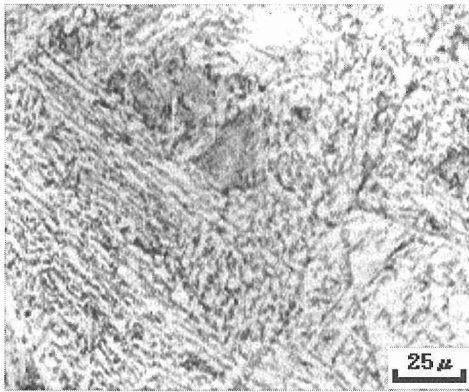




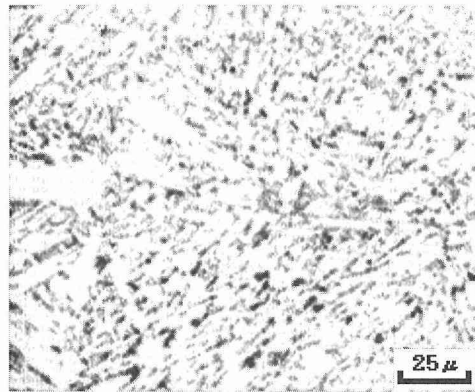
Hv 426



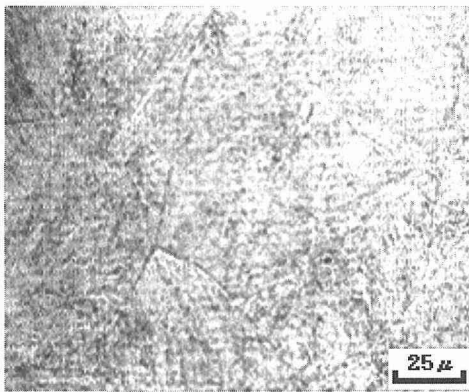
Hv 406



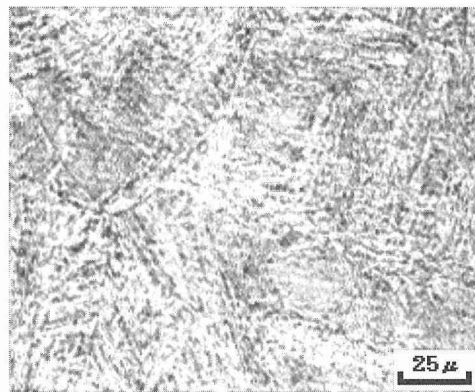
Hv 263



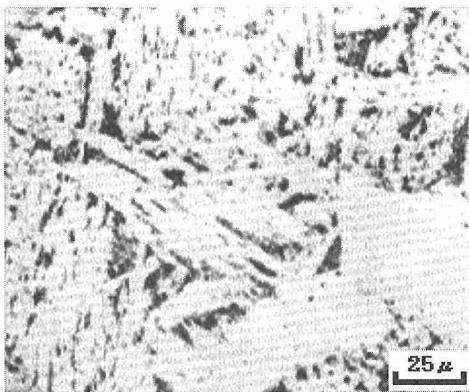
Hv 242



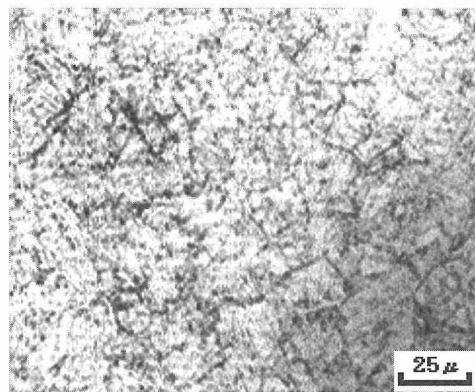
Hv 375



Hv 309



Hv 228



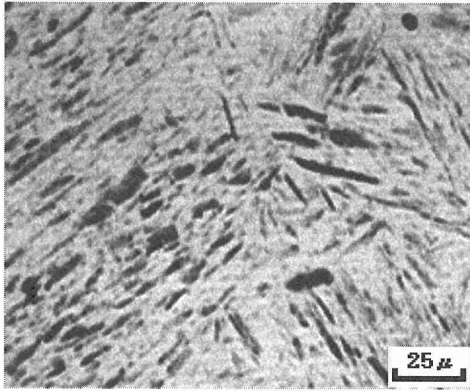
Hv 324

As received

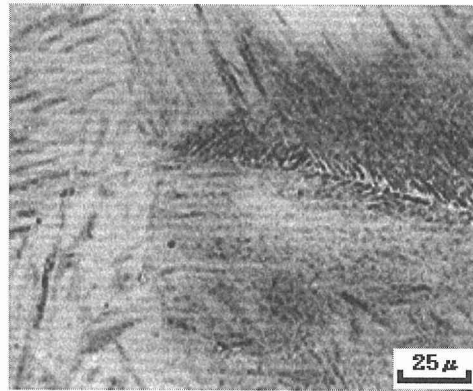
Cryogenic Steel

Steel	13 Chemical Composition (wt%)															Page	Ref.
	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Nb	B	O		
N-TUF33 [121-A]	0.1	0.235	1.22	0.015	0.004	-	-	-	-	0.027	-	-	-	-	-	46	1
N-TUF CR130 [120N-A]	0.12	0.19	0.48	0.011	0.007	-	3.38	-	-	-	-	-	-	-	-	48	1
N-TUF CR130 [120N3-B] HT	0.12	0.21	0.59	0.01	0.003	-	3.38	-	-	-	-	-	-	-	-	50	1
N-TUF CR196 [121NCM2-A]	0.052	0.23	1.11	0.003	0.005	0.036	5.37	0.14	-	-	-	-	-	-	-	52	1
N-TUF CR196 [121NCM2-B] HT	0.052	0.23	1.11	0.003	0.005	0.036	5.37	0.14	-	-	-	-	-	-	-	54	1
ASTM A537.A [141-A]	0.14	0.42	1.26	0.01	0.002	0.1	0.03	0.01	-	-	-	-	-	-	-	56	1
ASTM A353/553 [131N-B] HT	0.08	0.26	0.54	0.005	0.005	0.04	8.51	0.012	-	-	-	-	-	-	-	58	1
ASTM A353/553 [131N-A]	0.08	0.26	0.54	0.005	0.005	0.04	8.51	0.012	-	-	-	-	-	-	-	60	1

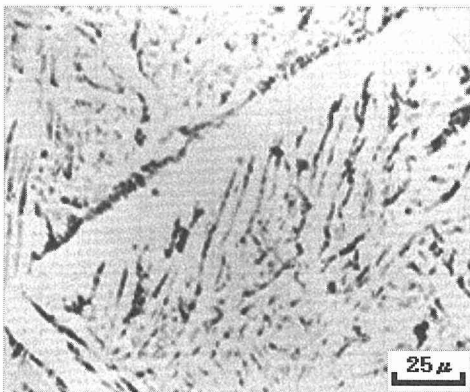
HT: CCT diagram to be used the purpose of heat treatment. Heating at temperature below 1623K for welding.



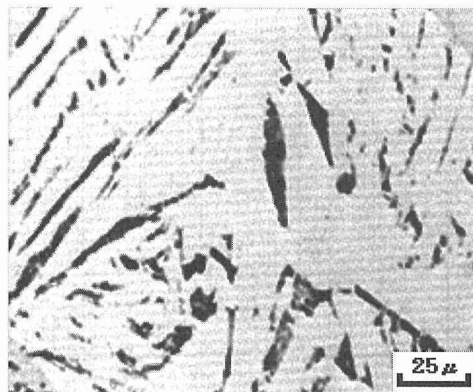
Hv 400



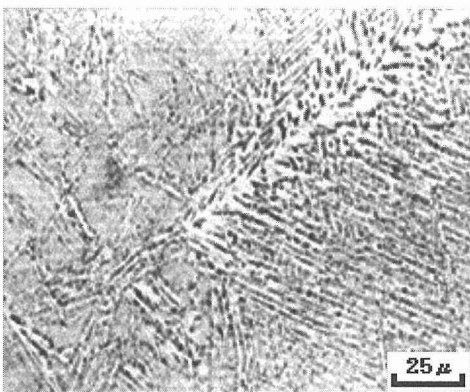
Hv 340



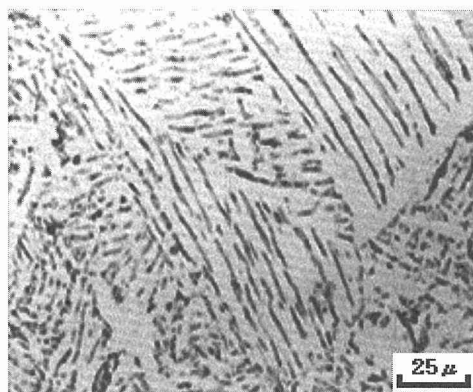
Hv 181



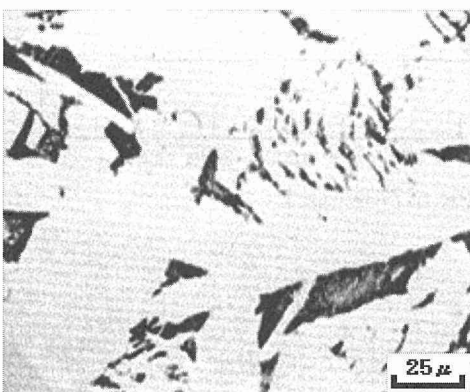
Hv 163



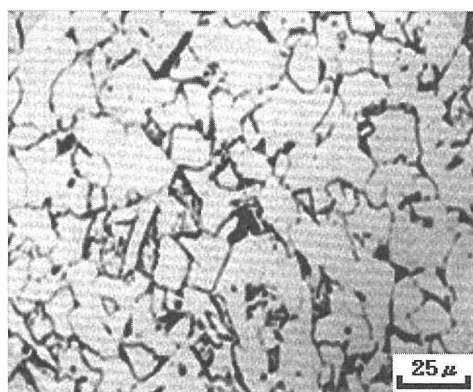
Hv 252



Hv 193

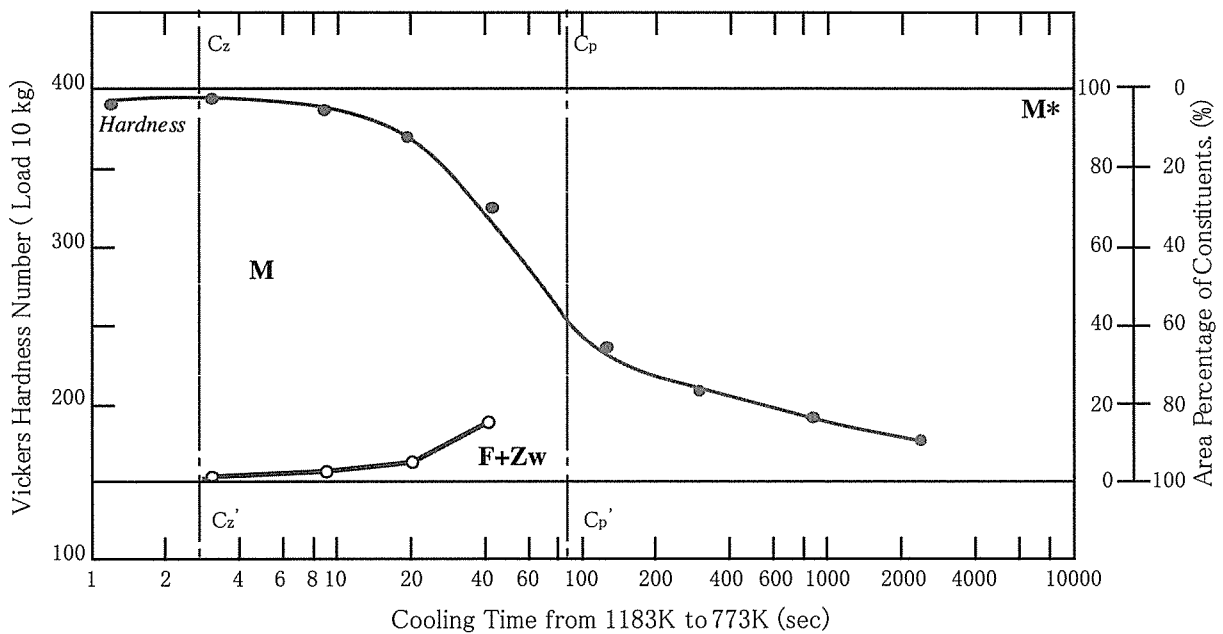
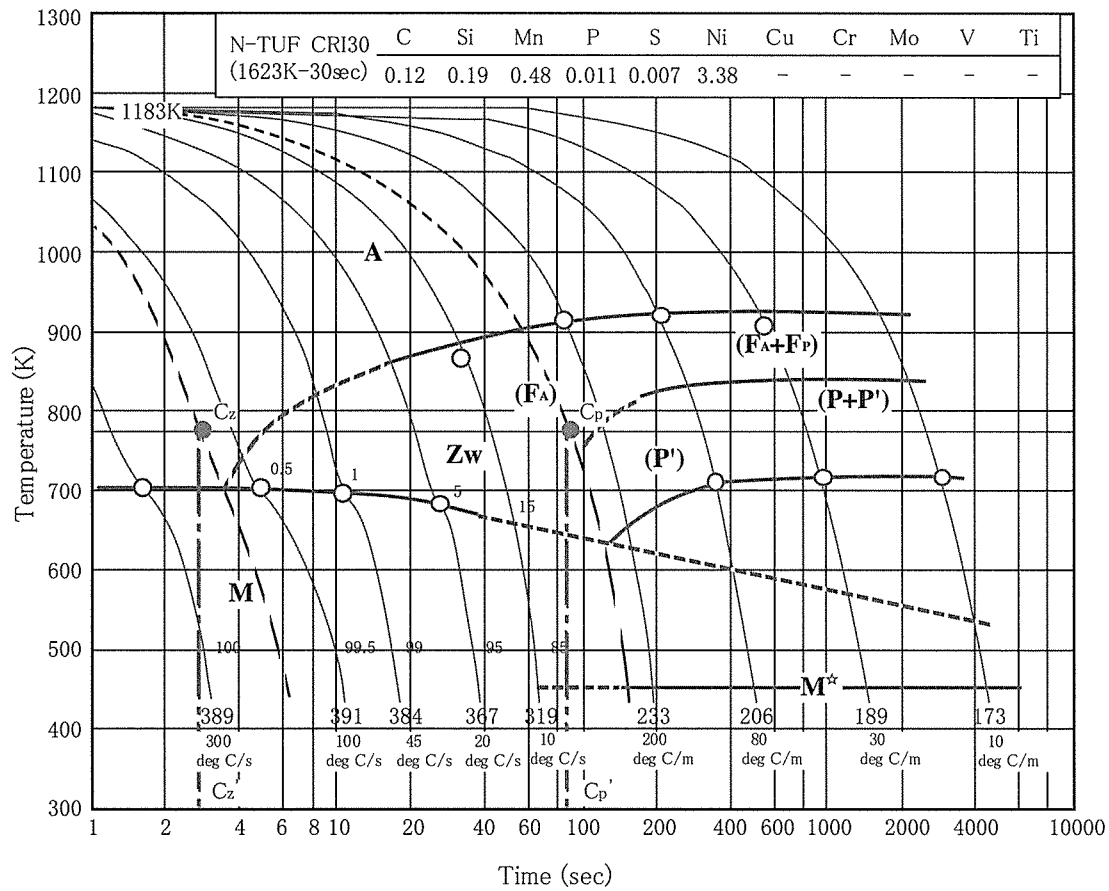


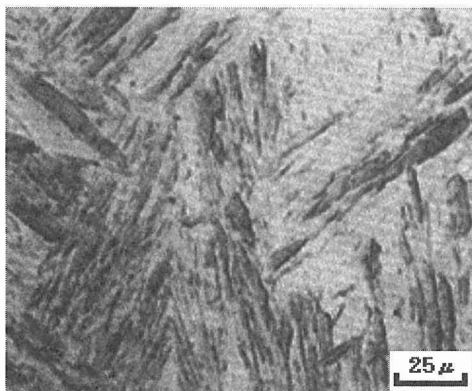
Hv 155



As received

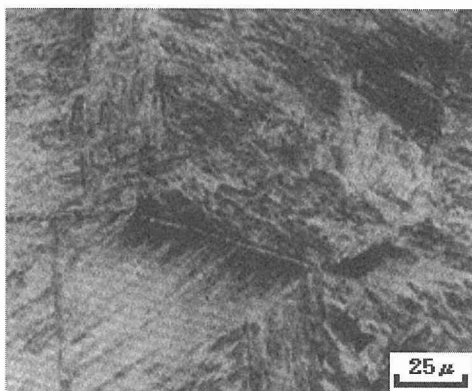
Hv 133





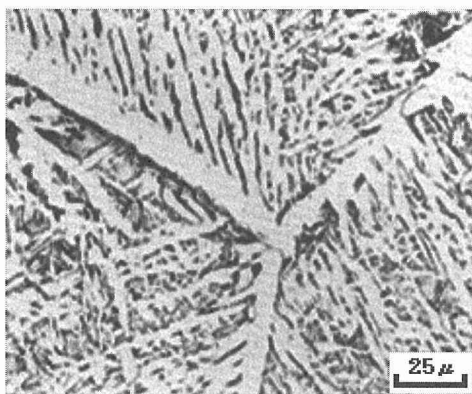
300 deg C/s

Hv 389



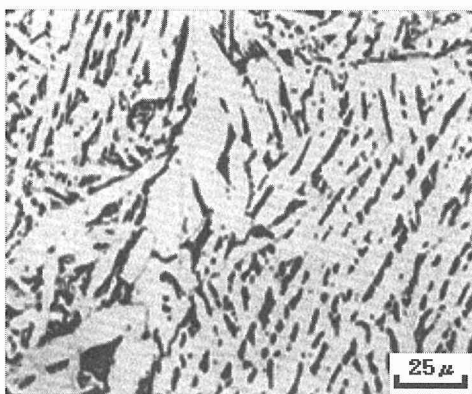
100 deg C/s

Hv 391



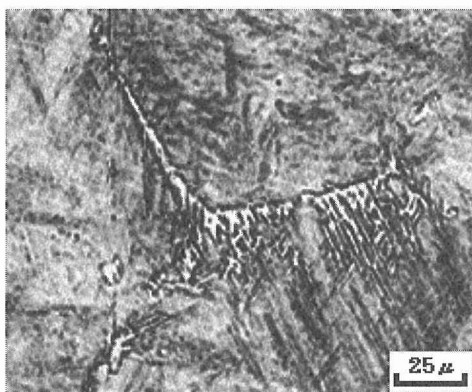
200 deg C/m

Hv 233



80 deg C/m

Hv 206



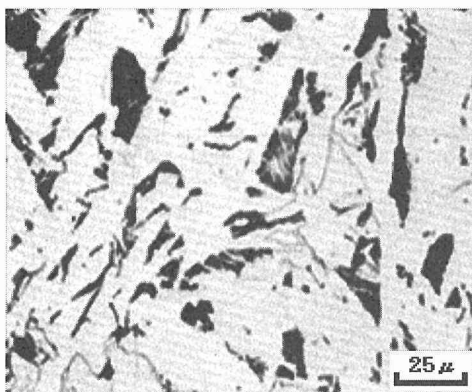
20 deg C/s

Hv 367



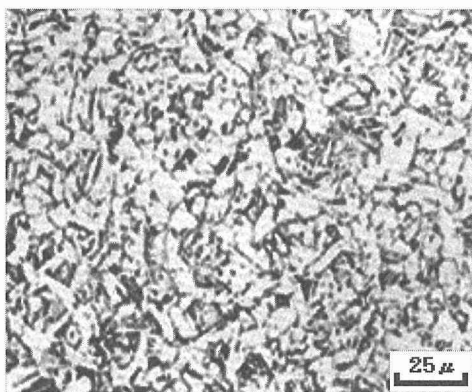
10 deg C/s

Hv 319



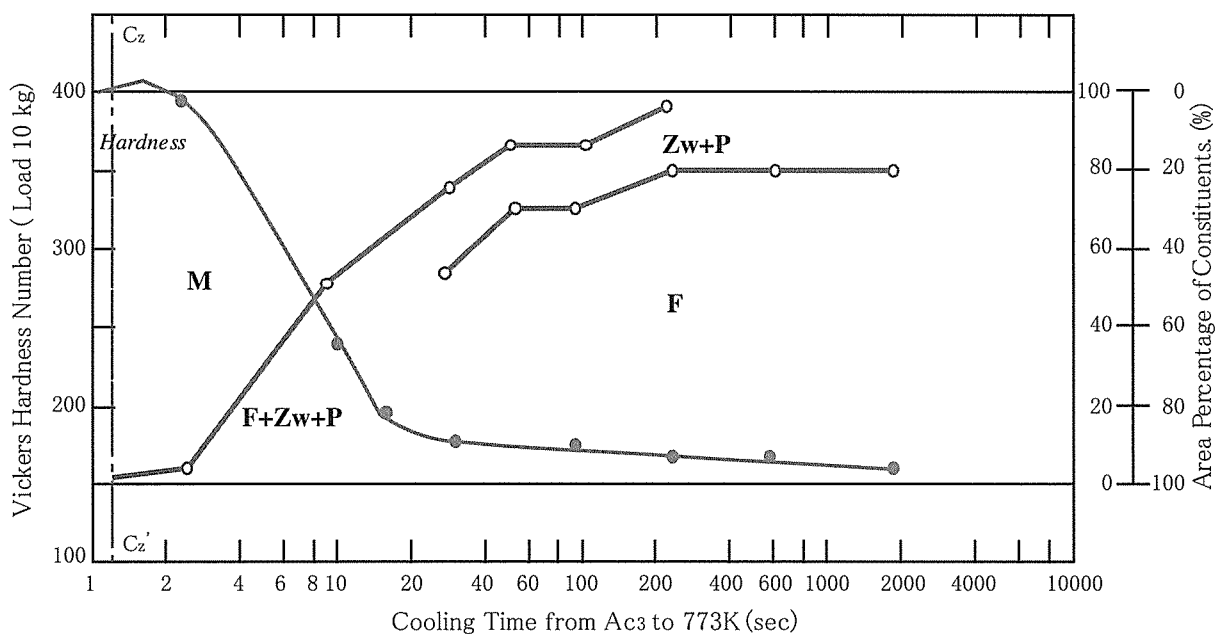
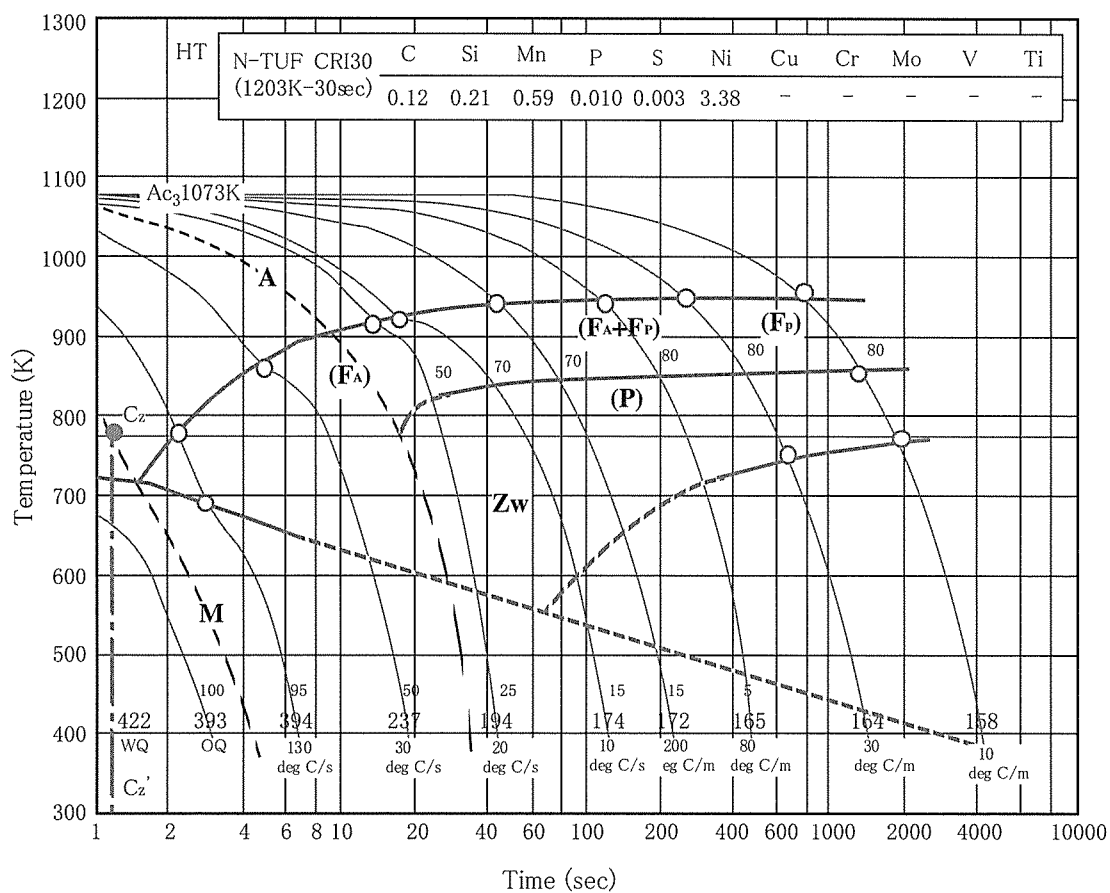
10 deg C/m

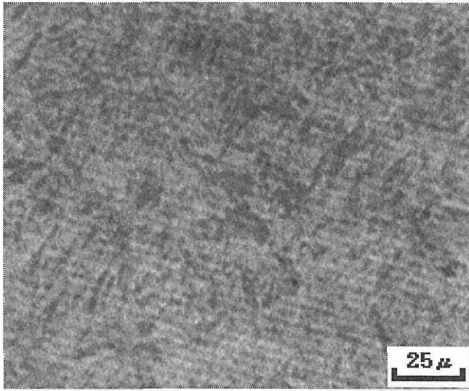
Hv 173



As received

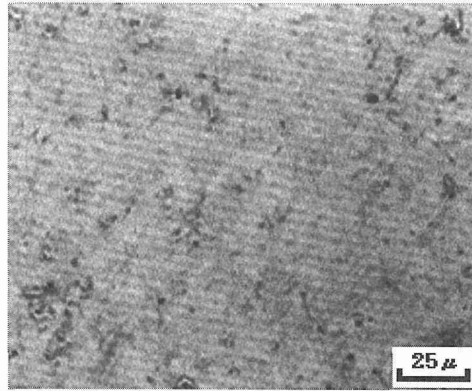
Hv 188





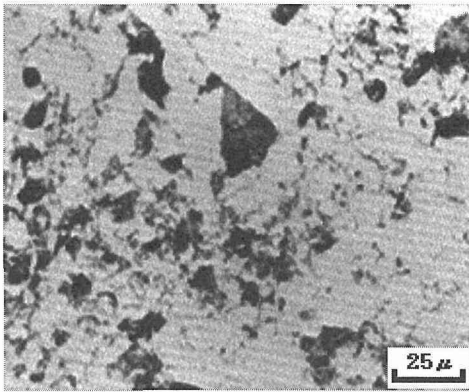
WQ

Hv 422



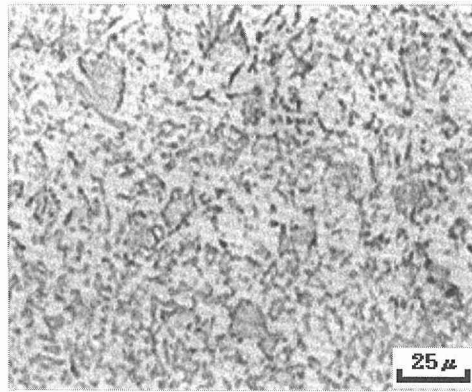
130 deg C/s

Hv 394



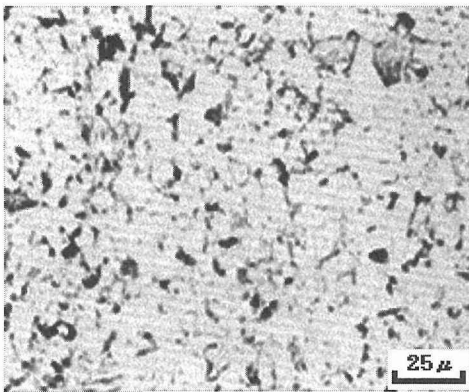
10 deg C/m

Hv 158



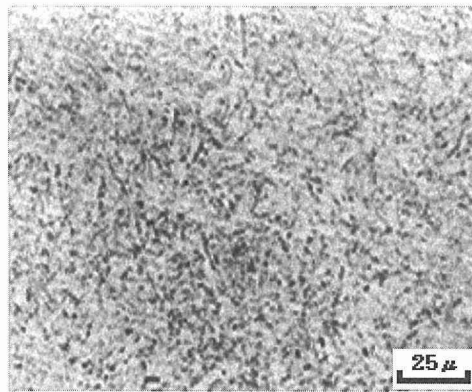
20 deg C/s

Hv 194



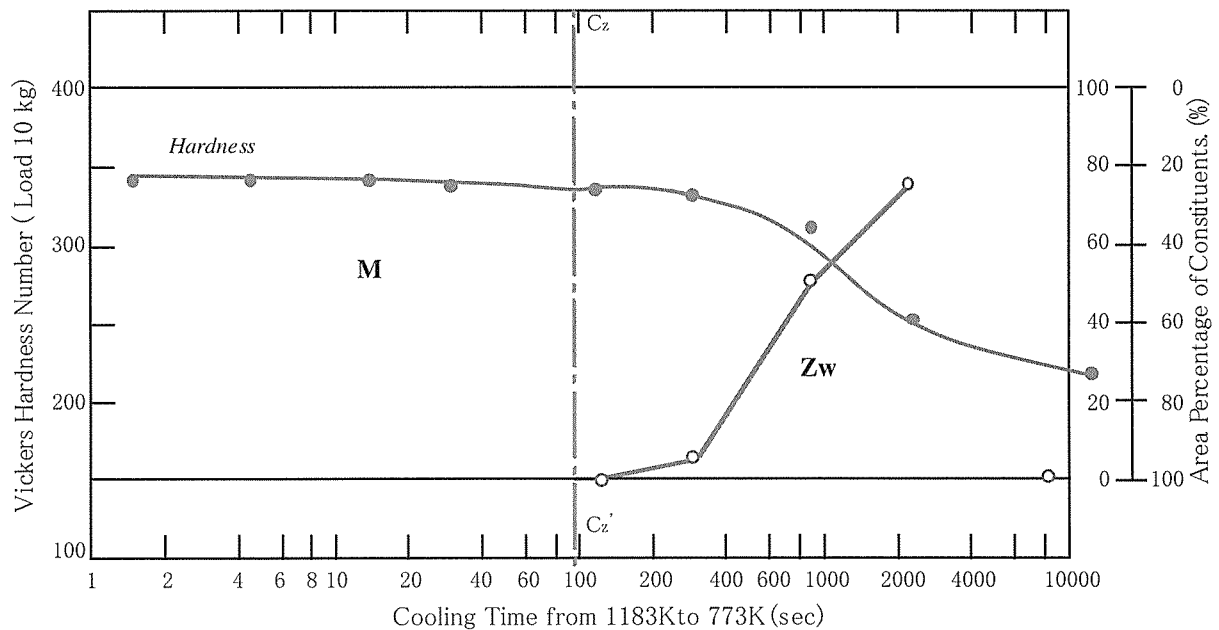
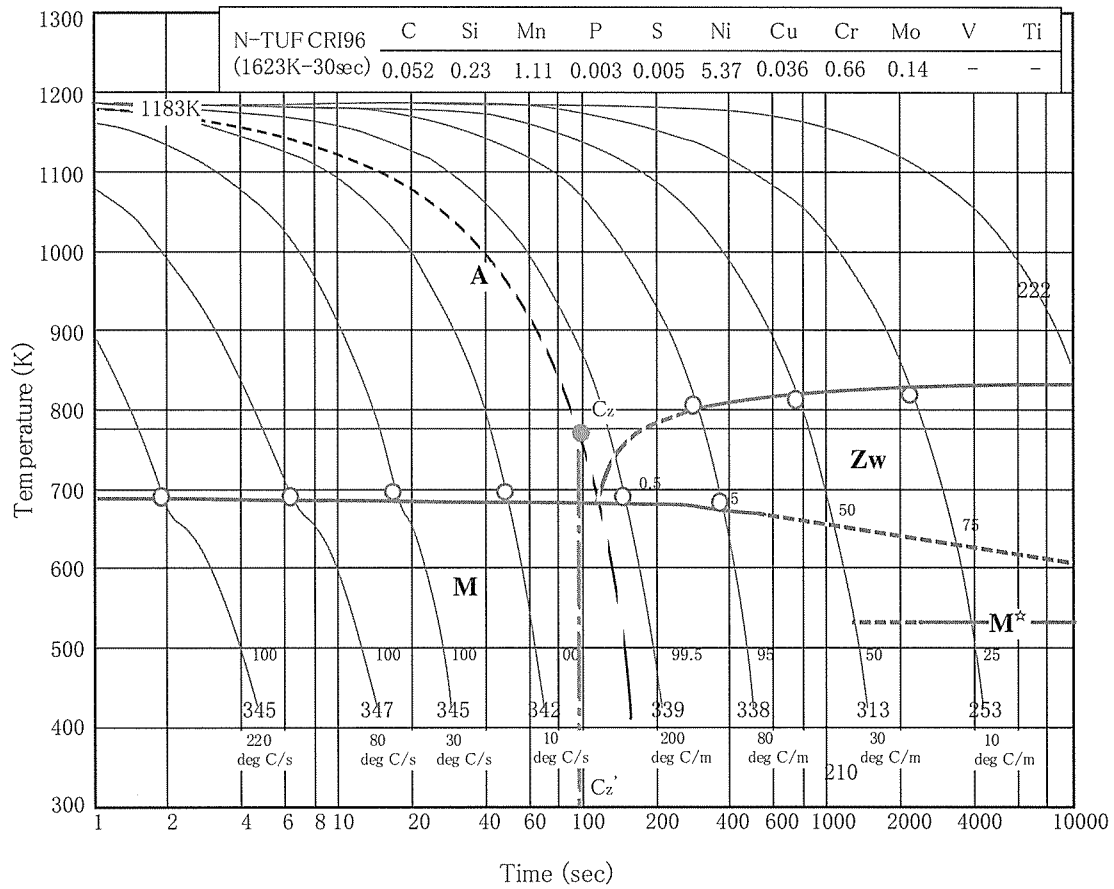
10 deg C/s

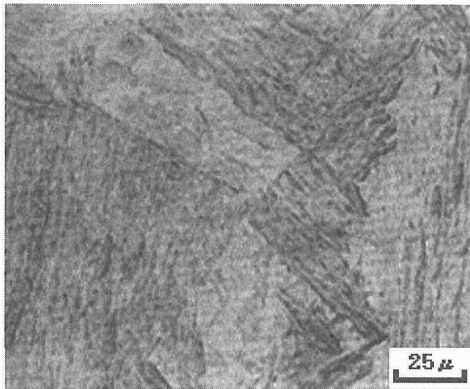
Hv 174



As received

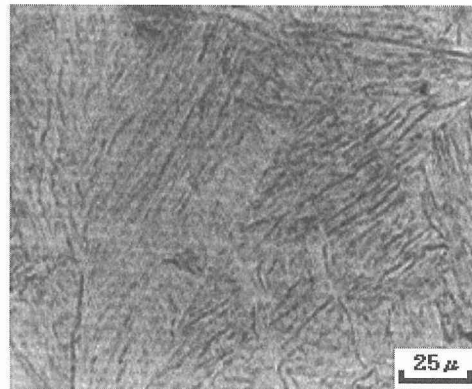
Hv 194





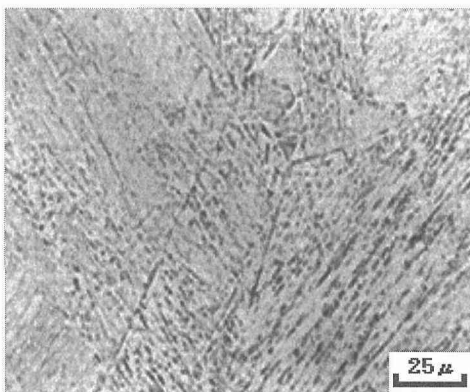
220 deg C/s

Hv 346



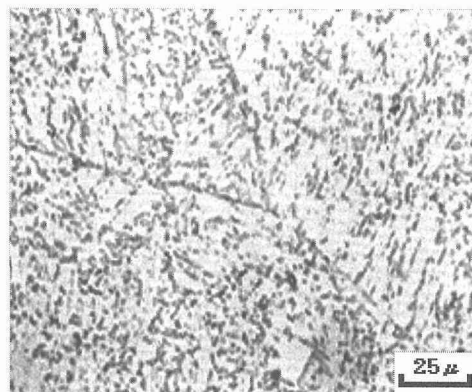
10 deg C/s

Hv 342



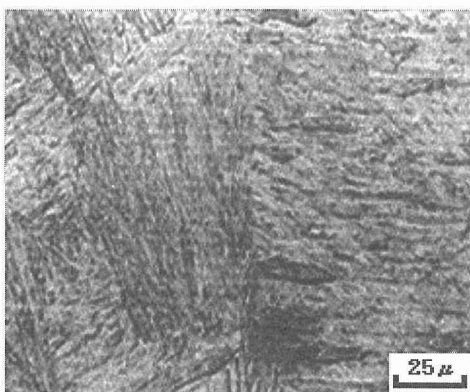
30 deg C/m

Hv 313



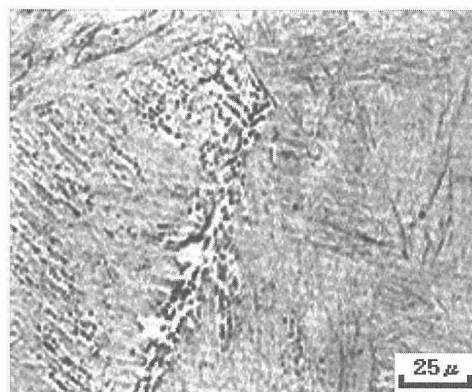
10 deg C/m

Hv 253



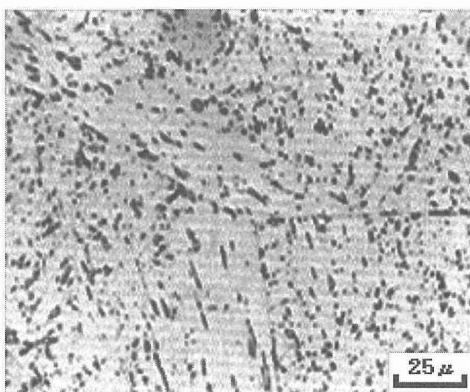
200 deg C/m

Hv 339



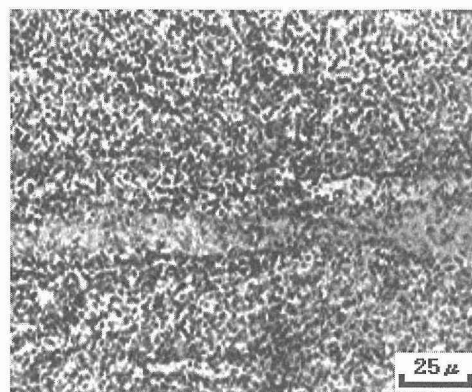
80 deg C/m

Hv 338



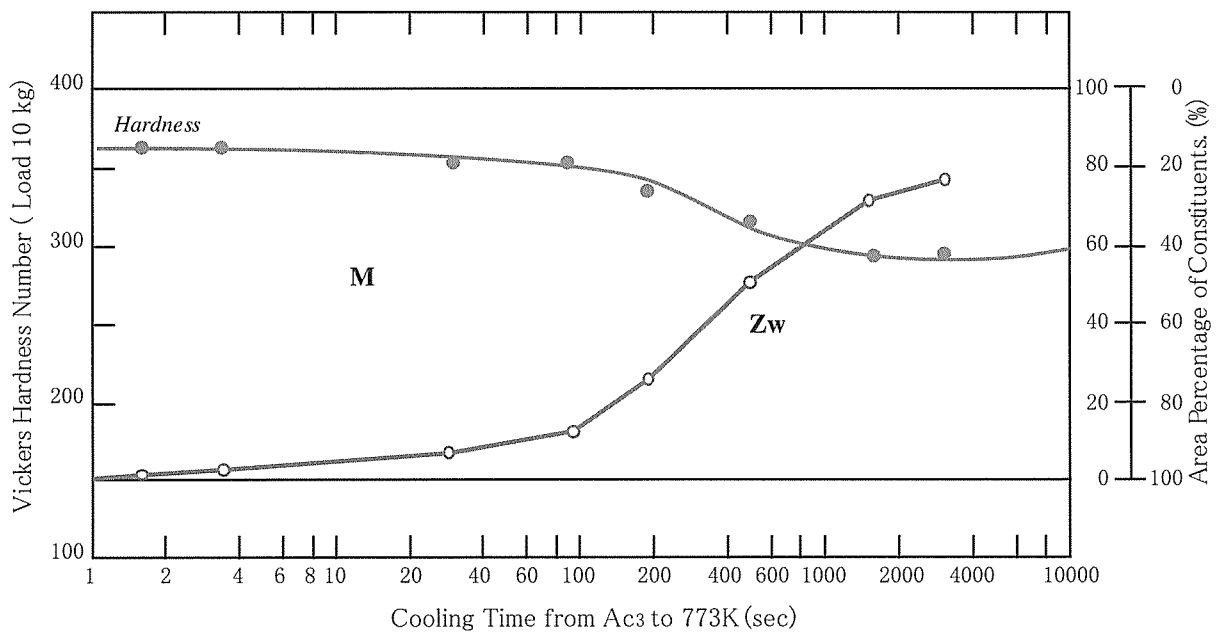
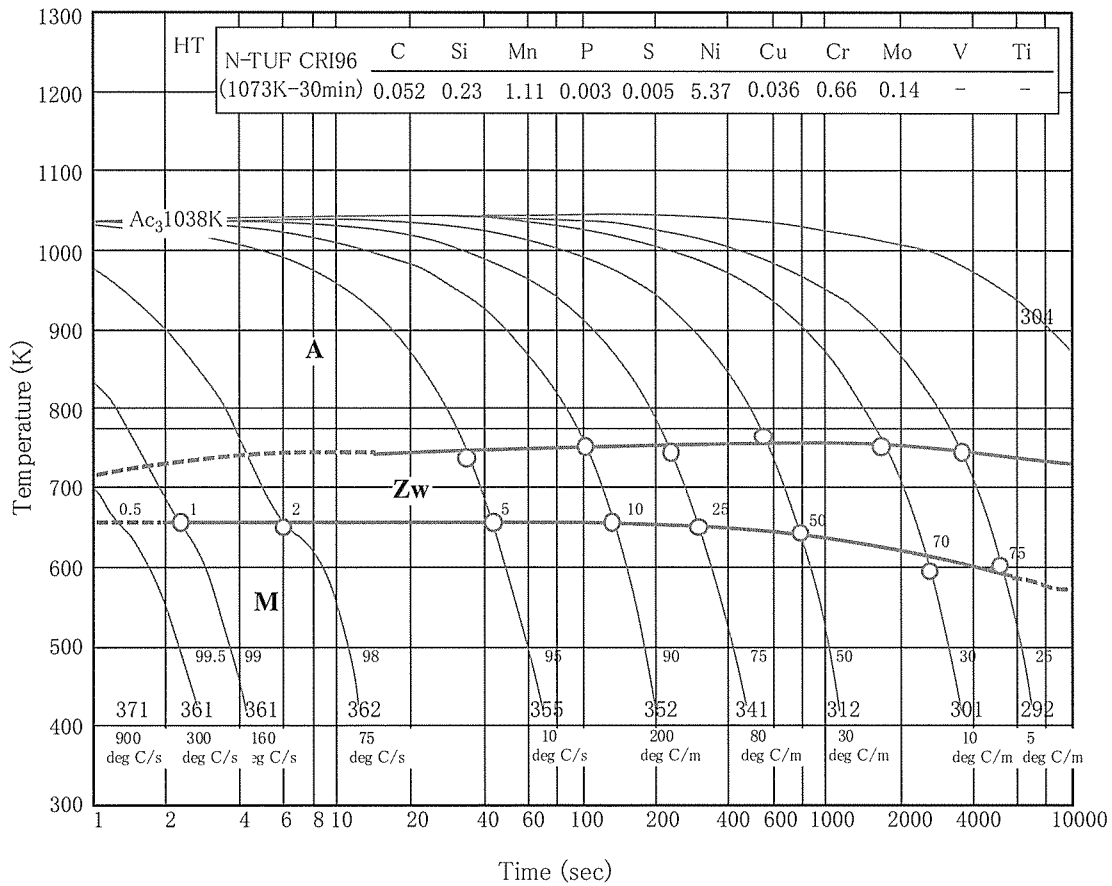
2 deg C/m

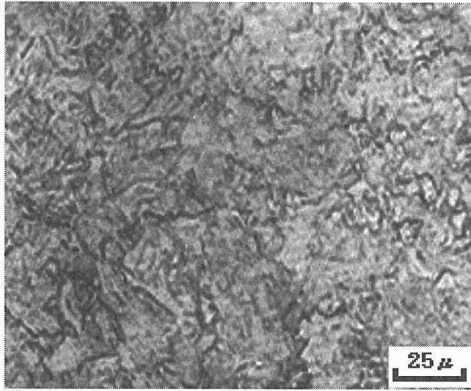
Hv 222



As received

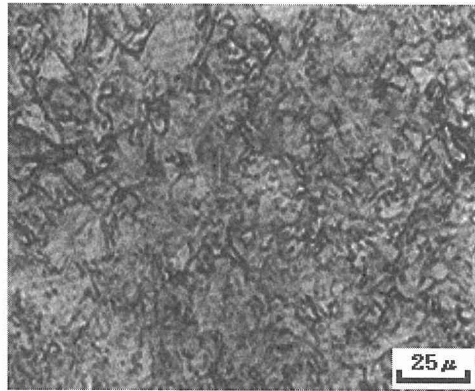
Hv 294





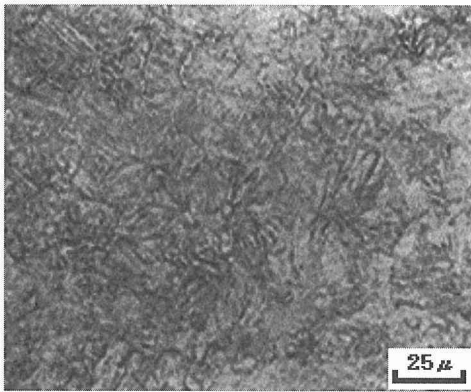
900 deg C/s

Hv 371



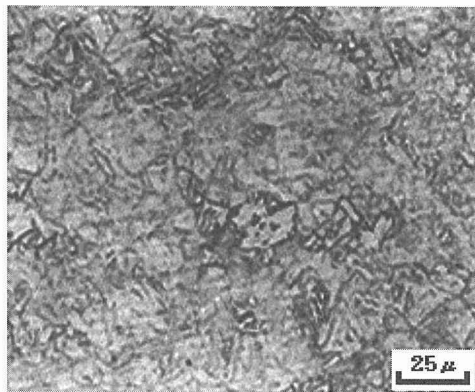
160 deg C/s

Hv 361



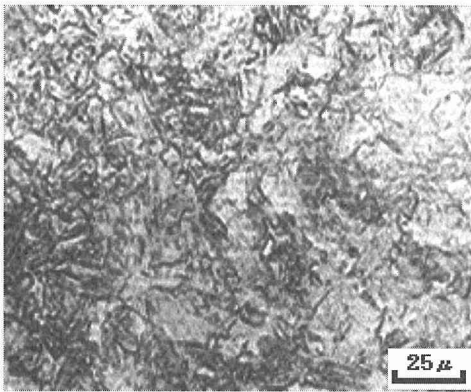
80 deg C/m

Hv 341



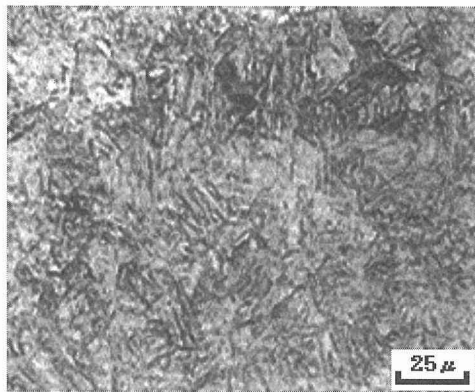
30 deg C/m

Hv 312



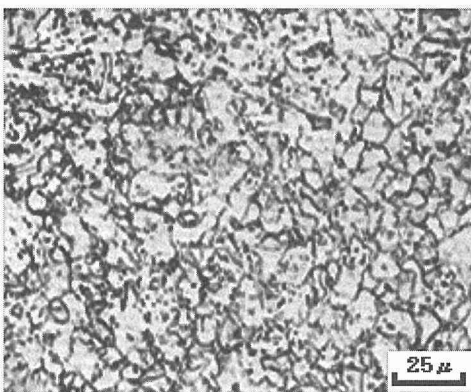
10 deg C/s

Hv 355



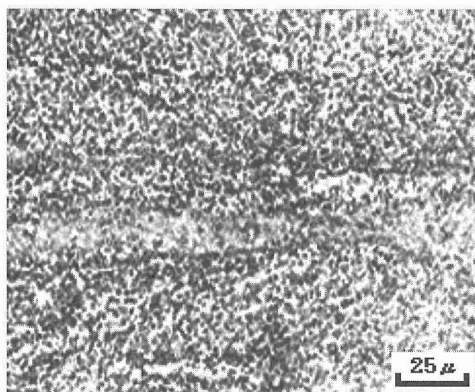
200 deg C/m

Hv 352



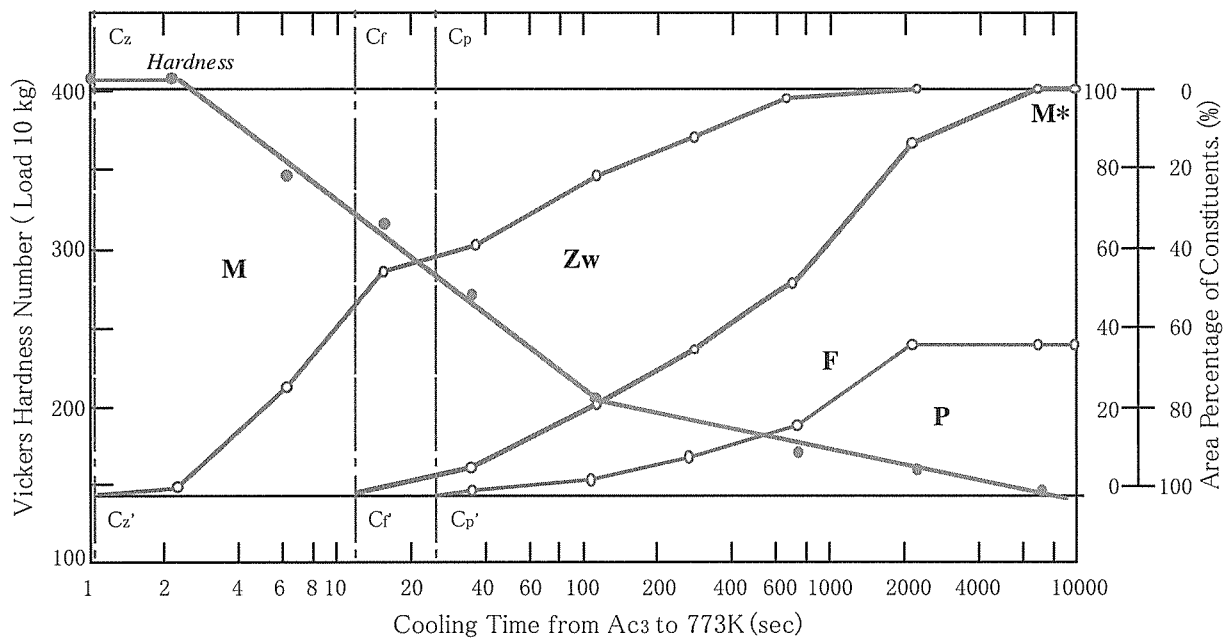
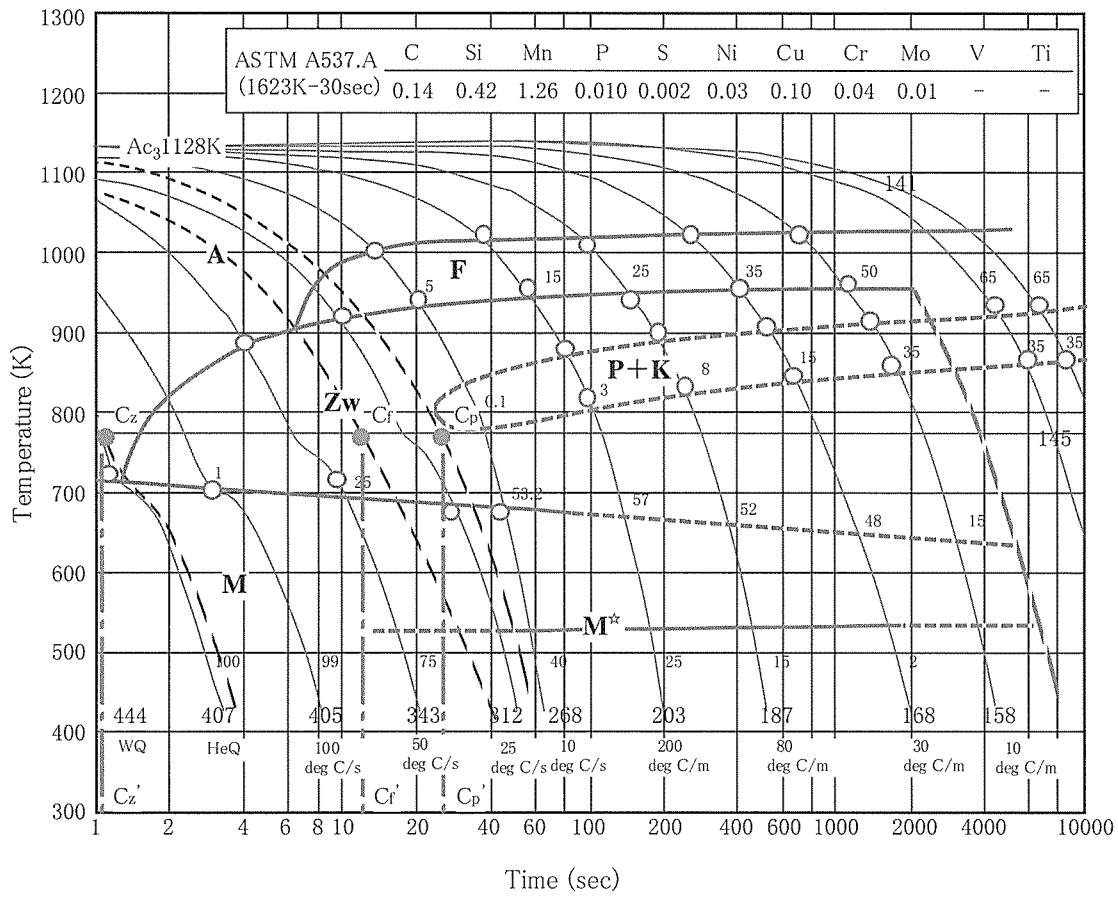
1 deg C/m

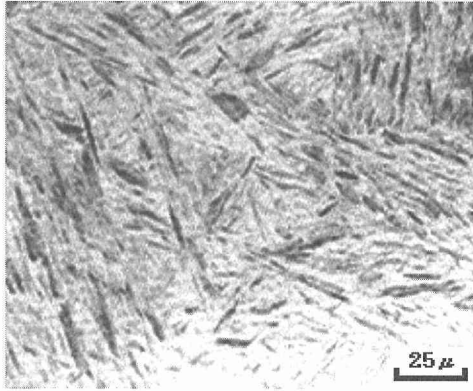
Hv 304



As received

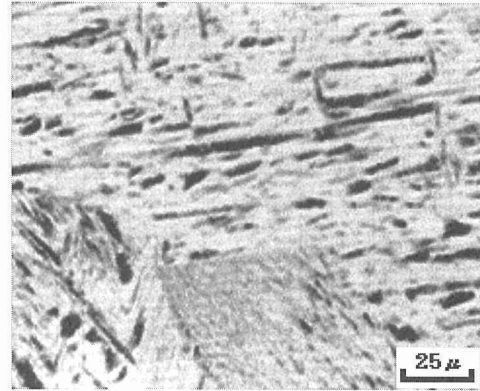
Hv 294





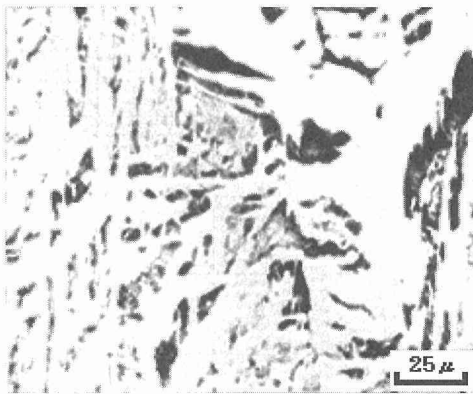
WQ

Hv 444



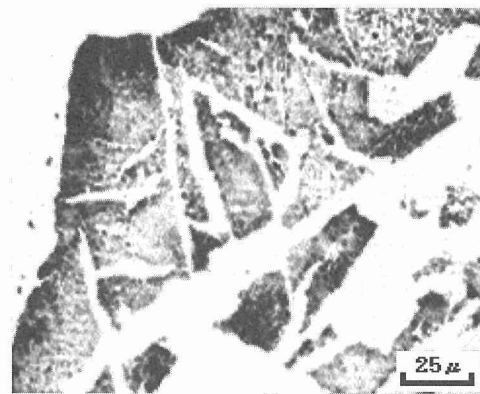
100 deg C/s

Hv 405



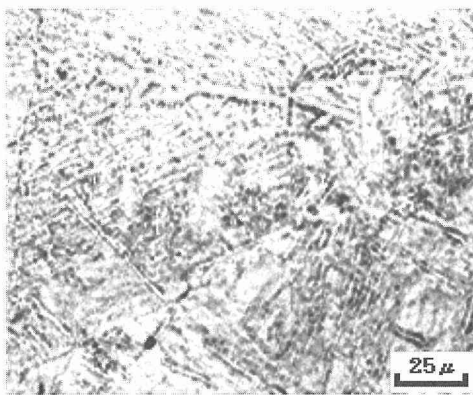
80 deg C/m

Hv 187



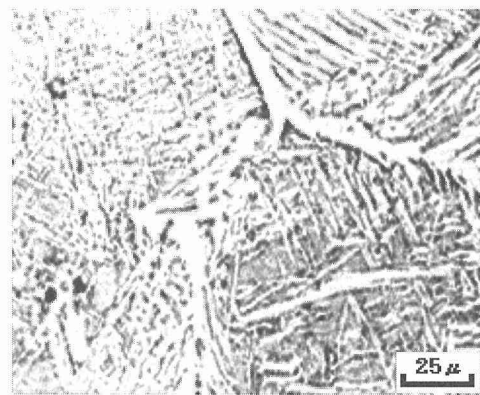
10 deg C/m

Hv 158



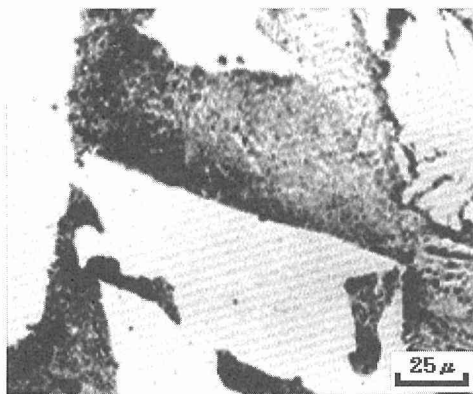
50 deg C/s

Hv 343



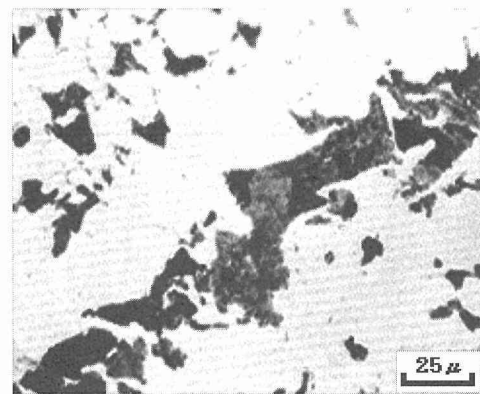
10 deg C/s

Hv 268



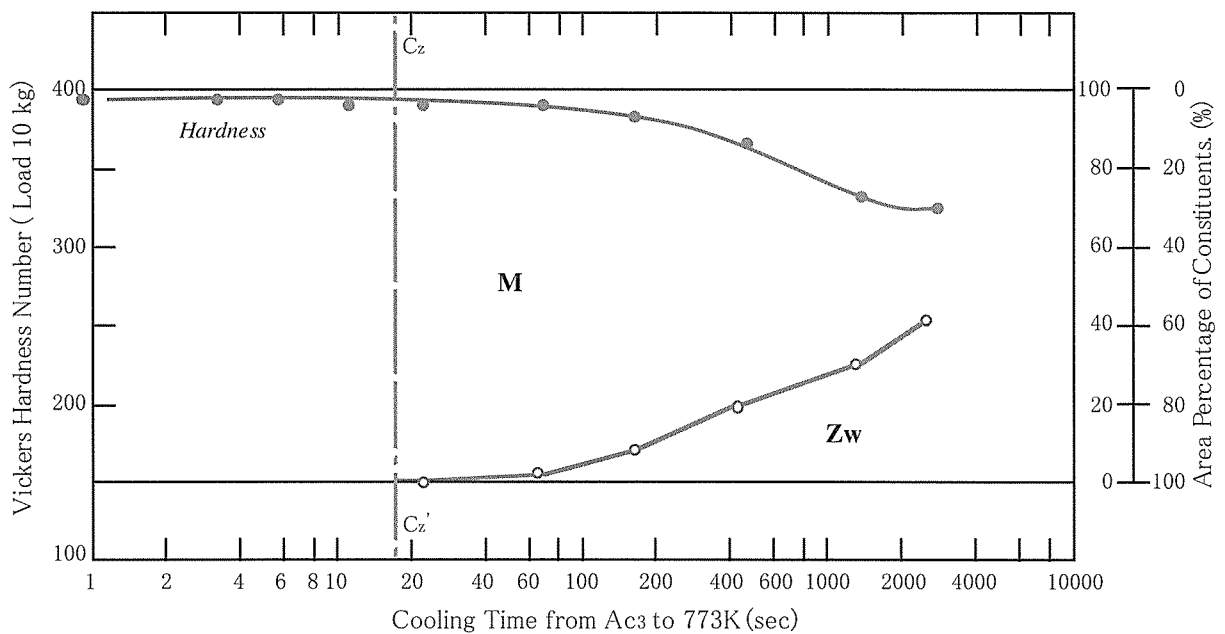
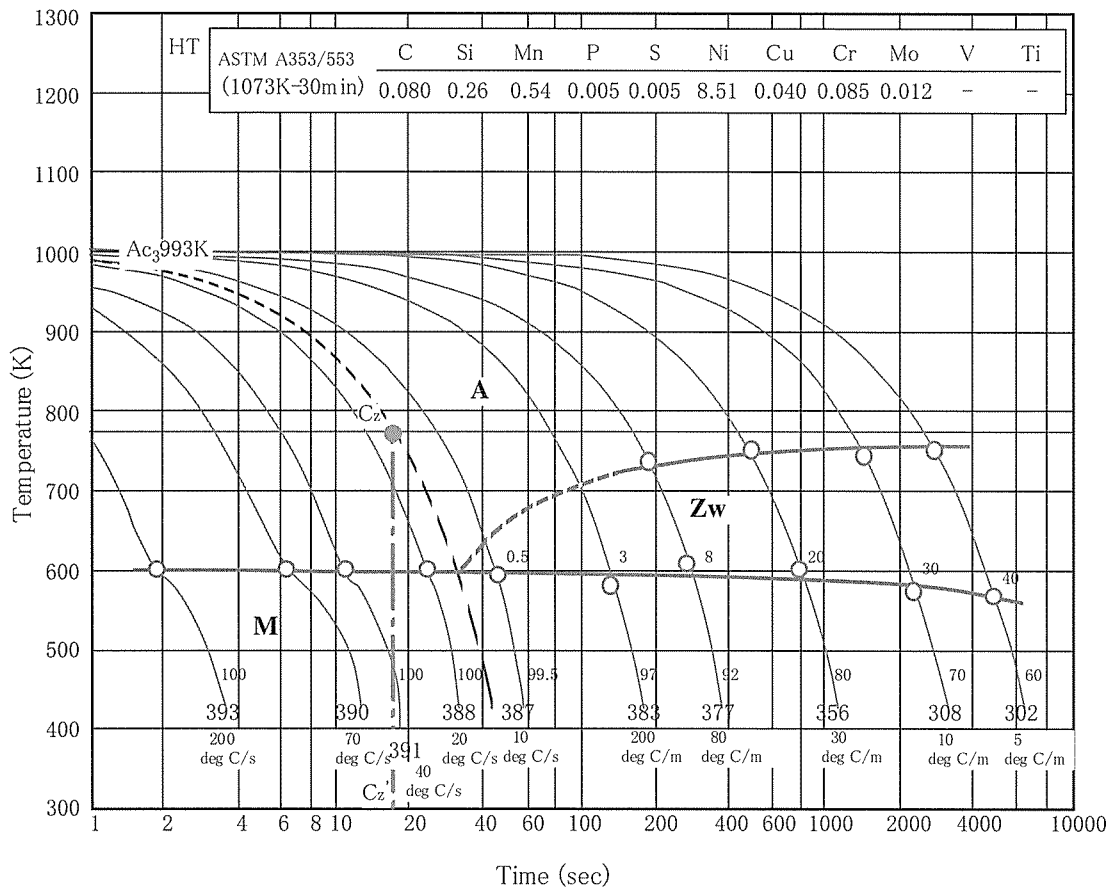
2 deg C/m

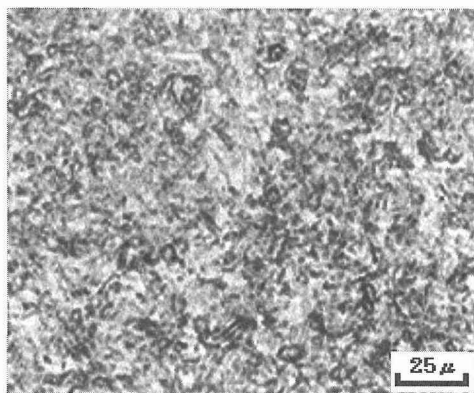
Hv 141



As received

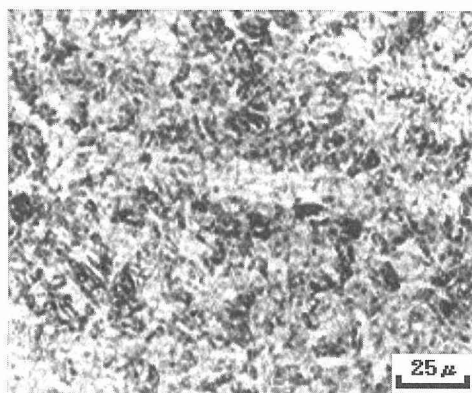
Hv 145





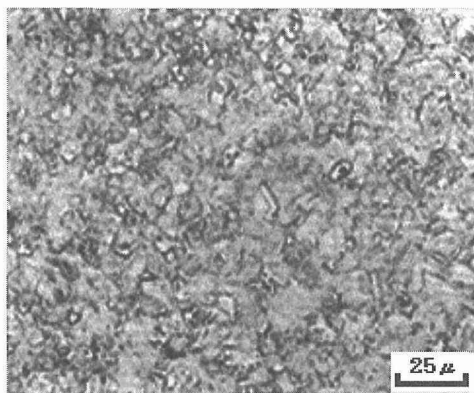
200 deg C/s

Hv 393



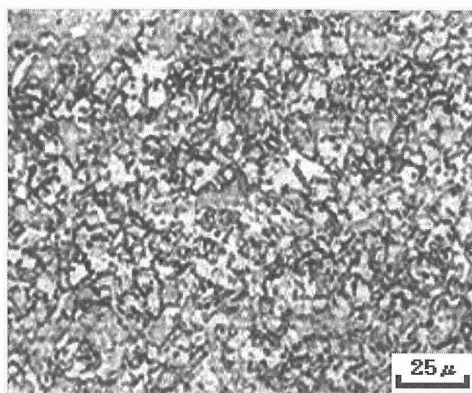
20 deg C/s

Hv 388



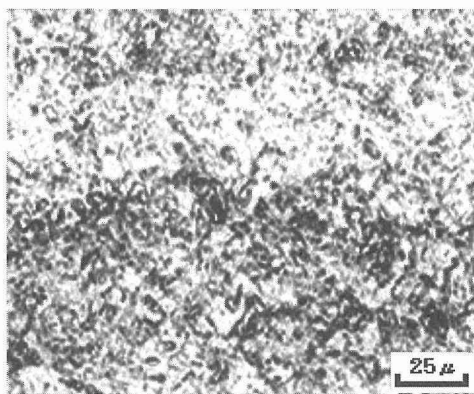
80 deg C/m

Hv 377



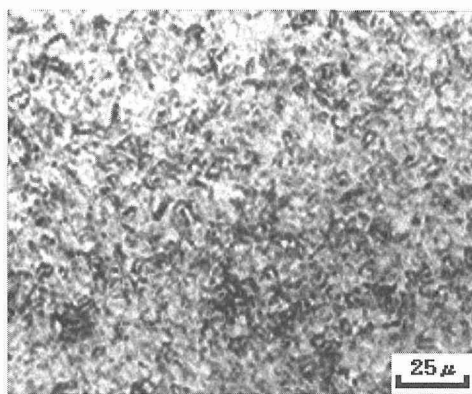
10 deg C/m

Hv 308



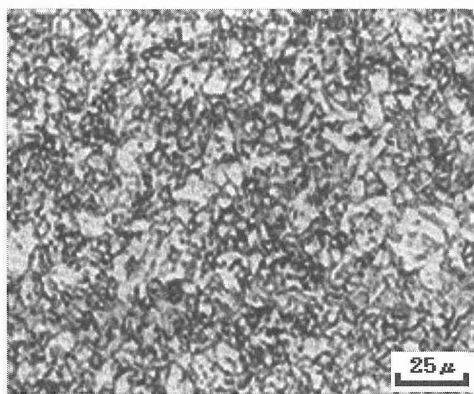
10 deg C/s

Hv 387



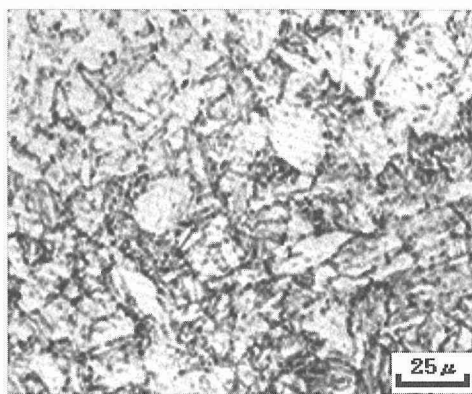
200 deg C/m

Hv 383



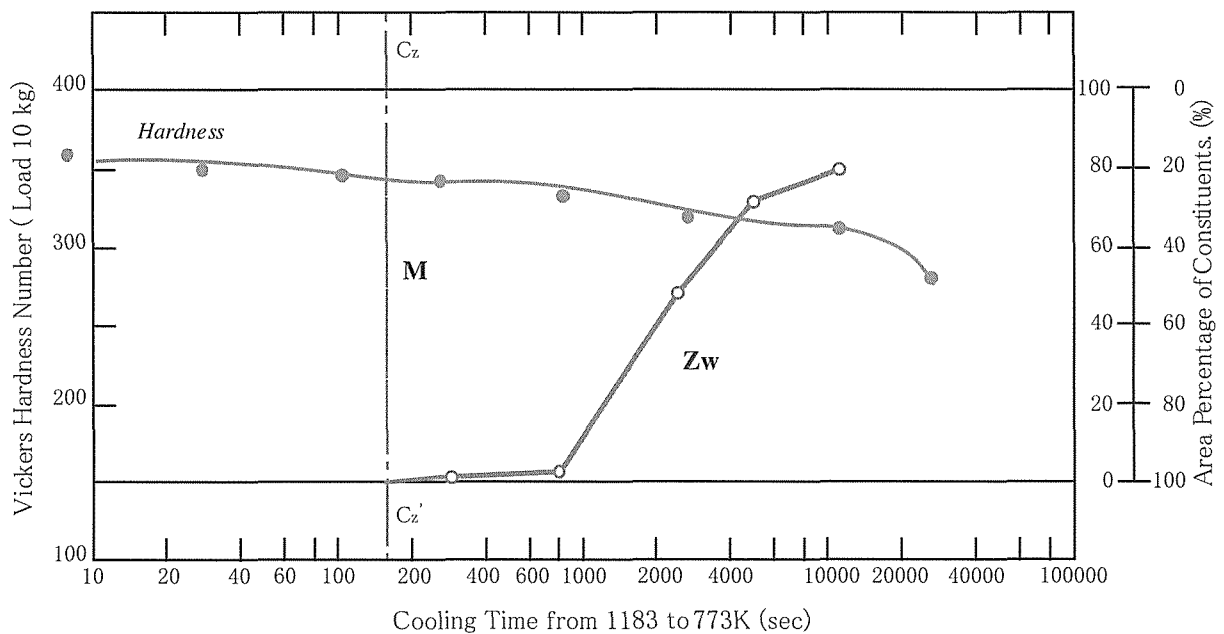
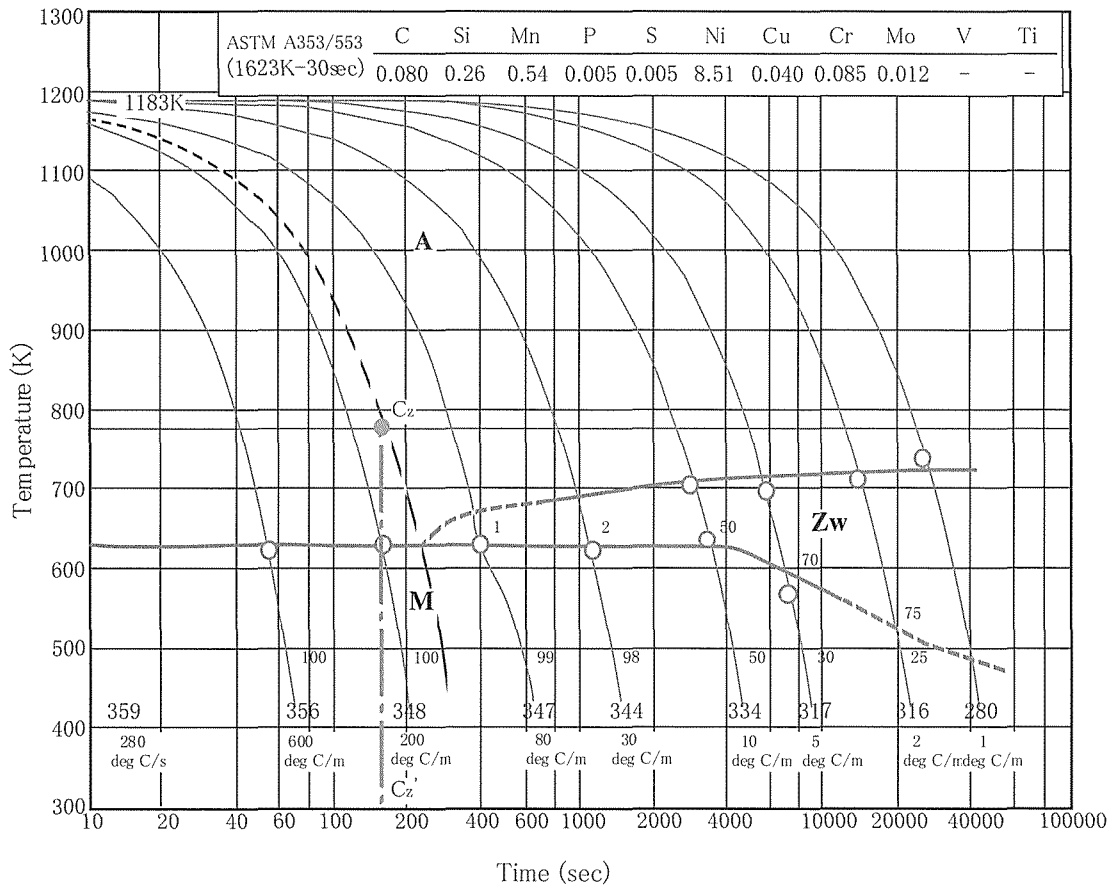
5 deg C/m

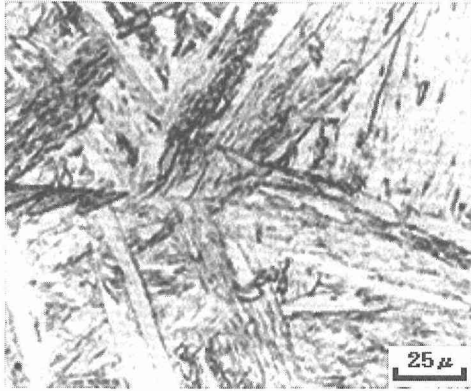
Hv 302



As received

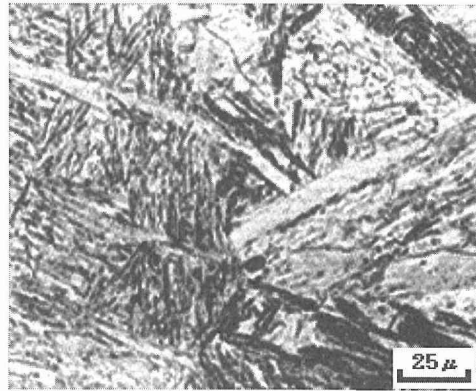
Hv 256





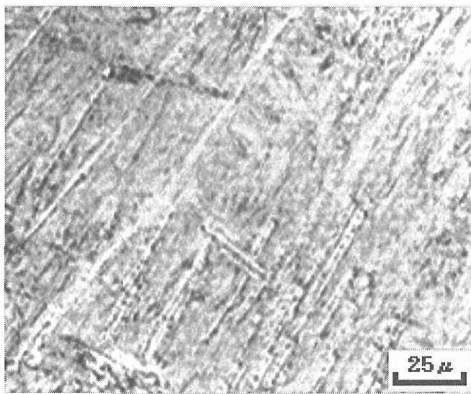
280 deg C/s

Hv 359



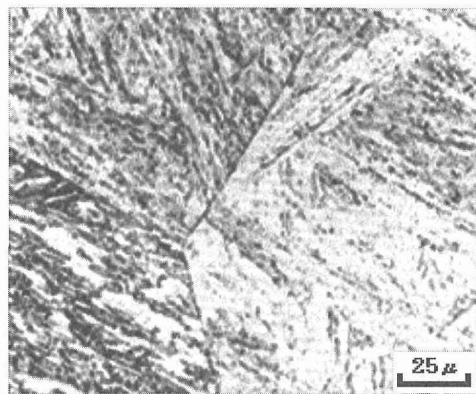
200 deg C/m

Hv 348



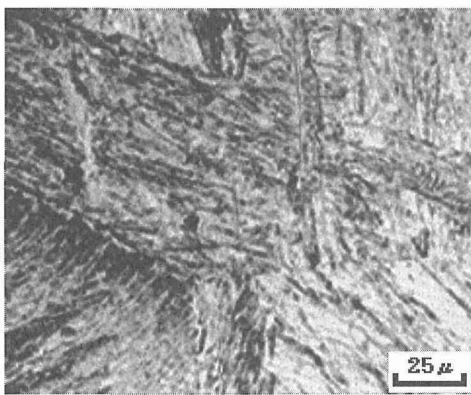
5 deg C/m

Hv 317



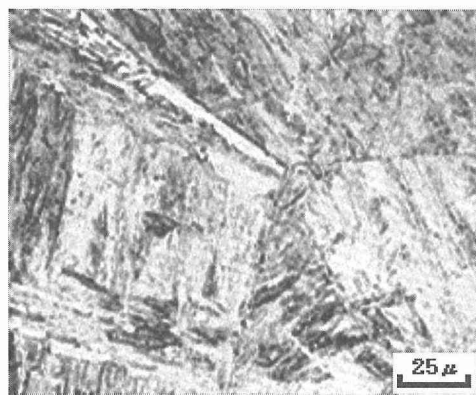
2 deg C/m

Hv 316



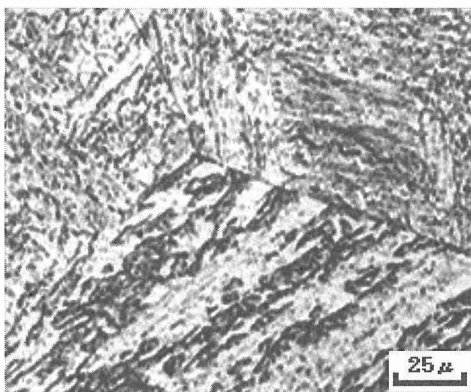
80 deg C/m

Hv 347



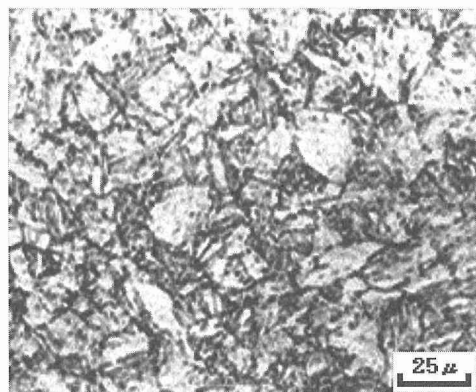
30 deg C/m

Hv 344



1 deg C/m

Hv 280



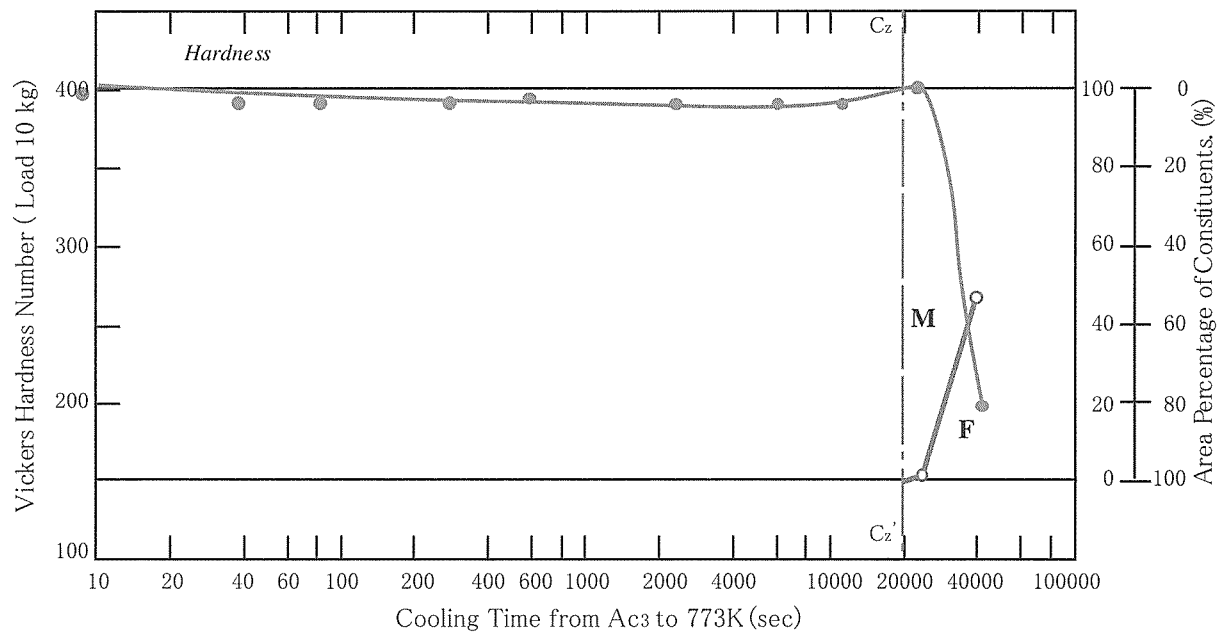
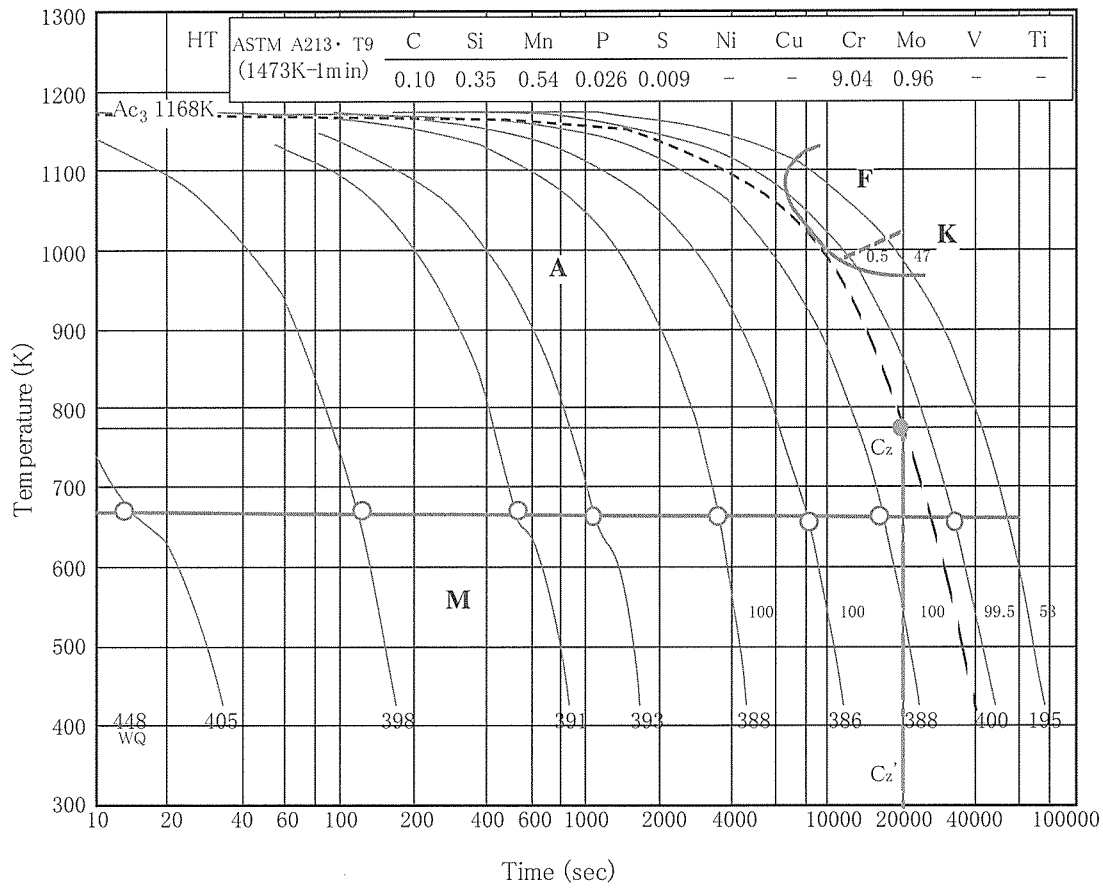
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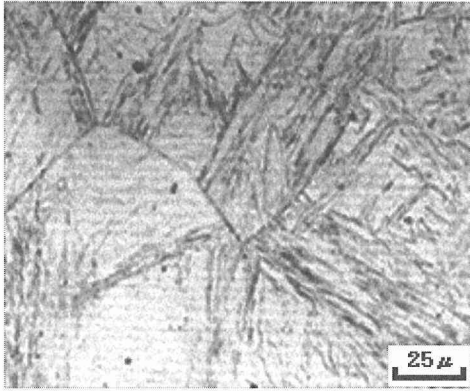
Hv 256

High Tensile Strength Steel for Pressure Vessels ASTM A series

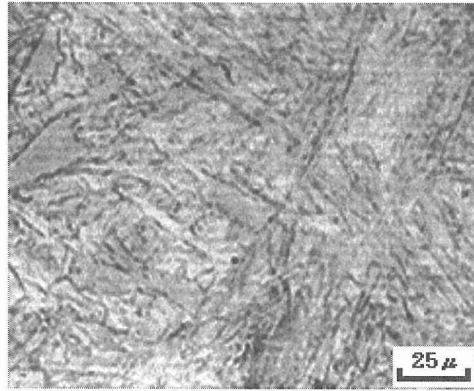
Steel	Chemical Composition (wt%)															Page	Ref.
	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Nb	B	O		
ASTM A213.T9 [141CM-B] HT	0.1	0.35	0.54	0.026	0.009	-	-	0.96	-	-	-	-	-	-	-	64	1
ASTM A213.T9 [141CM-C] HT	0.1	0.35	0.54	0.026	0.009	-	-	0.96	-	-	-	-	-	-	-	66	1
ASTM A302.B [221-NM-B] HT	0.19	0.17	1.36	0.016	0.007	-	0.66	0.46	-	-	-	-	-	-	-	68	1
ASTM A387.D [131CM-A]	0.12	0.28	0.5	0.019	0.006	0.1	0.071	1	-	-	-	-	-	-	-	70	1
ASTM A387.D [131CM-B] HT	0.12	0.28	0.5	0.019	0.006	0.1	0.071	1	-	-	-	-	-	-	-	72	1
ASTM A387.E [121CMS-B] HT	0.11	0.19	0.76	0.01	0.003	0.1	0.045	1.14	-	-	-	-	-	-	-	74	1
ASTM A516.Gr70 [251NS-A]	0.15	0.53	1.31	0.019	0.005	0.057	0.75	-	-	-	-	-	0.04	-	-	76	1
ASTM A516.Gr70 [251NS-B] HT	0.15	0.53	1.31	0.019	0.005	0.057	0.75	-	-	-	-	-	0.04	-	-	78	1
ASTM A543 [230NCMS-B] HT	0.16	0.34	0.38	0.006	0.004	0.11	3.33	0.51	-	-	-	-	-	-	-	80	1

HT: CCT diagram to be used the purpose of heat treatment. Heating at temperature below 1623K for welding.

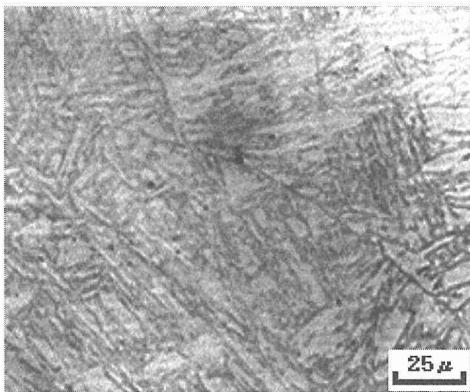




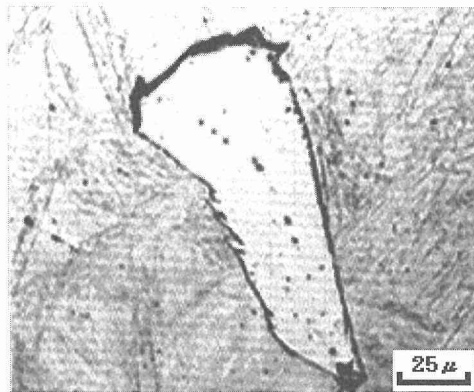
Hv 448



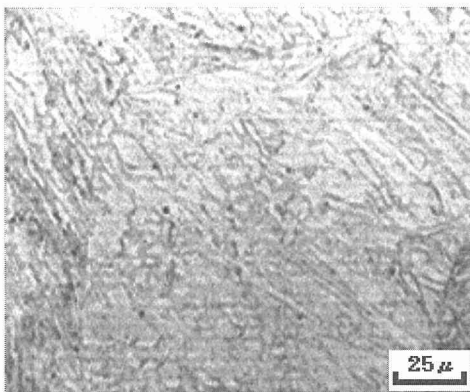
Hv 398



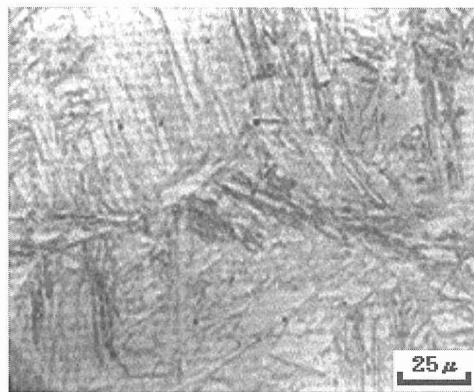
Hv 386



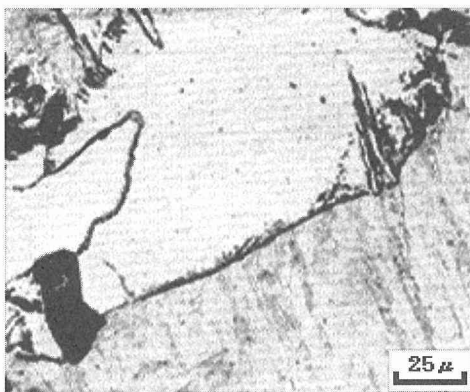
Hv 400



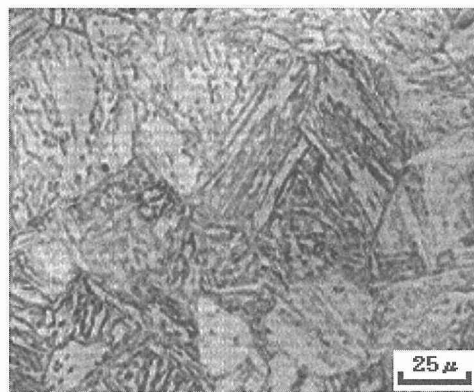
Hv 391



Hv 388

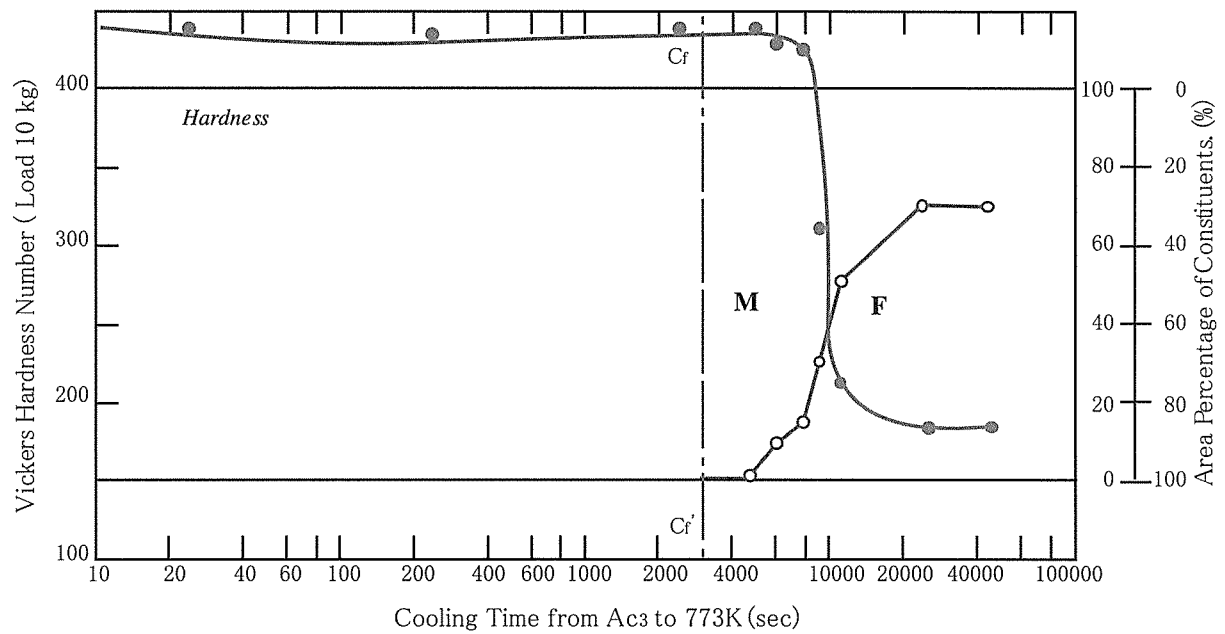
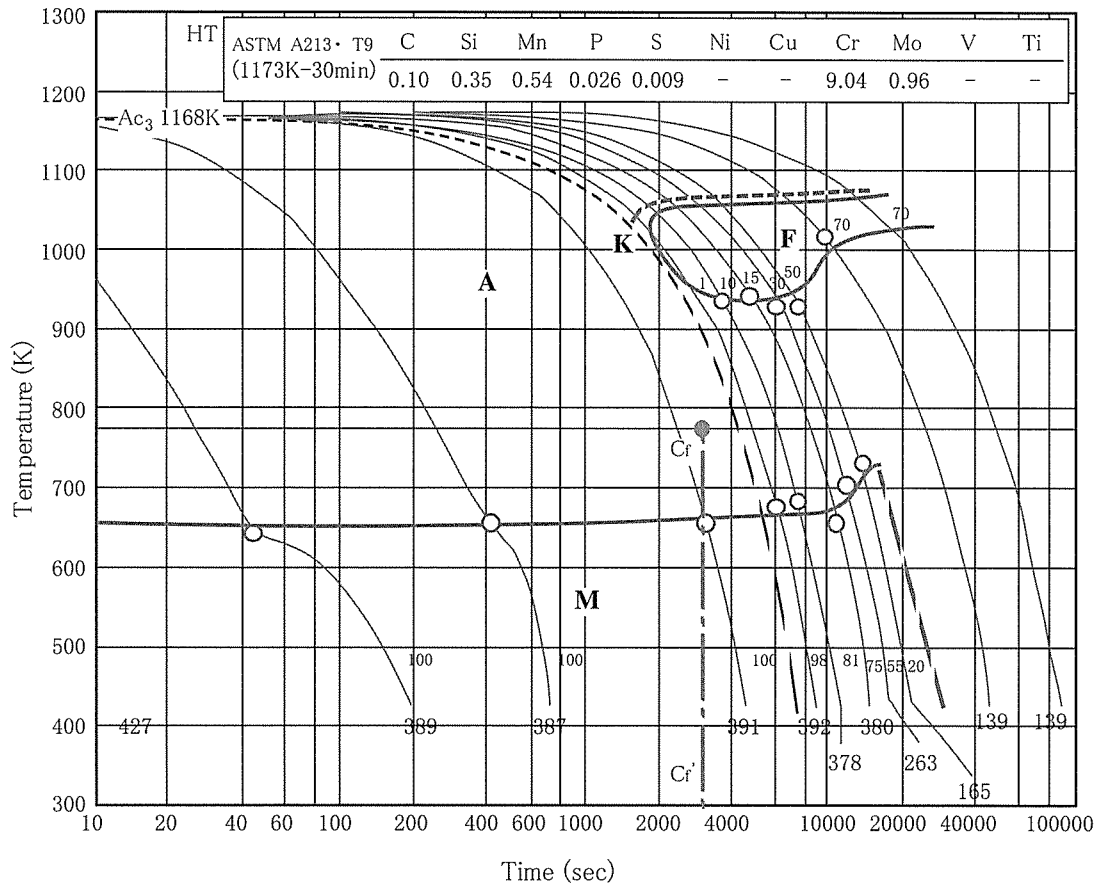


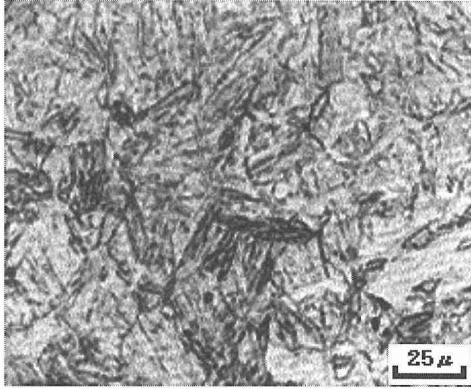
Hv 195



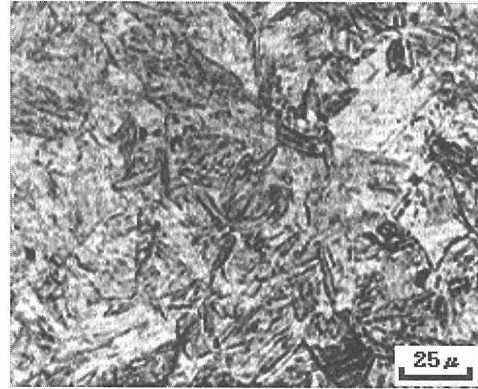
As received

Hv 391

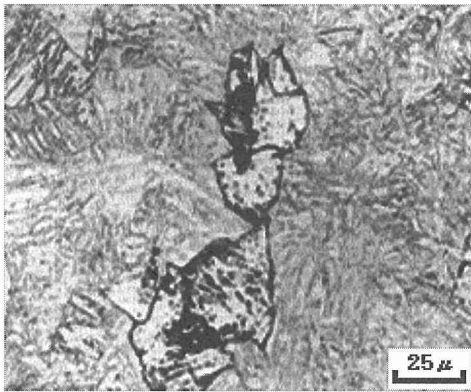




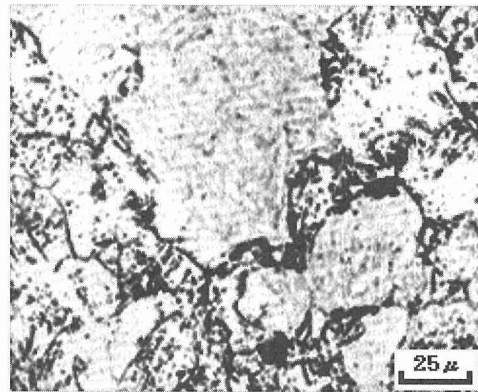
Hv 427



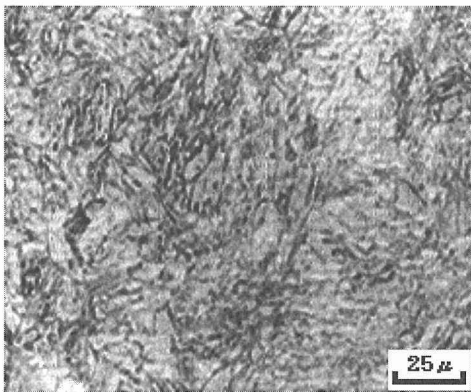
Hv 389



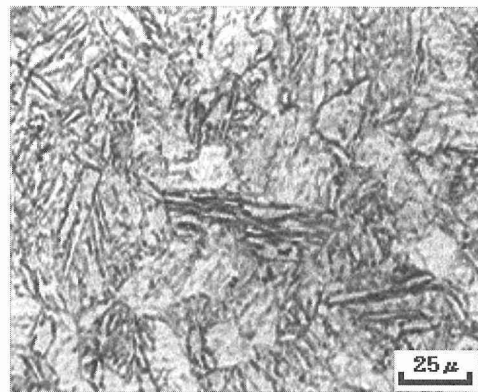
Hv 378



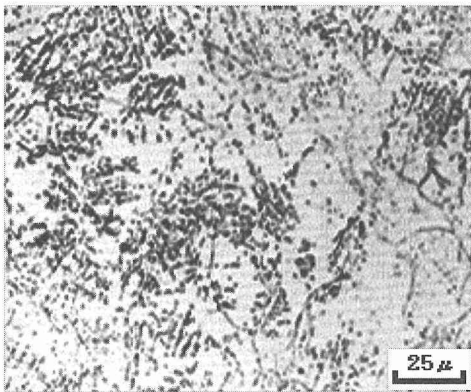
Hv 165



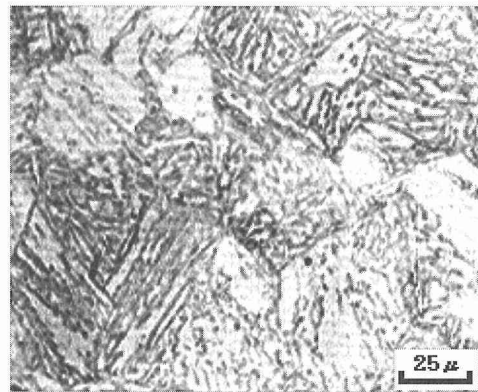
Hv 387



Hv 391

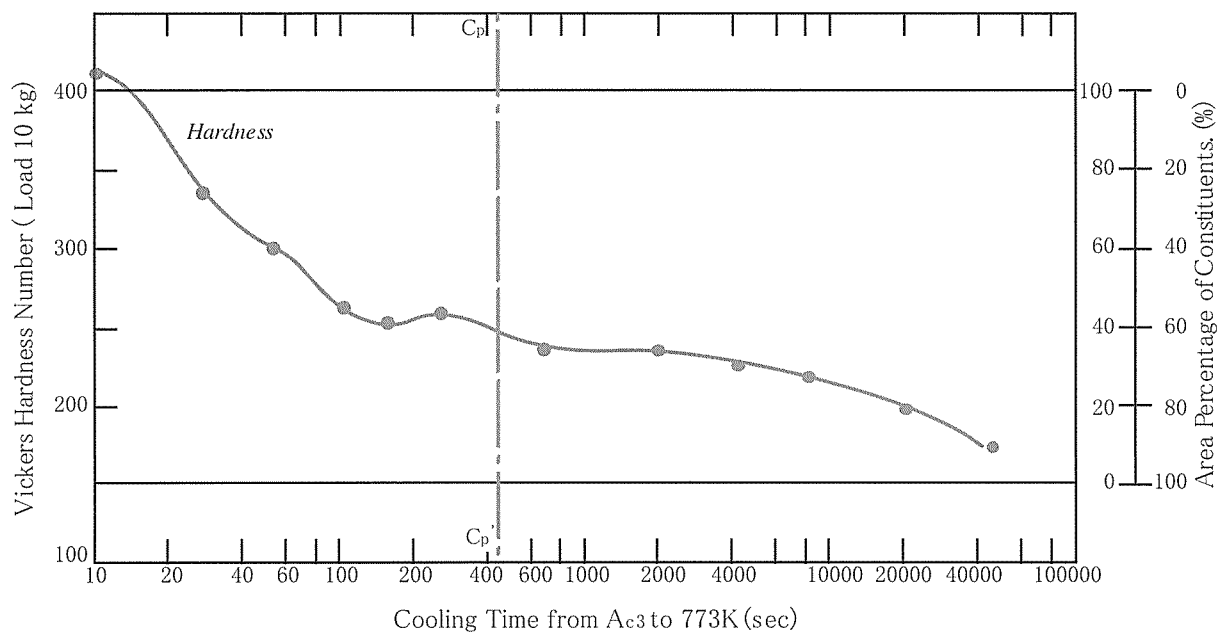
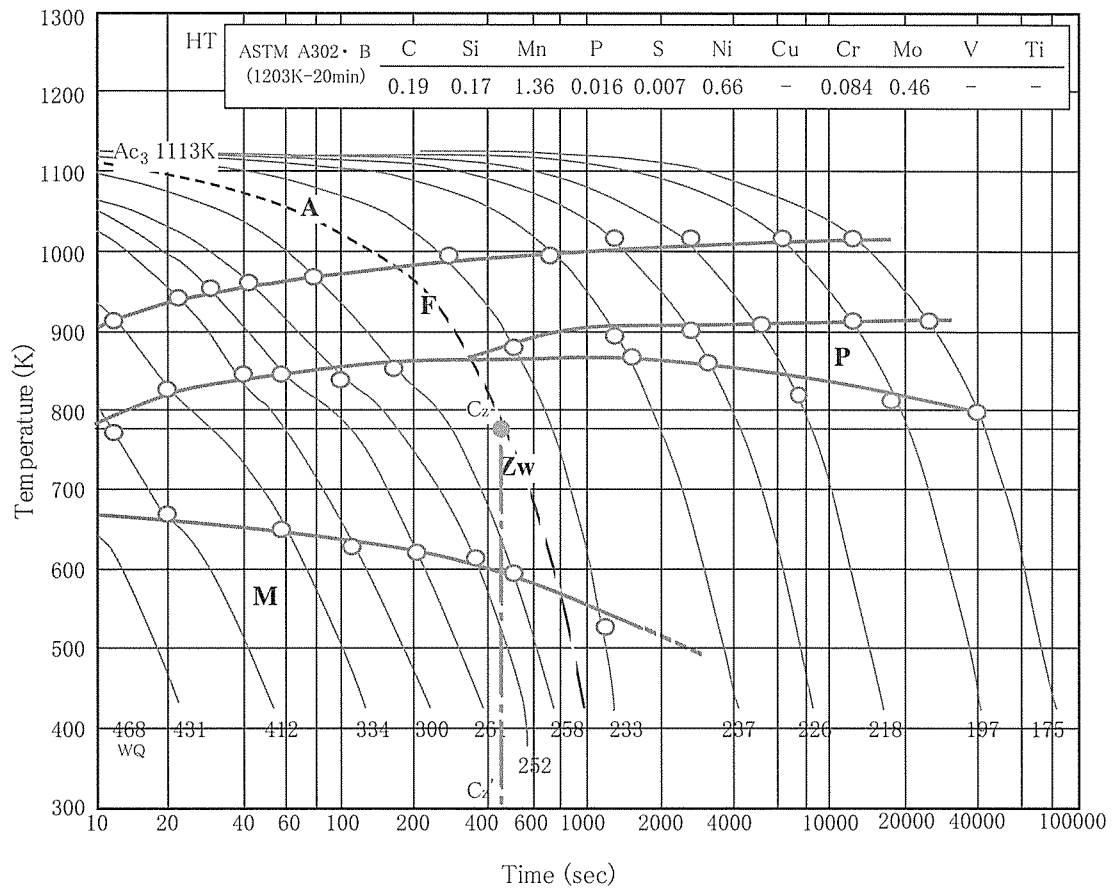


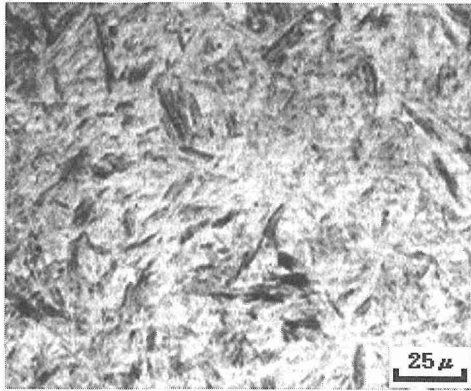
Hv 139



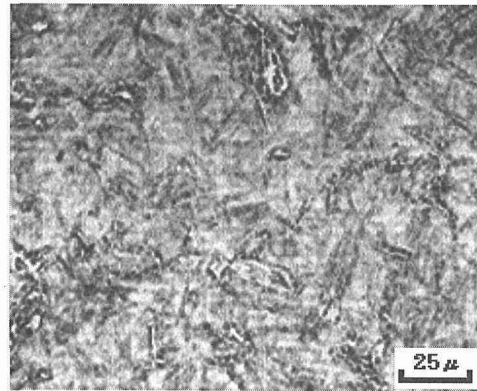
As received

Hv 391

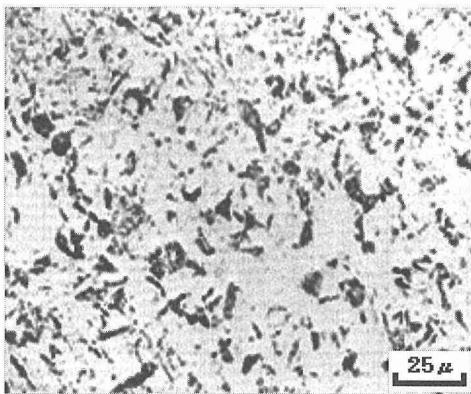




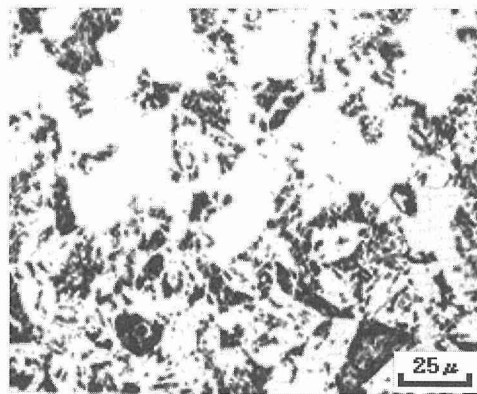
Hv 468



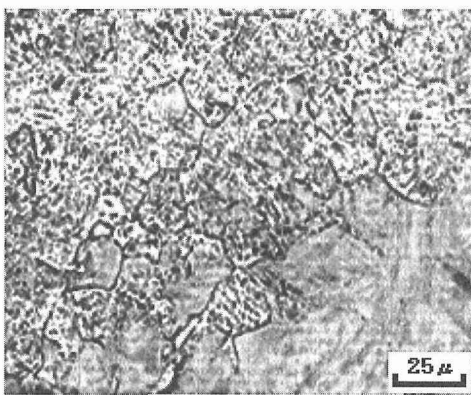
Hv 412



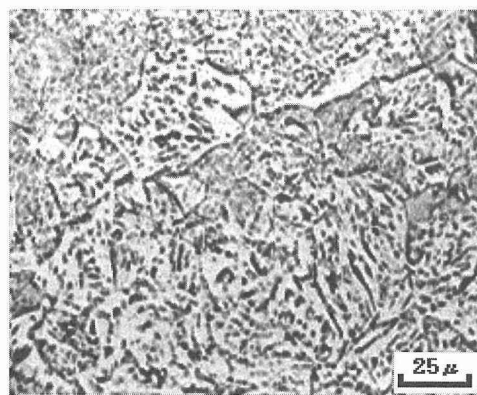
Hv 237



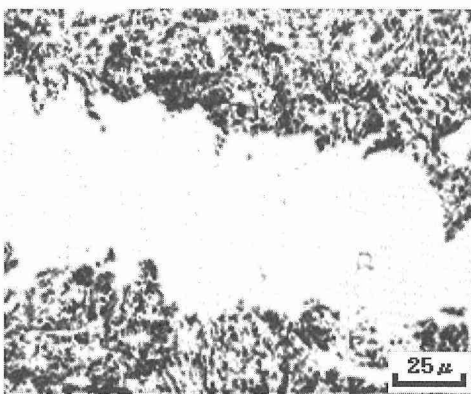
Hv 218



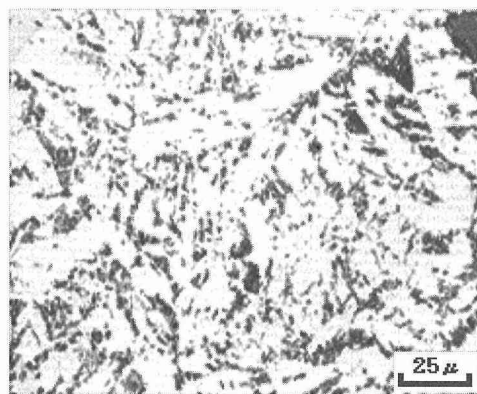
Hv 334



Hv 261

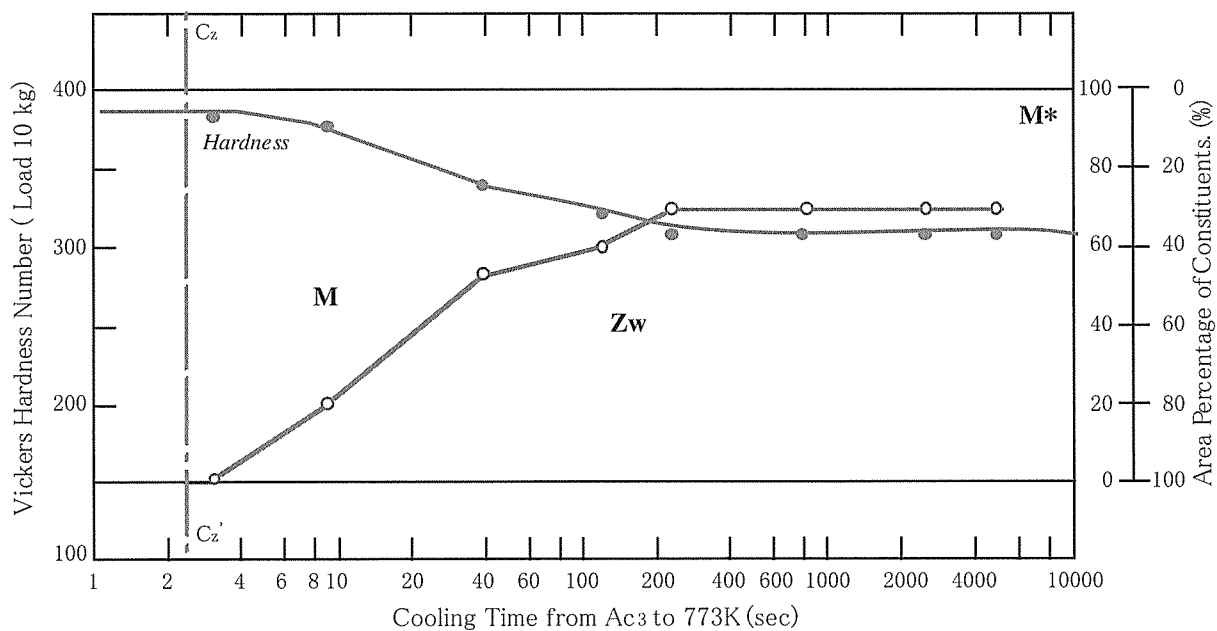
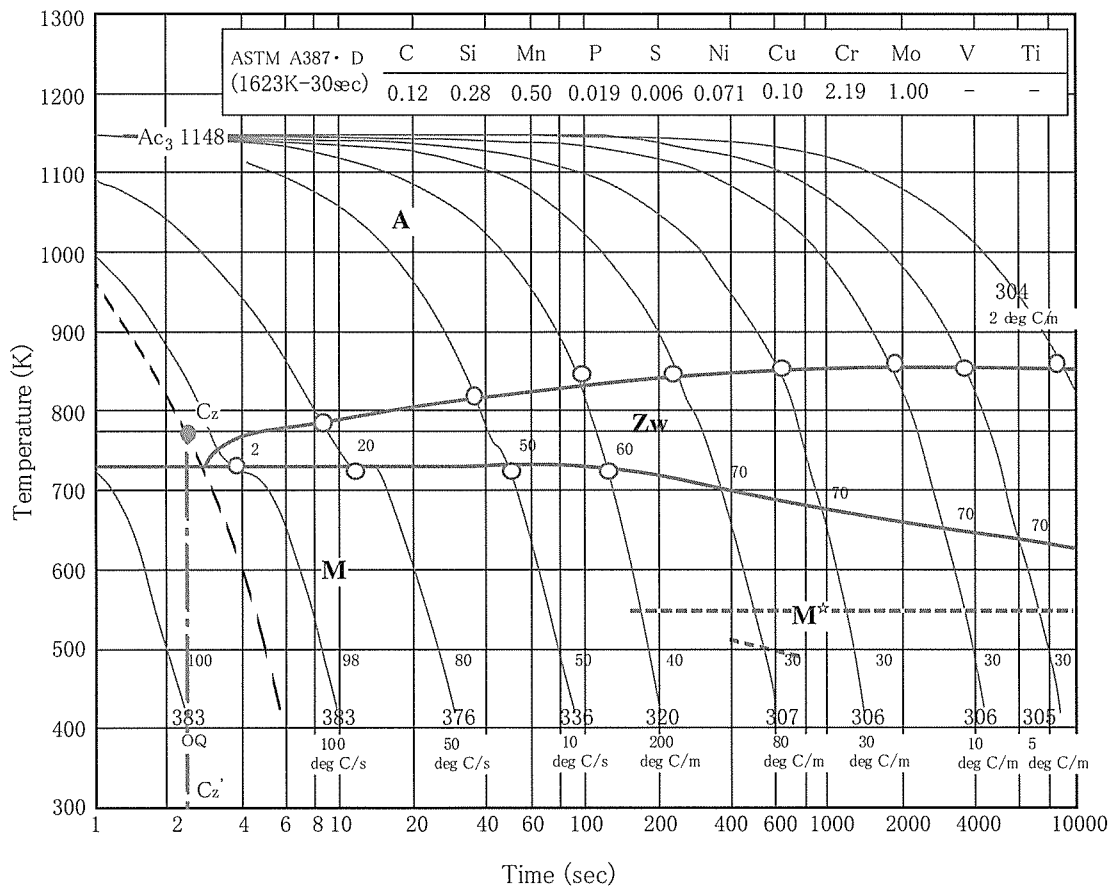


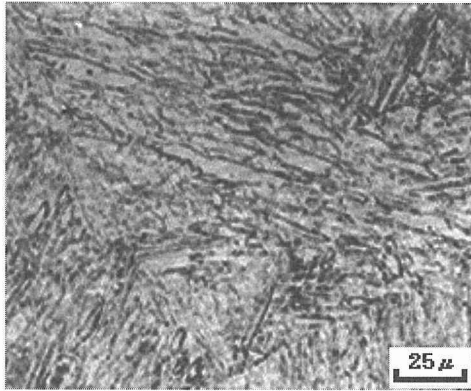
Hv 175



Hv 187

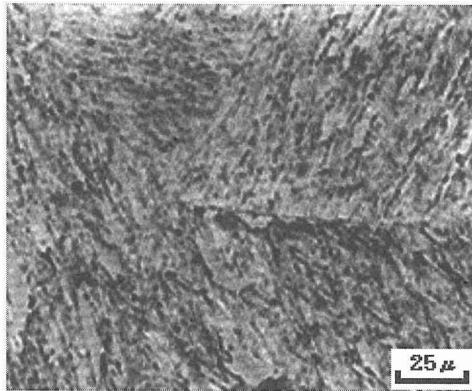
As received





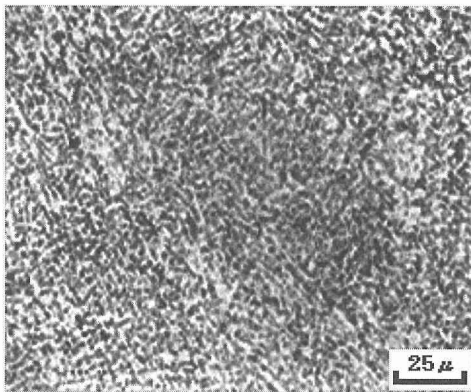
OQ

Hv 383



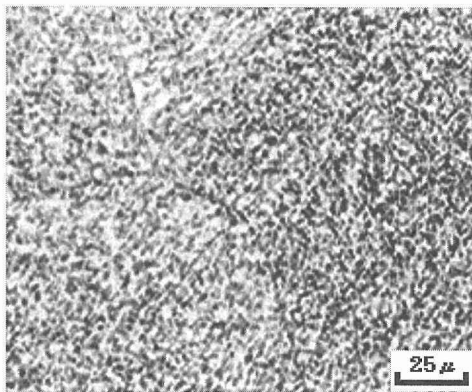
100 deg C/s

Hv 383



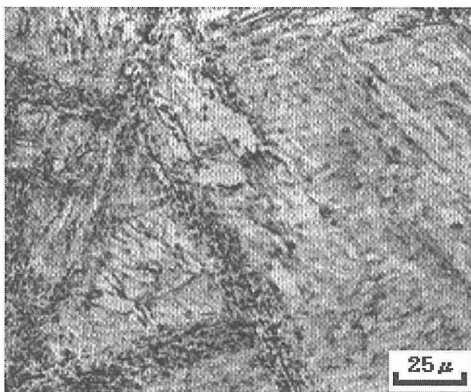
80 deg C/m

Hv 307



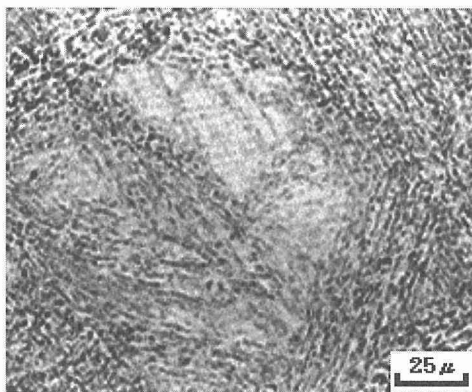
10 deg C/m

Hv 306



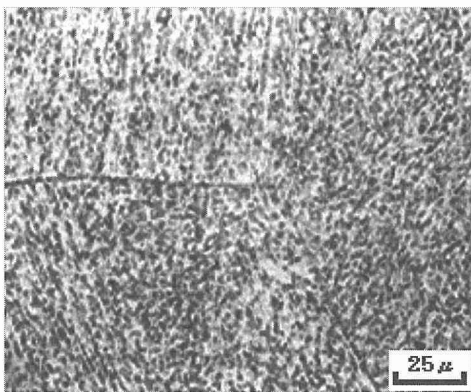
50 deg C/s

Hv 376



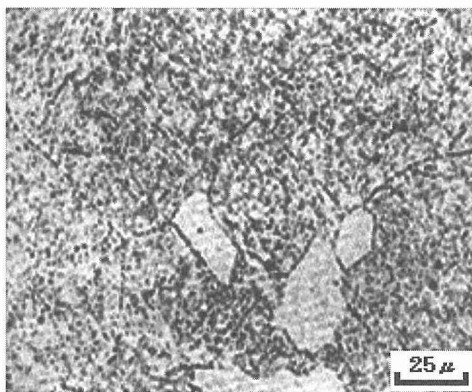
200 deg C/m

Hv 320



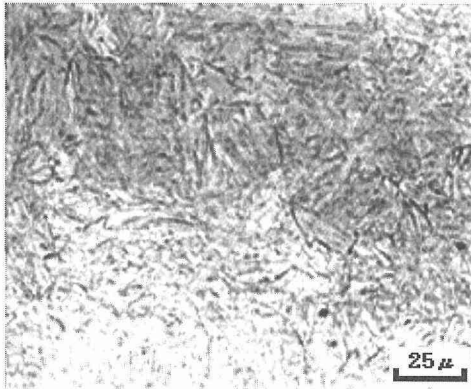
5 deg C/m

Hv 305



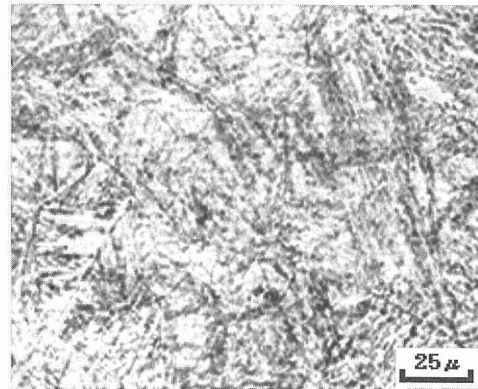
As received

Hv 197



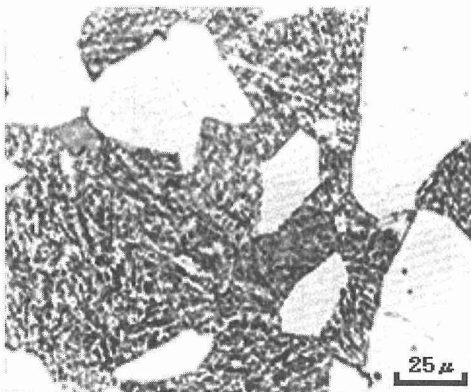
OQ

Hv 389



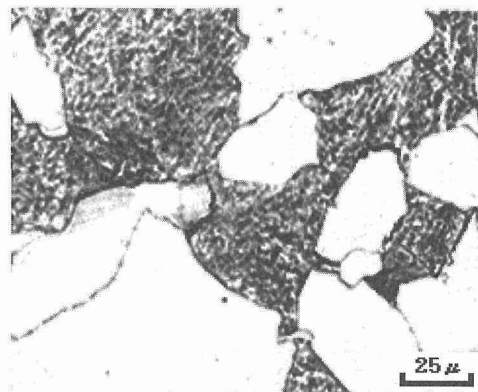
50 deg C/s

Hv 383



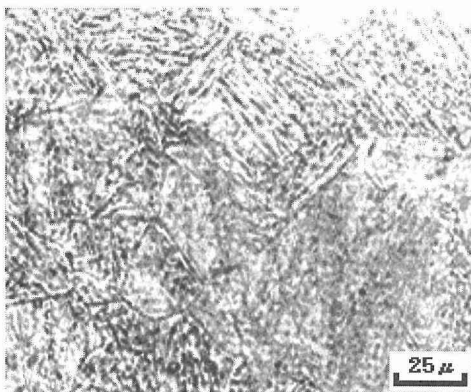
10 deg C/m

Hv 242



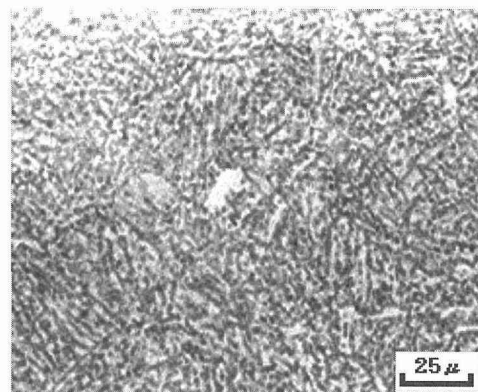
5 deg C/m

Hv 179



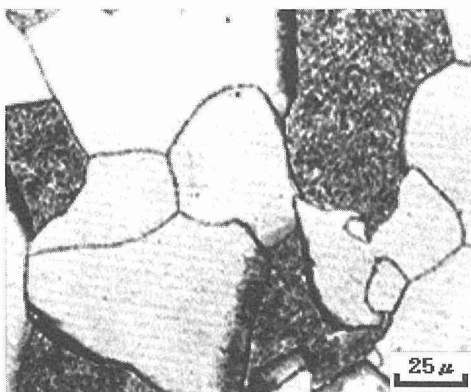
200 deg C/m

Hv 343



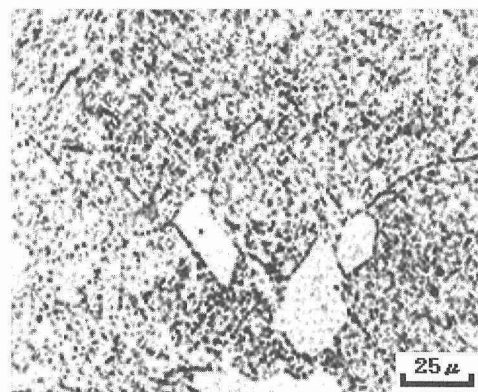
80 deg C/m

Hv 319



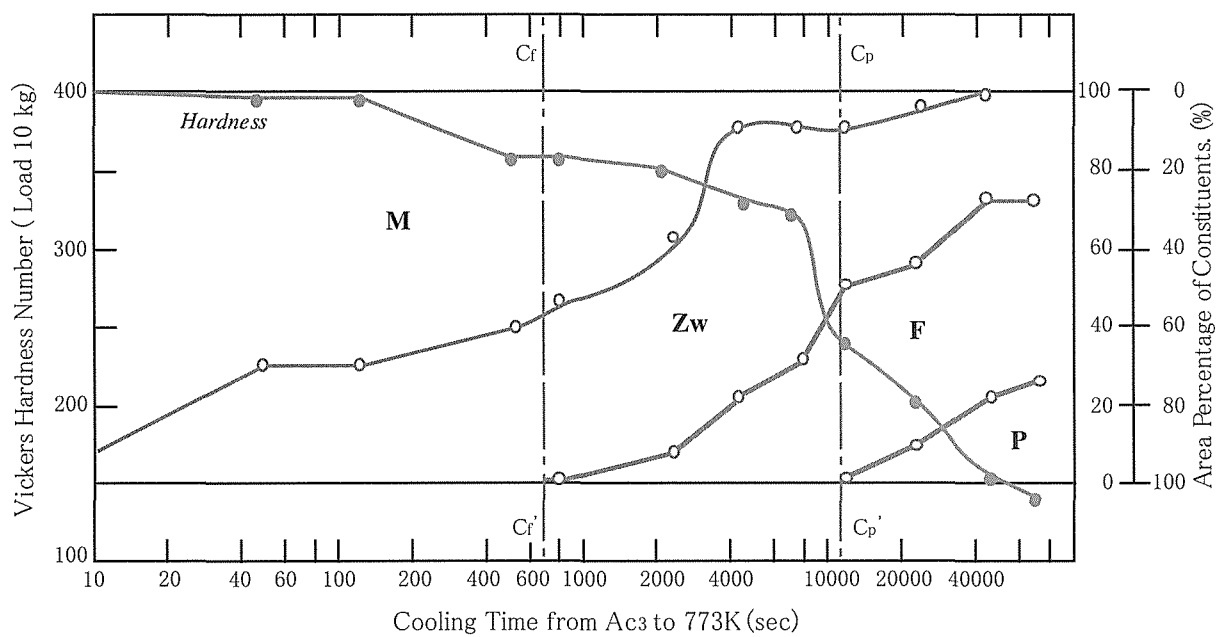
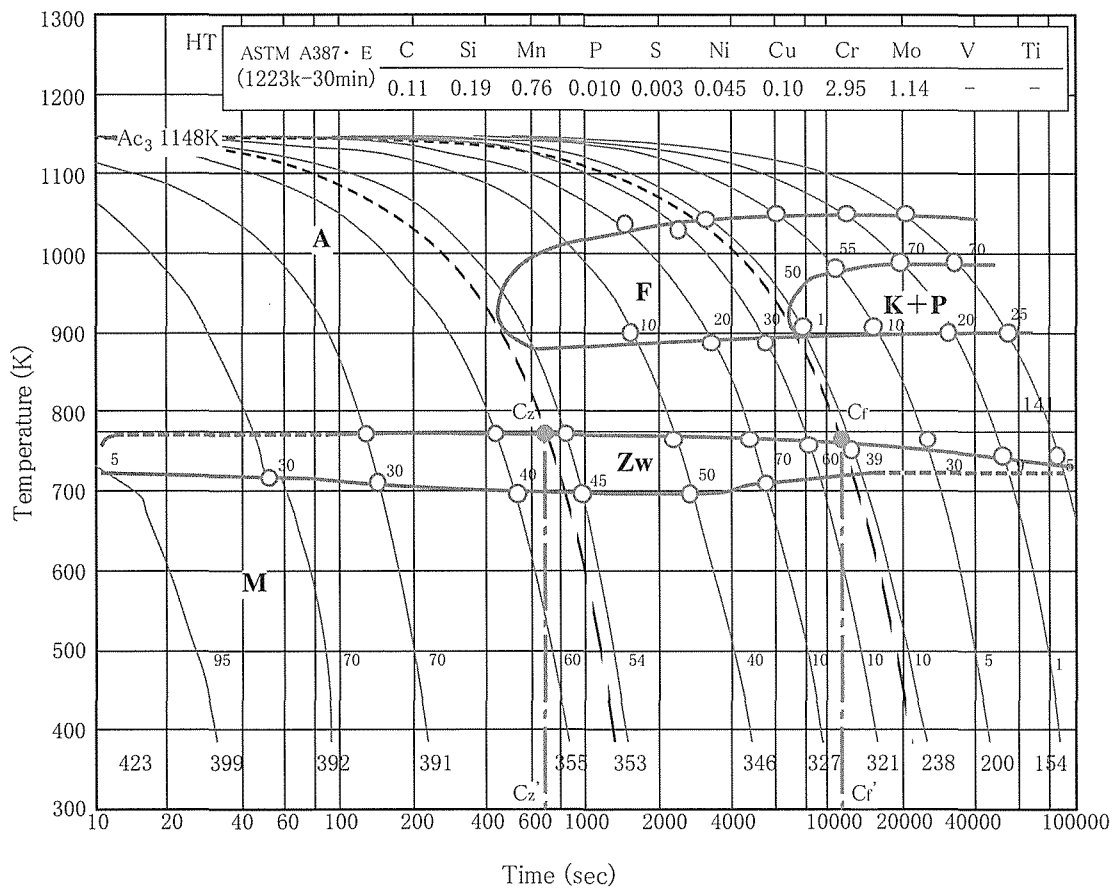
2 deg C/m

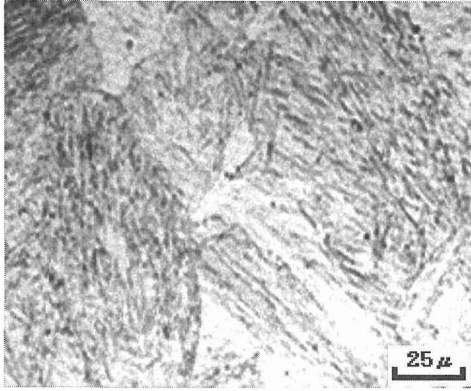
Hv 163



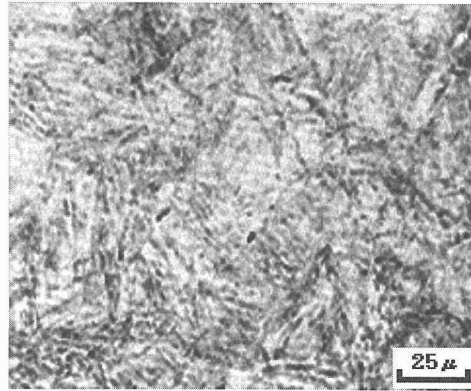
As received

Hv 197

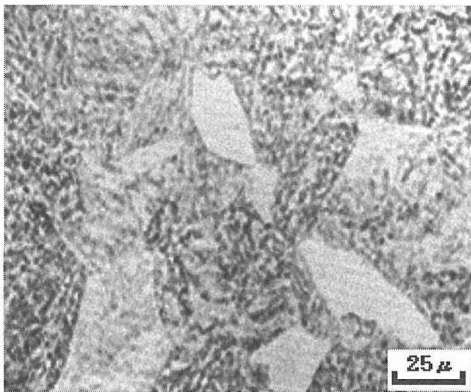




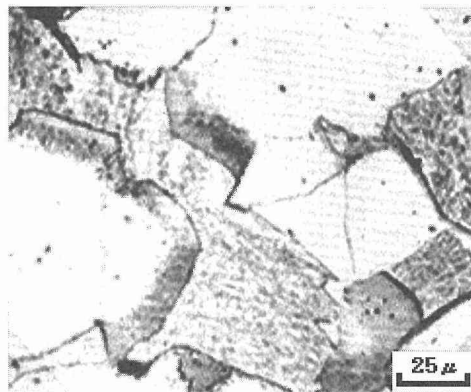
Hv 423



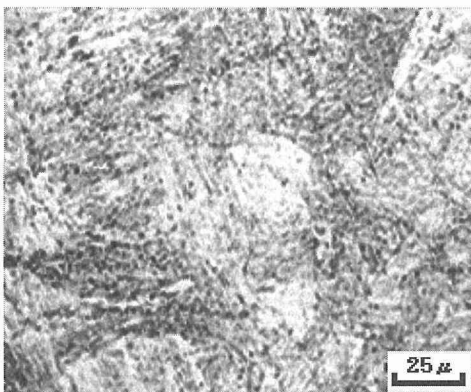
Hv 392



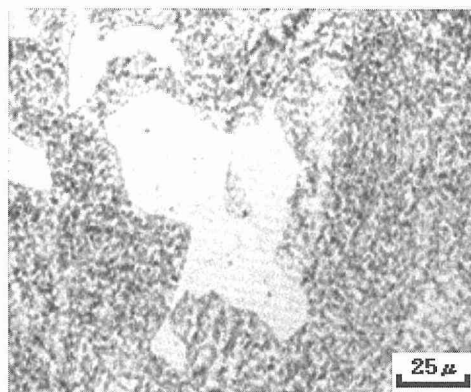
Hv 321



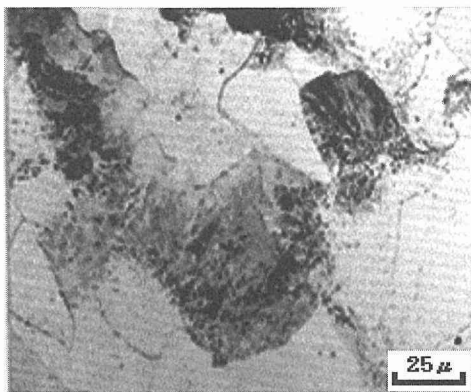
Hv 200



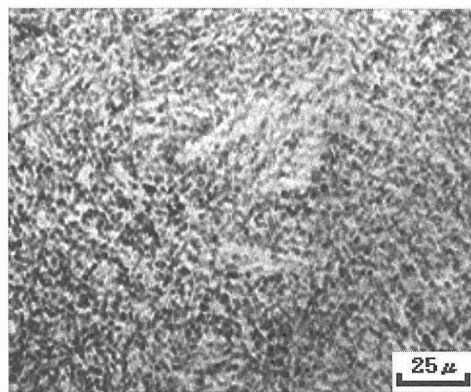
Hv 391



Hv 346

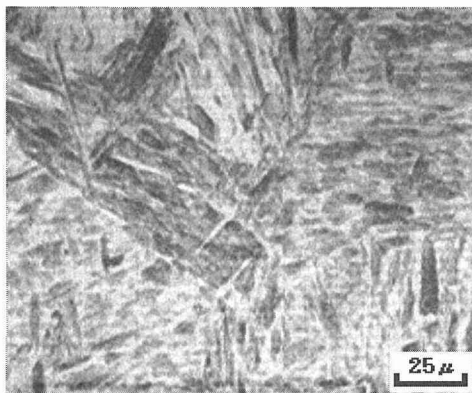


Hv 141



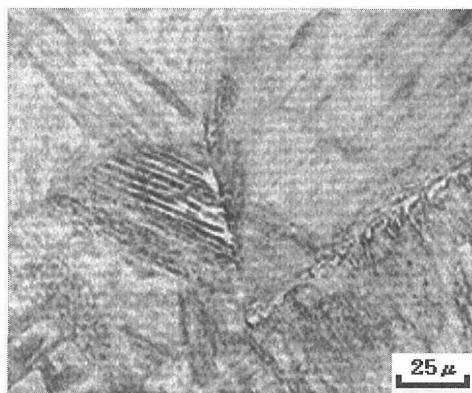
Hv 356

As received



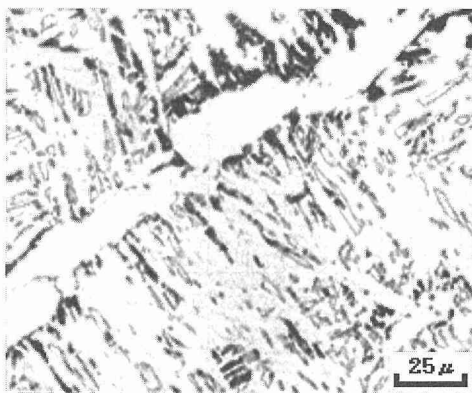
160 deg C/s

Hv 414



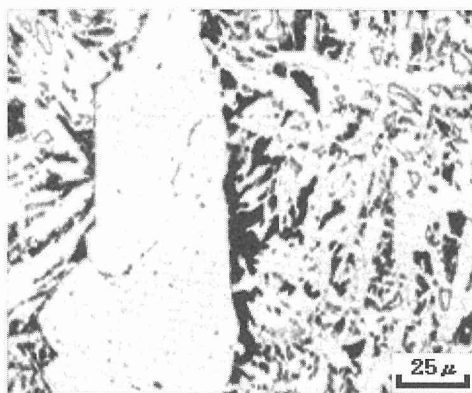
30 deg C/s

Hv 398



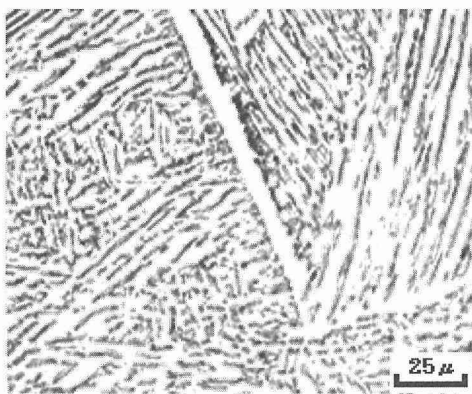
30 deg C/m

Hv 221



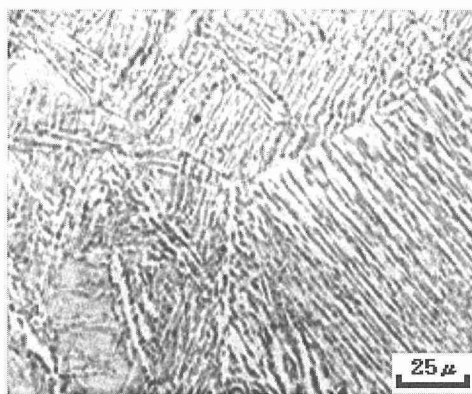
5 deg C/m

Hv 219



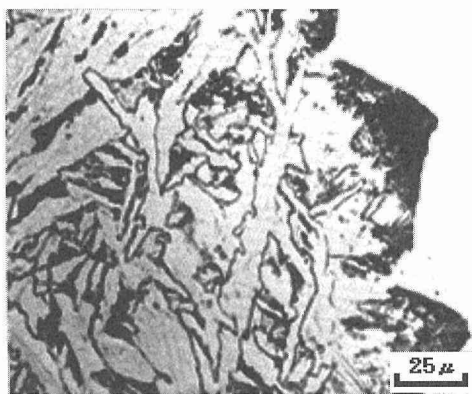
10 deg C/s

Hv 291



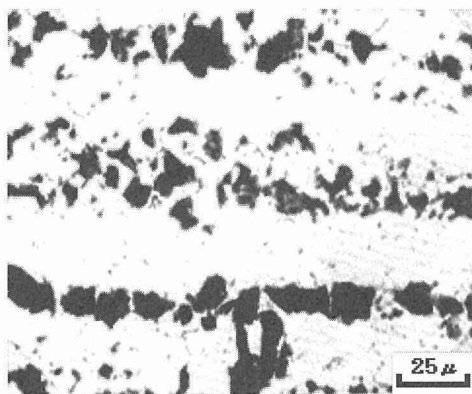
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Hv 239



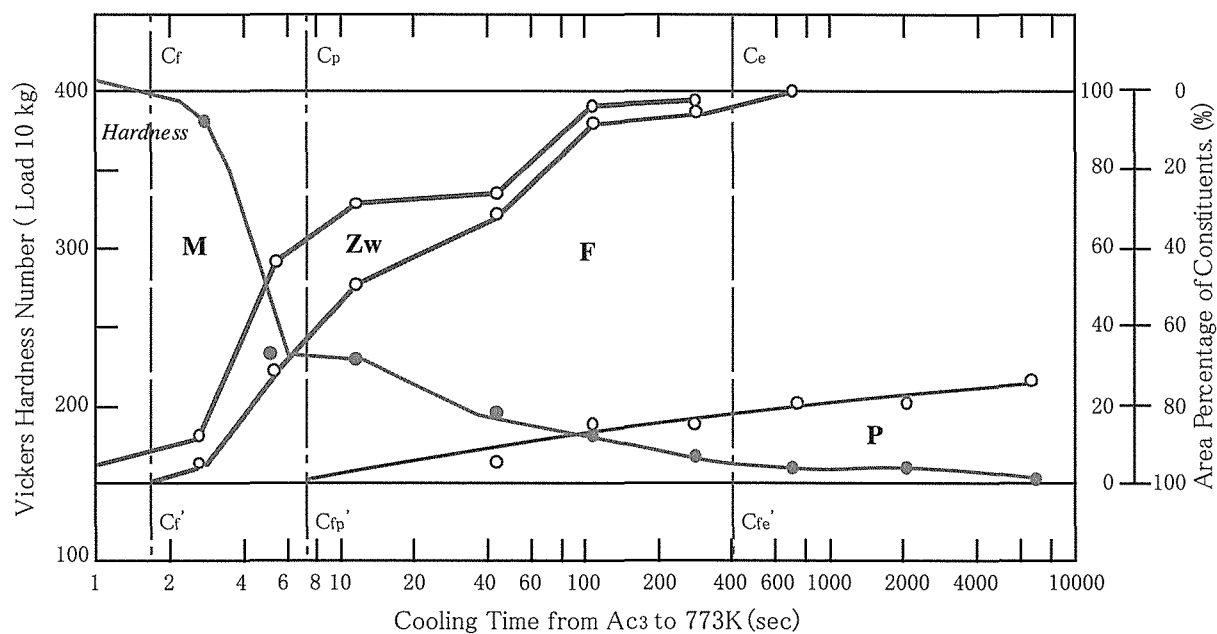
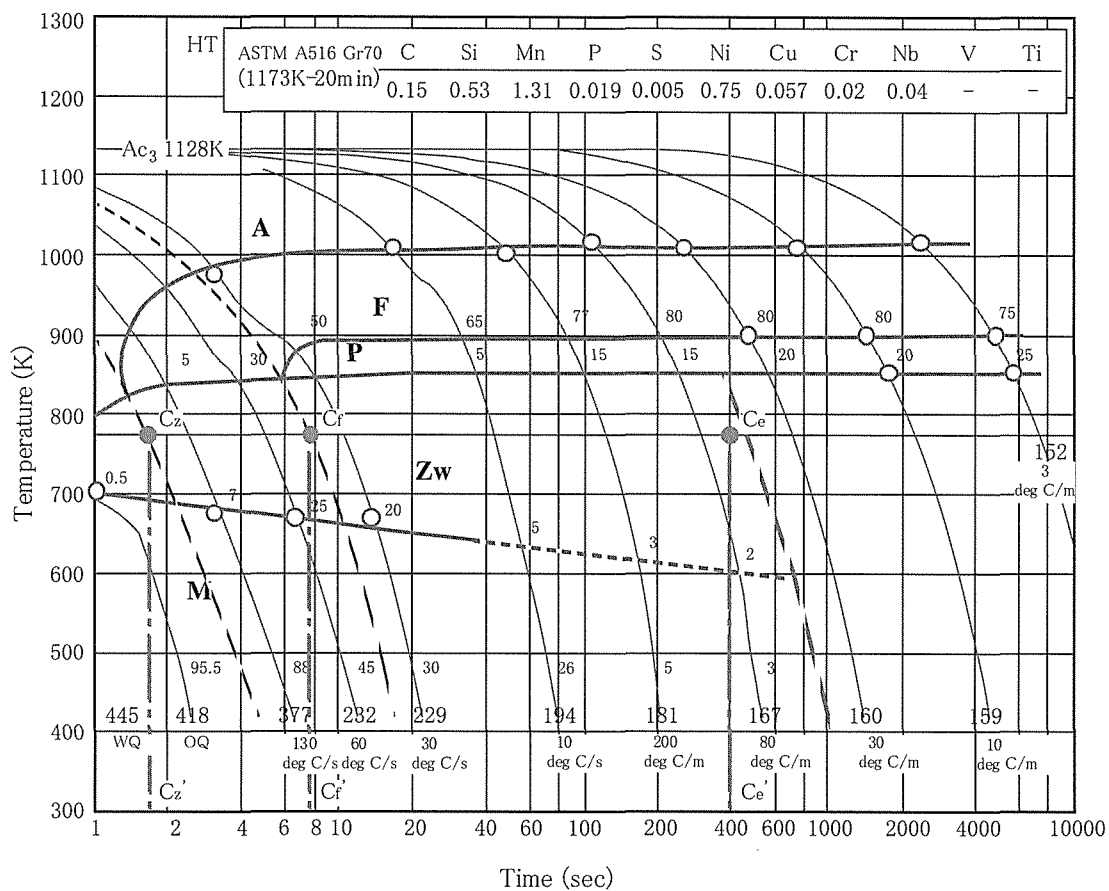
2 deg C/m

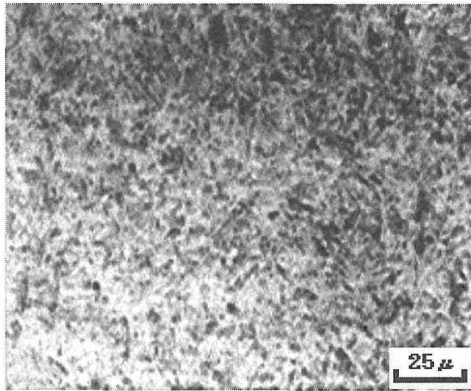
Hv 226



As received

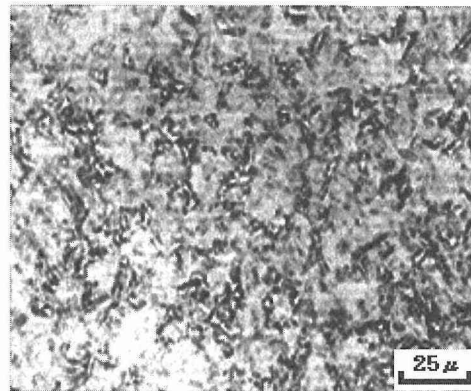
Hv 162





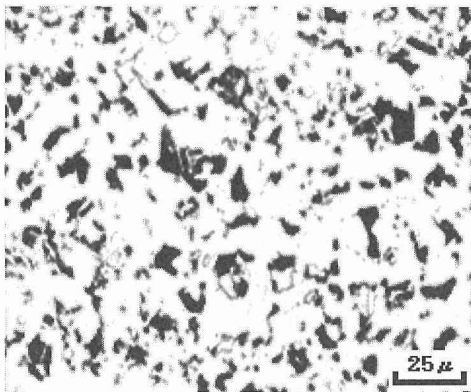
WQ

Hv 445



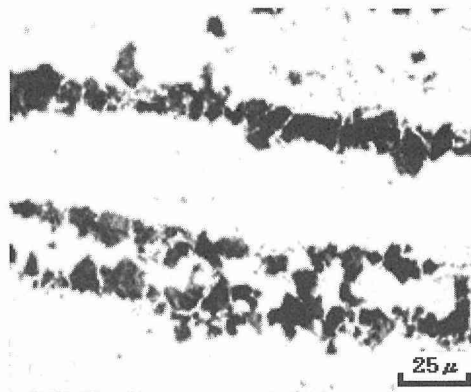
130 deg C/s

Hv 377



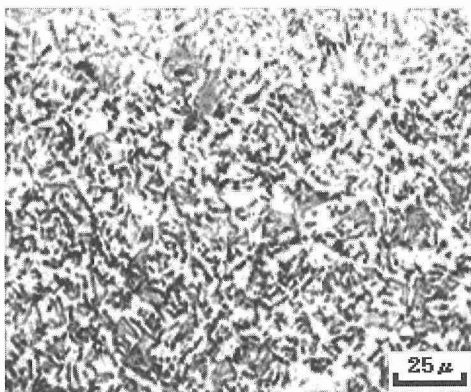
200 deg C/m

Hv 181



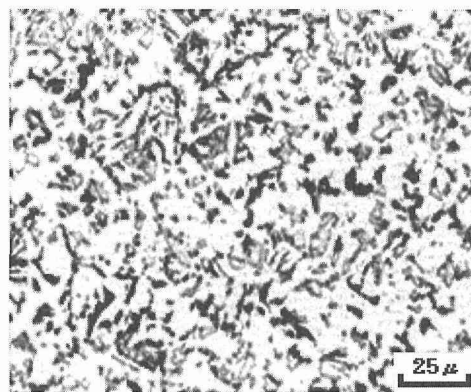
30 deg C/m

Hv 160



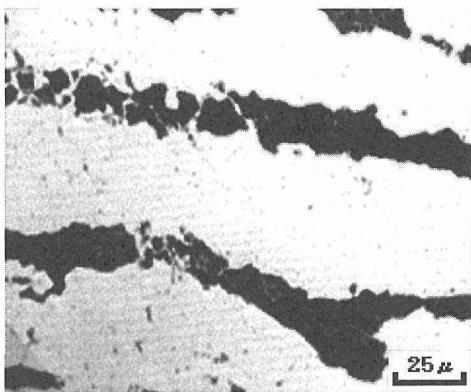
30 deg C/s

Hv 229



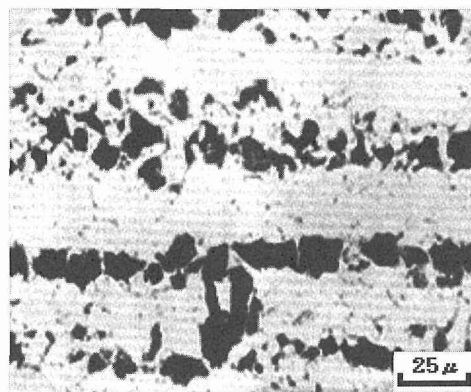
10 deg C/s

Hv 194



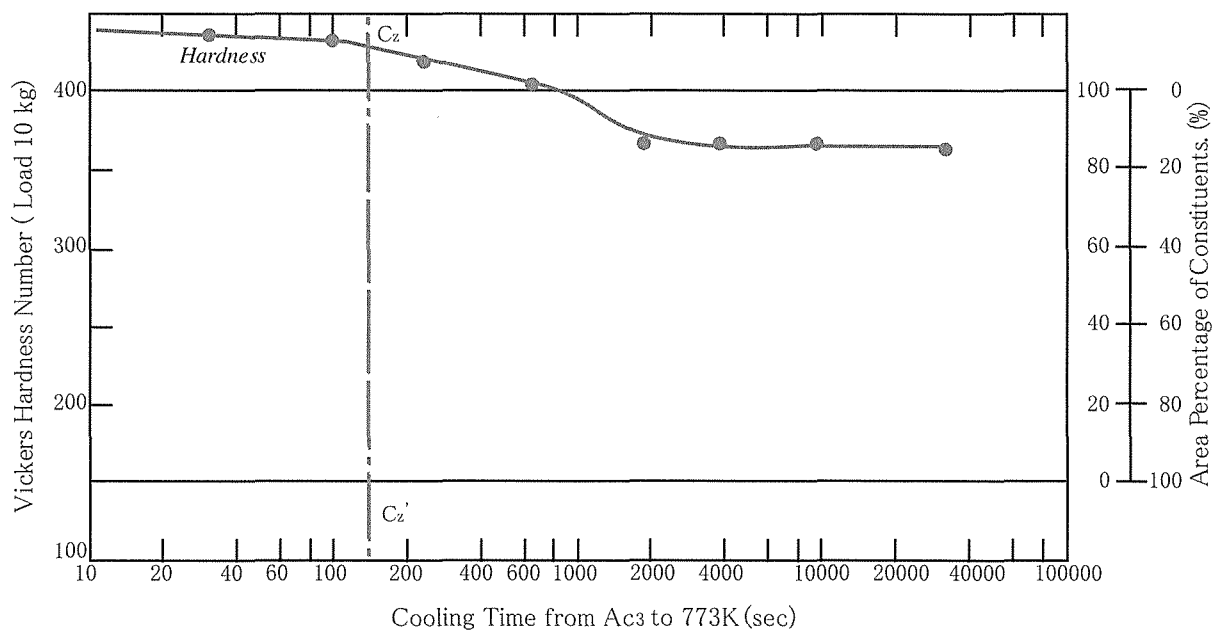
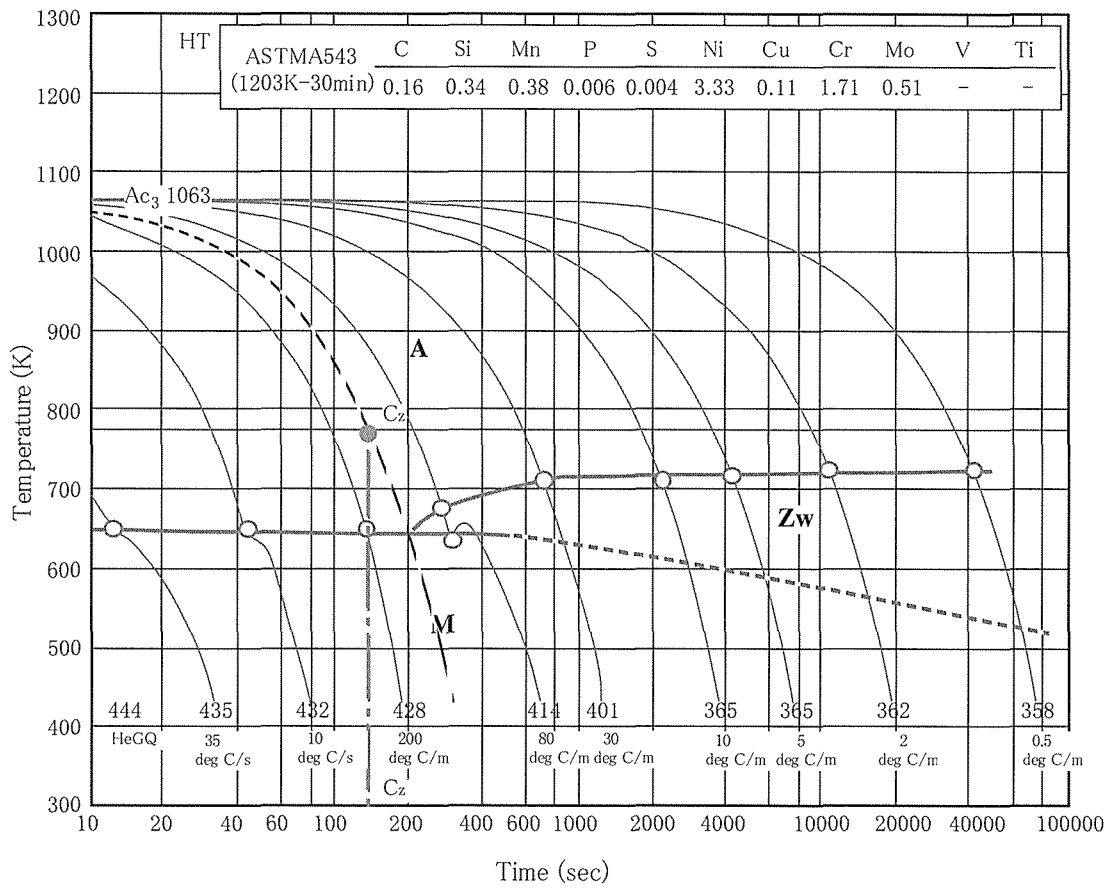
3 deg C/m

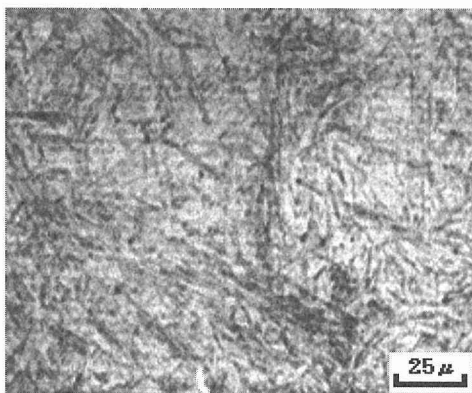
Hv 152



As received

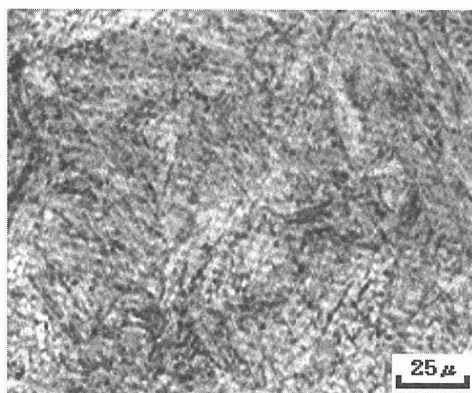
Hv 162





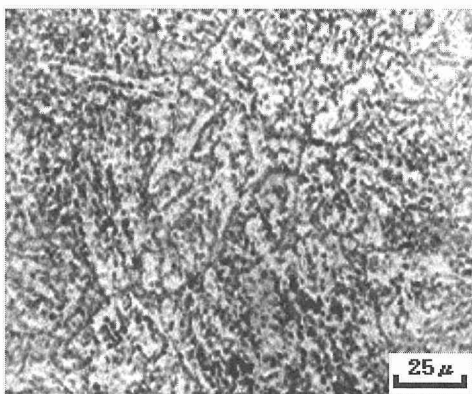
HeQ

Hv 444



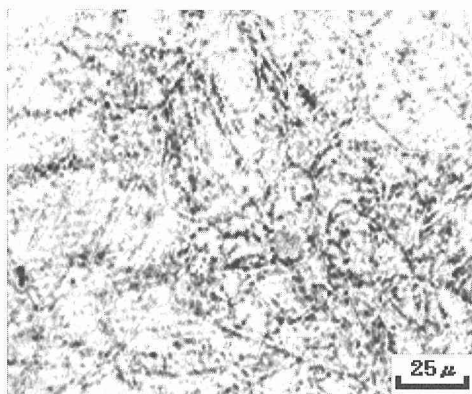
200 deg C/m

Hv 428



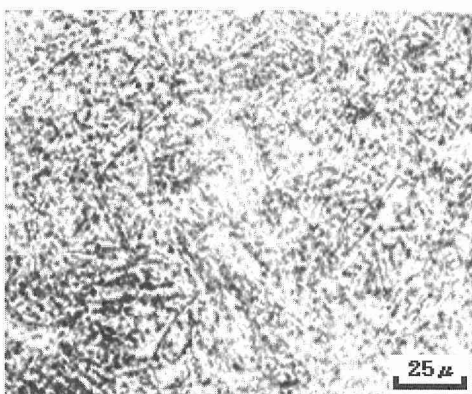
0.5 deg C/m

Hv 358



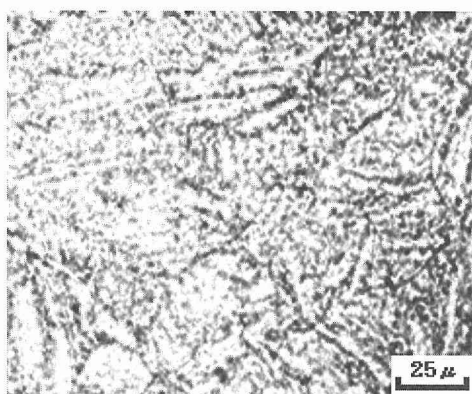
80 deg C/m

Hv 414



10 deg C/m

Hv 365



As received

Hv 349

High Tensile Strength Steel (80-150Mpa)

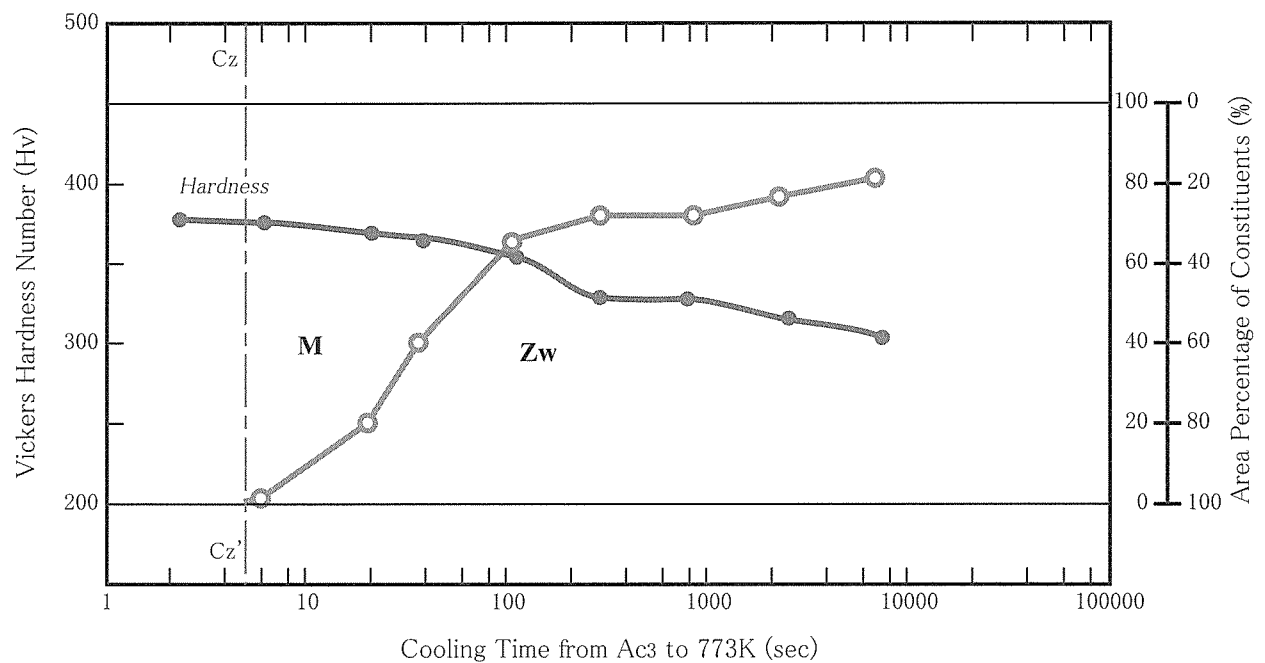
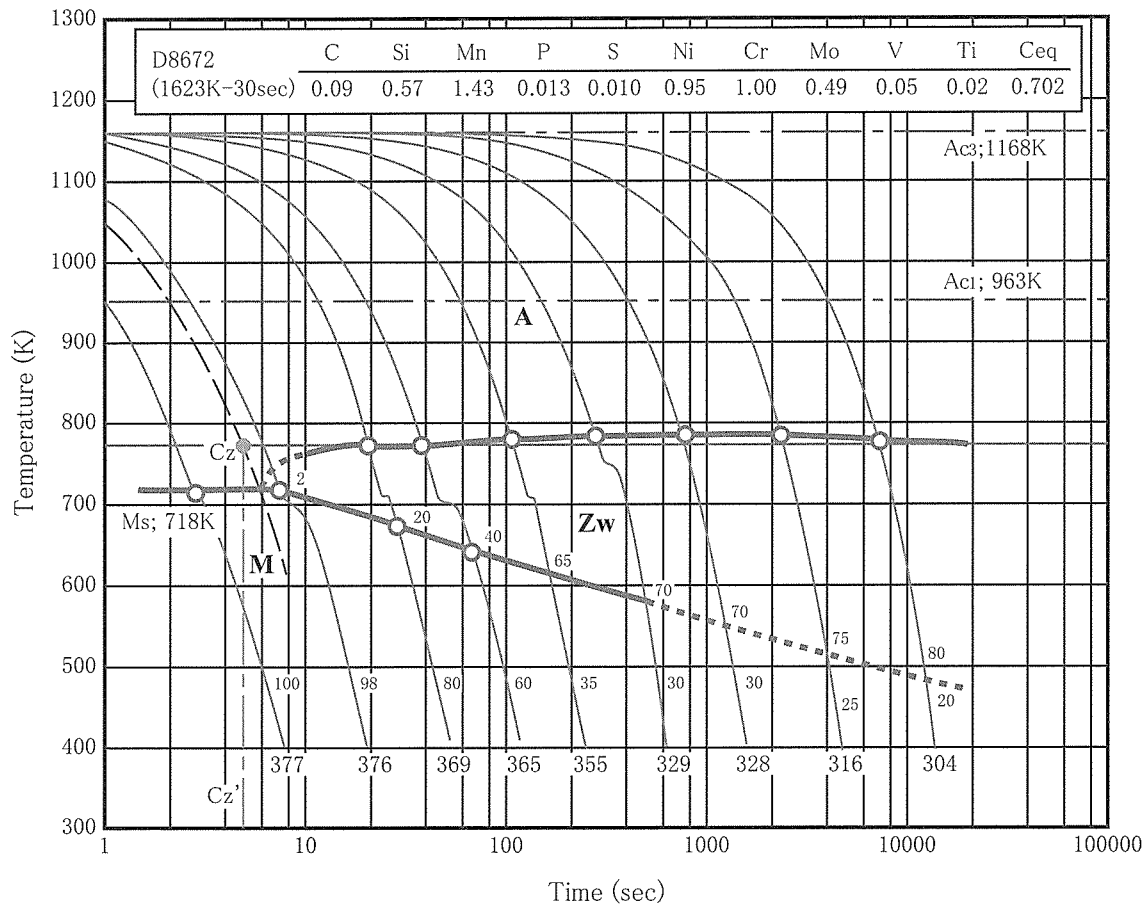
Steel	Chemical Composition (wt%)															Page	Ref.
	C	Si	Mn	P	S	Cu	Ni	Mg	V	Ti	N	Nb	B				
D8672	0.09	0.57	1.43	0.013	0.01	-	0.95	0.49	0.05	0.02	-	-	-	-	-	84	2
HT780	0.12	0.24	0.88	0.004	0.001	0.17	0.98	0.4	0.04	-	-		0.0013	-	-	85	3
B-steel	0.06	0.26	1.34	0.007	0.002	0.97	1.03	0.31	0.041	-	-	0.009		-	-	86	3

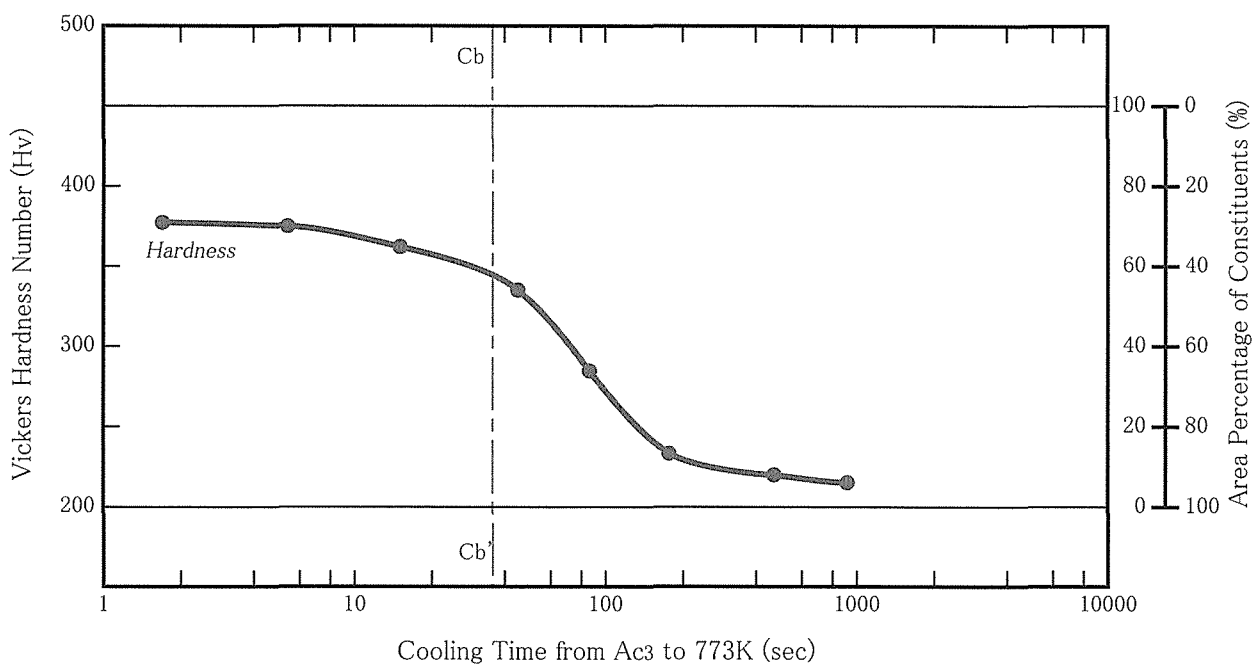
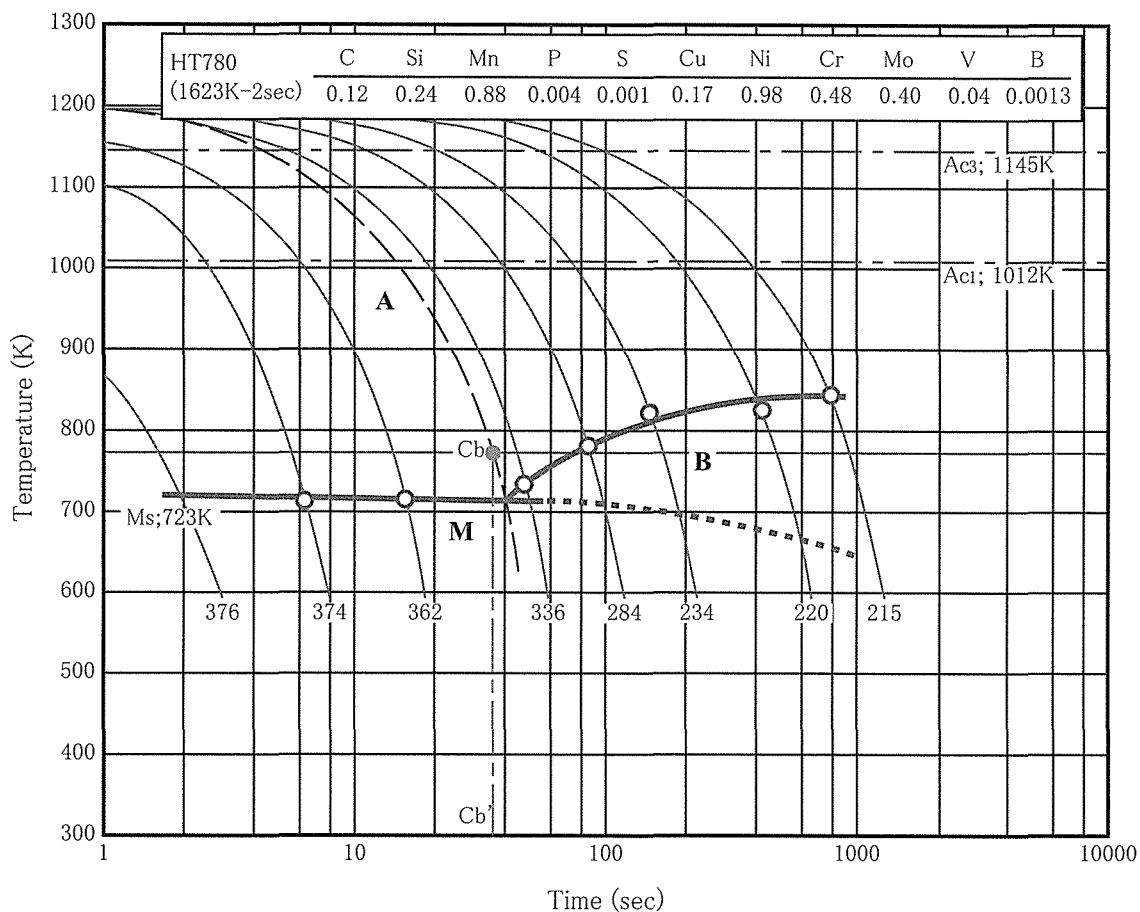
Steel	C	Si	Mn	P	S	Ni	Cr	Mo	Nb	O	Co	A lsol	N sol	N insol	H diff	H nodiff	Page	Ref.
PZ150 HT	0.2	0.18	0.28	0.007	0.003	8.74	1.59	2.83	0.068	0.0011	4.34	0.025	0.0013	0.0053	0.0053	0.0011	87	4

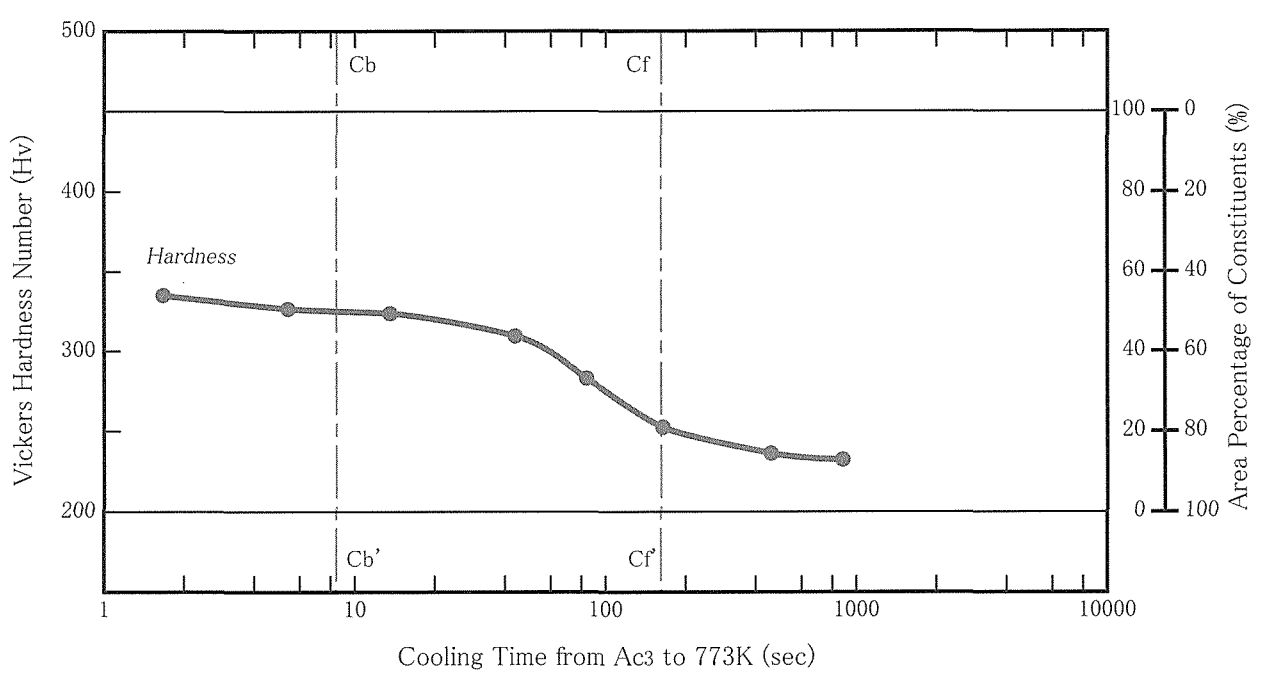
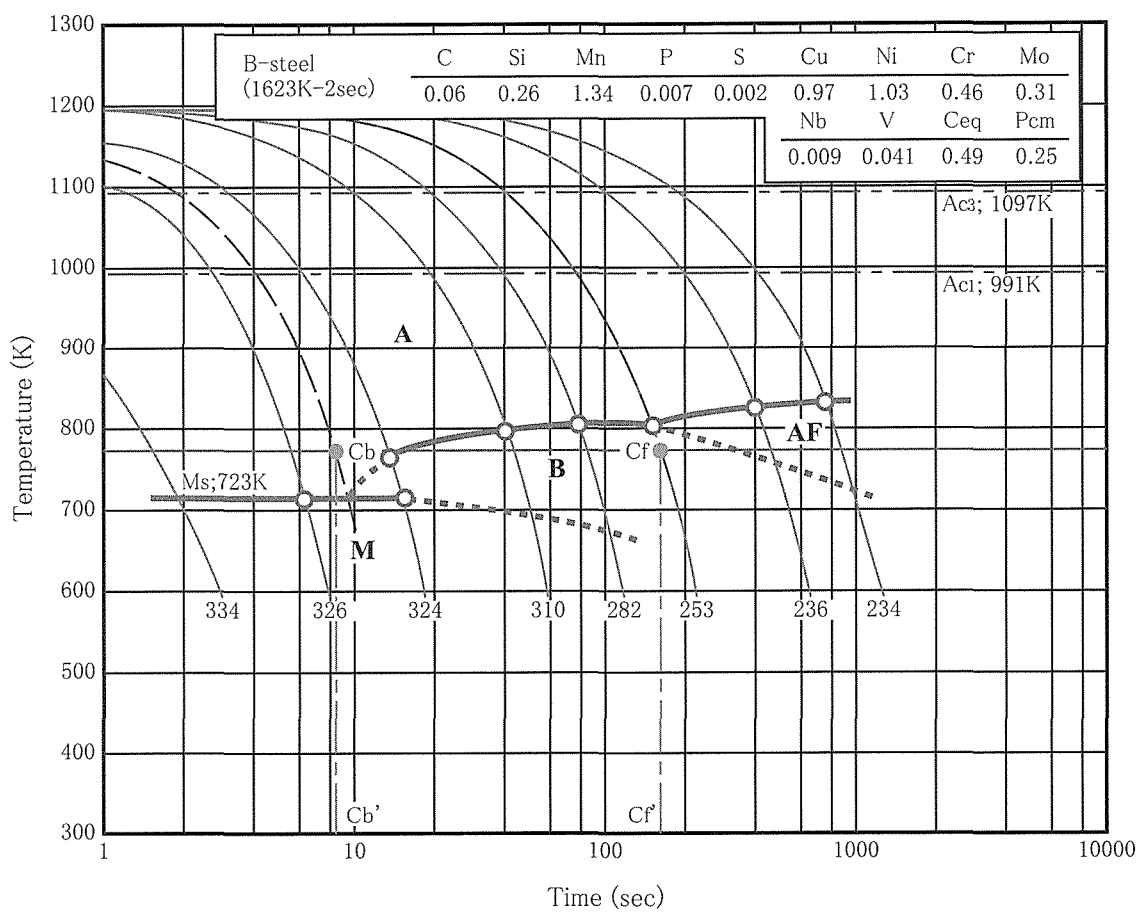
Steel	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Pb	Ca	O	Page	Ref.
1200MPa	0.248	0.649	1.824	0.011	0.06	-	-	-	0.132	-	-	-	0.2	0.0012	-	88	5
100kg/mm2 Chain HT	0.2		1.5	-	-	-	0.8	0.5	-	-	-	-	-	-	-	89	6
Gleeble test	0.15	0.37	1.42	-	-	-	-	-	-	-	-	-	-	-	-	90	7

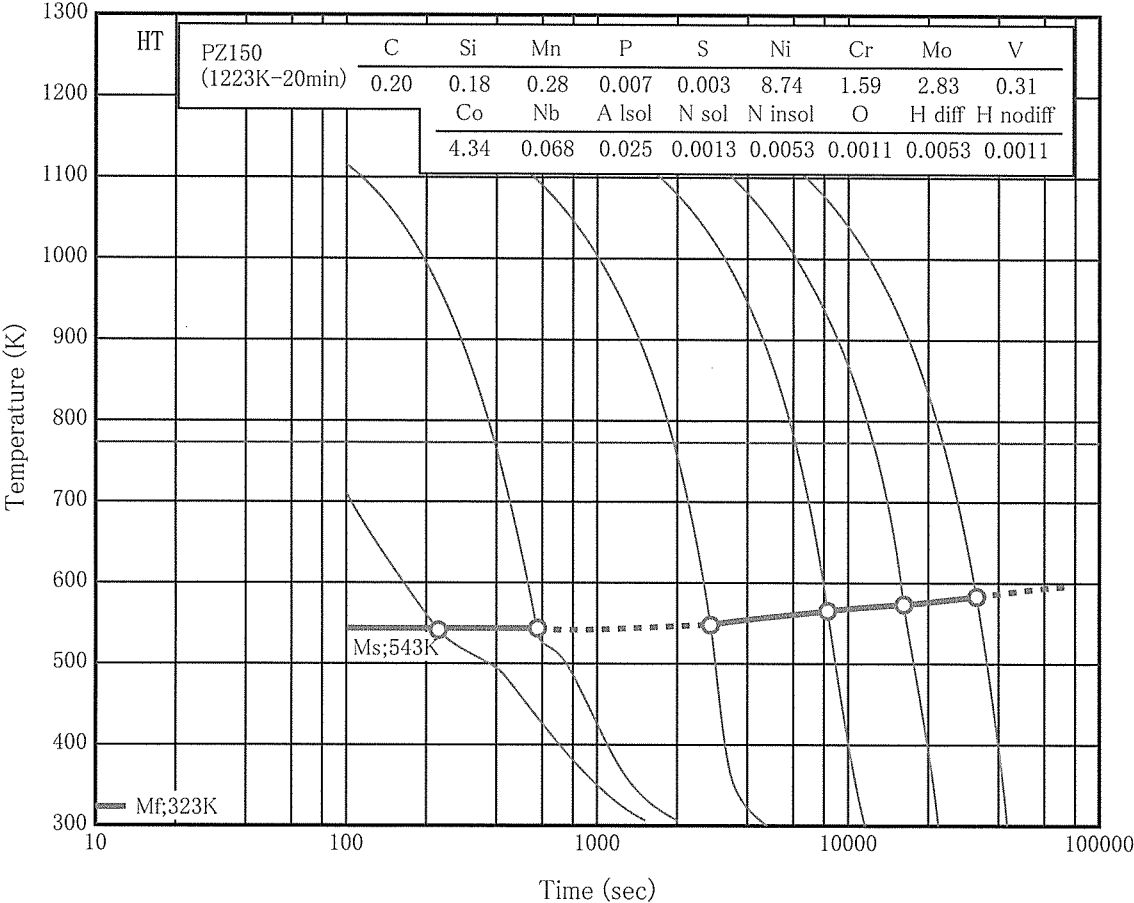
Steel	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Nb	B	O	Page	Ref.
Mn-Ti-B	0.12		1.45	-	-	-	-	-	-	-	-	-	-	-	-	91	8
Mn-Nb L	0.1	0.2	1.55	-	-	-	-	-	-	-	-	-	-	-	-	92	8
Mn-Nb H	0.15	1.5	1.2	-	-	-	-	-	-	-	-	-	-	-	-	93	8
HY130 HT	0.11	0.3	0.43	0.002	0.002	1.1	5.6	0.57	0.1	-	-	-	-	-	-	94	9

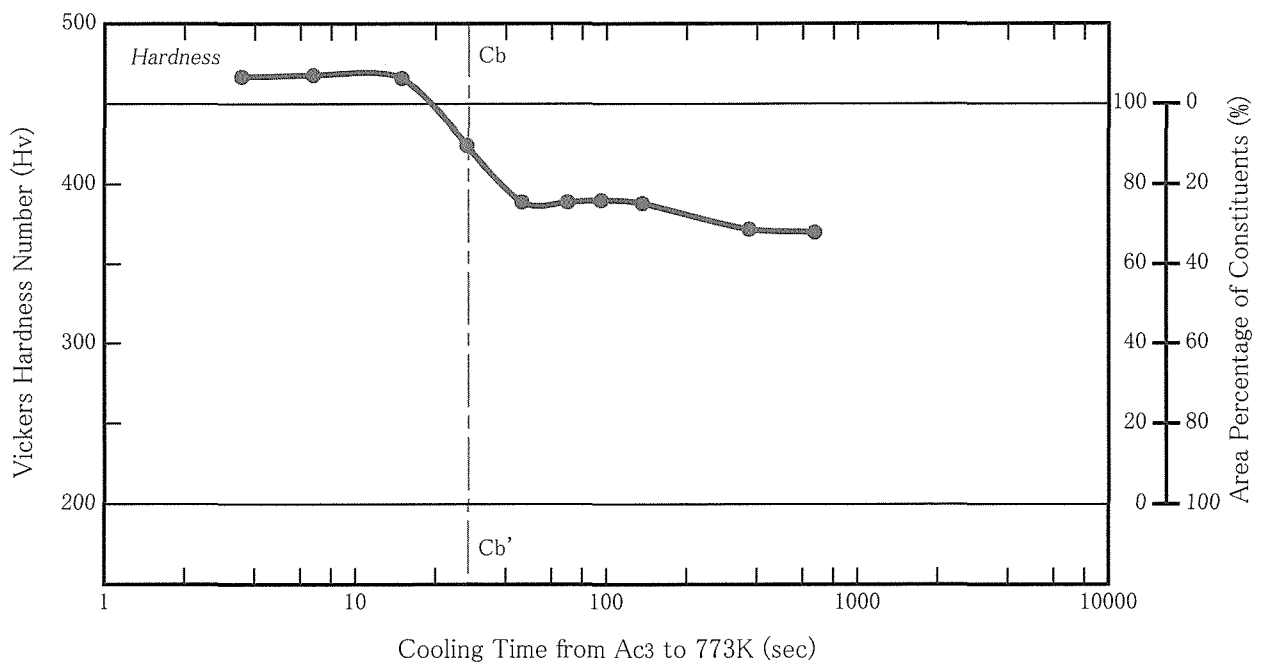
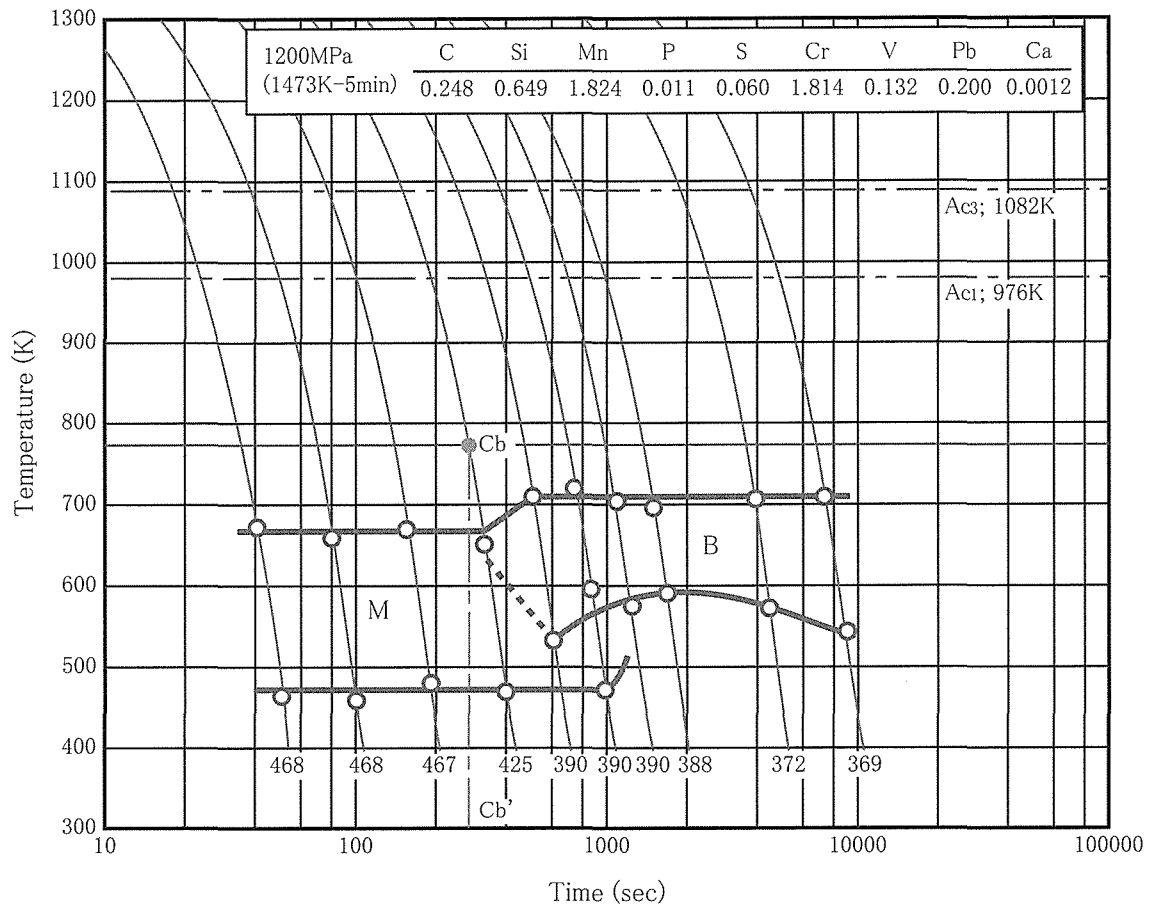
HT: CCT diagram to be used the purpose of heat treatment. Heating at temperature below 1623K for welding.

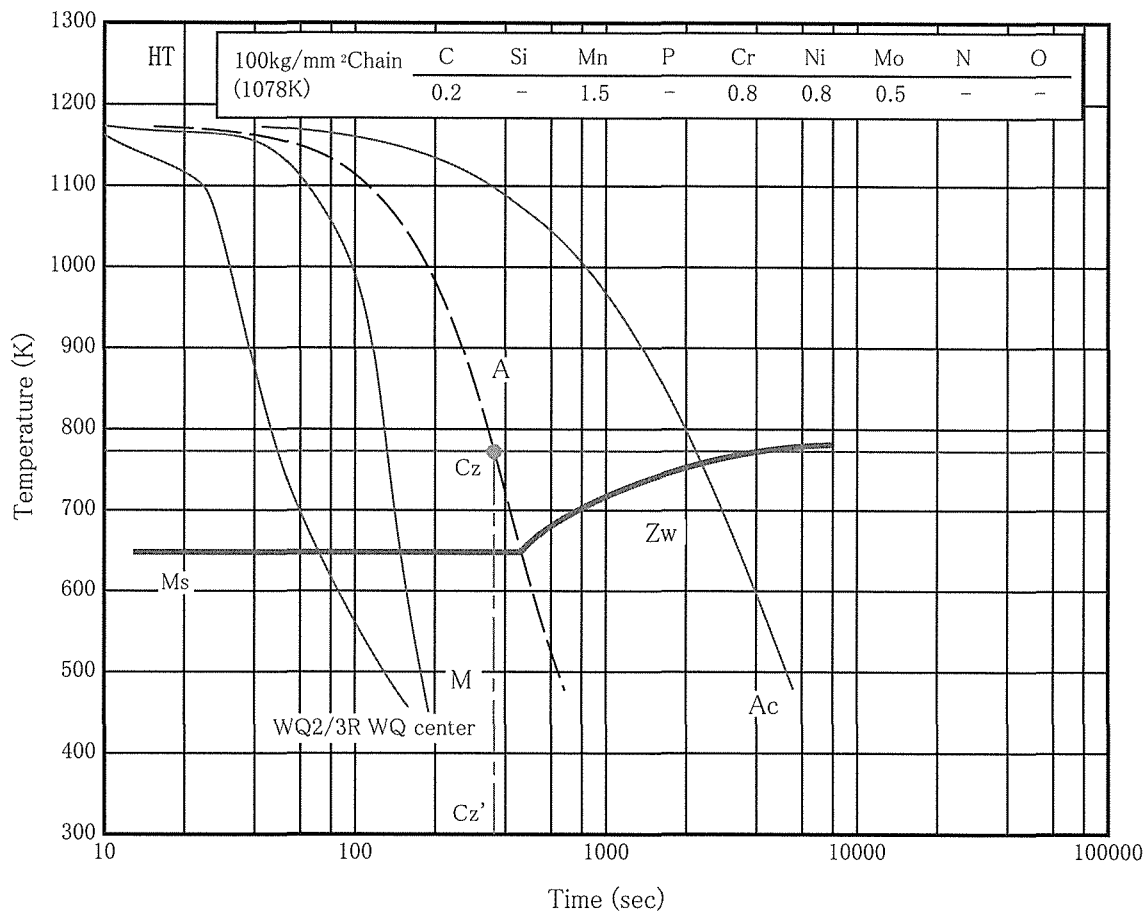


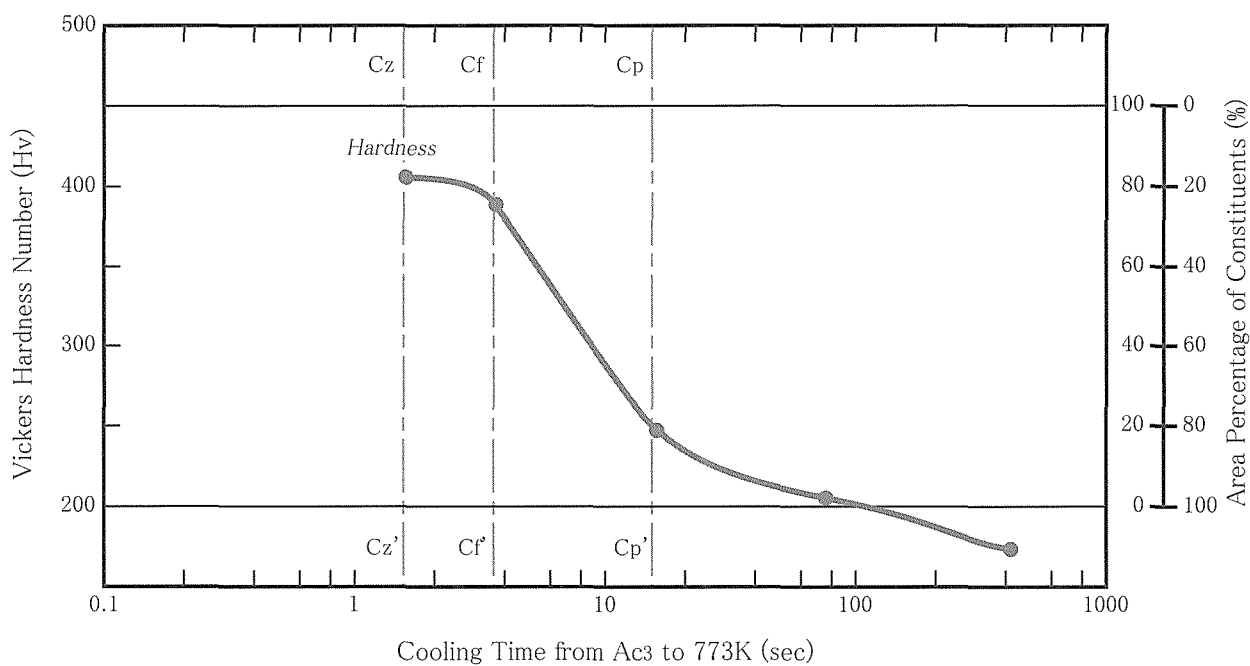
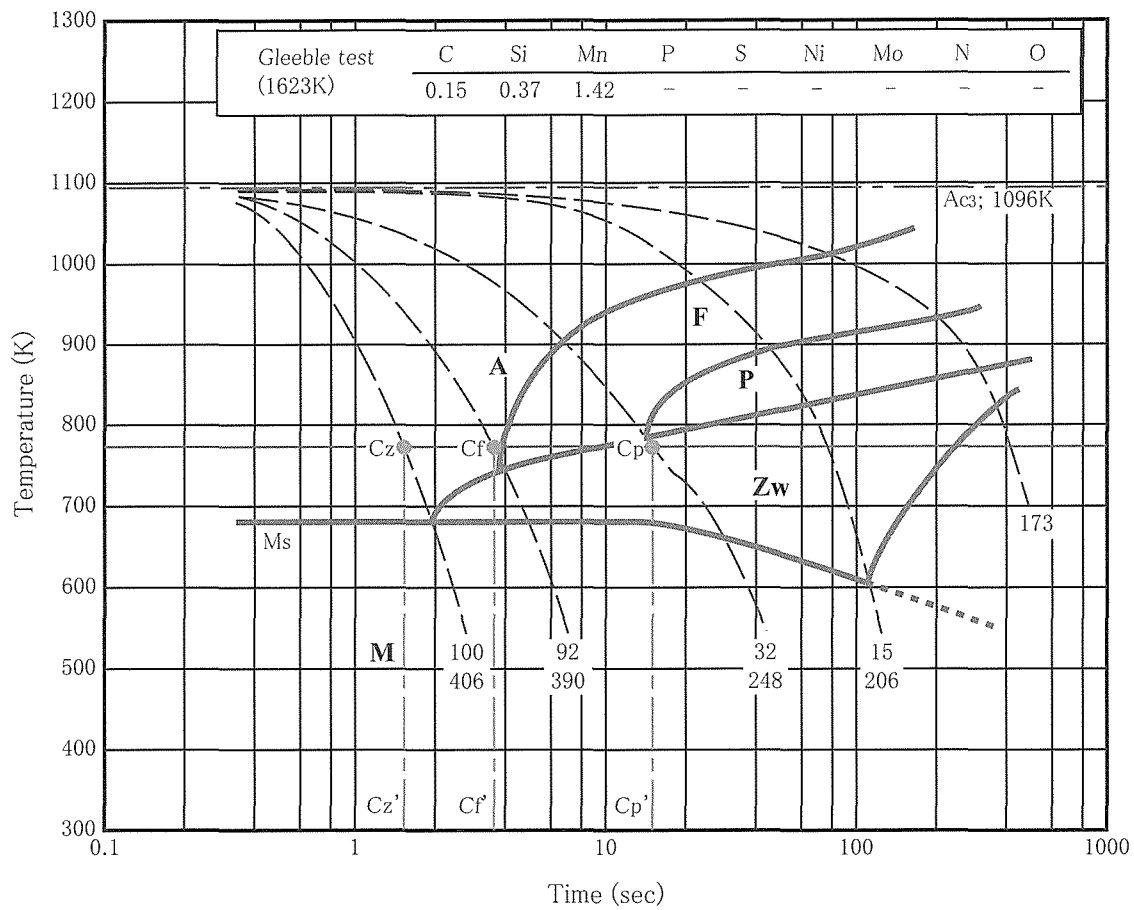


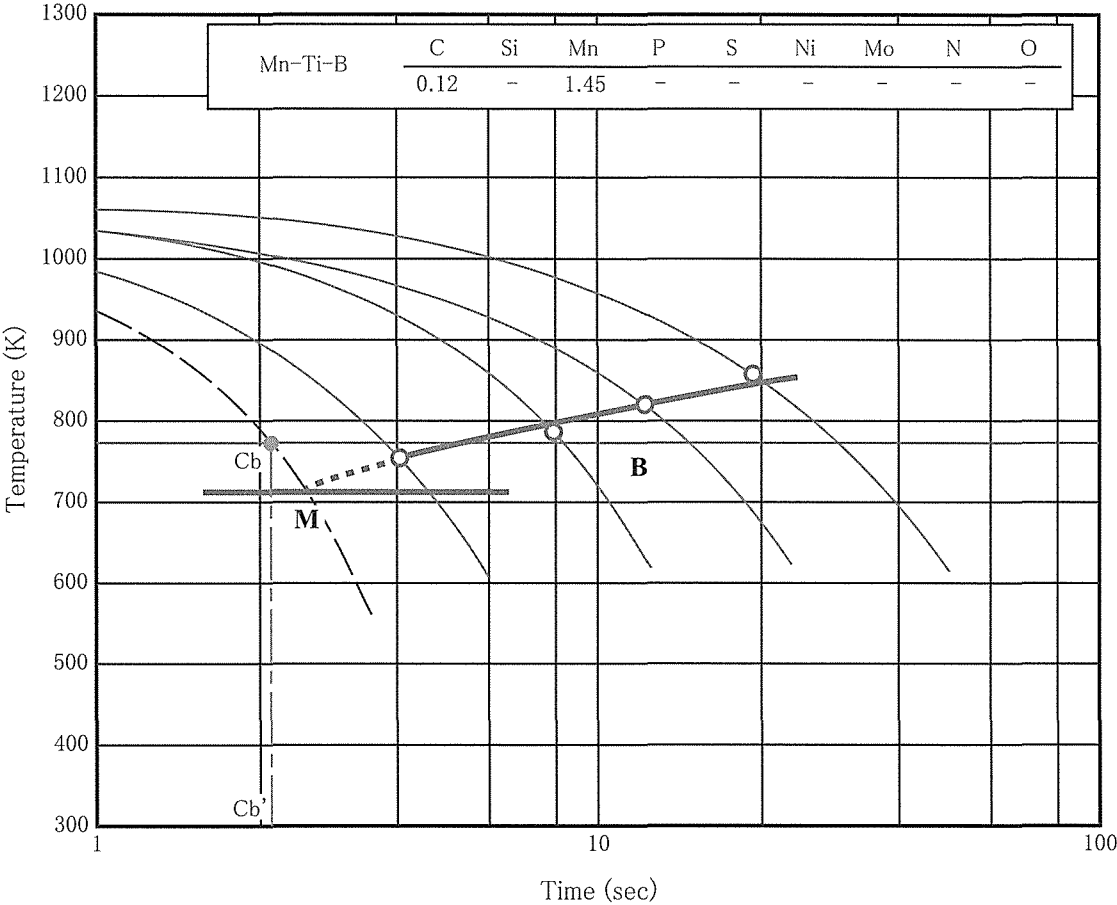


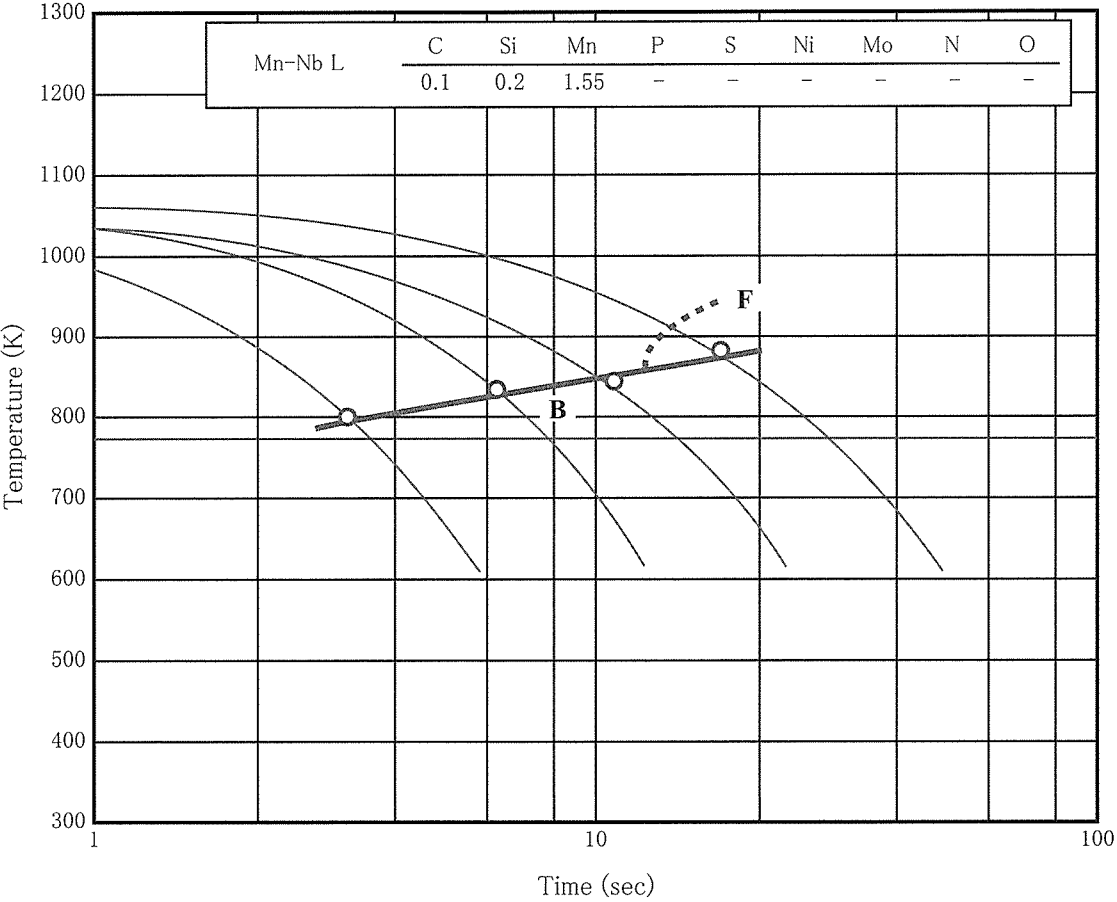


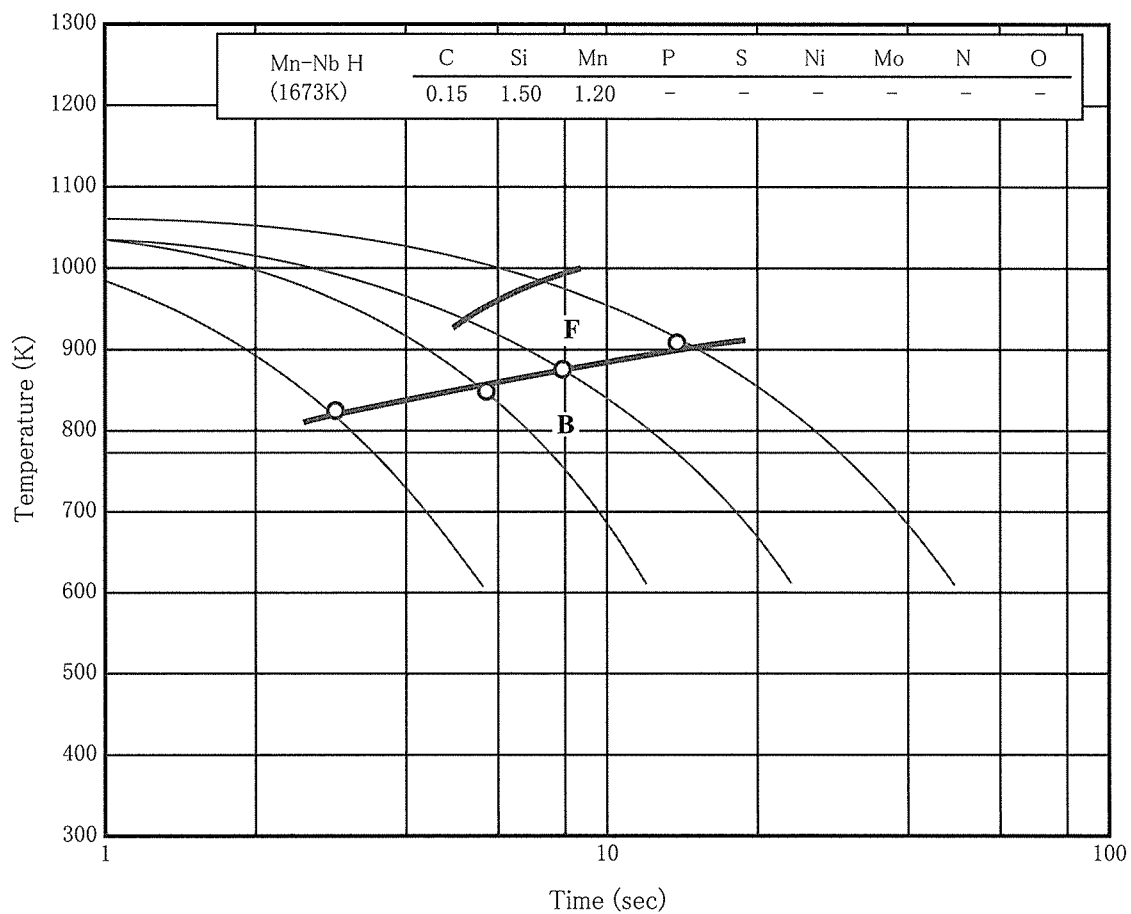


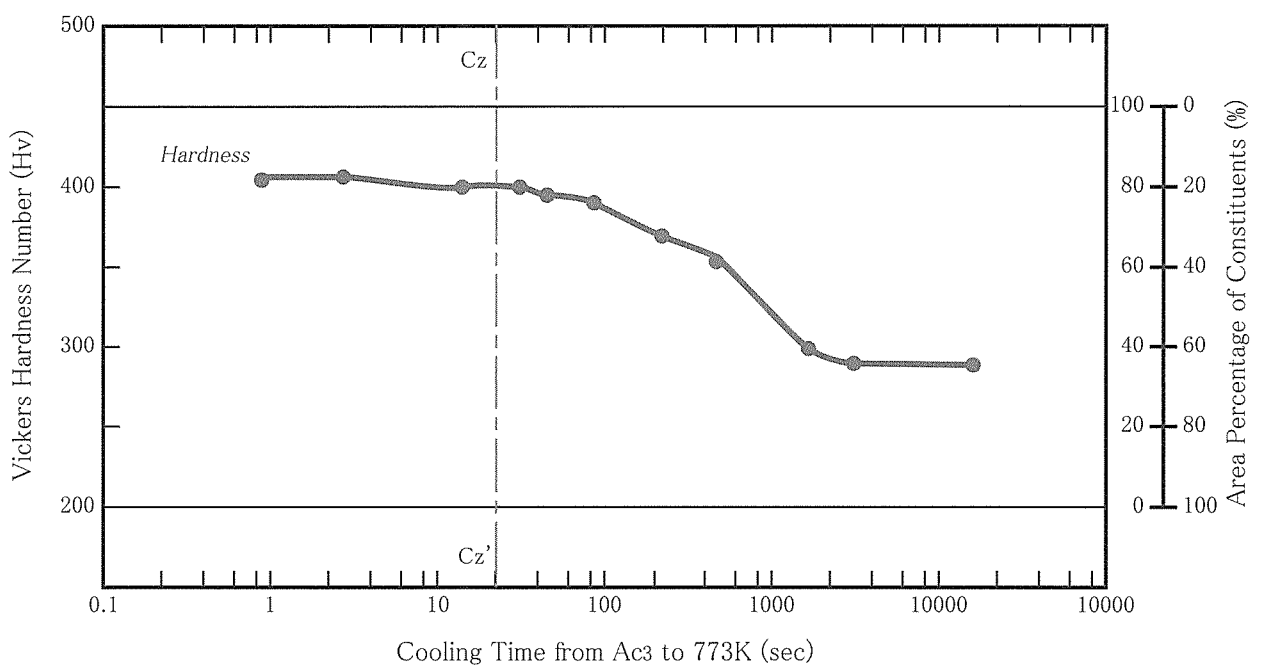
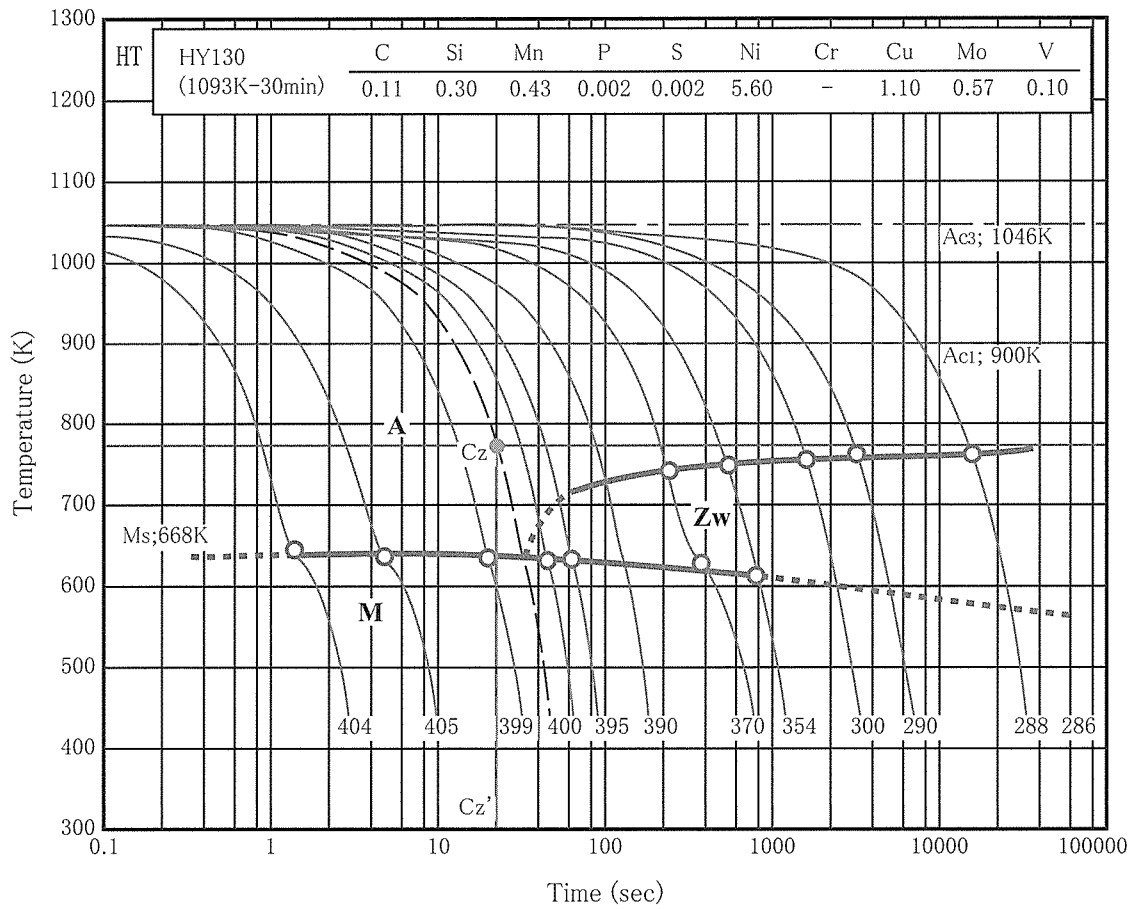












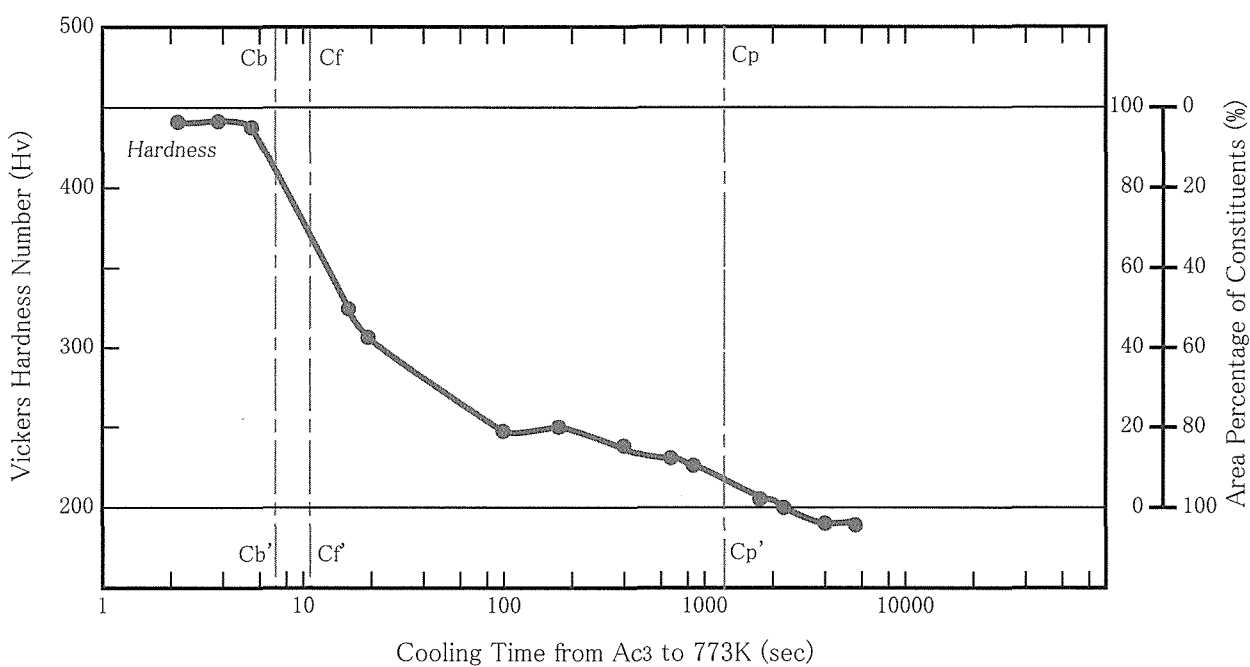
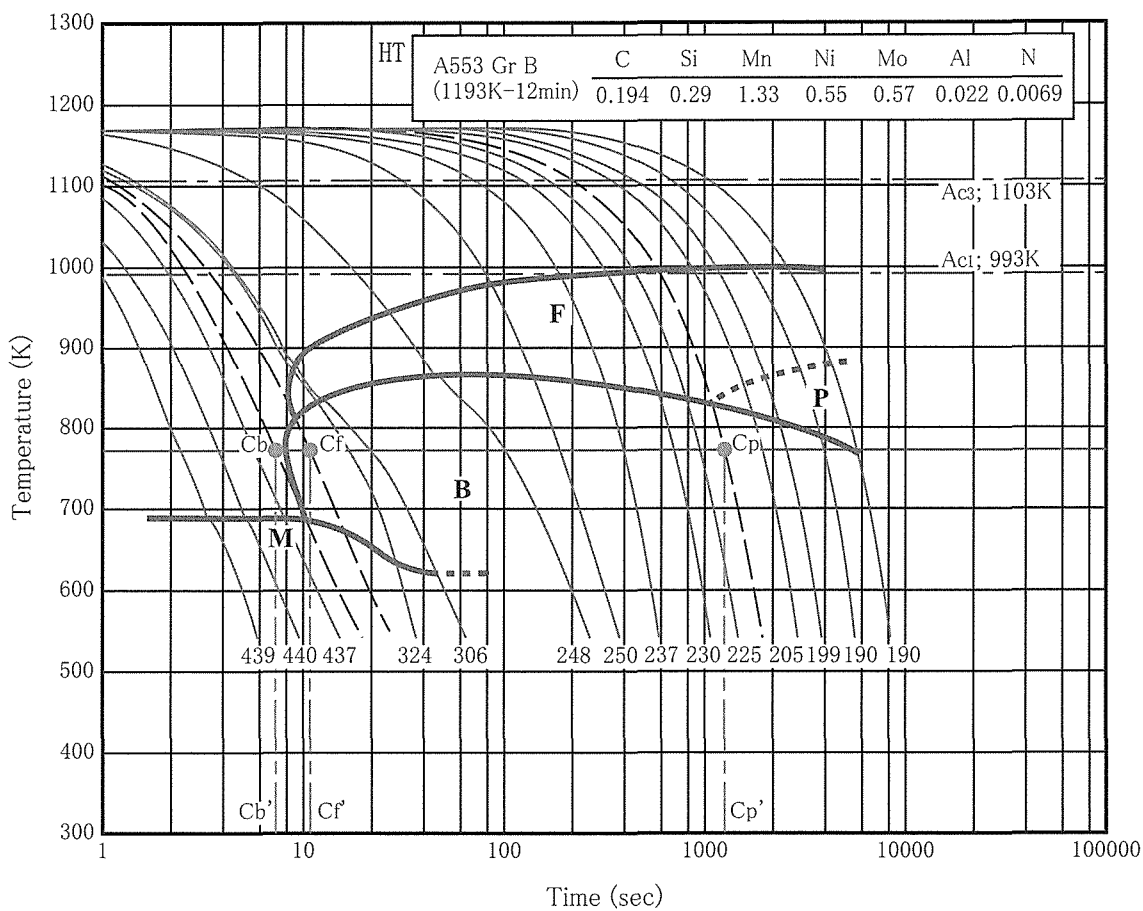
Pressure Vessel

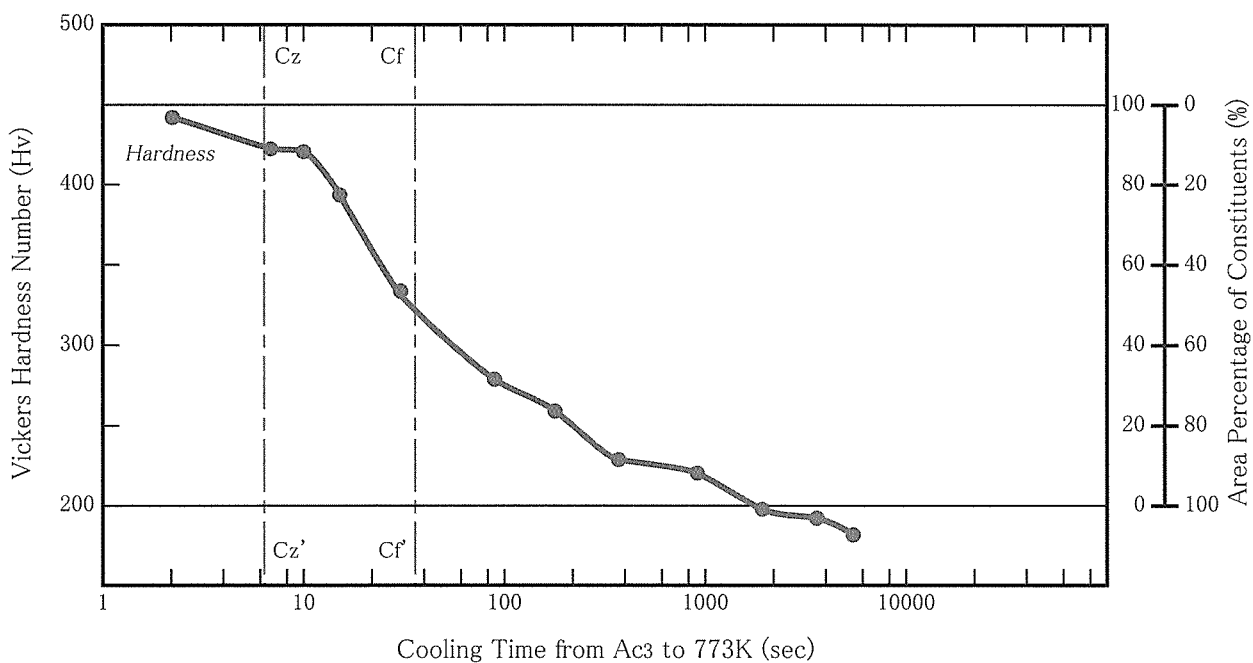
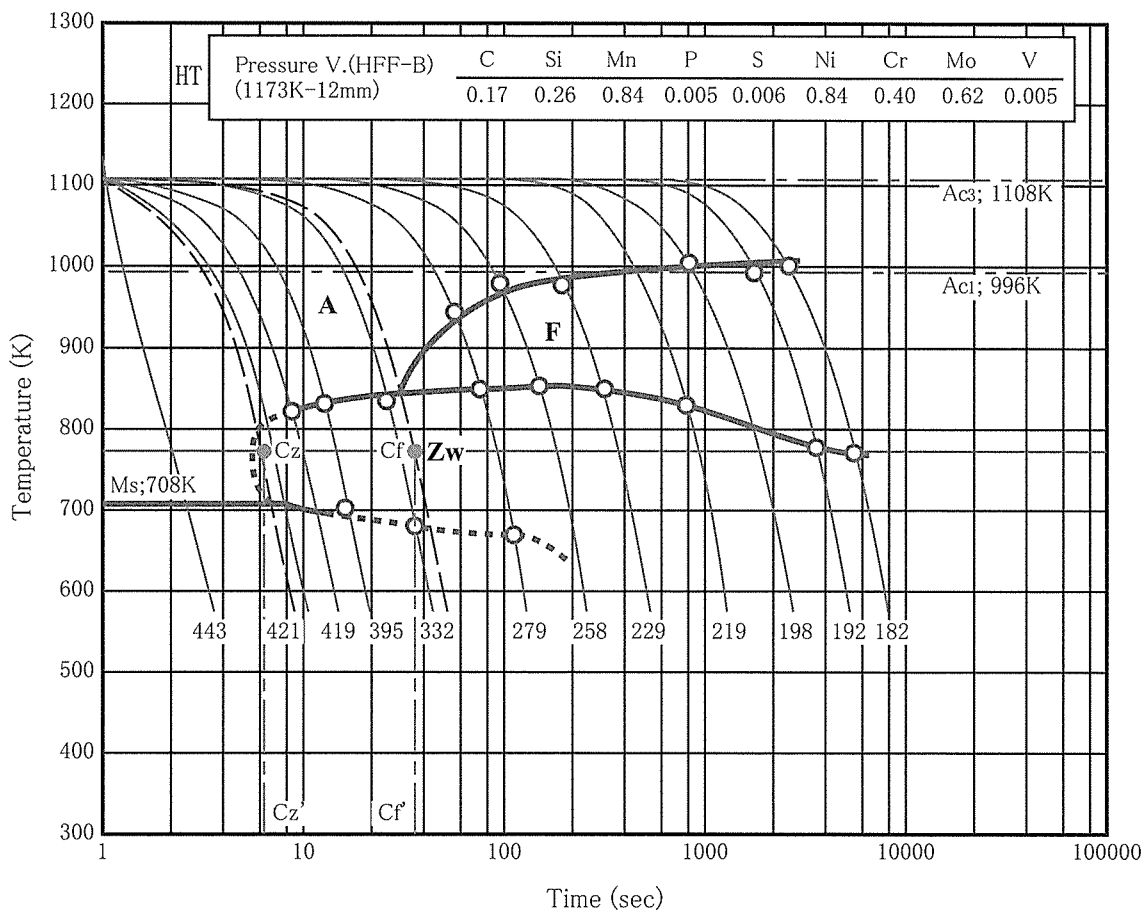
	Chemical Composition (wt%)																
Steel	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Pb	Ca	O	Page	Ref.
A533 Gr B HT	0.194	0.29	1.33	-	-	-	0.55	0.57	-	0.022	-	0.0069	-	-	-	96	10
Pressure V. (HFF-B) HT	0.17	0.26	0.84	0.005	0.006	-	0.84	0.62	0.005	-	-	-	-	-	-	97	11

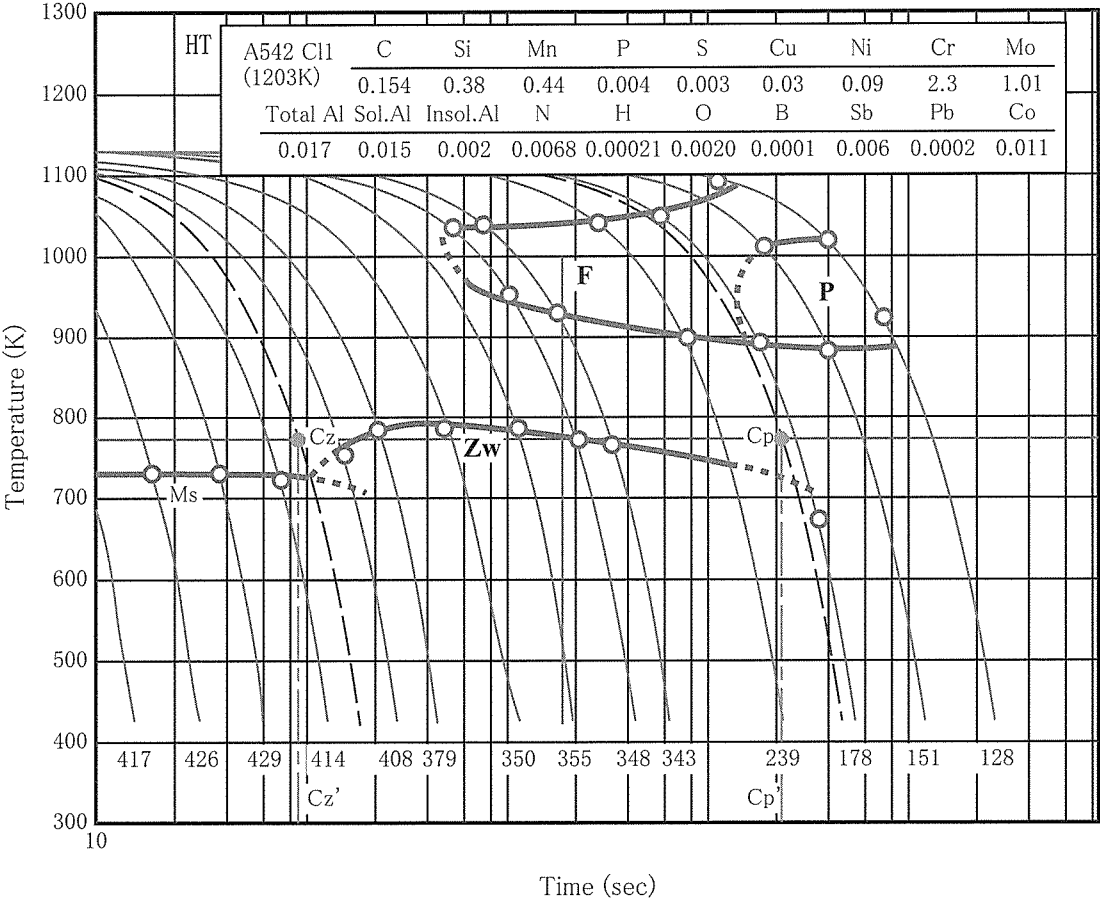
Steel	C	Si	Mn	P	S	Cu	Ni	Cr	N	B	O	Sb	Pb	Co	H	Total Al	Sol Al	Insol Al
A542 CIIHT	0.154	0.38	0.44	0.004	0.003	0.03	0.09	2.3	0.0068	0.0001	0.002	0.006	0.0002	0.011	0.0002	0.017	0.015	0.002
															Page	98	Ref.	12

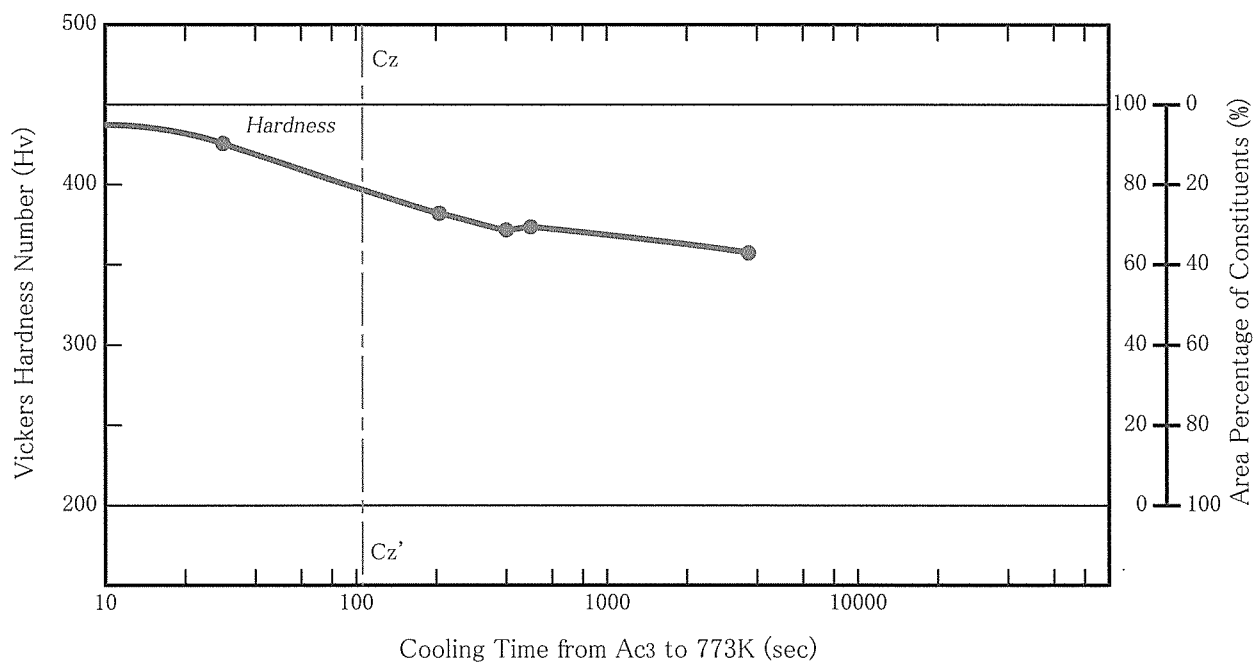
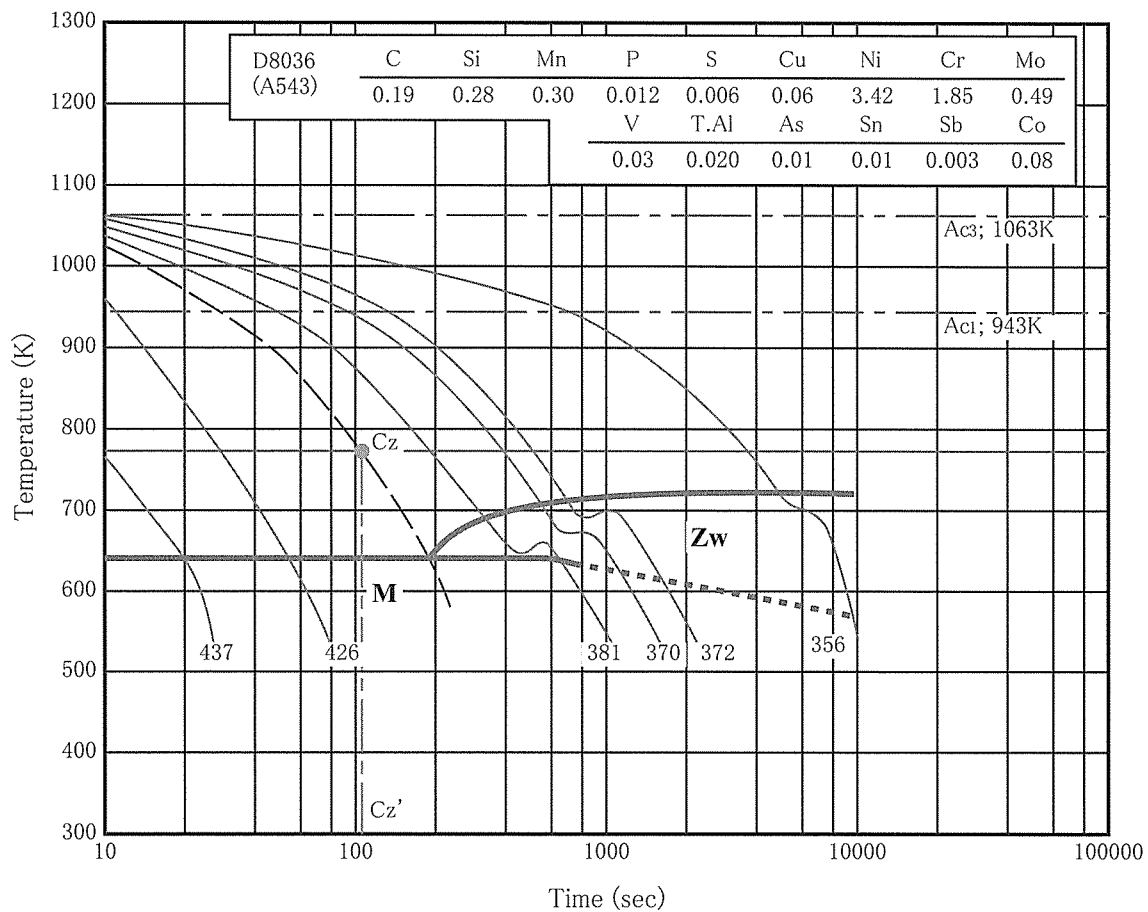
Steel	C	Si	Mn	P	S	Cu	Ni	Mo	V	Total Al	Sn	Sb	Co	As	O	Page	Ref.
D8036 (A543)	0.19	0.28	0.3	0.012	0.006	0.06	3.42	0.49	0.03	0.02	0.01	0.003	0.08	0.01	-	99	12

HT: CCT diagram to be used the purpose of heat treatment. Heating at temperature below 1623K for welding.



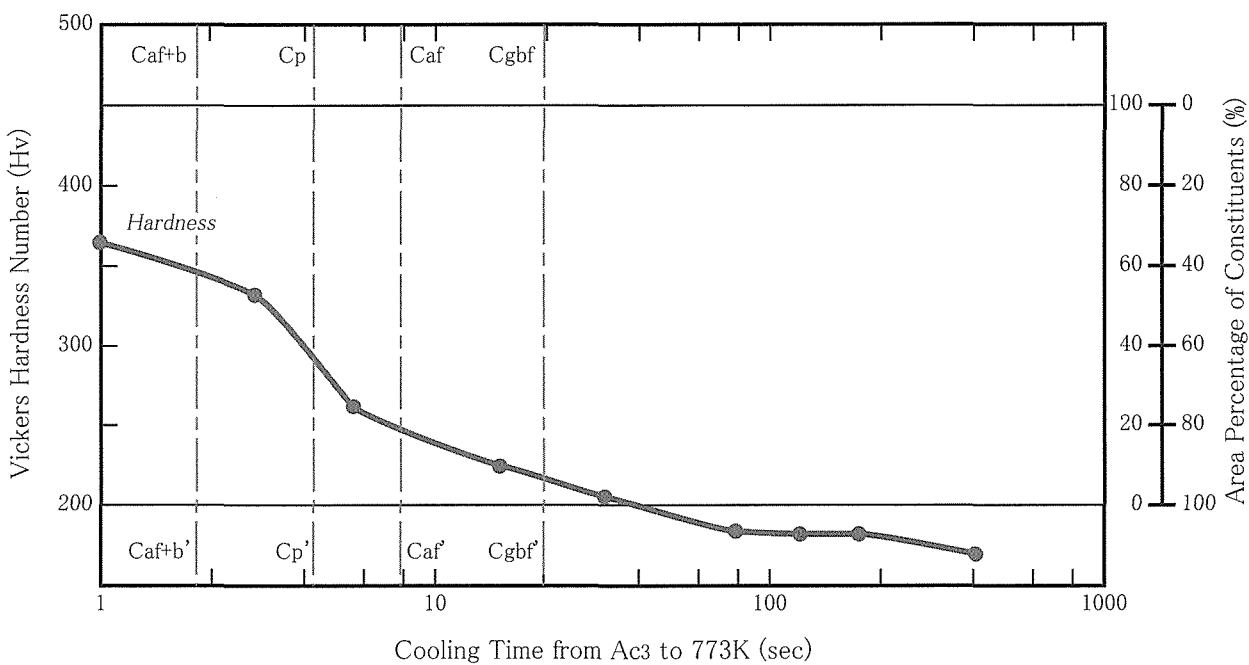
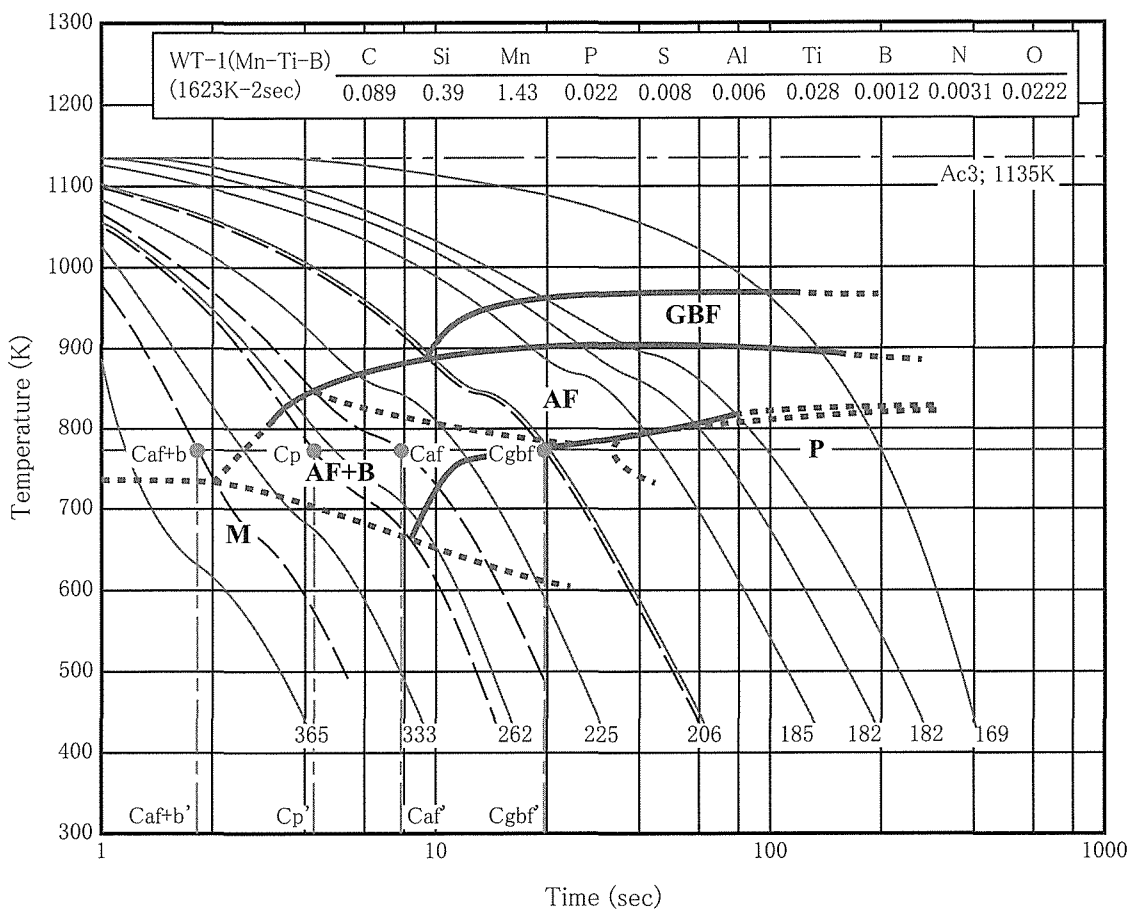


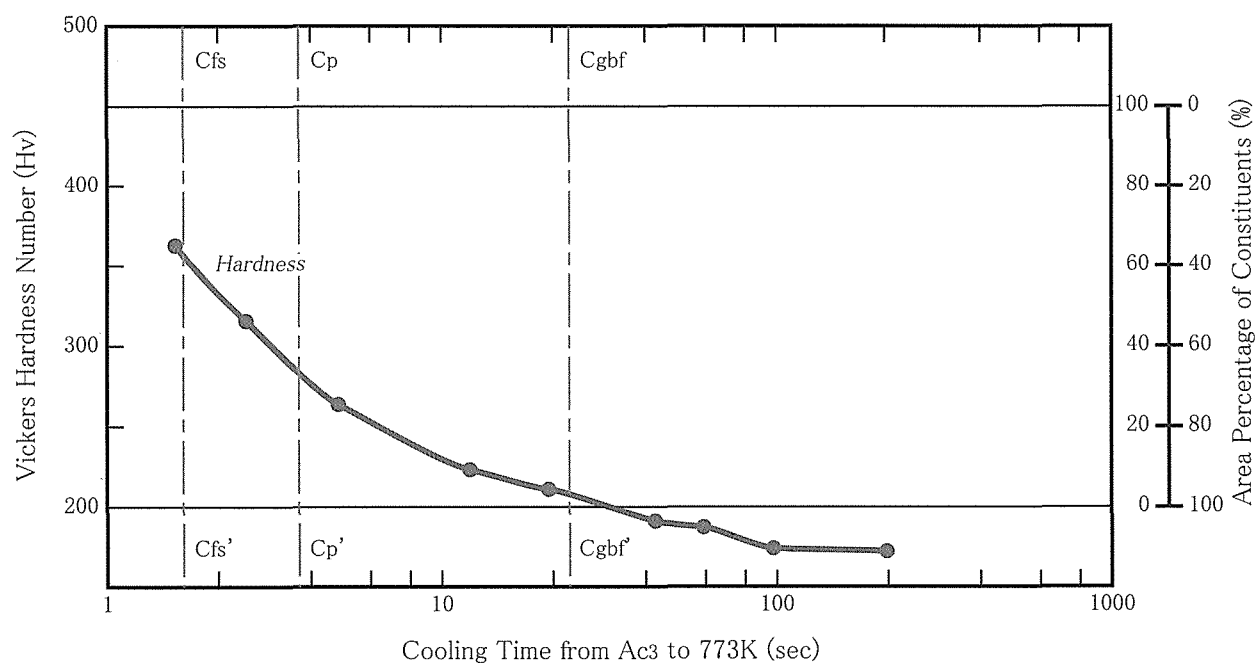
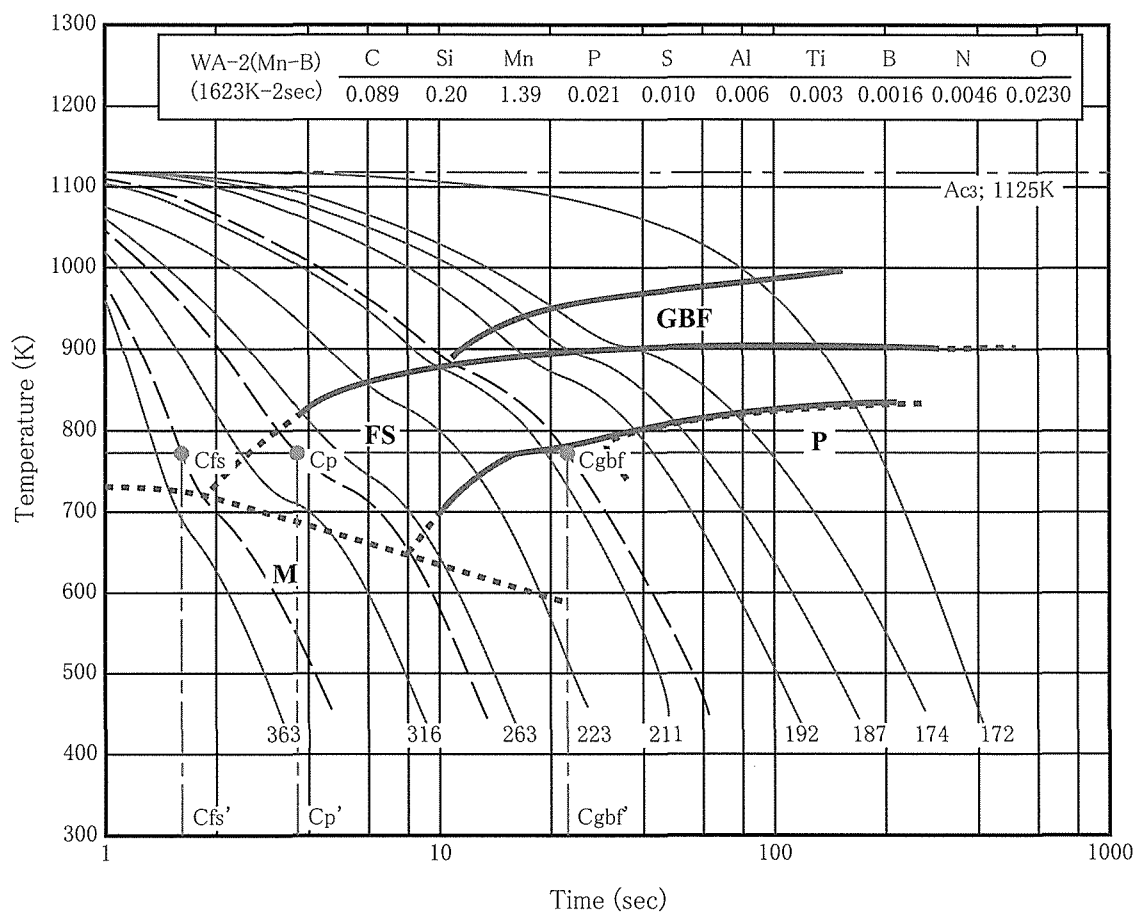


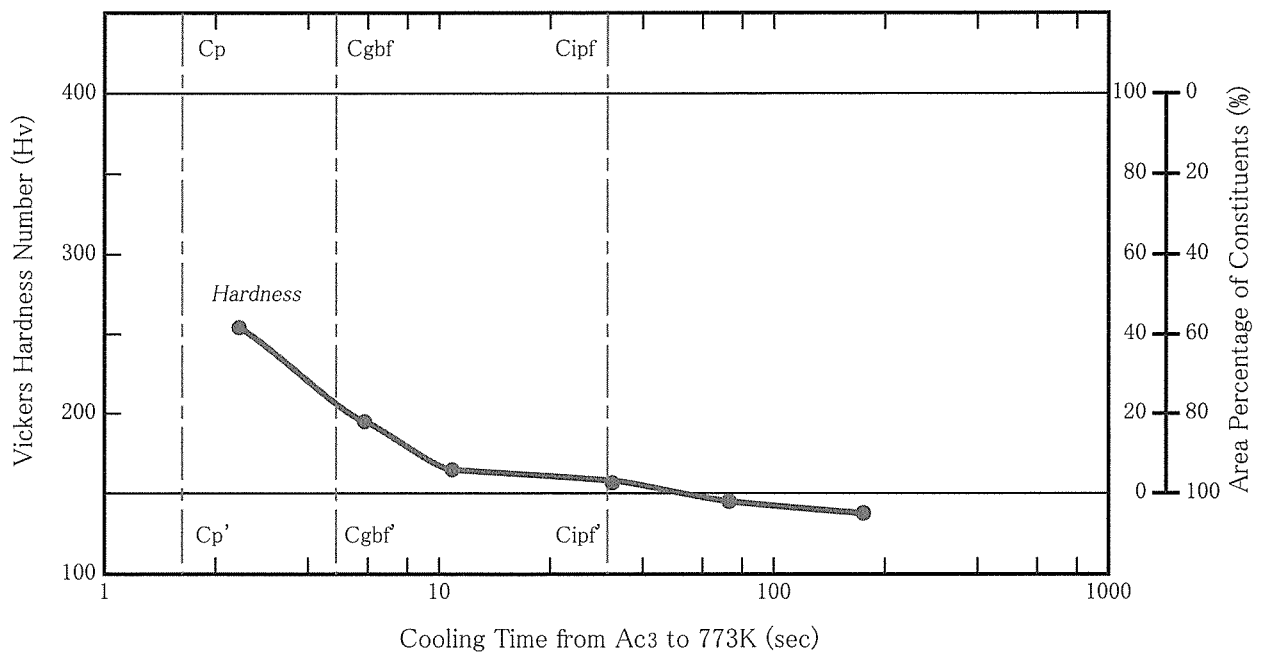
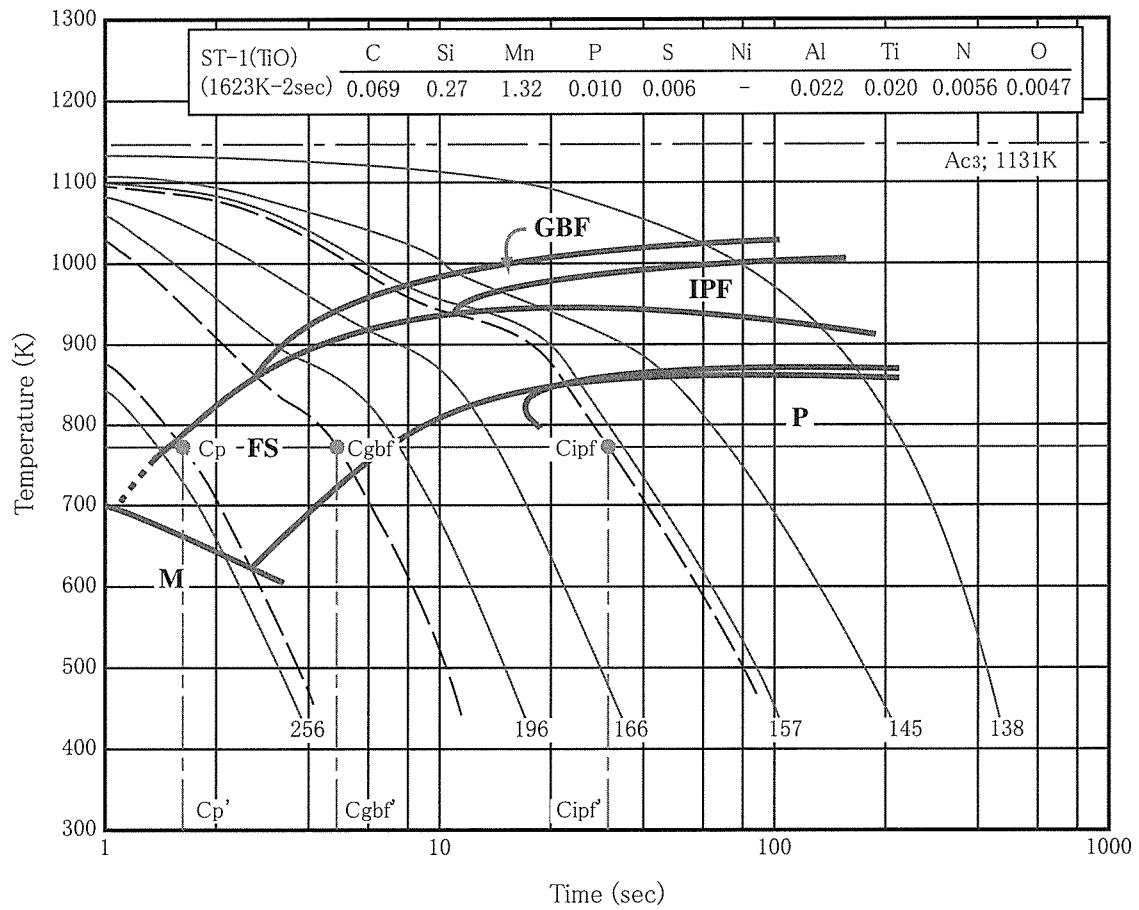


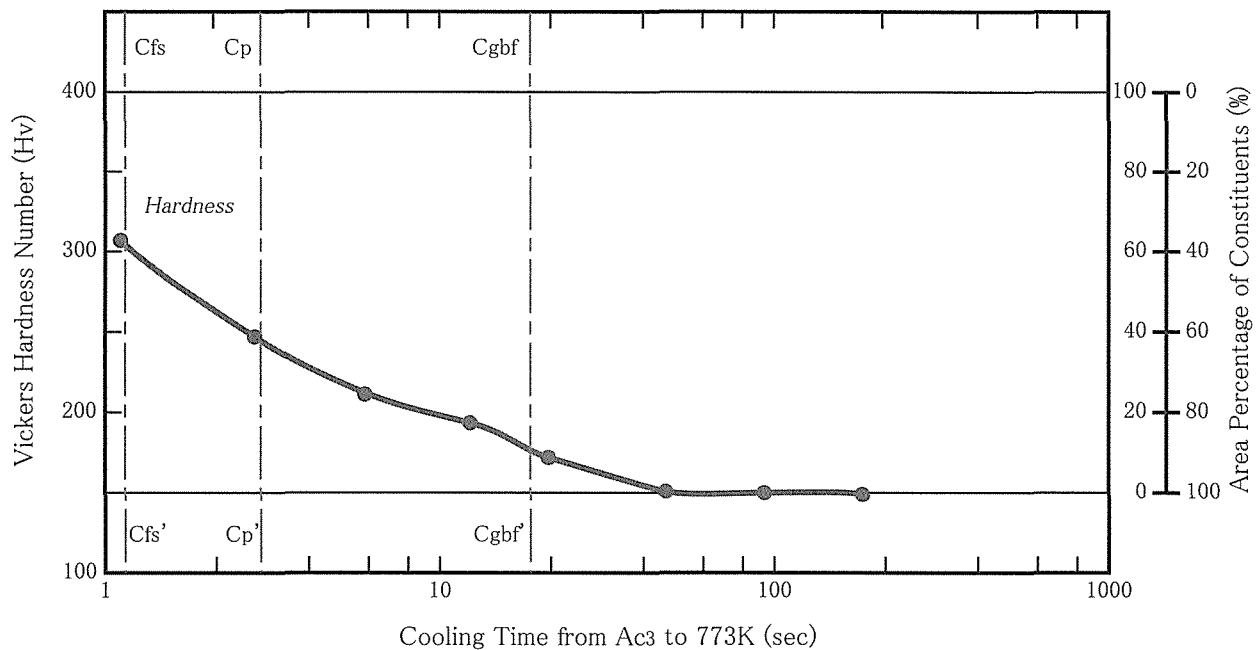
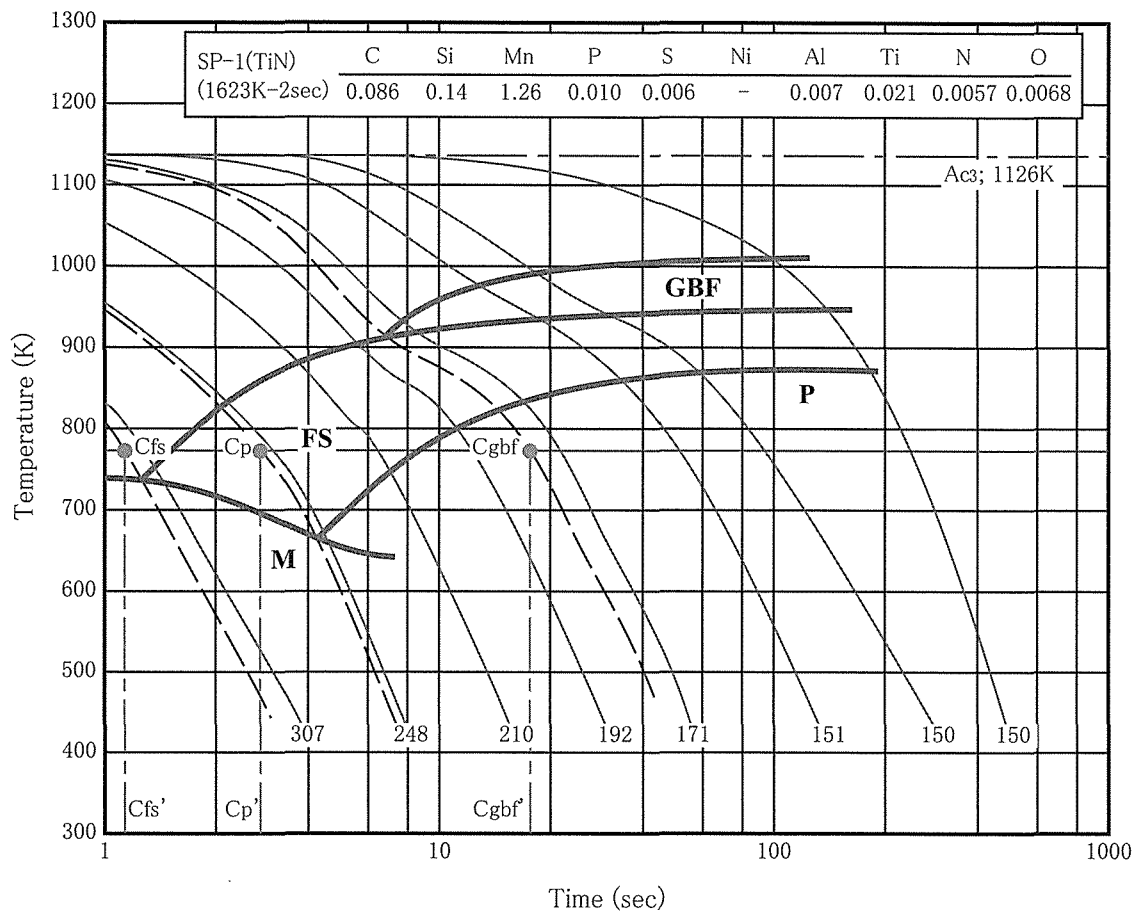
HSLA

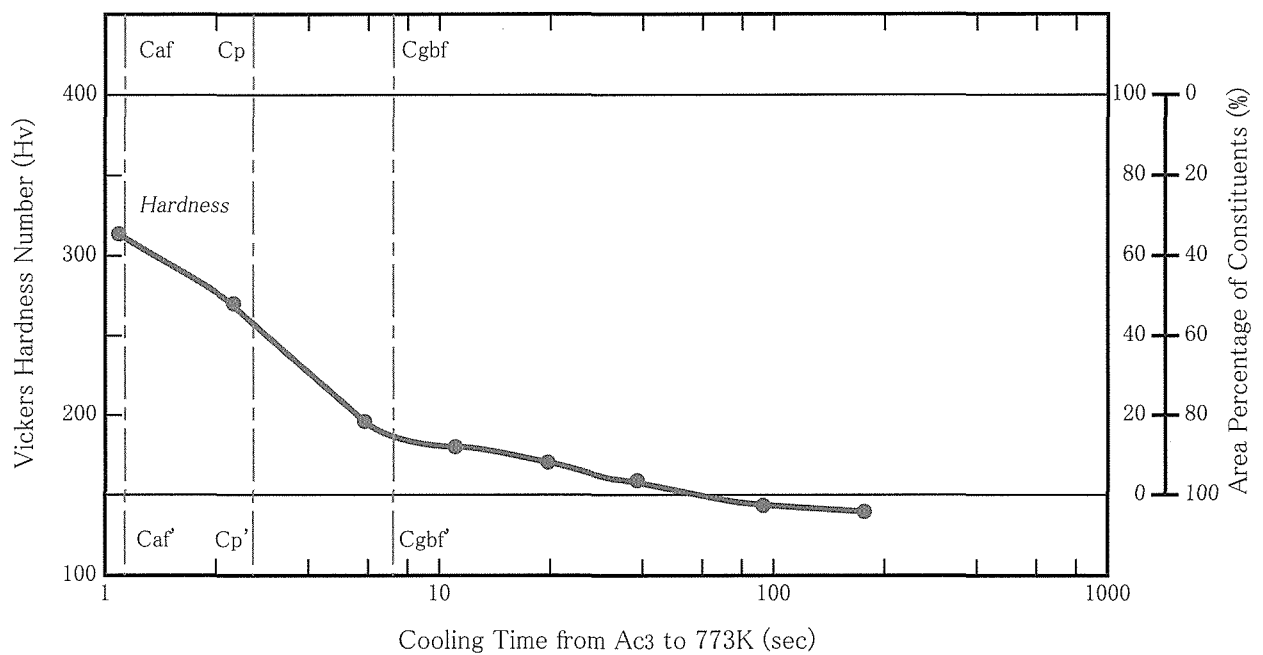
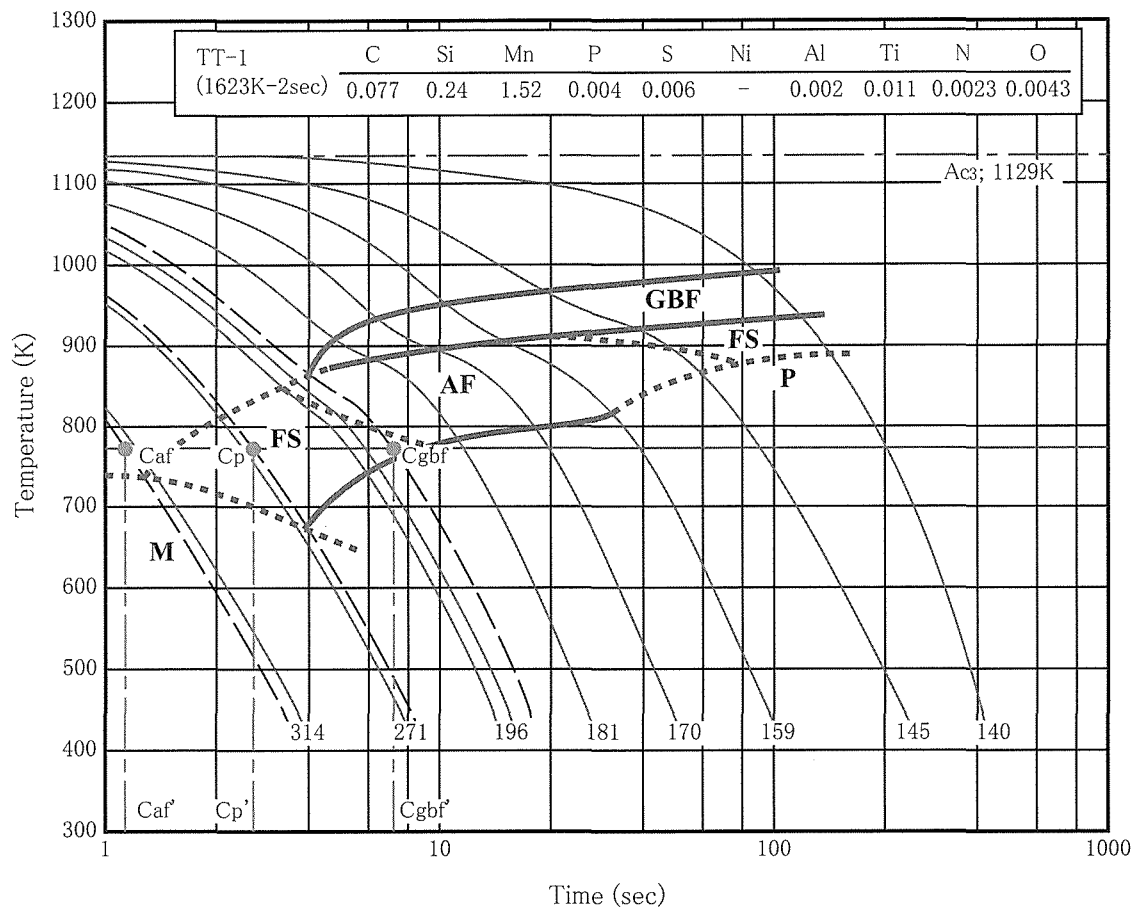
	Chemical Composition (wt%)																
Steel	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Nb	B	O	Page	Ref.
WT-1 (Mn-Ti-B)	0.089	0.39	1.43	0.022	0.008	-	-	-	-	0.006	0.028	0.0031	-	0.0012	0.0222	102	13
WA-2 (Mn-B)	0.089	0.2	1.39	0.021	0.01	-	-	-	-	0.006	0.003	0.0046	-	0.0016	0.023	103	13
ST-1 (TiO)	0.069	0.27	1.32	0.01	0.006	-	-	-	-	0.022	0.02	0.0056	-	-	0.0047	104	13
SP-1 (TiN)	0.086	0.14	1.26	0.01	0.006	-	-	-	-	0.007	0.021	0.0057	-	-	0.0068	105	13
TT-1	0.077	0.24	1.52	0.004	0.006	-	-	-	-	0.002	0.011	0.0023	-	-	0.0043	106	13







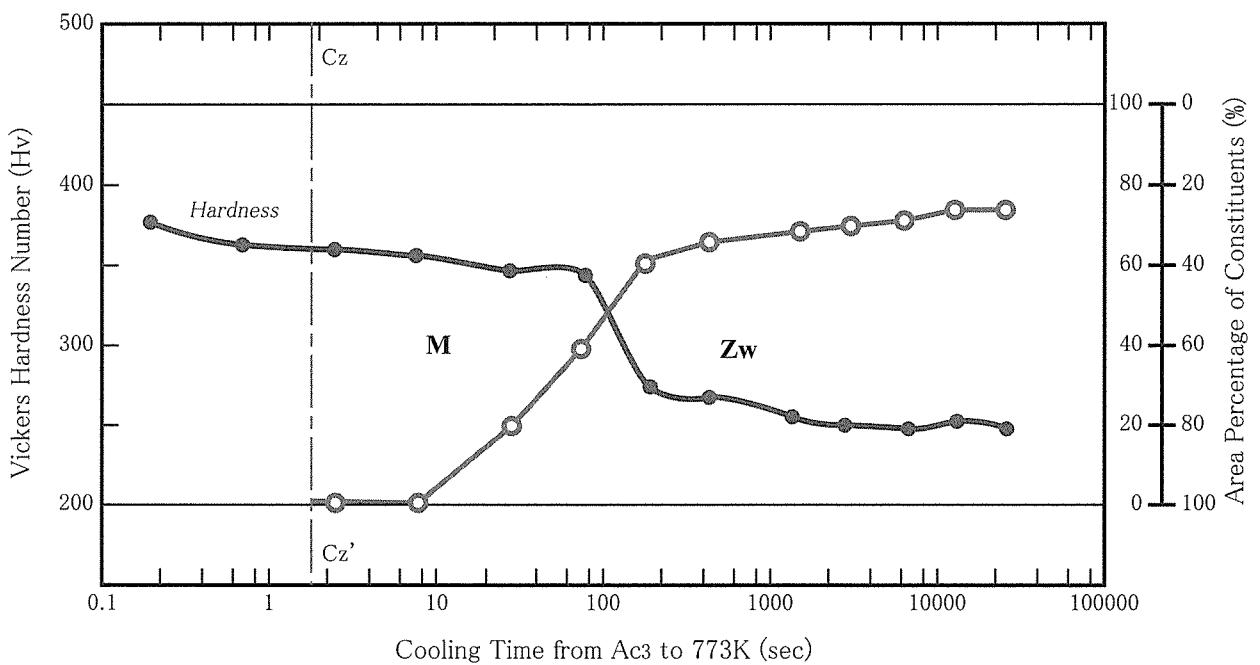
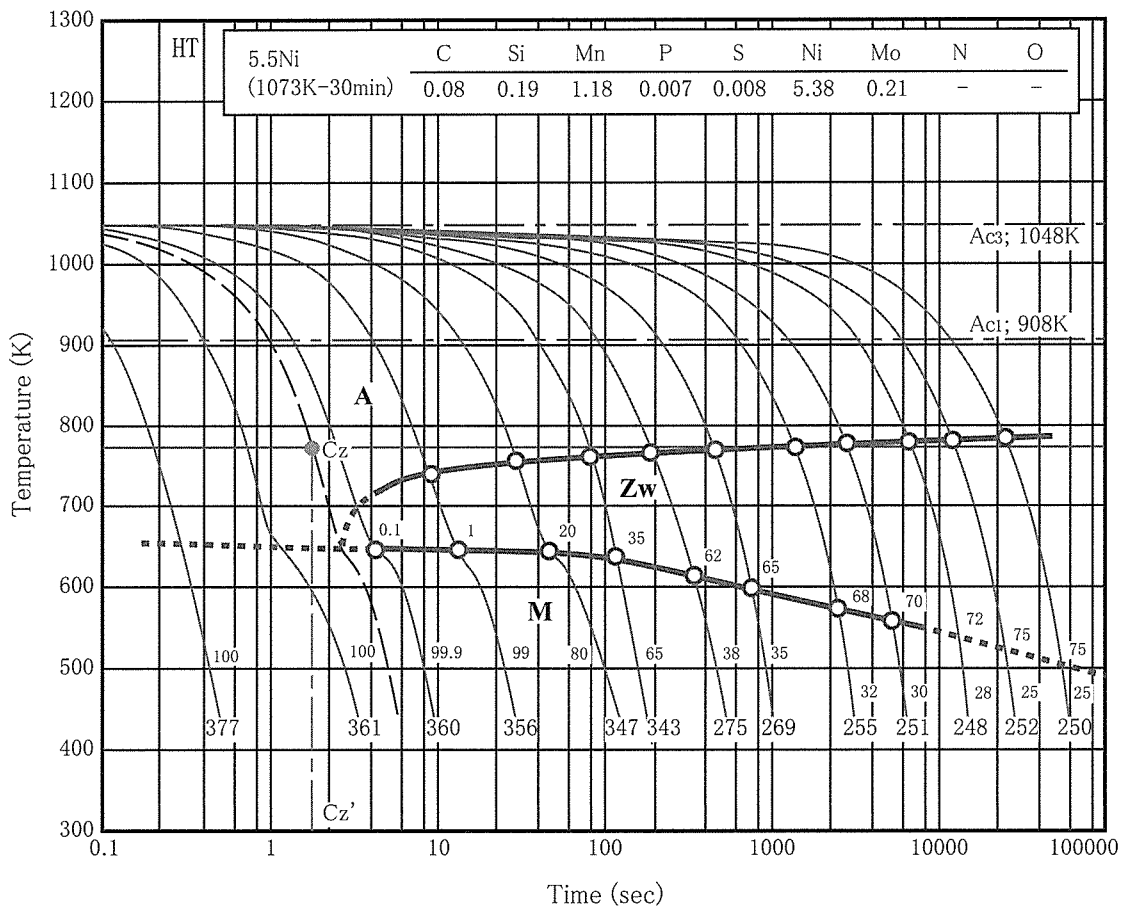


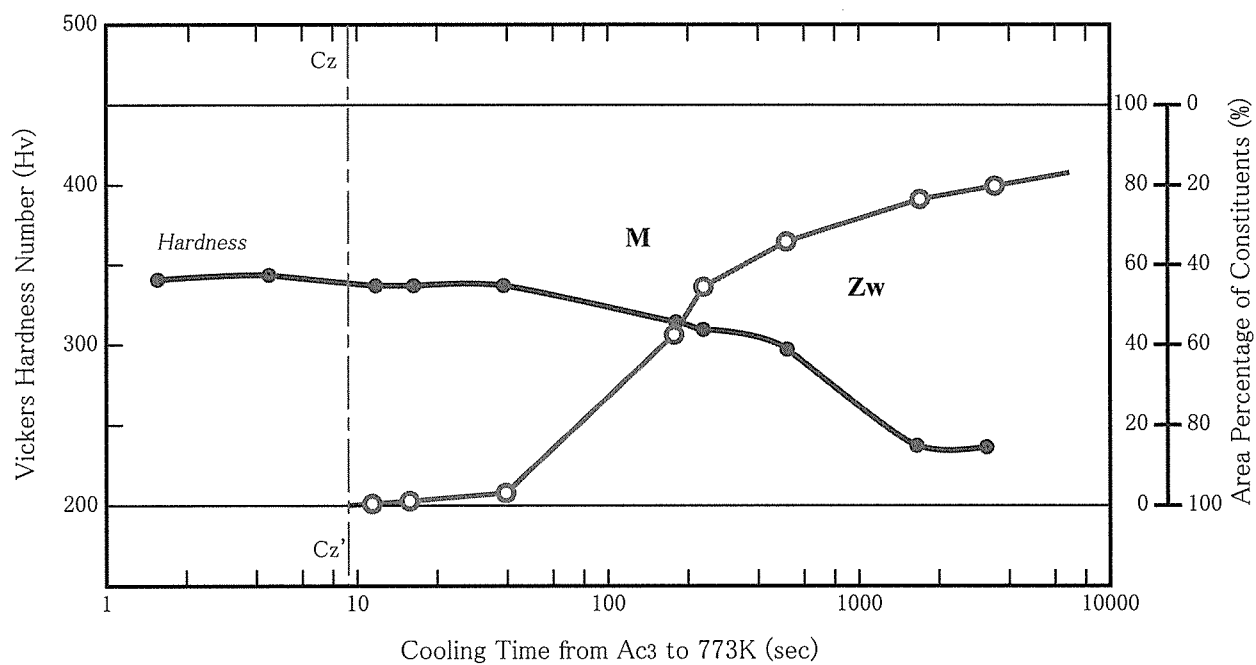
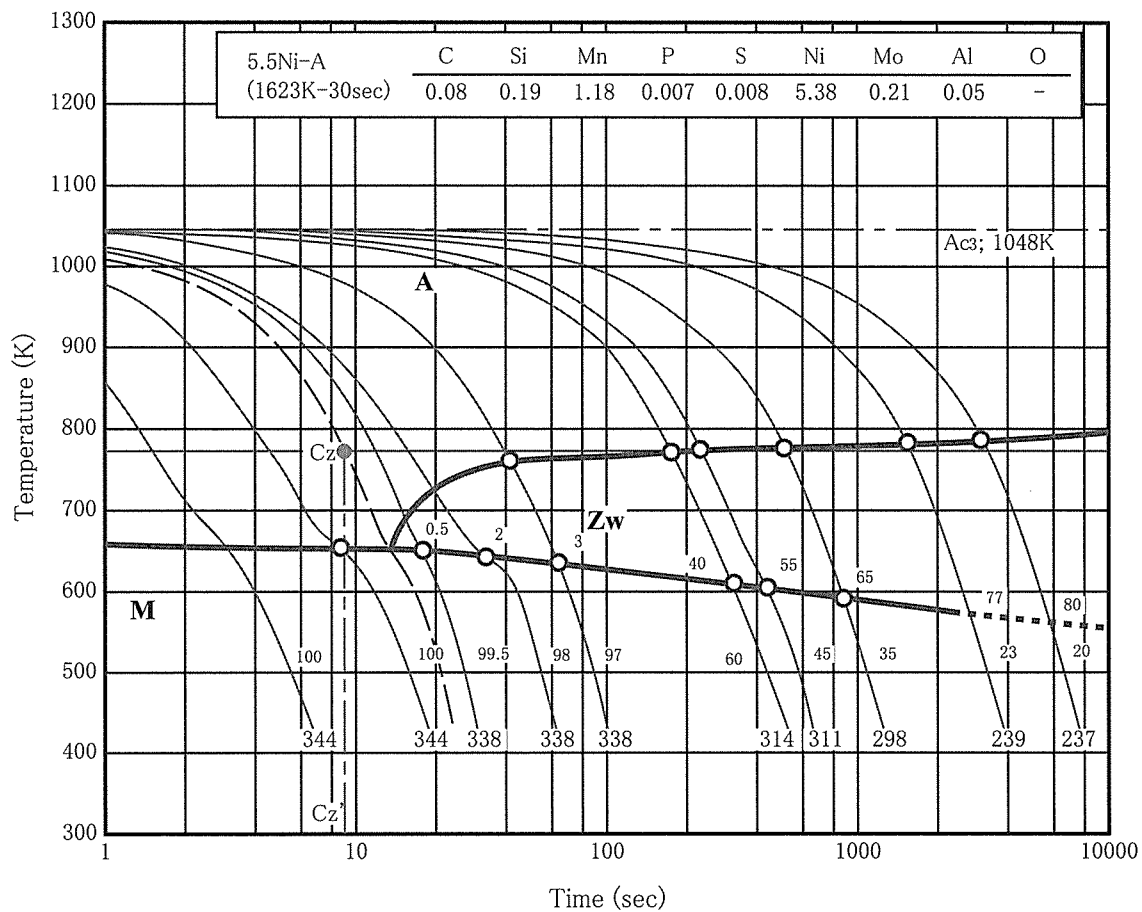


Cryogenic Steel

	Chemical Composition (wt%)																
Steel	C	Si	Mn	P	S	Cu	Ni	Mo	V	Al	Ti	N	Nb	B	O	Page	Ref.
5.5Ni HT	0.08	0.19	1.18	0.007	0.008	-	5.38	0.21	-	-	-	-	-	-	-	108	14
5.5Ni-A	0.08	0.19	1.18	0.007	0.008	-	5.38	0.21	-	0.05	-	-	-	-	-	109	14

HT: CCT diagram to be used the purpose of heat treatment. Heating at temperature below 1623K for welding.





Reference

- 1) "Continuous Cooling Transformation Diagrams" by Fundamental Research Laboratories R and D Bureau, Nippon Steel Corporation, 1972.
- 2) Makoto SATO, et.al., Seitetsu Kenkyu, No.273 (1971) P23-38.
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NIMS-MITS Special Report 2008

Atlas of CCT Diagrams for Welding. (II)

Edited by

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Publisher:

Masayoshi YAMAZAKI

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2008.5.1.