Nickel and Nickel-Copper Alloys: Metallographic Techniques and Microstructures
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Atlas of Microstructures for Nickel and Nickel-Copper Alloys

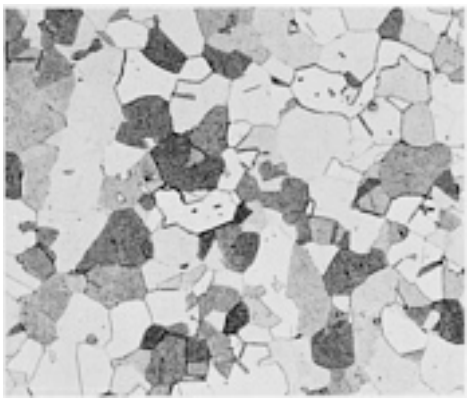

Fig. 1 Nickel 200, cold drawn and annealed in a continuous process at 830 °C (1525 °F). Structure: nickel solid solution. See also Fig. 2. NaCN, $(NH_4)_2S_2O_8$. 100×

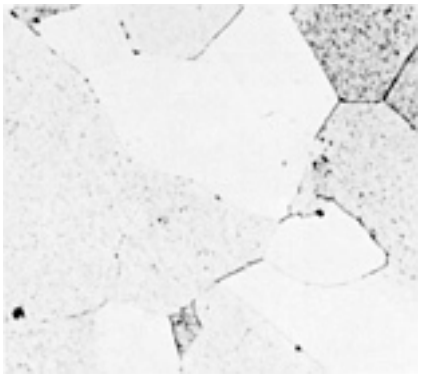

Fig. 2 Same as Fig. 1, but at higher magnification. Variation in shade of grains is caused by variation in grain orientation. NaCN, $(NH_4)_2S_2O_8$. 500×

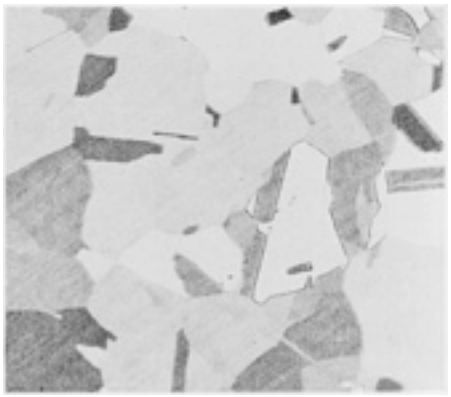

Fig. 3 Nickel 270, hot rolled and annealed in a continuous process at 830 °C (1525 °F). Structure: nickel solid solution. See also Fig. 4. NaCN, $(NH_4)_2S_2O_8$. 100×

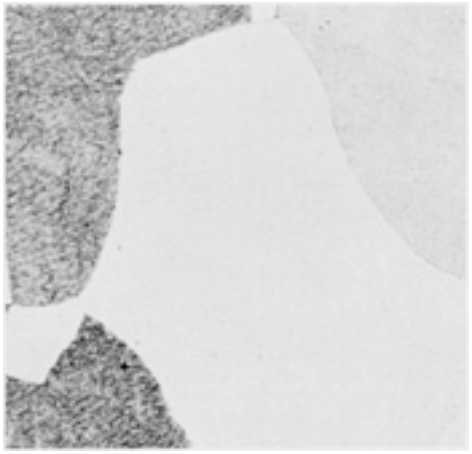

Fig. 4 Same alloy and same processing as in Fig. 3, but shown at a higher magnification. The variation in shade of the grains (dark, gray, and white) is the result of variation in grain orientation. NaCN, $(NH_4)_2S_2O_8$. 500×

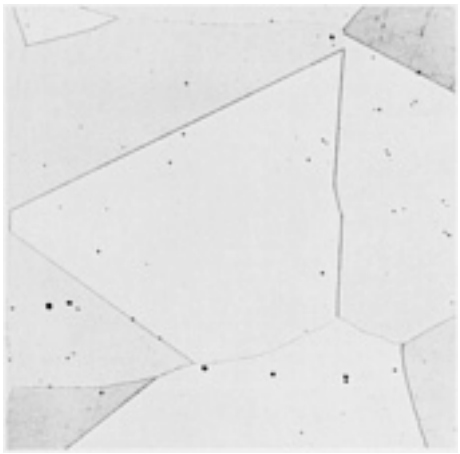

Fig. 5 Permanickel 300, solution annealed 1 h at 1205 °C (2200 °F) and water quenched, aged 10 h at 480 °C (900 °F) and water quenched. Dispersed particles of TiN and graphite (black dots) in nickel solid solution. NaCN, $(NH_4)_2S_2O_8$. 100×

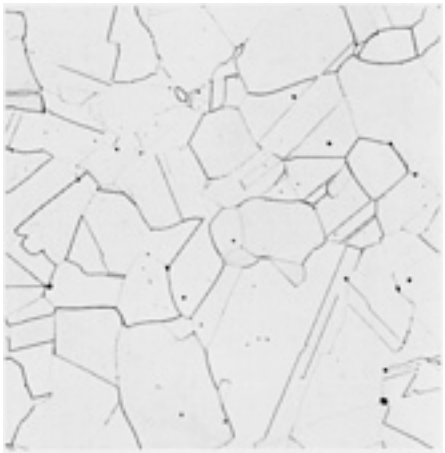

Fig. 6 Duranickel 301, solution annealed for 30 min at 980 °C (1800 °F) and water quenched, aged for 20 h at 480 °C (900 °F) and water quenched. Microstructure: nickel solid solution; graphite particles (black dots). NaCN, $(NH_4)_2S_2O_8$. 50×

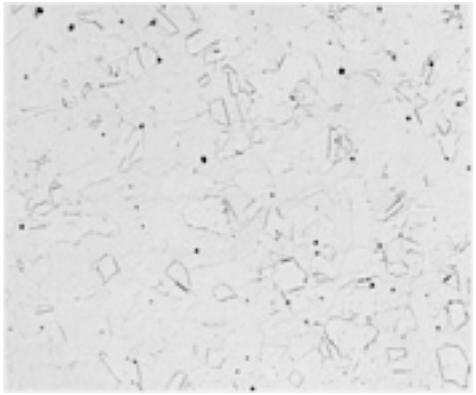

Fig. 7 Monel 400, cold drawn and annealed in a continuous process at 830 °C (1525 °F). Nickel-copper solid solution with a few unidentified nonmetallic inclusions (black). NaCN, $(NH_4)_2S_2O_8$. 100×

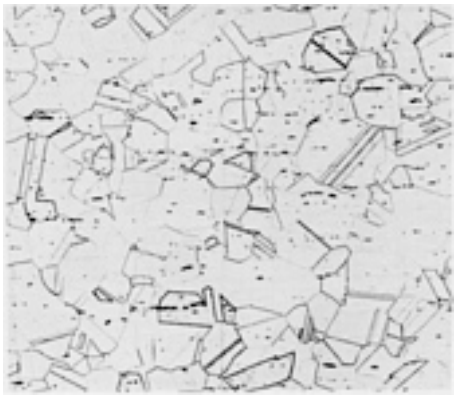

Fig. 8 Monel R-405, cold drawn, and annealed in a continuous process at 830 °C (1525 °F). Microstructure: nickel-copper solid solution with sulfide stringers (black constituent). NaCN, $(NH_4)_2S_2O_8$. 100×

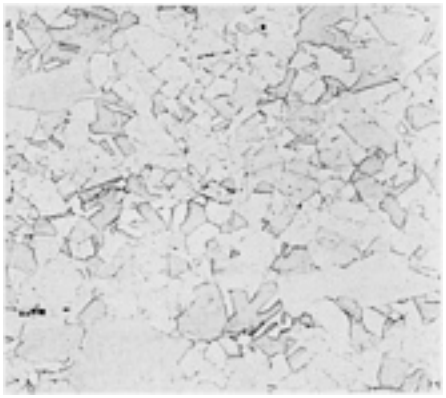

Fig. 9 Monel K-500 in the hot rolled condition. Structure: nickel-copper solid solution. Variation in shade of grains is the result of variation in grain orientation. Glyceregia. 100×

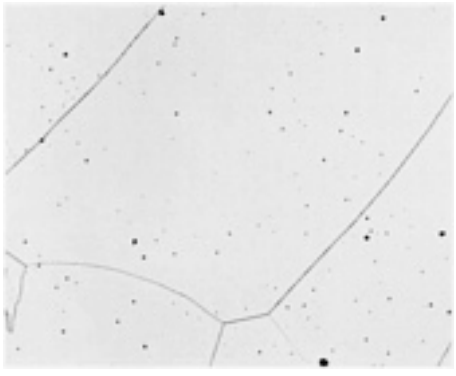

Fig. 10 Monel K-500, solution annealed for 1 h at 1205 °C (2200 °F) and quenched in water. Nickel-copper solid-solution matrix. See also Fig. 11, 12, 13, 14, and 15. NaCN, $(NH_4)_2S_2O_8$. 100×

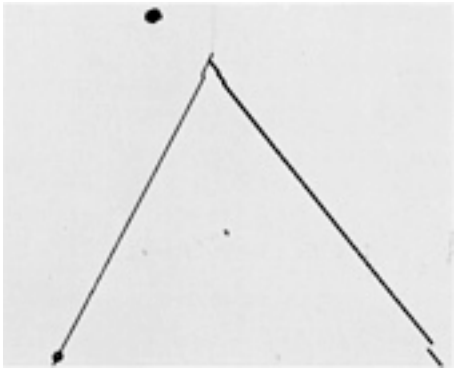

Fig. 11 Same as Fig. 10, but at higher magnification. Portions of only three grains are visible. The black dots are nitride particles. See also Fig. 10, 12, 13, 14, and 15. NaCN, $(NH_4)_2S_2O_8$. 1000×

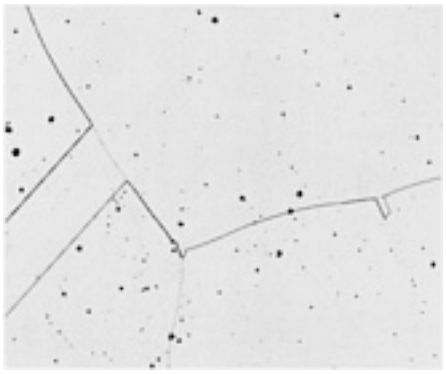

Fig. 12 Monel K-500, held 1 h at 1205 °C (2200 °F), transferred to a furnace at 595 °C (1100 °F) and aged 4 h, water quenched. Solid-solution matrix; nitride particles. See also Fig. 10, 11, 13, 14, and 15. NaCN, $(NH_4)_2S_2O_8$. 100×

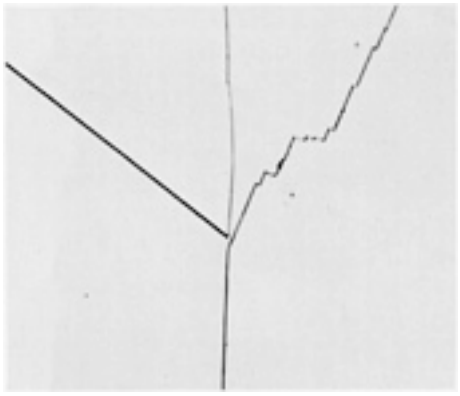

Fig. 13 Same as Fig. 12, but at higher magnification. Structure contains precipitated $Ni_3(Al,Ti)$, resolvable only by electron microscopy unless aging temperature is higher than 595 °C (1100 °F). See also Fig. 10, 11, 12, 14, and 15. NaCN, $(NH_4)_2S_2O_8$. 1000×

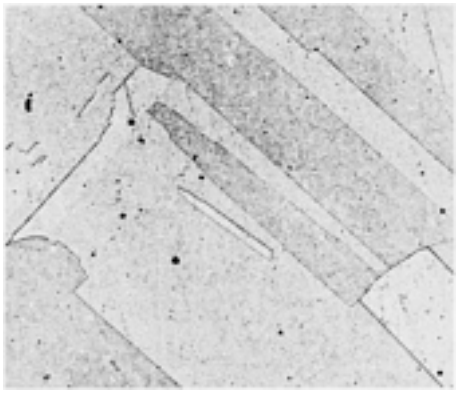

Fig. 14 Monel K-500, held 1 h at 1205 °C (2200 °F), transferred to a furnace at 705 °C (1300 °F) and aged 4 h, water quenched. Precipitated $Ni_3(Al,Ti)$ appears as tiny particles dispersed in the matrix solid solution. See also Fig. 10, 11, 12, 13, and 15. NaCN, $(NH_4)_2S_2O_8$. 100×

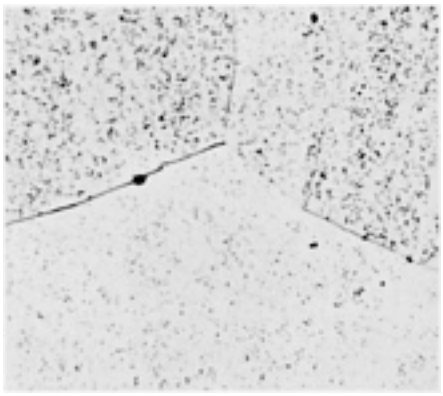

Fig. 15 Same as Fig. 14 except at a higher magnification. The $Ni_3(Al,Ti)$ precipitate is better resolved. When this precipitate is resolvable by optical microscopy, overaging is indicated. See also Fig. 10, 11, 12, 13, and 14. NaCN, $(NH_4)_2S_2O_8$. 1000×

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